Compilation of Research on Assessment of Civil Engineering Students

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1. OBJECTIVES OF WORK

The objectives of this work were:

- Use the CALOHEE (Comparing Achievements of Learning Outcomes in Higher Education in Europe - www.calohee.eu) framework for Civil Engineering.
- Analyse and study the implementation of the referred framework.
- Consider possibilities of adapting bachelor and master programs in Civil Engineering in terms of learning outcomes and of assessment of learning.

Method proposed consisted in testing the fitness for purpose of the framework in Civil Engineering by piloting the practical application in contexts for which this was intended, in particular in quality assurance and accreditation, internal quality assurance, curriculum development, qualification frameworks/standards and teaching improvement.

It is intended to prepare a blueprint of transnational skills tests by identifying aspects of learning outcomes and grading schemes and overcoming the challenges of the cultural, disciplinary and educational specificities. The aim of this sabbatical will focus in particular on the last item, that is to develop an ambitious and sophisticated instrument to measure performance.

The current testing/assessment methods are not an objective of this sabbatical. The instrument should build upon and be a good reflection of the Assessment Reference Frameworks of the Civil Engineering área of the project CALOHEE. The assessments/test items should not express the idea of standardised testing. These assessment methods should allow for identifying/measuring (real understanding, analytical and critical thinking/awareness, making solid judgement and preparing for a societal role, both for the world of work and civic, social and cultural engagement.

It is intended to develop different forms and formats of assessment according with cultures and practices of the institutions visited and analyzed. The assessments should go beyond the measuring/assessment of knowledge only and will include skills and attitudes in accordance with the European Qualification Framework and with ENAEE/BUR-ACE performance standards.

The institutions chosen have participated in CALOHEE or have experience in assessment of learning outcomes and competences. These may represent mostly the different educational cultures in the EU/BEA. These schools and experts have demonstrable experience with state of the art and relevant assessment forms/formats. This expertise reflects the different dimensions of the frameworks, but also - and in particular - the three columns representing knowledge, skills and - most challenging - autonomy and responsibility.

The aspects to address in this study are:
• understanding of the framework concerned, in particular the last column (autonomy and responsibility);
• mindset and self-reflection as a teacher;
• experience in the use of modern approaches and techniques regarding learning, teaching and related assessment, such as for example project work/teamwork, peer learning, work-based learning (work placements, entrepreneurial approaches), training / education of cultural, social and civic awareness which result in engagement;
• digital learning, such as blended learning.

In 2021 the effects of the Covid19 pandemic were strong and effective around the world. Restriction of travel and stay were in place in most countries. The universities where the stays and collaboration had also rules to accommodate newcomers. Text was produced using research references and texts by the author. References are not indicated in the text due to the plurarility and juxtaposition of sources. Tables were transcribed from the respective sources indicated in the title. Case studies are reproduced from the original texts with editing considering adequate for a clearer understanding of the situations reported. References are supplied with no particular order of relevance or of historical input.

3. ASSESSMENT OF CIVIL ENGINEERING STUDENTS

Trying to define what is assessment it is an action that occurs frequently in anybody's life. In terms of education it is a fact that assessment, principles and practices, are fundamental for effective learning to take place. Assessment done properly can be a catalyser for positive change of students attitudes in terms of learning and to teachers for information on how teaching can be improved. It is therefore necessary to develop the assessment literacy of teachers to enable them to innovate and to contribute to effective and useful earning outcomes of learners.

Some competencies of teachers can have indicators of respective assessment literacy such as: can describe different purposes of assessment, know why and how assessments are standardised and moderated, know how to prepare students effectively for assessment, can contribute to the debate on how assessments can evolve in the future and can explain to others key concepts in educational assessment to others. Of course, the listed indicators are not complete and many others can translate the competencies of teachers to produce effective assessment and to transform the teaching techniques to improve learning.

A common definition of assessment of learning is to collect and recording evidence(s) with respect to something that teachers want students to learn. For instance, the analysis of a student response to an assigned task. This type of assessment is done sometimes at end of the teaching activities or during the process of teaching. The first one is considered a summative assessment.

and the second formative assessment. Currently the latter is adopted by most teacher allowing adaptation of teaching techniques and remedial activities. Summative assessment is sometimes denominated assessment of learning and the formative assessment is designated as assessment for learning.

For Engineering assessment there is a variety of types. One type is a practical examination like a set of practical tasks that is completed and reported upon an examination of some kind. Another class is the controlled assessment where teachers and students compare their answers. A third group is the coursework where practical tasks are done during class time or as homework. A fourth kind are practical activities with supporting examination with assigned practical tasks and verified in an exam or in a laboratory environment.

Of course Civil Engineering assessments may have different purposes in terms of education and of training. One purpose is the comparability to establish evolution or regression among different groups of learners. A second goal can be diagnosis to identify learning issues or difficulties. A third aim is the formative to identify learner needs and to redirect teaching activities. An important one in Engineering is the qualification to ensure learners has acquired required competencies to assume a professional role.

Civil engineering is a professional engineering discipline that deals with the design, construction, and maintenance of the physical and naturally built environment, including works like buildings, bridges, canals, dams and roads. There are several specializations, like construction, hydraulics, structures, etc. Several other specializations were created within civil engineering and have gained independent status like mining and mechanical. It is oldest engineering specialization and it is intertwined with architecture. Architecture conceives, civil engineering executes.

Civil engineering provides the majority of the infrastructure and significant parts of the public and private facilities that are used in our day to day lives. It is the area of engineering that most affects and transforms the physical world and is the backbone of modern living related with, buildings, urban planning, environment and materials, running and clean water, transportation infrastructures. Additionally, most civil engineering projects are unique and have a long design life in contrast with the short lifetime/obsolescence of many manufactured products of other engineering fields.

Civil engineering work has an inherently high degree of complexity, where non-engineering issues dealing with social, political, economic and environmental concerns, as ethical issues, have become far more important than previously, with the emerging of new fields of activity such as Urban and Environmental Planning, Strategic Environmental Assessment, Economic Evaluation of Projects and so on. Also sustainability calls for civil engineers to be leaders.
There have been initiatives to find proper assessment methods for the different types of Learning Outcomes in Civil Engineering programs. Research members of the academia and profession showed evidence that assessment is mostly by written or oral end-of-semester examination, often supplemented by mid-term examinations, homework exercises, and where relevant project assignments and programming assignments.

If the end-of-semester examinations are the sole assessment there is of course less feedback, and therefore less opportunity to learn through assessment, available to the students. It has been noted that shortcomings in students 'understanding of what is required of them often only becomes apparent at the time of assessment.

Final year projects and second cycle dissertations have feedback built in as part of the supervision process. Some students perform better in this situation than in the traditional examination format. They also afford the opportunity to assess the acquisition of the generic and subject-specific competences for each cycle.

Learning Outcomes in Civil Engineering, especially when mapped to specific educational experiences, can also be used by students to assess their own progress. A valuable tool in this regard is e-portfolios, which may be used by both students and their teachers to assess knowledge, skills and attitudes in engineering. In addition to the standard, summative teacher-course evaluations, face-to-face interactions between students and ‘trusted ’advisors can be used to obtain more detailed information regarding the ‘success ’of the education experiences.

Within the research carried out within the framework of CALOHEE it was shown that the type of sectors where Civil Engineering graduates find employment are Private Enterprises, Government (including departments, statutory authorities and government owned businesses), Local Government and Public Companies. With respect to other engineering specializations, in consideration of their ability to solve important societal problems Civil Engineers are privileged for entering public service in policy-making or political roles where their engineering education is instrumental since they have decision making power at high levels..

Furthermore, due to the civil and criminal responsibility of Civil Engineering activities, the profession is regulated by government agencies, professional bodies or private organizations in many countries. In this case, in order to become a licensed/registered engineer, graduates may be required to complete a period of supervised work experience and, in some cases, pass one or more examinations. Furthermore, in some countries the type of work open to graduates with only a first cycle degree may be limited. Some professional organisations in several countries require a second cycle degree or its equivalent to become registered or to practice. Other professional organisations have opposed such a requirement and believe that a first cycle degree is sufficient to enter those professions.

The investigation by questionnaire carried out in the framework of the CALOHEE project has shown that the titles of the Bachelors also vary and are, for instance, called in English Civil Engineering, Environmental Engineering, Construction Management and Civil and Territorial Engineering.

Specializations or tracks of the Bachelor programmes can be, in accordance with the major theme, called in English Applied Mechanics, Hydraulics, Hydromechanics, Coastal and Harbour Engineering, Geotechnical Engineering, Structures, Earthquake Engineering, Geodesy, Transportation Engineering, Materials, Construction, Engineering and Management fields, Structural Engineering, Hydraulics and Environmental Engineering, Geotechnical Engineering, Transport, Infrastructure and Regional Planning, Civil Constructions, Hydrology and Transports and Urban Services.

In terms of their profile, Bachelor programmes can be characterized as:
a) broad programmes covering typical elements of the sector involved, followed later by specialization in a particular subject area / discipline;
b) specialized programmes focusing (mainly or only) on the subject area involved;
broad programmes covering different paradigms, which are /can be also positioned outside the realm of the sector.

Furthermore, with respect to the teaching and learning approach, the investigation has shown that Bachelor programmes can be characterized as:

a) traditional programmes in which the focus is mainly on knowledge acquisition and transfer: the programmes are largely based on lecture classes, which might be supported by seminar groups and, if applicable, limited laboratory work;
b) student-centred programmes, which require active student learning, which is mainly based on seminar/exercise course unit model and, if applicable, extended laboratory work.

Some Bachelor programmes include a work based learning component like work placement or traineeship. The number of credits ECTS for this part of the programme range from 5 to 20. Most students in Bachelor programmes are expected to prepare reports or research reports.
Second cycle Master degrees are finalised to enter the practising profession.
Some institutions or countries offer integrated first and second cycle programmes. In some cases, these integrated programmes are a combination of a first and second cycle programme. In other cases (e.g. the UK MEng degree), the programmes are more fully integrated.

In consideration of the different lengths of the Master programmes (from 60 to 120 ECTS credits, from 240 to 300 ECTS credits in case of integrated Masters), the level of achievement of the programme learning outcomes, consistent with the ones of QF-EHEA 2nd cycle or EQF for LLL level 7, can not be the same.

Because students at this level are now focusing more on one technical area, more specialised degrees could be offered. For instance, the English titles identified in the context of the CALOHEE investigation have been Civil Engineering, Environmental Engineering, Building Engineering, Mathematical Engineering, Construction and Project Management, Structural Engineering, Water Engineering, Architectural Engineering, Structural Engineering and Architecture, Reconstruction and Modernization of Buildings and Facilities, Environmental Protection and Sustainable Development and Engineering Project Management.

Also Master programmes can have orientations (the ones identified in the context of the CALOHEE investigation have been Structural design and construction, Project management, Rehabilitation and strengthening of civil engineering structures and facilities, Structures, Construction and Geomaterials, Water Resources). The investigation done with desk research has also shown that, in terms of their profile, Master programmes can be characterized as:

a) specialized programmes focusing (mainly or only) on the subject area involved;
b) broad programmes covering typical elements of the sector involved, followed later by specialization in a particular subject area / discipline.

Furthermore, with respect to the teaching and learning approach, the investigation has shown that Master programmes can be characterized as:

a) traditional programmes in which the focus is mainly on knowledge acquisition and transfer: the programmes are largely based on lecture classes, which might be supported by seminar groups and, if applicable, limited laboratory work;
b) student-centred programmes, which require active student learning, which is mainly based on seminar/exercise course unit model and, if applicable, extended laboratory work;
c) programmes based on research driven education;
d) programmes based on applied driven education.

Most Master programmes have minor or elective subjects with credits of ECTS ranging from 10 to 45. Some Master programmes include a work based learning component like work placement or traineeship. The number of credits ECTS for this part of the programme range from 5 to 30. All students in Master programmes are expected to prepare a final thesis.

In most cases, first cycle graduates go to work directly for organisations that design, produce, and/or sell products, sub-systems, systems, and/or services. In most such employment, the graduate will begin to work under the supervision of a more senior engineer. The graduates are involved with duties ranging through the full life cycle of these products and services. Such roles might include limited basic research, design of the organisation's products or services, the production of the product or service, selling of the product or services to other technical or non-technical organisations, or the operation, servicing and/or maintenance of the product or service in field applications.

Many first cycle graduates will pursue additional education often leading to second cycle degrees. In some cases, the students will continue their education while being employed as a practicing engineer. Graduates with second cycle degrees are less likely to enter positions that primarily focus on the narrow application of engineering methods or positions such as sales engineering and applications engineering. On the other hand, graduates of second cycle programmes are more likely to enter a higher level specialised engineering positions with a research focus, more loosely defined problems, and management responsibility.

For Bachelor graduates, the twelve most common jobs identified in the context of the CALOHEE investigation carried have been Civil engineer, Site engineer, Site manager, Site inspector, Project manager, Design engineer, Structural engineer, Geotechnical engineer, Hydromechanics engineer, Health and safety coordinator, Teacher, Technician.

The first twelve typical tasks performed by bachelor graduates have been identified in Designing structures, Analysing structural stability of structures, Planning construction of structures, Overseeing construction and maintenance of structures, Testing samples from site and structures, Making cost calculations, Controlling budget, schedule, and quality, Organizing and directing, Analysing data and preparing reports, Inspecting job sites, Overseeing construction and maintenance of building structures and facilities, testing (soil, building materials).

For Master graduates, the twelve most common jobs identified in the context of the investigation carried have been Engineer, Consultant, Analyst, PhD, Structural engineer, Project manager, Associate, Works engineer, Data scientist, Research engineer, Civil engineer, Site engineer. The first twelve typical tasks performed by Master graduates have been identified in Undertaking technical and feasibility studies including site investigations, Using a range of computer packages for developing detailed designs, Undertaking complex and repetitive calculations, Liaising with clients and a variety of professionals including architects and subcontractors, Compiling job specs and supervising tendering procedures, Resolving design and development problems, Managing budgets and project resources, Scheduling material and equipment purchases and deliveries, Making sure the project complies with legal requirements, Assessing the sustainability and environmental impact of projects, Designing structures, Analysing structural stability of structures.

4. COMPETENCES TO ANALYZE OF CIVIL ENGINEERING STUDENTS

The typical degree programmes in Civil Engineering are denominated in English as:
a) Bachelor with a total of ECTS credits ranging from 180 to 240;
b) Master with a total of ECTS credits ranging from 60 to 120;
c) Integrated Master with a total of ECTS credits ranging from 240 to 300.

Depending on the country, first cycle degrees may be either a three or a four years´ programme. In reference to the Bologna Process, first cycle graduates should be both employable and qualified to enter a second cycle programme. Graduation from a first cycle programme, however, does not necessarily signify that the graduate is prepared to enter the practising profession. In some countries, there are two tracks for first-cycle degrees. One is designed to prepare students for more applied careers; these students may not be adequately prepared to enter advanced (second cycle) educational programmes in engineering without additional preparation. The second track is more focused on theoretical and abstract thinking and creative analysis in problem solving. It sets the ground for continuing on to advanced degrees in engineering.

In general, three years Bachelors are finalised or to enter the practising profession or to prosecute studies in Master programmes, while four years Bachelors prepare students for entering the labour market. Furthermore, four years Bachelors have programme learning outcomes more consistent with the ones of the 2nd cycle Qualification Framework of European Higher Education Area (QF-EHEA) or of the level 7 of the European Qualification Framework for Lifelong Learning (QF for LLL) than to the ones of QF-EHEA 1st cycle or EQF for LLL level 6. Of course, if the programme learning outcomes are consistent with those of Master programmes, the level of their achievement cannot be the same as in Master programmes, at least in Master programmes of 300 ECTS credits.

While researching the set of competences for Civil Engineering students (bachelor and master degrees) the adopted approach was that proposed in CALOHEE. It offers a relevant tool for understanding, defining and visualising the requirements for any degree programme in Civil Engineering. It shows, in a detailed but also general and flexible way, which competences should be developed by such types of programmes. It provides useful suggestions about knowledge, skills and attitudes.

These three types of competences are grouped in dimensions that are knowledge and understanding, analysis and problem solving, design and investigation, practice, design, team-working, communication and lifelong learning. These are learning outcomes of the Civil Engineering programmes that intend to provide competences that are recognized by society, by professional engineering organizations and by employers as those required to operate. This set of competences is proposed for first and second cycle levels in Civil Engineering as levels 6 and 7 of the European Qualification framework.

The CALOHEE frameworks, also labelled as Terms of Reference, comprise reference tables containing descriptors covering knowledge, skills and attiudes. These tables were described and explained in the TUNING Guidelines and Reference Points for the Design and Delivery of Degree Programmes in Civil Engineering. The advantages of being able to refer to this framework is that it provides a widely accepted comprehensive overview of the key learning outcomes that a Civil Engineering degree programme can include taking into account that it was developed by an international group of experts and validated by peers and other stakeholders; a range of proposed strategies, methodologies and approaches to learn, teach and assess the learning outcomes.

Stakeholders in the Civil Engineering subject area were consulted that included disciplinary experts, teaching staff, university and faculty management, professional organisations, employers and students. Therefore a list of the learning outcomes through which an individual degree programme at bachelor or master level can be defined on the basis of rational choices of content, modes of teaching and methods of assessment. It appears also as a fair indicator of the completeness and quality of a degree programme which allows for diversity according to institutional missions and contexts.

CALOHEE may be used as a reliable mechanism for quality assurance based on the terms of reference based on well-defined sets of measurable learning outcomes. It has a format for comparing different degree programmes in terms of profile, content and approach and it is a robust and articulated framework for developing comparable diagnostic assessments. It can offer reliable evidence regarding the strengths and weaknesses of a particular degree programme benchmarked against programmes with comparable missions and profiles.

CALOHEE terms of reference can be seen as a general table providing a complete overview of Civil Engineering in terms of measurable learning outcomes statements. The focus in the framework is not only on ‘what ’to learn, but also on ‘how ’this ‘what ’can be learned and taught. The hierarchy in qualification frameworks starts with the overarching European frameworks, followed by national, sectoral and the subject area frameworks. It organises its descriptors according to the categories knowledge, skills and attitudes distributed among the relevant Civil Engineering dimensions. The dimensions are seen as the main building blocks of Civil Engineering. The descriptors, formulated in this way, provide structure and transparency in a general way to look at Civil Engineering through which specific programmes can be formulated.

According to CALOHEE learning, teaching and assessment – in that order - should be aligned. A specific body of learning (knowledge, skills and attitudes), identified by the intended learning outcomes in Civil Engineering, is split into modules or units spread over the available learning period. Appropriate modes of learning, teaching and assessment are then linked to each unit or module of the Civil Engineering programme. Examples of aligning teaching and learning methods, in chapter 5, illustrate what is expected in terms of alignment of these methods with the learning outcomes.

The teaching and learning modes proposed as examples in the Assessment Framework were obtained from surveys, from desk research and from the contributions of several Civil Engineering stakeholders. Concerning the assessment methods chosen for CALOHEE the proposal for each learning outcome is based on the model ALOA using the web-tool TALOE.

This web-tool advises about proper methods of assessment aligned with the different types of learning outcomes (competences) to be verified. The tool is applicable to all areas of science and humanities where there is a definition of expected learning outcomes. This web-tool was based on the revised Bloom’s taxonomy and on the work of alignment assessment methods with learning outcomes by Anderson et al. Methods are proposed in Table 1.

These assessment methods were used for the definition of examples of good practices of assessment for each descriptor of the Terms of Reference of CALOHEE for Civil Engineering.

It is important to underline that the CALOHEE terms of reference should be understood as a source of reference, an inspiration or a guidance for modernising, revising and enhancing existing degree programmes and constructing new ones to meet the needs of the learners. The objective is to prepare Civil Engineering graduates appropriately for their role in society, in terms of employability and as citizens.

The tables 2 and 3 show the list of competencies, teaching and assessment methods proposed for Civil Engineers of levels 6 (bachelor) and 7 (master) of the European Qualification Framework.

Table 1. ALOA model assessment methods (TALOE).

Assessment Methods	Sub-categories
Multiple Choice Questions (MCQ)	A) Remember B) Understand C) Apply D) Analyse E) Evaluate F) Create
Essays	3.1. Essay – Speculative essay 3.2. Essay – Quote to discuss 3.3. Essay – Assertion 3.4. Essay – Write on 3.5. Essay – Describe/Explain 3.6. Essay – Discuss 3.7. Essay – Compare 3.8. Essay – Evaluate 3.9. Essay – Problem
Problem solving	4.1. Problem solving – Routines 4.2. Problem solving – Diagnosis 4.3. Problem solving – Strategy 4.4. Problem solving – Interpretation 4.5. Problem solving – Generation
Practical work	5.1. Practical work – Demonstration 5.2. Practical work – Exercise 5.3. Practical work – Structured enquiry 5.4. Practical work – Open ended enquiry 5.5. Practical work – Project

Short-answer questions (SAQ)	6.1. SAQ – Select crucial evidence 6.2. SAQ – Explain methods, procedures and relationships 6.3. SAQ – Present arguments 6.4. SAQ – Describe limitations of data 6.5. SAQ – Formulate valid conclusions 6.6. SAQ – Identify assumptions 6.7. SAQ – Formulate hypothesis 6.8. SAQ – Formulate action plans
Reflective Practice Assignments	7.1. Reflective practice assignments – Concrete experience 7.2. Reflective practice assignments – Reflective observation 7.3. Reflective practice assignments – Abstract conceptualization 7.4. Reflective practice assignments – Active experimentation

The dimensions considered for the CALOHEE framework were nine. These dimensions were Knowledge and Understanding, Analysis and Problem Solving, Design, Investigation, Practice, Decision Making, Team Work, Communication and Lifelong Learning. These were identified over perspectives of Knowledge, Skills and Attitudes. For each one the assessment techniques, the teaching and the learning modes are proposed. These are stated in Table 2 transcribed from the CALOHEE publications for the Terms of Reference for Civil Engineering programs, level 7 of the European Qualification Framework or Master degree. Table 3 is similar for level 6 or bachelor degree.

Table 2. Second Cycle – LEVEL 7 – Master (CALOHEE).

Dimension 1: Knowledge and Understanding			
(Sub)descriptor / TLA approaches	*Knowledge*	*Skills*	*Wider Competences (Responsibility and Autonomy)*

L7_1. Level descriptor	K7_1 Demonstrate in-depth knowledge and understanding of mathematics as well as sciences and engineering disciplines underlying civil engineering specialisation at a level necessary to achieve the other programme outcomes.	S7_1 Apply knowledge and understanding of mathematics as well as sciences and engineering disciplines underlying civil engineering specialisation to solve / design / investigate / conduct very complex civil engineering problems / products, processes and systems / issues / activities.	C7_1 Identify and justify knowledge and understanding of mathematics as well as sciences and engineering disciplines underlying civil engineering specialisation necessary to solve / design / investigate / conduct very complex civil engineering problems / products, processes and systems / issues / activities.
Subset 1 L7_1.1 Mathematics	K7_1.1 Define and describe key factual information related to mathematics through differential equations and explain key concepts and problem-solving processes.	S7_1.1 Solve / design / investigate / conduct very complex civil engineering problems / products, processes and systems / issues / activities using and applying knowledge and understanding of mathematics through differential equations.	C7_1.1 Identify and justify knowledge and understanding of mathematics necessary to solve / design / investigate / conduct very complex civil engineering problems / products, processes and systems / issues / activities through differential equations.

Subset 2 L7_1.2 Sciences underlying civil engineering specialisation	K7_1.2 Define and describe key factual information related to calculus-based physics and chemistry and explain key concepts and problem-solving processes.	S7_1.2 Solve / design / investigate / conduct very complex civil engineering problems / products, processes and systems / issues / activities using and applying knowledge and understanding of calculus-based physics and chemistry.	C7_1.2 Identify and justify knowledge and understanding of calculus-based physics and chemistry to solve / design / investigate / conduct very complex civil engineering problems / products, processes and systems / issues / activities.
Subset 3 L7_1.3 Engineering disciplines underlying civil engineering specialisation	K7_1.3 Define and describe key factual information related to engineering disciplines underlying civil engineering specialisation and explain key concepts and problem-solving processes having a critical awareness of the forefront of civil engineering specialisation, of the knowledge issues at the interface between different fields and of the wider multidisciplinary context of engineering.	S7_1.3 Solve / design / investigate / conduct very complex civil engineering problems / products, processes and systems / issues / activities, using and applying knowledge and understanding of engineering disciplines underlying civil engineering specialisation.	C7_1.3 Identify and justify knowledge and understanding of engineering disciplines underlying civil engineering specialisation necessary to solve / design / investigate / conduct very complex civil engineering problems / products, processes and systems / issues / activities.
Assessment approaches	Short Answer Questions Multiple Choice Questions Essays	Essays Problem Solving Practical Work	Problem Solving Practical Work Reflective Practice Assignments

Learning approaches	Attending lectures Attending seminars Attending tutorials Participating in flipped classroom Blended learning Preparing and making oral presentations Researching and writing papers, reports, dissertations	Participating in exercise courses/ practical classes Preparing and making oral presentations Researching and writing papers, reports, dissertations Problem-based learning Design-based learning	Participating in exercise courses/ practical classes Problem-based learning Design-based learning
Teaching approaches	Lectures Seminars Tutorials Flipped classroom Blended teaching Oral Assessment Written assessment	Exercise courses/Practical classes Oral Assessment Written assessment Problem-based classes Design-based classes	Exercise courses/Practical classes Problem-based classes Design-based classes

Dimension 2: Analysis and problem solving			
(Sub)descriptor / TLA approaches	*Knowledge*	*Skills*	*Wider Competences (Attitudes)*

L7_2. Level descriptor	K7_2 Demonstrate comprehensive knowledge and understanding of the processes and methods of analysis / solution of engineering issues (products, processes, systems, situations) / engineering problems in the civil engineering subject area, including new and innovative methods, and of their limitations.	S7_2 Analyse / solve very complex engineering issues (products, processes, systems, situations) / engineering problems in civil engineering subject area by applying appropriate and relevant methods of analysis / solution.	C7_2 Identify and justify appropriate and relevant methods of analysis / solution of very complex civil engineering issues (products, processes, systems, situations) / engineering problems from established or new and innovative methods.
Subset 1 L7_2.1 Analysis of civil engineering issues	K7_2.1 Define and describe key factual information related to civil engineering issues (products, processes, systems, situations), applicable processes and methods of analysis, including new and innovative methods, and their limitations, and explain key concepts related to issue recognition and how analysis methods are applied.	S7_2.1 Conceptualise and analyse very complex civil engineering issues (products, processes, systems, situations) by applying appropriate and relevant analysis methods and report the results of the analysis process.	C7_2.1 Identify and justify appropriate and relevant analysis methods of very complex civil engineering issues (products, processes, systems, situations) from established or new and innovative methods, critically interpret the analysis outcomes and present an understanding of the issue and recommendations for necessary measures taking requirements and constraints into account.

Subset 2 L7_2.2 Solution of civil engineering problems	K7_2.2 Define and describe key factual information related to civil engineering problem recognition, applicable processes and methods of solution, including new and innovative methods, and their limitations, and explain key concepts related to problem recognition and how solution methods are applied.	S7_2.2 Identify, formulate and solve very complex civil engineering problems by applying appropriate and relevant solution methods and report the results of the solution process.	C7_2.2 Identify and justify appropriate and relevant solution methods of very complex civil engineering problems from established or new and innovative methods and present an understanding of the problems and recommendations for necessary measures taking requirements and constraints into account.
Subset 3 L7_2.3 Safe, sustainable and of low impact solutions	K7_2.3 Define, describe and explain key aspects of safety, sustainability and impact on society and environment related to civil engineering phenomena and to the ethical obligation and social responsibility of professional engineers.	S7_2.3 Identify, formulate and solve very complex civil engineering problems that may involve non-technical – societal, health and safety, environmental, economic and industrial – constraints by applying appropriate and relevant solution methods and report the results of the solution process.	C7_2.3 Identify and justify appropriate and relevant solution methods of very complex civil engineering problems that may involve non-technical – societal, health and safety, environmental, economic and industrial – constraints from established or new and innovative methods and identify solutions safe, sustainable and of low impact on society and environment.
Assessment approaches	Short Answer Questions Multiple Choice Questions Essays	Essays Problem Solving	Problem Solving Reflective Practice Assignments

Learning approaches	Attending lectures Attending seminars Attending tutorials Participating in flipped classroom Blended learning Problem-based learning	Participating in exercise courses/ practical classes Problem-based learning	Participating in exercise courses/ practical classes Problem-based learning Individual supervision
Teaching approaches	Lectures Seminars Tutorials Flipped classroom Blended teaching Problem-based classes	Exercise courses / Practical classes Problem-based classes	Exercise courses / Practical classes Problem-based classes Individual supervision

Dimension 3: Design

(Sub)descriptor / TLA approaches	*Knowledge*	*Skills*	*Wider Competences (Attitudes)*
L7_3. Level descriptor	K7_3 Demonstrate comprehensive knowledge and understanding of the process and methods of design in civil engineering subject area, including new and original methods, and of their limitations.	S7_3 Conceive and design very complex civil engineering products (devices, artefacts, etc.), processes and systems by applying appropriate and relevant design methods.	C7_3 Identify and justify appropriate and relevant design methods of very complex civil engineering products (devices, artefacts, etc.), processes and systems from established or new and innovative methods.

Subset 1 L7_3.1 Design of civil engineering products, processes and systems	K7_3.1 Define and describe key factual information related to civil engineering products (devices, artefacts, etc.), processes and systems, applicable processes and methods of design, including new and innovative methods, and their limitations, list major steps in the design process, explain how design methods are applied and define and describe constraints that affect and explain how they affect the process and results of engineering designs.	S7_3.1 Conceive and design very complex civil engineering products (devices, artefacts, etc.), processes and systems by applying appropriate and relevant design methods and being able to use knowledge and understanding at the forefront of the engineering specialisation, and report the results of the design process.	C7_3.1 Analyse civil engineering products (devices, artefacts, etc.), processes and systems to determine requirements and constraints, identify and justify appropriate and relevant design methods of very complex civil engineering products, processes and systems from established or new and innovative methods systems and present recommendations for necessary measures taking requirements and constraints into account.
Subset 2 L7_3.2 Safe, sustainable and of low impact designs	K7-3.2 Define, describe and explain key aspects of safety, sustainability and impact on society and environment related to civil engineering phenomena and to the ethical obligation and social responsibility of professional engineers.	S7_3.2 Conceive and design very complex civil engineering products (devices, artefacts, etc.), processes and systems that may involve non-technical – societal, health and safety, environmental, economic and industrial – constraints by applying appropriate and relevant design methods and report the results of the design process.	C7_3.2 Identify and justify appropriate and relevant design methods of very complex civil engineering products (devices, artefacts, etc.), processes and systems that may involve non-technical – societal, health and safety, environmental, economic and industrial – constraints from established or new and innovative methods and design safe, sustainable and of low impact on society and environment products, processes and systems and present recommendations for necessary measures taking requirements and constraints into account.

Assessment approaches	Short Answer Questions Multiple Choice Questions Essays	Essays Problem Solving	Problem Solving Reflective Practice Assignments
Learning approaches	Attending lectures Attending seminars Attending tutorials Participating in flipped classroom Blended learning Design-based learning	Participating in exercise courses/ practical classes Design-based learning	Participating in exercise courses/ practical classes Design-based learning Individual supervision
Teaching approaches	Lectures Seminars Tutorials Flipped classroom Blended teaching Design-based classes	Exercise courses / Practical classes Design-based classes	Exercise courses / Practical classes Design-based classes Individual supervision

Dimension 4: Investigation			
(Sub)descriptor / TLA approaches	*Knowledge*	*Skills*	*Wider Competences (Attitudes)*
L7_4. Level descriptor	K7_4 Demonstrate comprehensive knowledge and understanding of codes of practice and safety regulations and of investigation methods (consultation of sources of information, simulations, experimental methods) in civil engineering subject area, including new and original emerging methods, and of their limitations.	S7_4 Consult and apply codes of practice and safety regulations and conduct investigations (consultation of sources of information, simulations, experimental methods) in civil engineering subject area and within broader or multidisciplinary contexts in order to meet specified needs and report the investigation results.	C7_4 Identify and justify appropriate and relevant investigation approaches (among codes of practice and safety regulations, consultation of sources of information, simulations, experimental methods) in civil engineering subject area and within broader or multidisciplinary contexts, and analyse, explain and critically evaluate the investigation results with respect to the needs to be met.

Subset 1 L7_4.1 Codes of practice and safety regulations	K7_4.1 Identify and describe codes of practice and safety regulations in the civil engineering subject area, and explain their purpose, procedures and practical applications, potentialities and limitations, also with respect to other investigation approaches.	S7_4.1 Consult and apply codes of practice and safety regulations in the civil engineering subject area and within broader or multidisciplinary contexts in order to meet specified needs and report the investigation results.	C7_4.1 Identify and justify appropriate and relevant codes of practice and safety regulations in the civil engineering subject area and within broader or multidisciplinary contexts to be consulted and applied, analyse, explain and critically evaluate the investigation results with respect to the needs to be met and draw conclusions.
Subset 2 L7_4.2 Consultation of sources of information	K7_4.2 Identify and describe literary sources, databases and other sources of information in civil engineering subject area, and explain their purpose, procedures, practical applications, potentialities and limitations, also with respect to other investigation approaches.	S7_4.2 Conduct searches of literature, consult and critically use databases and other sources of information in civil engineering subject area and within broader or multidisciplinary contexts in order to meet specified needs and report the investigation results.	C7_4.2 Identify and justify appropriate and relevant source of information (literature sources, databases and other sources of information) in civil engineering subject area and within broader or multidisciplinary contexts to be consulted, analyse, explain and critically evaluate the investigation results with respect to the needs to be met and draw conclusions.
Assessment approaches	Short Answer Questions Essays Practical Work	Essays Practical Work	Practical Work Reflective Practice Assignments
Learning approaches	Attending lectures Attending seminars Attending tutorials Participating in flipped classroom Blended learning Researching and writing papers, reports, dissertations Carrying out investigation assignments	Participating in exercise courses/ practical classes Researching and writing papers, reports, dissertations Carrying out investigation assignments	Participating in exercise courses/ practical classes Practising professional skills Individual supervision

Teaching approaches	Lectures Seminars Tutorials Flipped classroom Blended teaching Written assignments Investigation assignments	Exercise courses / Practical classes Written assignments Investigation assignments	Exercise courses / Practical classes Work-based practice Individual supervision
Subset 3 L7_4.3 Simulations	K7_4.3 Identify and describe simulation approaches in the civil engineering subject area, and explain their purpose, procedures, practical applications potentialities and limitations, also with respect to other investigation approaches.	S7_4.3 Conduct simulations in order to pursue detailed investigations and research of technical issues in civil engineering subject area and within broader or multidisciplinary contexts in order to meet specified needs and report the simulation results.	C7_4.3 Identify and justify appropriate and relevant simulation methods in civil engineering subject area and within broader or multidisciplinary contexts to be conducted, analyse, explain and critically evaluate the investigation results with respect to the needs to be met and draw conclusions.
Subset 4 L7_4.4 Experimental methods	K7_4.4 Identify and describe the procedures and equipment necessary to conduct civil engineering experiments in more than one of the technical areas of civil engineering, and explain their purpose, procedures and practical applications, potentialities and limitations, also with respect to other investigation approaches.	S7_4.4 Provide evidence of advanced laboratory/workshop skills and design and conduct experiments in more than one of the technical areas of civil engineering according to established procedures in order to meet specified needs and report the experiment results.	C7_4.4 Identify and justify appropriate and relevant experiments to be conducted, analyse, evaluate the accuracy of the results within the known boundaries of the tests, explain and critically evaluate the experiment results according to established procedures with respect to the needs to be met and draw conclusions.
Assessment approaches	Short Answer Questions Essays Practical Work	Essays Practical Work	Practical Work Reflective Practice Assignments
Learning approaches	Attending lectures Attending seminars Attending tutorials Participating in flipped classroom Blended learning Carrying out numerical modelling/laboratory assignments	Participating in exercise courses/ practical classes Carrying out numerical modelling/laboratory assignments	Participating in exercise courses/ practical classes Practising professional skills Individual supervision

Teaching approaches	Lectures Seminars Tutorials Flipped classroom Blended teaching Numerical modelling/laboratory assignments	Exercise courses / Practical classes Numerical modelling/laboratory assignments	Exercise courses / Practical classes Work-based practice Individual supervision
Subset 5 L7_4.5 New and emerging technologies	K7_4.5 Identify and describe new and emerging technologies at the forefront of civil engineering specialisation.	S7_4.5 Investigate the application of new and emerging technologies at the forefront of civil engineering specialisation and their potentialities and limitations, also with respect to technologies already in use.	C7_4.5 Identify, analyse and explain the impact of new and emerging technologies on society and environment.
Assessment approaches	Short Answer Questions Essays	Essays Problem Solving Reflective Practice Assignments	Problem Solving Reflective Practice Assignments
Learning approaches	Attending lectures Attending seminars Attending tutorials Participating in flipped classroom Blended learning	Participating in exercise courses/ practical classes Preparing and making oral presentations Researching and writing papers, reports, dissertations Individual supervision	Participating in exercise courses/ practical classes Individual supervision
Teaching approaches	Lectures Seminars Tutorials Flipped classroom Blended teaching	Exercise courses / Practical classes Oral Assessment Written assessment Individual supervision	Exercise courses / Practical classes Individual supervision

Dimension 5: Practice			
(Sub)descriptor / TLA approaches	*Knowledge*	*Skills*	*Wider Competences (Attitudes)*

L7_5. Level descriptor	K7_5 Demonstrate comprehensive practical knowledge and understanding of materials, equipment and tools, processes and technologies in civil engineering subject area and of their limitations.	S7_5 Implement and conduct complex engineering activities in civil engineering subject area and within broader or multidisciplinary contexts, using and applying practical knowledge and understanding of materials, equipment and tools, processes and technologies.	C7_5 Identify and justify practical knowledge and understanding of materials, equipment and tools, processes and technologies necessary to conduct complex engineering activities in civil engineering subject area and within broader or multidisciplinary contexts.
Subset 1 L7_5.1 Materials, equipment and tools, technologies and processes	K7_5.1 Define and describe key factual information related to materials, equipment and tools, technologies and processes and explain their practical application in civil engineering subject area.	S7_5.1 Apply appropriate practical knowledge and understanding on materials, equipment and tools, technologies and processes to solve / design / investigate / conduct complex engineering problems / products, processes and systems / issues / activities in civil engineering subject area and within broader or multidisciplinary contexts, integrating theory and practice.	C7_5.1 Analyze existing practices in the use and identify and justify appropriate practical knowledge and understanding of materials, equipment and tools, technologies and processes to solve / design / investigate / conduct complex engineering problems / products, processes and systems / issues / activities in civil engineering subject area and within broader or multidisciplinary contexts.
Assessment approaches	Short Answer Questions Essays Practical Work	Essays Problem Solving Practical Work	Problem Solving Practical Work Reflective Practice Assignments
Learning approaches	Attending lectures Attending seminars Attending tutorials Participating in flipped classroom Blended learning Practising professional skills Fieldwork	Participating in exercise courses/ practical classes Preparing and making oral presentations Researching and writing papers, reports, dissertations Practising professional skills	Participating in exercise courses/ practical classes Practising professional skills

Teaching approaches	Lectures Seminars Tutorials Flipped classroom Blended teaching Work-based practice Fieldwork	Exercise courses / Practical classes Oral Assessment Written assessment Work-based practice	Exercise courses / Practical classes Work-based practice
Subset 2 L7_5.2 Societal, health and safety, environmental implications and risks	K7_5.2 Define, describe and explain societal, health and safety, environmental implications and risks in conducting complex civil engineering activities.	S7_5.2 Implement and conduct complex engineering activities in civil engineering subject area and within broader or multidisciplinary contexts identifying and taking into account societal, health and safety, environmental impact and risks.	C7_5.2 Act appropriately, by meeting deliverable, schedule and budget requirements, while fulfilling all legal and regulatory requirements, and evaluating and mitigating/minimizing societal, health and safety, environmental impact and risks.
Subset 3 L7_5.3 Economic, industrial and managerial implications	K7_5.3 Define, describe and explain key aspects of economic, industrial and managerial implications of complex civil engineering activities, what a project is and key aspects of project management.	S7_5.3 Implement and conduct complex engineering activities in civil engineering subject area and within broader or multidisciplinary contexts identifying and taking into account economic, industrial and managerial implications.	C7_5.3 Act appropriately, by meeting deliverable, schedule and budget requirements, while fulfilling all legal and regulatory requirements, evaluating and optimizing economic, industrial and managerial implications and developing solutions to well-defined management problems.
Assessment approaches	Short Answer Questions Essays Problem Solving Practical Work	Essays Problem Solving Practical Work	Problem Solving Practical Work Reflective Practice Assignments
Learning approaches	Attending lectures Attending seminars Attending tutorials Participating in flipped classroom Blended learning Practising professional skill	Participating in exercise courses/ practical classes Practising professional skills	Participating in exercise courses/ practical classes Practising professional skills

Teaching approaches	Lectures Seminars Tutorials Flipped classroom Blended teaching Work-based practice	Exercise courses / Practical classes Work-based practice	Exercise courses / Practical classes Work-based practice

Dimension 6: Decision making			
(Sub)descriptor / TLA approaches	*Knowledge*	*Skills*	*Wider Competences (Attitudes)*
Level descriptor	K7_6 Demonstrate critical awareness of the key aspects of professional, ethical and social responsibilities linked to management of work contexts, decision making and judgment formulation in civil engineering subject area.	S7_6 Manage work contexts in civil engineering subject area and within broader or multidisciplinary contexts that may be unpredictable and require new strategic approaches, take decisions and formulate judgments.	C7_6 Identify and justify appropriate and relevant strategic approaches and analyse professional, ethical and social responsibilities linked to the management of work contexts in civil engineering subject area and within broader or multidisciplinary contexts, taking coherent decisions and formulating coherent judgments.
Subset 1 L7_6.1 Managing work contexts, taking decisions and formulating judgments	K7_6.1 Describe and explain key aspects of professional, ethical and social responsibilities linked to management, decision making and judgment formulation of work contexts in civil engineering subject area.	S7_6.1 Manage work contexts in civil engineering subject area and within broader or multidisciplinary contexts that may be unpredictable and require new strategic approaches, identify, locate, obtain, organize and evaluate information and data, take decisions and formulate judgments.	C7_6.1 Identify and justify appropriate and relevant strategic approaches to manage work contexts in civil engineering subject area and within broader or multidisciplinary contexts, identify and analyse situations involving multiple conflicting professional, ethical and social interests to determine an appropriate course of action, take coherent decisions and formulate coherent judgments also with incomplete or limited information and data.

Assessment approaches	Essays Problem Solving Practical Work	Essays Problem Solving Practical Work	Problem Solving Practical Work Reflective Practice Assignments
Learning approaches	Attending lectures Attending seminars Attending tutorials Participating in flipped classroom Blended learning Problem-based learning Design-based learning Practising professional skills	Participating in exercise courses/ practical classes Problem-based learning Design-based learning Practising professional skills Role play Peer reviewing	Participating in exercise courses/ practical classes Problem-based learning Design-based learning Practising professional skills Role play Peer reviewing
Teaching approaches	Lectures Seminars Tutorials Flipped classroom Blended teaching Problem-based classes Design-based classes Work-based practice	Exercise courses / Practical classes Problem-based classes Design-based classes Work-based practice Role play Peer reviewing	Exercise courses / Practical classes Problem-based classes Design-based classes Work-based practice Role play Peer reviewing

Dimension 7: Team-working			
(Sub)descriptor / TLA approaches	*Knowledge*	*Skills*	*Wider Competences (Attitudes)*
L7_7. Level descriptor	K7_7 Demonstrate knowledge and understanding of functioning methods and management strategies of teams that may be composed of different disciplines and levels and awareness of leadership responsibilities.	S7_7 Function effectively in national and international contexts as member/leader of teams that may be composed of different disciplines and levels meeting deliverable, schedule and budget requirements.	C7_7 Identify and justify appropriate and relevant functioning methods and management strategies of teams that may be composed of different disciplines and levels and elements of successful teamwork.

Subset 1 L7_2.1 Team functioning	K7_7.1 Define and describe key characteristics and functioning methods of effective teams that may be composed of different disciplines and levels.	S7_7.1 Function effectively as a member of teams that may be composed of different disciplines and levels contributing to meet deliverable, schedule and budget requirements.	C7_7.1 Identify and justify appropriate and relevant functioning methods of teams that may be composed of different disciplines and levels and analyse factors affecting the ability to function effectively and to meet deliverable, schedule and budget requirements.
Assessment approaches	Essays Problem Solving Practical Work	Problem Solving Practical Work	Problem Solving Practical Work Reflective Practice Assignments
Learning approaches	Attending lectures Attending seminars Attending tutorials Participating in flipped classroom Blended learning Fieldwork	Problem-based learning Design-based learning Practising professional skills Role play Peer reviewing	Problem-based learning Design-based learning Practising professional skills Role play Peer reviewing
Teaching approaches	Lectures Seminars Tutorials Flipped classroom Blended teaching Fieldwork	Problem-based classes Design-based classes Work-based practice Role play Peer reviewing	Problem-based classes Design-based classes Work-based practice Role play Peer reviewing
Subset 2 L7_7.2 Team management	K7_7.2 Define and describe leadership principles and attitudes, role and responsibilities of a leader and management strategies of teams that may be composed of different disciplines and levels.	S7_7.2 Organize and direct the efforts of teams that may be composed of different disciplines and levels applying leadership principles and meeting deliverable, schedule and budget requirements.	C7_7.2 Identify and justify appropriate and relevant management strategies of teams that may be composed of different disciplines and levels and possible needs for reviewing the strategic performance, and take responsibility for contributing to professional knowledge and practice of team members.
Assessment approaches	Essays Problem Solving	Problem Solving Practical Work	Problem Solving Practical Work

	Practical Work		
Learning approaches	Attending lectures Attending seminars Attending tutorials Participating in flipped classroom Blended learning Problem-based learning Design-based learning Practising professional skills	Problem-based learning Design-based learning Practising professional skills Role play Peer reviewing	Problem-based learning Design-based learning Practising professional skills
Teaching approaches	Lectures Seminars Tutorials Flipped classroom Blended teaching Problem-based classes Design-based classes Work-based practice	Problem-based classes Design-based classes Work-based practice Role play Peer reviewing	Problem-based learning Design-based learning Work-based practice

Dimension 8: Communication			
(Sub)descriptor / TLA approaches	*Knowledge*	*Skills*	*Wider Competences (Attitudes)*
L7_8. Level descriptor	K7_8 Demonstrate knowledge and understanding of communication strategies, methods and tools, including new and innovative ones, and of their limitations.	S7_8 Communicate effectively, clearly and unambiguously information, describe activities and communicate their exits/results – and the knowledge and rationale underpinning these – to specialist and non-specialist audiences in national and international contexts and society at large, using appropriate communication strategies, methods and tools.	C7_8 Identify and justify appropriate and relevant communication strategies, methods and tools from established or new and innovative ones.

Subset 1 L7_8.1 Communication strategies, methods and tools	K7_8.1 Define and describe communication strategies, methods and tools, the characteristics of effective verbal, written, virtual, and graphical communications and their limitations to communicate effectively, clearly and unambiguously information, describe activities and communicate their exits/results – and the knowledge and rationale underpinning these – to specialist and non-specialist audiences in national and international contexts and society at large.	S7_8.1 Plan, compose, integrate and deliver effective verbal, written, virtual and graphical communications for describing activities and communicating their exits/results – and the knowledge and rationale underpinning – these to specialist and non-specialist audiences in national and international contexts and society at large, by applying rules of grammar and composition in verbal and written communications, properly citing sources, and using appropriate graphical standards in preparing engineering drawings.	C7_8.1 Identify and justify appropriate and relevant communication strategies, methods and tools among standard and new and innovative ones to communicate effectively, clearly and unambiguously information, describe activities and communicate their exits/results – and the knowledge and rationale underpinning these – to specialist and non-specialist audiences in national and international contexts and society at large.
Assessment approaches	Essays Problem Solving Practical Work	Problem Solving Practical Work	Problem Solving Practical Work Reflective Practice Assignments
Learning approaches	Attending lectures Attending seminars Attending tutorials Participating in flipped classroom Blended learning Fieldwork	Problem-based learning Design-based learning Practising professional skills Role play Peer reviewing	Problem-based learning Design-based learning Practising professional skills Individual supervision
Teaching approaches	Lectures Seminars Tutorials Flipped classroom Blended teaching Fieldwork	Problem-based classes Design-based classes Work-based practice Role play Peer reviewing	Problem-based classes Design-based classes Work-based practice Individual supervision

Dimension 9: Lifelong Learning

(Sub)descriptor / TLA approaches	*Knowledge*	*Skills*	*Wider Competences (Attitudes)*
L7_2. Level descriptor	K7_9 Demonstrate knowledge and understanding of the learning methods necessary to follow developments in science and technology and undertake further studies in new and emerging technologies in civil engineering subject area and within broader or multidisciplinary contexts.	S7_9 Engage in independent lifelong learning and follow developments in science and technology and undertake further studies in new and emerging technologies in civil engineering subject area and within broader or multidisciplinary contexts autonomously.	C7_9 Identify and justify appropriate learning strategies and methods in independent lifelong learning to follow developments in science and technology and undertake further studies in new and emerging technologies in civil engineering subject area and within broader or multidisciplinary contexts.
Subset 1 L7_2.1 Learning strategies and methods	K7_9.1 Define lifelong learning, explain the need for lifelong learning, describe the skills required of a lifelong learner and the learning methods necessary to follow developments in science and technology and undertake further studies in new and emerging technologies in civil engineering subject area and within broader or multidisciplinary contexts.	S7_9.1 Engage in independent lifelong learning to follow developments in science and technology and undertake further studies in new and emerging technologies in civil engineering subject area and within broader or multidisciplinary contexts autonomously.	C7_9.1 Identify and justify appropriate learning strategies and methods in independent lifelong learning to follow developments in science and technology and undertake further studies in new and emerging technologies in civil engineering subject area and within broader or multidisciplinary contexts.
Assessment approaches	Essays Problem Solving Practical Work Reflective Practice Assignments	Problem Solving Practical Work	Problem Solving Practical Work Reflective Practice Assignments

Learning approaches	Attending lectures Attending seminars Attending tutorials Problem-based learning Design-based learning Work-based practice	Problem-based learning Design-based learning Practising professional skills	Problem-based learning Design-based learning Practising professional skills Individual supervision
Teaching approaches	Lectures Seminars Tutorials Problem-based classes Design-based classes Work-based practice Individual supervision	Problem-based classes Design-based classes Work-based practice	Problem-based classes Design-based classes Work-based practice Individual supervision

Table 3. First Cycle – LEVEL 6 – Bachelor (CALOHEE).

Dimension 1: Knowledge and Understanding			
(Sub)descriptor / TLA approaches	*Knowledge*	*Skills*	*Wider Competences (Attitudes)*
L6_1. Level descriptor	K6_1 Demonstrate knowledge and understanding of mathematics as well as sciences and engineering disciplines underlying civil engineering specialisation at a level necessary to achieve the other programme outcomes.	S6_1 Apply knowledge and understanding of mathematics as well as sciences and engineering disciplines underlying civil engineering specialisation to solve / design / investigate / conduct complex civil engineering problems / products, processes and systems / issues / activities.	C6_1 Identify knowledge and understanding of mathematics as well as sciences and engineering disciplines underlying civil engineering specialisation necessary to solve / design / investigate / conduct complex civil engineering problems / products, processes and systems / issues / activities.

Subset 1 L6_1.1 Mathematics	K6_1.1 Define and describe key factual information and problem-solving processes related to mathematics through differential equations.	S6_1.1 Solve / design / investigate / conduct civil engineering problems / products, processes and systems / issues / activities using and applying knowledge and understanding of mathematics through differential equations.	C6_1.1 Identify knowledge and understanding of mathematics necessary to solve / design / investigate / conduct civil engineering problems / products, processes and systems / issues / activities through differential equations.
Subset 2 L6_1.2 Sciences underlying civil engineering specialisation	K6_1.2 Define and describe key factual information and problem-solving processes related to calculus-based physics and chemistry.	S6_1.2 Solve / design / investigate / conduct civil engineering problems / products, processes and systems / issues / activities using and applying knowledge and understanding of calculus-based physics and chemistry.	C6_1.2 Identify and justify knowledge and understanding of calculus-based physics and chemistry to solve / design / investigate / conduct civil engineering problems / products, processes and systems / issues / activities.
Subset 3 L6_1.3 Engineering disciplines underlying civil engineering specialisation	K6_1.3 Define and describe key factual information and problem-solving processes related to engineering disciplines underlying civil engineering specialisation being aware of the forefront of civil engineering specialisation and of the wider multidisciplinary context of engineering.	S6_1.3 Solve / design / investigate / conduct complex civil engineering problems / products, processes and systems / issues / activities, using and applying knowledge and understanding of engineering disciplines underlying civil engineering specialisation.	C6_1.3 Identify knowledge and understanding of engineering disciplines underlying civil engineering specialisation necessary to solve / design / investigate / conduct complex civil engineering problems / products, processes and systems / issues / activities.
Assessment approaches	Short Answer Questions Multiple Choice Questions Essays	Essays Problem Solving Practical Work	Problem Solving Practical Work Reflective Practice Assignments

Learning approaches	Attending lectures Attending seminars Attending tutorials Participating in flipped classroom Blended learning Preparing and making oral presentations Researching and writing papers, reports, dissertations	Participating in exercise courses/ practical classes Preparing and making oral presentations Researching and writing papers, reports, dissertations Problem-based learning Design-based learning	Participating in exercise courses/ practical classes Problem-based learning Design-based learning
Teaching approaches	Lectures Seminars Tutorials Flipped classroom Blended teaching Oral Assessment Written assessment	Exercise courses/Practical classes Oral Assessment Written assessment Problem-based classes Design-based classes	Exercise courses/Practical classes Problem-based classes Design-based classes

Dimension 2: Analysis and problem solving			
(Sub)descriptor / TLA approaches	*Knowledge*	*Skills*	*Wider Competences (Attitudes)*
L6_2. Level descriptor	K6_2 Demonstrate knowledge and understanding of the processes and established methods of analysis / solution of engineering issues (products, processes, systems, situations) / engineering problems in the civil engineering subject area and of their limitations.	S6_2 Analyse / solve complex engineering issues (products, processes, systems, situations) / engineering problems in civil engineering subject area by applying appropriate and relevant established methods of analysis / solution.	C6_2 Identify appropriate and relevant established methods of analysis / solution of complex civil engineering issues (products, processes, systems, situations) / engineering problems.

Subset 1 L6_2.1 Analysis of civil engineering issues	K6_2.1 Define and describe key factual information related to civil engineering issues (products, processes, systems, situations), applicable processes and established methods of analysis and their limitations, and how analysis methods are applied.	S6_2.1 Analyse complex civil engineering issues (products, processes, systems, situations) by applying appropriate and relevant established analysis methods and report the results of the analysis process.	C6_2.1 Identify appropriate and relevant established analysis methods of complex civil engineering issues (products, processes, systems, situations), correctly interpret the analysis outcomes and present recommendations for necessary measures taking requirements and constraints into account.
Subset 2 L6_2.2 Solution of civil engineering problems	K6_2.2 Define and describe key factual information related to civil engineering problem recognition, applicable processes and established methods of solution and their limitations, and how solution methods are applied.	S6_2.2 Solve complex civil engineering problems by applying appropriate and relevant established solution methods and report the results of the solution process	C6_2.2 Identify appropriate and relevant established solution methods of complex civil engineering problems and present recommendations for necessary measures taking requirements and constraints into account.
Subset 3 L6_2.3 Safe, sustainable and of low impact solutions	K6_2.3 Define and describe key aspects of safety, sustainability and impact on society and environment related to civil engineering phenomena and to the ethical obligation and social responsibility of professional engineers.	S6_2.3 Solve complex civil engineering problems that may involve non-technical – societal, health and safety, environmental, economic and industrial – implications by applying appropriate and relevant established solution methods and report the results of the solution process.	C6_2.3 Identify appropriate and relevant established solution methods of complex civil engineering problems having awareness of non-technical – societal, health and safety, environmental, economic and industrial – implications in formulating recommendations for necessary measures.
Assessment approaches	Short Answer Questions Multiple Choice Questions Essays	Essays Problem Solving	Problem Solving Reflective Practice Assignments
Learning approaches	Attending lectures Attending seminars Attending tutorials Participating in flipped classroom Blended learning Problem-based learning	Participating in exercise courses/ practical classes Problem-based learning	Participating in exercise courses/ practical classes Problem-based learning Individual supervision

Teaching approaches	Lectures Seminars Tutorials Flipped classroom Blended teaching Problem-based classes	Exercise courses / Practical classes Problem-based classes	Exercise courses / Practical classes Problem-based classes Individual supervision

Dimension 3: Design			
(Sub)descriptor / TLA approaches	*Knowledge*	*Skills*	*Wider Competences (Attitudes)*
L6_3. Level descriptor	K6_3 Demonstrate knowledge and understanding of the process and established methods of design in civil engineering subject area and of their limitations.	S6_3 Design complex civil engineering products (devices, artefacts, etc.), processes and systems by applying appropriate and relevant established design methods.	C6_3 Identify appropriate and relevant established design methods of complex civil engineering products (devices, artefacts, etc.), processes and systems.
Subset 1 L6_3.1 Design of civil engineering products, processes and systems	K6_3.1 Define and describe key factual information related to civil engineering products (devices, artefacts, etc.), processes and systems, applicable processes and methods of design, and their limitations, list major steps in the design process, describe how design methods are applied and define and describe constraints that affect the process and results of engineering designs.	S6_3.1 Design complex civil engineering products (devices, artefacts, etc.), processes and systems by applying appropriate and relevant established design methods and report the results of the design process.	C6_3.1 Identify appropriate and relevant established design methods of complex civil engineering products (devices, artefacts, etc.), processes and systems and present recommendations for necessary measures taking requirements and constraints into account.

Subset 2 L6_3.2 Safe, sustainable and of low impact designs	K6-3.2 Define and describe key aspects of safety, sustainability and impact on society and environment related to civil engineering phenomena and to the ethical obligation and social responsibility of professional engineers.	S6_3.2 Design complex civil engineering products (devices, artefacts, etc.), processes and systems that may involve non-technical – societal, health and safety, environmental, economic and industrial – implications by applying appropriate and relevant established design methods and report the results of the design process.	C6_3.2 Identify appropriate and relevant established design methods and reflect on non-technical – societal, health and safety, environmental, economic and industrial – implications in designing complex civil engineering products (devices, artefacts, etc.), processes and systems, and present recommendations for necessary measures taking requirements and constraints into account.
Assessment approaches	Short Answer Questions Multiple Choice Questions Essays	Essays Problem Solving	Problem Solving Reflective Practice Assignments
Learning approaches	Attending lectures Attending seminars Attending tutorials Participating in flipped classroom Blended learning Design-based learning	Participating in exercise courses/ practical classes Design-based learning	Participating in exercise courses/ practical classes Design-based learning Individual supervision
Teaching approaches	Lectures Seminars Tutorials Flipped classroom Blended teaching Design-based classes	Exercise courses / Practical classes Design-based classes	Exercise courses / Practical classes Design-based classes Individual supervision

Dimension 4: Investigation			
(Sub)descriptor / TLA approaches	*Knowledge*	*Skills*	*Wider Competences (Attitudes)*

L6_4. Level descriptor	K6_4 Demonstrate knowledge and understanding of codes of practice and safety regulations and of investigation methods (consultation of sources of information, simulations, experimental methods) in civil engineering subject area and of their limitations.	S6_4 Consult and apply codes of practice and safety regulations and conduct investigations (consultation of sources of information, simulations, experimental methods) in civil engineering subject area in order to meet specified needs and report the investigation results.	C6_4 Identify appropriate and relevant investigation approaches (among codes of practice and safety regulations, consultation of sources of information, simulations, experimental methods) in civil engineering subject area and analyse, explain and interpret the investigation results with respect to the needs to be met.
Subset 1 L6_4.1 Codes of practice and safety regulations	K6_4.1 Identify and describe codes of practice and safety regulations in the civil engineering subject area, their purpose, procedures and practical applications, potentialities and limitations, also with respect to other investigation approaches.	S6_4.1 Consult and apply codes of practice and safety regulations in the civil engineering subject area in order to meet specified needs and report the investigation results.	C6_4.1 Identify appropriate and relevant codes of practice and safety regulations in the civil engineering subject area to be consulted and applied and analyse and interpret the investigation results with respect to the needs to be met and draw conclusions.
Subset 2 L6_4.2 Consultation of sources of information	K6_4.2 Identify and describe literary sources, databases and other sources of information in civil engineering subject area, their purpose, procedures and practical applications, potentialities and limitations, also with respect to other investigation approaches.	S6_4.2 Conduct searches of literature, consult and critically use databases and other sources of information in civil engineering subject area in order to meet specified needs and report the investigation results.	C6_4.2 Identify appropriate and relevant source of information (literature sources, databases and other sources of information) in civil engineering subject area to be consulted, analyse and interpret the investigation results with respect to the needs to be met and draw conclusions.
Assessment approaches	Short Answer Questions Essays Practical Work	Essays Practical Work	Practical Work Reflective Practice Assignments

Learning approaches	Attending lectures Attending seminars Attending tutorials Participating in flipped classroom Blended learning Researching and writing papers, reports, dissertations Carrying out investigation assignments	Participating in exercise courses/ practical classes Researching and writing papers, reports, dissertations Carrying out investigation assignments	Participating in exercise courses/ practical classes Practising professional skills Individual supervision
Teaching approaches	Lectures Seminars Tutorials Flipped classroom Blended teaching Written assignments Investigation assignments	Exercise courses / Practical classes Written assignments Investigation assignments	Exercise courses / Practical classes Work-based practice Individual supervision
Subset 3 L6_4.3 Simulations	K6_4.3 Identify and describe simulation approaches in the civil engineering subject area, their purpose, procedures and practical applications potentialities and limitations, also with respect to other investigation approaches.	S6_4.3 Conduct simulations in order to pursue detailed investigations and research of technical issues in civil engineering subject area in order to meet specified needs and report the simulation results.	C6_4.3 Identify appropriate and relevant simulation methods in civil engineering subject area to be conducted, analyse and interpret the simulation results with respect to the needs to be met and draw conclusions.
Subset 4 L6_4.4 Experimental methods	K6_4.4 Identify and describe the procedures and equipment necessary to conduct civil engineering experiments in at least one of the technical areas of civil engineering, their purpose, procedures and practical applications, potentialities and limitations, also with respect to other investigation approaches.	S6_4.4 Provide evidence of laboratory/workshop skills and design and conduct experiments according to established procedures in order to meet specified needs and report the experiment results.	C6_4.4 Identify appropriate and relevant experiments to be conducted, analyse and interpret the experiment results with respect to the needs to be met and draw conclusions.
Assessment approaches	Short Answer Questions Essays Practical Work	Essays Practical Work	Practical Work Reflective Practice Assignments

Learning approaches	Attending lectures Attending seminars Attending tutorials Participating in flipped classroom Blended learning Carrying out numerical modelling/laboratory assignments	Participating in exercise courses/ practical classes Carrying out numerical modelling/laboratory assignments	Participating in exercise courses/ practical classes Practising professional skills Individual supervision
Teaching approaches	Lectures Seminars Tutorials Flipped classroom Blended teaching Numerical modelling/laboratory assignments	Exercise courses / Practical classes Numerical modelling/laboratory assignments	Exercise courses / Practical classes Work-based practice Individual supervision

Dimension 5: Practice			
(Sub)descriptor / TLA approaches	*Knowledge*	*Skills*	*Wider Competences (Attitudes)*
L6_5. Level descriptor	K6_5 Demonstrate practical knowledge and understanding of materials, equipment and tools, processes and technologies in civil engineering subject area and of their limitations.	S6_5 Conduct complex engineering activities in civil engineering subject area, using and applying practical knowledge and understanding of materials, equipment and tools, processes and technologies.	C6_5 Identify practical knowledge and understanding of materials, equipment and tools, processes and technologies necessary to conduct complex engineering activities in civil engineering subject area.

Subset 1 L6_5.1 Materials, equipment and tools, technologies and processes	K6_5.1 Define and describe key factual information related to materials, equipment and tools, technologies and processes and to their practical application in civil engineering subject area.	S6_5.1 Apply appropriate practical knowledge and understanding on materials, equipment and tools, technologies and processes to solve / design / investigate / conduct complex engineering problems / products, processes and systems / issues / activities in civil engineering subject area.	C6_5.1 Identify appropriate practical knowledge and understanding of materials, equipment and tools, technologies and processes to solve / design / investigate / conduct complex engineering problems / products, processes and systems / issues / activities in civil engineering subject area.
Assessment approaches	Short Answer Questions Essays Practical Work	Essays Problem Solving Practical Work	Problem Solving Practical Work Reflective Practice Assignments
Learning approaches	Attending lectures Attending seminars Attending tutorials Participating in flipped classroom Blended learning Practising professional skills Fieldwork	Participating in exercise courses/ practical classes Preparing and making oral presentations Researching and writing papers, reports, dissertations Practising professional skills	Participating in exercise courses/ practical classes Practising professional skills
Teaching approaches	Lectures Seminars Tutorials Flipped classroom Blended teaching Work-based practice Fieldwork	Exercise courses / Practical classes Oral Assessment Written assessment Work-based practice	Exercise courses / Practical classes Work-based practice
Subset 2 L6_5.2 Societal, health and safety, environmental implications and risks	K6_5.2 Define and describe societal, health and safety, environmental implications and risks in conducting complex civil engineering activities.	S6_5.2 Conduct complex engineering activities in civil engineering subject area having awareness of societal, health and safety, environmental impact and risks.	C6_5.2 Act appropriately, by meeting deliverable, schedule and budget requirements, while fulfilling all legal and regulatory requirements, reflecting on societal, health and safety, environmental impact and risks.
Subset 3 L6_5.3 Economic, industrial and managerial implications	K6_5.3 Define and describe key aspects of economic, industrial and managerial implications of complex civil engineering activities, what a project is and key aspects of project management.	S6_5.3 Conduct complex engineering activities in civil engineering subject area having awareness of economic, industrial and managerial implications.	C6_5.3 Act appropriately, by meeting deliverable, schedule and budget requirements, while fulfilling all legal and regulatory requirements, reflecting on economic, industrial and managerial implications.

Assessment approaches	Short Answer Questions Essays Problem Solving Practical Work	Essays Problem Solving Practical Work	Problem Solving Practical Work Reflective Practice Assignments
Learning approaches	Attending lectures Attending seminars Attending tutorials Participating in flipped classroom Blended learning Practising professional skill	Participating in exercise courses/ practical classes Practising professional skills	Participating in exercise courses/ practical classes Practising professional skills
Teaching approaches	Lectures Seminars Tutorials Flipped classroom Blended teaching Work-based practice	Exercise courses / Practical classes Work-based practice	Exercise courses / Practical classes Work-based practice

Dimension 6: Decision making			
(Sub)descriptor / TLA approaches	*Knowledge*	*Skills*	*Wider Competences (Attitudes)*
L6_6. Level descriptor	K6_6 Demonstrate awareness of the key aspects of professional, ethical and social responsibilities linked to management of civil engineering activities, decision making and judgment formulation.	S6_6 Manage work contexts in civil engineering subject area, take decisions and formulate judgments.	C6_6 Identify appropriate and relevant approaches to manage work contexts in civil engineering subject area and reflect on professional, ethical and social responsibilities in taking decisions and formulating judgments.
Subset 1 L6_6.1 Managing complex work contexts, taking decisions and formulating judgments	K6_6.1 Describe key aspects of professional ethical and social responsibilities linked to management, decision making and judgment formulation of work contexts in civil engineering subject area.	S6_6.1 Manage work contexts in civil engineering subject area, gather and interpret information and data, take decisions and formulate judgments.	C6_6.1 Identify appropriate and relevant approaches to manage work contexts in civil engineering subject area and reflect on situations involving professional, ethical and social interests in taking decisions and formulating judgments based on available information and data.

Assessment approaches	Essays Problem Solving Practical Work	Essays Problem Solving Practical Work	Problem Solving Practical Work Reflective Practice Assignments
Learning approaches	Attending lectures Attending seminars Attending tutorials Participating in flipped classroom Blended learning Problem-based learning Design-based learning Practising professional skills	Participating in exercise courses/ practical classes Problem-based learning Design-based learning Practising professional skills Role play Peer reviewing	Participating in exercise courses/ practical classes Problem-based learning Design-based learning Practising professional skills Role play Peer reviewing
Teaching approaches	Lectures Seminars Tutorials Flipped classroom Blended teaching Problem-based classes Design-based classes Work-based practice	Exercise courses / Practical classes Problem-based classes Design-based classes Work-based practice Role play Peer reviewing	Exercise courses / Practical classes Problem-based classes Design-based classes Work-based practice Role play Peer reviewing

Dimension 7: Team-working

(Sub)descriptor / TLA approaches	*Knowledge*	*Skills*	*Wider Competences (Attitudes)*
L6_7. Level descriptor	K6_7 Demonstrate knowledge and understanding of functioning methods of teams that may be composed of different disciplines and levels.	S6_7 Function effectively in national and international contexts as member of teams that may be composed of different disciplines and levels contributing to meet deliverable, schedule and budget requirements.	C6_6 Identify appropriate functioning methods and relevant management strategies of teams that may be composed of different disciplines and levels and elements of successful teamwork.
Subset 1 L6_2.1 Team functioning	K6_7.1 Define and describe key characteristics and functioning methods of effective teams that may be composed of different disciplines and levels.	S6_7.1 Function effectively as a member of teams that may be composed of different disciplines and levels in national and international contexts contributing to meet deliverable, schedule and budget requirements.	C6_7.1 Take responsibility for contributing to professional development of individuals and teams in to meet deliverable, schedule and budget requirements.

Assessment approaches	Essays Problem Solving Practical Work	Problem Solving Practical Work	Problem Solving Practical Work Reflective Practice Assignments
Learning approaches	Attending lectures Attending seminars Attending tutorials Participating in flipped classroom Blended learning Fieldwork	Problem-based learning Design-based learning Practising professional skills Role play Peer reviewing	Problem-based learning Design-based learning Practising professional skills Role play Peer reviewing
Teaching approaches	Lectures Seminars Tutorials Flipped classroom Blended teaching Fieldwork	Problem-based classes Design-based classes Work-based practice Role play Peer reviewing	Problem-based classes Design-based classes Work-based practice Role play Peer reviewing

Dimension 8: Communication			
(Sub)descriptor / TLA approaches	*Knowledge*	*Skills*	*Wider Competences Attitudes)*
L6_8. Level descriptor	K6_8 Demonstrate knowledge and understanding of established communication methods and tools and of their limitations.	S6_8 Communicate effectively, clearly and unambiguously information, describe activities and communicate their exits/results to engineers or wider audiences in national and international contexts, using appropriate established communication methods and tools.	C6_8 Identify appropriate and relevant established communication methods and tools.

Subset 1 L6_8.1 Communication strategies, methods and tools	K6_8.1 Define and describe established communication methods and tools, the characteristics of effective verbal, written, virtual, and graphical communications and their limitations to communicate effectively, clearly and unambiguously information, describe activities and communicate their exits/results to engineers or wider audiences in national and international contexts.	S6_8.1 Plan, compose, integrate and deliver effective verbal, written, virtual and graphical communications for describing activities and communicating their exits/results to engineers or wider audiences in national and international contexts, by applying rules of grammar and composition in verbal and written communications, properly citing sources, and using appropriate graphical standards in preparing engineering drawings.	C6_8.1 Identify appropriate and relevant established communication strategies, methods and tools to communicate effectively, clearly and unambiguously information, describe activities and communicate their exits/ results to engineers or wider audiences in national and international contexts.
Assessment approaches	Essays Problem Solving Practical Work	Problem Solving Practical Work	Problem Solving Practical Work Reflective Practice Assignments
Learning approaches	Attending lectures Attending seminars Attending tutorials Participating in flipped classroom Blended learning Fieldwork	Problem-based learning Design-based learning Practising professional skills Role play Peer reviewing	Problem-based learning Design-based learning Practising professional skills Individual supervision
Teaching approaches	Lectures Seminars Tutorials Flipped classroom Blended teaching Fieldwork	Problem-based classes Design-based classes Work-based practice Role play Peer reviewing	Problem-based classes Design-based classes Work-based practice Individual supervision

Dimension 9: Lifelong Learning			
(Sub)descriptor / TLA approaches	*Knowledge*	*Skills*	*Wider Competences (Attitudes)*

L6_2. Level descriptor	K6_9 Demonstrate knowledge and understanding of the learning methods necessary to follow developments in science and technology in civil engineering subject area.	S6_9 Engage in independent lifelong learning and follow developments in science and technology in civil engineering subject area autonomously.	C6_9 Identify appropriate learning methods in independent lifelong learning to follow developments in science and technology in civil engineering subject area.
Subset 1 L6_2.1 Lifelong learning strategies and methods	K6_9.1 Define lifelong learning, explain the need for lifelong learning, describe the skills required of a lifelong learner and the learning methods necessary to follow developments in science and technology in civil engineering subject area.	S6_9.1 Engage in independent lifelong learning to follow developments in science and technology in civil engineering subject area autonomously.	C6_9.1 Identify appropriate learning methods in independent lifelong learning to follow developments in science and technology in civil engineering subject area.
Assessment approaches	Essays Problem Solving Practical Work Reflective Practice Assignments	Problem Solving Practical Work	Problem Solving Practical Work Reflective Practice Assignments
Learning approaches	Attending lectures Attending seminars Attending tutorials Problem-based learning Design-based learning Work-based practice	Problem-based learning Design-based learning Practising professional skills	Problem-based learning Design-based learning Practising professional skills Individual supervision
Teaching approaches	Lectures Seminars Tutorials Problem-based classes Design-based classes Work-based practice Individual supervision	Problem-based classes Design-based classes Work-based practice	Problem-based classes Design-based classes Work-based practice Individual supervision

To complement the CALOHEE professional framework or terms of reference to operate successfully in the workplace another set of dimensions was considered to include civic, social and cultural engagement. These competences may be essential to define attitudes as an integral part of each Civil Engineering program. It has four dimensions that address Society's and Cultures, Processes of Information and Communication, Processes of Governance and Decision Making and Ethics, Norms, values and Professional Standards. Table 4 represents the indicators/descriptors considered adequate to represente the needed competences in Civil Engineering.

Table 4. Civic, social and cultural engagement (Tuning Academy).

Dimension	**Knowledge**	**Skills**	**Wider competences** (Attitudes)
1. Society and Cultures	Demonstrate critical understanding of differences in and between societies and cultures	Identify, describe and analyse issues in and between societies and cultures	Demonstrate engagement by developing scenarios and alternatives for identifying best practices and interventions in the case of tensions and conflicts
2. Information and Communication	Demonstrate critical understanding of the processes of *information and communication*	Review and judge (mis)use of sources, data, evidence, qualities, intentions and transparency and expert opinions	Active contribution to societal debates using reliable data and information sources and informed judgements
3. Governance and decision making	Demonstrate critical understanding of the processes of governance and decision making	Apply and support agreed governing principles, norms and values regarding fairness, transparency, accountability, democracy and relevance in policy making processes	Active contribution to and with local and (inter)national communities, community groups, (political) organisations and pressure groups respecting agreed principles, norms and values
4. Ethics, norms, values and standards	Demonstrate critical understanding of general ethical principles, norms and values and professional standards	Understand and apply the processes of decision making and the consequences of actions taking into account principles, norms, values and standards both from a personal and a professional standpoint.	Active contribution to upholding, promoting and defending general ethical principles, norms, values and professional standards in governance, communication and cultural interaction.

Although presented here as a possible supplementary stand-alone framework, the descriptors indicated in the table above can be integrated in the Civil Engineering programs of first and second cycle (bachelor and master). The descriptors described can be checked to verify if some exist already in the terms of reference while the remaining may be added explicitly or indirectly in the nine dimensions.

5. EXAMPLE - CASE STUDIES

5.1. Thibaut Skrzpek, École des Ponts, France

Based on a publication by Gilles Buisson & Gabriel Stoltz (ENPC, 2017)
Ref to Assessment Framework Template First Cycle
Dimension: Knowledge & Understanding / N1
Knowledge Descriptor: Knowledge and understanding of mathematics at a level necessary to achieve the other programme outcomes

Summary
Flipped classroom has been implemented with small groups of 25 students in the Spectral Analysis course available at the "École des Ponts" since 2011. Since the beginning of school year 2015-2016, the Spectral Analysis course has opened to all first-year Engineering students – about 140 students being divided in six "smaller groups" composed of 25 students. The necessary conditions of such a method are – first – finding a team of teachers open to the "flipped classroom" educational method and – second – standardizing parts of it. At the end of the first flipped-classroom session, the approach is praised by students and teachers alike, it being seen as an efficient tool for adapting to different types of audience.

1. The context: from a small-scale course to an entire class

1.1. A pedagogical method proven since 2011: flipped classroom with a small number of students

Flipped classroom was first introduced at ENPC (École nationale des ponts et chaussées or “École des Ponts”) in 2011 for the course "Spectral Analysis", a course deemed difficult and aimed at a student audience of engineers with a mathematician profile. This course was built in 2008 on a classical alternation between lectures and tutorials. Gabriel Stoltz, a young researcher and teacher at the École des Ponts, became in charge of the course in 2009. After a first year in which he alternated between lectures and tutorials, he noticed an unsatisfactory course of action: passivity of students, difficulties in assimilating concepts and apply them.
So he decides to review the format of the course in depth and to refocus it more on the answers to the students' questions. The concept of flipped classroom is adopted. In the classroom, students work on solving small group exercises. The lectures are replaced by the handout that the students have to read at home. At the first session, an initial time is dedicated for reading the syllabus to explain the method of the flipped classroom to the students. The course evolved towards a formative and continuous assessment through the implementation of intermediate exams and quizzes given at the beginning of sessions to increase the quality and quantity of work at home.

Flipped classroom has made possible to make a significant change in class dynamics. From 2009 to 2013, there is a marked increase in terms of results (Poitrat and Stoltz, 2013). Compared to the former lecture and tutorial format, there are two points more on the median note. From a qualitative point of view, students are more active and ask more questions. From the teacher's point of view, one of the main advantages of the method is that it allows students to better understand their knowledge and gaps, what is easy for them and what is difficult for them.

1.2. The change of scale with a core course

The "Analysis and Scientific Computation" course, which is the subject of a flipped classroom for all engineering students, is a compulsory common core curriculum that exists in its current form since the beginning of 2015. It is the result of the merger of two pre-existing courses: the "Analysis" course in the first semester and the "Scientific Computing" course in the second semester, which were also two compulsory courses.

The change in format of these modules is due to the evolution of the program of the preparatory classes which form less the students who integrate ENPC with the techniques of the analysis in mathematics. The "Analysis" course covered all first-year students, but operated in level groups. The course of "Analysis and scientific computation" which replaces it is intended to address all the students with a perspective of introduction to the subject. The main idea of this course is to give students a basic content for those who do not want to continue to deepen mathematics. According to the teacher, it is "doing less, but doing better". This introductory course is accompanied by an optional in-depth course in the second semester, which is intended for students who target the most demanding following programs on the mathematical point of view.

The number of students in the "Analysis and Scientific Computing" course is 145 students. This class is divided into six small classes of up to twenty-five students. The course comprises twelve sessions of 2h45 in face-to-face and six "restructuring lectures”. Teachers are also available one hour a week during "office hours" which are set up to answer questions from students who so desire.

2. Design and implementation of a large flipped classroom

2.1. Adjustment and refinement of the system

If the flipped classroom has been a success since few years at the École des Ponts, it remains a more complex system to set up than a traditional course, specifically for a large workforce. The flipped classroom challenges work habits for teachers and students. In an attempt to respond, each edition brings its own incremental adjustments and innovations listed below:

a) The syllabus which explains the choice of the method: if the principle of the flipped classroom may seem simple at first sight, it is not always the case of the pedagogical intention of the teacher. The interest of the method is not always understood or clear for the students. Some even wish to return to the blackboard and chalk. Take the time to explain in the syllabus the choice of the active method or even the reception of the flipped classroom by the students of the previous years makes possible to clarify the nature of the pedagogic contract.

b) The restructuring lecture: when solving exercises in small groups, the teacher, who is placed as an observer, realizes a certain number of difficulties of the students which he would not have noticed in case of a classical tutorial class. In response to these difficulties and on the suggestion of the pupils, "restructuring lectures" have been set up every two sessions in order to allow students to get away from a linear and local understanding (a chapter) and to put into perspective the whole course. Based on the difficulties observed and reported by all the teachers, the course leading teacher produces a synthesis of four to five slides maximum, gathers the students in an amphitheatre for fifteen minutes and explains each point that was noticed as difficult.

The place of the course on the pedagogical intranet platform: in the context of a large-scale course, the use of an online platform makes it possible have pedagogical resources available, but also has the role of centralizing information for all small classes. In addition to the already existing materials, this year's "Analysis and Scientific Computing" course space has been enriched with videos of the restructuring lectures and videos of correction for the most difficult exercises.

c) The use of quizzes: one of the recurring problems of the flipped classroom is to get the student to work regularly on the theoretical part at home before the sessions. The motivation for the introduction of quizzes is to strongly encourage students to read the handout before the course (Svinicki and McKeachie, 2011, Brauer, 2011). They include short questions on definitions, concepts or results that appear in the handout or in the answers to the exercises from the previous session. In addition, this year, has been set up self-assessment questions so that teachers have a first feedback on the points to be discussed during the session. These self-assessments are formative and allow a basis to initiate discussion at the beginning of the sessions.

2.2. Recruitment of the teaching team

The recruitment of the teaching team is a major point of the changeover to the format of the flipped classroom. As part of the "Analysis and Scientific Computing" course, the teaching team was mainly composed of researchers from the CERMICS laboratory attached to the ENPC. In addition to the course supervisor, this team includes a research director with 15 years of practice after PhD thesis, two lecturers with five years of post-thesis practice, one post-doctoral student and two doctoral students, one of them as a substitute. The fact that most teachers are young and that they belong to the same laboratory facilitates the adoption of the pedagogical method and the cohesion of the team.

The first condition for a good functioning of a large flipped classroom is to find teachers convinced and enthusiastic about the pedagogical method used. This factor is more decisive for the success of an active pedagogic concept than in traditional pedagogy. If the teacher is not engaged in his / her own course, the students will not adhere to the teaching method. For teachers engaged in flipped classroom, the second important condition is to be ready to break out of the traditional teaching posture, which is a comfort zone for many teachers. From this point of view, the script and course organization were thought by the module leader well beforehand. This provided security for teachers who were not experienced in the flipped classroom face-to-face session. For the flipped face-to-face, changing the posture means concretely mastering his / her subject sufficiently so as to be comfortable and responsive to questions that go beyond the strict course. Indeed, it has been observed in the first two editions that some students ask questions that they would not ask in a traditional pedagogical mode.

In general, there is a real internal debate among the teachers of ENPC between the advocates of teaching and those who experiment the active methods like flipped classroom. This debate raises both the question of the use of time allocated to the teacher in the system and the question of the objectives aimed and evaluated. Should the teacher pass more time on content or take time to observe active students by intervening as appropriate? The answer depends, among other things, on teachers' choices and perceptions concerning the coherence of the course in the training curriculum and, on the other hand, the pedagogical coherence of the module itself through the alignment between objectives, pedagogic activities and assessment methods. The case of the course of "Analysis and scientific computation" shows us that this pedagogical coherence can vary in time.

2.3. Coordination of the system: between standardization and communication

The scaling up of flipped classroom requires that the course be scripted more thoroughly than for a course alternating lectures and tutorials. The system must be standardized so that the team of teachers can follow the same pedagogical framework and ensure fairness in terms of content and feedback with students between small classes. At this level, the choice has been made to limit the number of students per class to 25, the limit according to the teachers for an effective supervision with this pedagogical approach.

To train his team upstream, Gabriel Stoltz asked the teachers of small classes to read the syllabus provided to the students and to see a video of presentation which details every aspect of the pedagogic process. He also organizes a one-and-a-half-hour meeting where he discusses the organization of the sessions, the work of the students at home and the schedule of the course.

Subsequently, the course of a session follows the same scenario for all teachers:

1. Set tables for 4 students group if possible before the start of the course (5 minutes).
2. Moment of initial exchange with students: feedback on self-assessment and answers to questions (between 5 and 15 minutes). In the first sessions, there are usually few questions. As time goes by, students are more confident and have a better view of the course. They typically ask five to six questions, sometimes more on some challenging sessions.
3. Knowledge Quiz (a quiz every two sessions approximately): definition of the notions in the handout to be read before the session or evaluation of the techniques acquired by the resolution of the exercises of the previous session (10 minutes).
4. Resolution of the compulsory exercises in small groups: during the rest of the session. Resolution of the compulsory exercises in small groups: during the rest of the session. Students are released early if a restructuring lecture is scheduled.

Before each face-to-face session, Gabriel Stoltz sends a weekly e-mail to all teachers. This e-mail contains a summary of the self-evaluation questionnaires available on the educational intranet platform and the instructions for the quizzes to be carried out during the session.

He also sends an e-mail just after the session to carry out a possible assessment of some problems and send the documents for the next session (quiz, subject of practical work and exam annals). After each session, he briefly debriefs new teachers on a weekly basis, specifically questions asked by the students.

3. Results and outlook

3.1. A first edition received favourably by the students

The "Analysis and Scientific Computing" course started in September 2015 is currently in its second edition. The evaluation of the first edition does not reveal any major objection as to the choice of format. Out of 143 students interviewed during the first evaluation of the module, 93 students responded, representing 65% of the total. Of these 93 students, 73% said the course could be maintained unchanged, 17% with minor changes, 9% with major changes.

In terms of exam results, it is not possible to compare the current system with what existed before, since it is a merger of two pre-existing courses. The choice was made to focus the assessment on skills related to the resolution of class exercises seen in class, rather than in the classical perspective of mathematics examinations. This assessment centred on the resolution skills resulted in a more precise handout on the concepts to be assimilated and more divided exercises during the face-to-face sessions. In general, Gabriel Stoltz has noticed fewer errors on the exercises worked in progress, but not so many improvements on things that were not so much studied in class.

On a qualitative level, students indicate that they are satisfied with being able to practice more exercises in a flipped classroom than in a classical tutorial. Indeed, it is not the teacher who spends most of the time solving the exercise, but the students. This leads to more frequent and relevant interactions on the course content both at the beginning and during

the session. Peer-to-peer exchange in exercises benefits both to students who need help for certain problems and to the most advanced students who can thus reformulate their solutions. Gabriel Stoltz noticed an increase in the questions asked during the sessions and during the holidays. He also noted that students were more likely to discuss the solutions to the problems and compare them with those of the teacher.
On the other hand, reverse pedagogy is not suitable for everyone and some students have expressed the wish to return to a traditional pedagogy. The flipped classroom imposes to the student a more regular and demanding personal work than a traditional one, since it is necessary to carefully prepare each face-to-face session where, for a classical approach, it is possible to revise only at the last moment before exams. Finally, the "surprise" quizzes at the beginning of the session do not appeal to all the students who may feel for some to be "infantilized". Apart from these minor remarks, the choice of the reverse approach is understood and accepted.

3.2. A good tool for differentiation for teachers
The first edition of the course "Analysis and Scientific Computing" was a first experiment into reverse pedagogy not only for students but also for teachers. For the six teachers of the pedagogical team, there was no questioning of the pedagogical method, rather a global membership. The main interest of the method is to allow more interaction with the students during the face-to-face sessions. This led into a better knowledge of the difficulties of the students and a better reactivity of the teachers in relation to them, especially for the less experienced teachers.
Compared to the "Spectral Analysis" course, which was intended for mathematician students, the course of "Analysis and scientific computation" also concerns non-specialists, which implies a difference in terms of technique and motivation. From this point of view, the flipped classroom format seemed the ideal tool for differentiating learning levels. The added value for motivated students is to have the teacher resource available and for the less good students, the opportunity to do the exercises at their own pace and to be assisted by their peers. All students have to complete the compulsory part and those who want to specialize do additional exercises.
In conclusion, we thus see through the example of the course of "Analysis and scientific computation" that the transition from an educational innovation such as the flipped classroom to the scale of a whole class of engineering programme is possible. In the context of the École des Ponts, this was greatly facilitated by the previous experience of the flipped classroom on smaller numbers. However, to succeed in such a scaling-up, it is imperative to recruit a team of teachers convinced by this method and curious to practice it. Such a scaling up requires in addition a careful scenario well before its launch in order to reduce the complexity and possible difficulties during the course. This also requires a clear pedagogical agreement between the teachers and the students on the pedagogical objectives.

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5.2. A Tuning-AHELO Conceptual Framework of Expected Desired/Learning Outcomes in Engineering about Design-Based Learning

Tuning Academy (www.tuningacademy.org)
«*Design-Based Learning* (DBL) is another interesting new collaborative approach to successfully learn, teach and assess key learning outcomes in engineering. DBL is conceived as 'an educational model in which a major part of the curriculum and study programme is aimed at learning to design in engineering'. In DBL, not only are the resulting products important, the underlying process is highly relevant as well. DBL explicitly involves a form of university education giving academic skills a prominent position. These would include strategic thinking regarding activities, critical analysis of design tasks, broad interpretation of design requirements, incorporation of contemporary scientific views, etc. DBL could be characterised particularly as integrative, multidisciplinary, practice-oriented, creative, cooperative (teamwork), competence-oriented (skills), activating, fostering responsibility, synthesising, and leading to professionalization. In DBL, once the design task is set, the teacher transfers all authority to (a group of) students. The students' tasks are open-ended and students become actively involved in defining design questions in their own language and working out solutions together instead of reproducing material presented by the teacher or the textbook. It is believed that students are truly thinking critically when they formulate their own constructs and solutions. By making use of DBL, students are stimulated to develop higher level thinking skills, gain a positive attitude toward the subject matter, practice modelling societal and work-related roles, and generate more and better design questions and solutions. DBL is assumed to increase knowledge retention, develop students' general problem-solving skills, improve integration of basic science concepts into real-life problems, stimulate the development of self-directed learning skills, and strengthen intrinsic motivation».

The following considerations were made:

a) Independently from the educational activity involved, an 'active learning 'approach should always be pursued. Students need an intellectually stimulating, inductive, and co-operative leadership environment in order to be more engaged in the learning experience. To this regard, active, collaborative learning approach appears particularly effective.
b) Many engineering faculty members enter the education environment with little or no understanding of desired LOs or how to design and execute a learning experience for such outcomes to be achieved. Institutions should create a supportive environment for education innovation and consider strengthening faculty development programmes so faculty members may more familiar with desired LOs and therefore carry out their duties more effectively.

5.3. Emilien Azéma, Université de Montpellier, France

Research question #1: *"concerning the assessment try to identify one or more methods that you are using and that you consider example(s); some of you have done that already"*

EQF Level 6: Licence de Mécanique

- 3 years/6 semesters full-time 180 credits ECTS.
- 42 modules ranging from 1,5 to 8 credits ECTS, mostly with 5 credits.
- The first year is common for all students.
- There is no elective courses, but in the second year, students begin to specialize in either numerical mechanics or mechanical design.
- Mix of assessment methods, some are midterms exams, some continuous control, reports or projects.

The majority of graduates continue their education by enrolling in a master's degree and a non-negligeable number switch to engineering school (a French particularity where engineering is taught both in science faculties and in engineering schools). The main feedback from colleagues teaching in Master program or in engineering schools is on the need to strengthen the mathematical foundations. For this reason, we have re-formatted the first year which is now common to all students with intensive reinforcement in mathematics in relation with the mathematics department. The courses are: geometry in the plane and in the complex plane, calculus, analysis of functions and sequences, reasoning and algebra, linear system 1 and 2. Kinematics and point mechanics are only introduced in the second semester. Over the two semesters a total of 18 ECTS are dedicated to mathematical reinforcement.

In the second and third year, students specialize further in computational mechanics or in mechanical design. Further study in mathematics and numeric continues but is more focused on their specialty in the form of "mathematical tools for..." for approximatively 20 ECTS, in year 2 for the computational mechanic program and 15ECTS for the mechanical design program. The same for the year 3 but in the form of "numerical and mathematical" projects.

EQF Level 7: Master in Mechanics

- Two years/four semesters full-time 120 credits ECTS.
- Year 1 : 11 modules of 3-5 ECTS + a long internship + dissertation for 15 ECTS.
- Year 2 : 9 modules of 3-5 ECTS + a long internship + dissertation for 15 ECTS + "end of school project" of 10 ECTS
- Program has a mix of assessment methods, formative and summative.
- Reports, continuous control) (no midterm examen), homework and oral presentations in some courses.
- Evaluation of each dissertation module is made by a jury of three teachers (president, external member and supervisor) for one hour and in a public event.
- Two specializations: computational mechanics or mechanical design
- Both specializations are open to apprenticeship (i.e, with a company)
- Both specializations are open to a double degree in "Management of Industrial Product" in collaboration with the faculty of administration.

After several years, the general feedback from employers has been that although students have a good overall level of numerical and mathematical skills, their knowledge in business and management could be improved. We then made a choice which, from our point of view, is very innovative:
We got closer to the faculty of administration, and we propose a double degree in Mechanics and Business Management. Additional courses in "project management", "group management" ... for a total of 20 ECTS per year are added in year 1 and year 2 (generally, for students not wishing to continue in thesis.

Research question #2: "compare your current program(s) with the levels 6 and 7 of EQF and identify gaps in terms of Learning Outcomes"

EQF Level 6 and 7: Licence and Master in mechanics.

Both the Licence and Master program have been accredited by the national accreditation agency HCERES.

Both programs are organized around 5 Program Learning Outcomes, which are split in several sub-Program Learning Outcomes:

1. Organizational Skills:

a. Implement a project: define the objectives and context, carry out and evaluate the action.
b. Carry out a search for information: specify the purpose of the search, identify the modes of access, analyze the b. Carry out a search for information: specify the purpose of the search, identify the means of access, analyze the relevance, explain and transmit, elaborate a synthesis, propose extensions.
c. Carry out a study: pose a problem, construct and develop an argument, interpret the results.
d. Define the objectives and develop a personal training project.
e. Use information and communication technologies.

2. Interpersonal Skills:

a. Communicating: writing clearly, preparing appropriate communication materials, public speaking andpublic speaking and commenting on materials, communicating in foreign languages.
b. Working in a team: integrating, positioning oneself, collaborating.
c. Integrate into a professional environment: identify and communicate one's skills, situate themselves into company or in an organization.

d. Integrate into a professional environment: identify and communicate one's skills, situate a company or an organization in its socio-economic context, identify the resource persons and the various functions of an organization, situate oneself in a hierarchical and functional environment, respect the procedures, legislation and safety standards.

3. General Science Skills:

a. Adhere to scientific ethics.

b. Identify and comply with regulations.

c. Demonstrate abstraction skills.

d. Analyze a complex situation.

e. Adopt a multidisciplinary approach.

f. use the most common measuring devices and techniques, identify sources of error, analyze experimental data and consider their modeling, validate a model by comparing its sources of error, analyze experimental data and consider their modeling, validate a model by comparing its predictions with experimental results, appreciate the limits of validity of a model, solve a complex problem by successive approximations.

g. Use mathematical and statistical tools

h. Use a programming language.

4. Science Disciplinary Skills:

a. Use current mechanical engineering techniques: use of CAD/CAM tools, sizing of parts under tension, compression, shear, torsion and bending, preparation and execution of a machining operation on a machine. CAD/CAM tools, sizing of parts loaded in tension, compression, shear, torsion, and bending, preparation and execution of machining on a traditional lathe and milling machine, selection of common components from a specification, functional dimensioning.

b. Use current techniques in project management: establish specifications, research and evaluate solution principles, build a technical file.

5. Associated competencies*:*

a. Master a foreign language, especially English or German.

Research question #3 : *“*try to identify new competences like sustainability or digital; some of you have already done that”

Ecological, climatic and environmental transitions push us to develop even more advanced knowledge often at the frontier between several disciplines: mathematics, biology and even sociology. A key skill that must be pushed is interdisciplinarity

5.4. Civil Engineering – Ken Thomas, South East Technological Univeristy, WIT, Ireland

Research question #1: “concerning the assessment try to identify one or more methods that you are using and that you consider example(s); some of you have done that already”.

EQF Level 6: BEng [Honours] in Sustainable Civil Engineering
· 4 years/8 semesters full-time 240 ECTS
· 44 modules ranging from 5 to 15 ECTS, mainly ‘Mandatory ’with limited ‘Electives’
· Mix of Assessment Methods, vast majority are Summative
· 33 ‘Traditional ’Exams – typically 2 hours written paper held on campus
· Others include Projects, Reports, Presentations, Practicals, Fieldwork and Dissertation

The feedback from the most recent industry advisory group meeting, was that graduates need to
have much better communication skills – verbal and written. This will require a rethink from the
Programme Team, including the approach to assessments for many of the modules. Replacing Exams with an increased number of Presentations and Reports is very likely to require more resources and time. The formative and summative balance of such assessments is also an issue. Ideally there would be a significant number of formative assessment to allow for individual feedback and improvement for the ‘connected ’ summative assessment.

Among the key modules on the programme are:
· SCE Placement in Year 3 (15 ECTS - students typically ‘placed’/employed in industry from March to August; with a range of assessments, including input from the employer).
· Dissertation in Year 4 (10 ECTS in total - 2 modules with a variety of formative and summative
assessments; including individual Presentations, Reports, Poster and final Dissertation)

EQF Level 7: MSc in Construction Project Management

· 1 year/3 semesters full-time 90 ECTS, part-time option over 2 years
· 13 modules in total, 12 at 5 ECTS and 1 at 30 ECTS (Dissertation)
· Mix of Assessment Methods, majority are Summative
· Only 2 'Traditional 'Exams – typically 2 hours written paper held on campus
· Others include Projects, Presentations and Dissertation

This programme has always been innovative in how the individual modules are assessed. The primary reasons have been that the majority of the students are more mature and taking the programme on a part-time basis. The flexibility of completing assessments in a format that suits
them and their employment is very much appreciated. It is also an opportunity in many cases for
them to explore and demonstrate the outcomes (knowledge, skills and wider competences) in the
context of their workplace. The various Projects, Presentations and Dissertation submitted not only fulfil the requirements of the Modules, in many case they also have a direct impact on improving the company that employs the student.

Among the key modules on the programme are:
· Professional Development and Effectiveness in Semester 1 (5 ECTS – includes a number of
formative and summative assessments that are very much individual and personal to the student; they include Reports, some confidential, and Presentations).
· Dissertation in Semester 3 (30 ECTS – the major module on the programme with a variety of
formative and summative assessments; including individual Presentations, Reports, Poster and
final Dissertation).

Research question #2: "compare your current program(s) with the levels 6 and 7 of EQF and identify gaps in terms of LOs"

EQF Level 6: BEng [Honours] in Sustainable Civil Engineering

· 4 Years/8 Semesters full-time 240 ECTS
· 44 Modules ranging from 5 to 15 ECTS, mainly 'Mandatory 'with limited 'Electives'
· Each Module has between 5 and 7 Module Learning Outcomes (MLOs)
· The overall Programme has 9 Programme Learning Outcomes (PLOs)
· These PLOs have been mapped against Engineers Ireland's Accreditation Criteria and their 8
required Programme Outcomes for 'Chartered with Further Learning'
(https://www.engineersireland.ie/listings/resource/519)
· These PLOs have also been mapped against Quality and Qualifications Ireland (QQI) against the NQF Level 8 Award Standard (https://www.qqi.ie/sites/default/files/2021-12/engineering-awards-standards.pdf)

In relation to the PLOs were mapped against the Level 6 and there were no significant gaps for the 9 Dimensions. Mapping against each of the Sub-Dimensions was not carried out, but this would require a more detailed analysis, including the various Multiple Learning Outcomes (approximately 260 in total).

EQF Level 7: MSc in Construction Project Management

· 1 year/3 semesters full-time 90 ECTS, part-time option over 2 years
· 13 modules ranging from 5 to 30 ECTS
· The overall programme has 9 Programme Learning Outcomes (PLOs)
· These PLOs have been mapped against Engineers Ireland's Accreditation Criteria and their 8
required Programme Outcomes for 'Chartered Engineer'
(https://www.engineersireland.ie/listings/resource/519)
· These PLOs have also been mapped against Quality and Qualifications Ireland (QQI) against the NQF Level 9 Award Standard (https://www.qqi.ie/sites/default/files/2021-12/engineering-
awards-standards.pdf)

The PLOs were mapped against the Level 7 and there were no significant gaps for the 9 Dimensions. Mapping against each of the Sub-Dimensions was not carried out, but this would require a more detailed analysis, including the various Multiple Learning Outcomes (approximately 80 in total).

Research question #3: "try to identify new competences like sustainability or digital"

The three key aligned and connected themes that we in SETU (WIT) are currently focussing on for our Engineering, Architecture and Built Environment education programmes, as well as our research and innovation activities are:

Ø Green – the SDGs and Climate Change targets;
Ø Lean – being more efficient, including the improved use of resources (people, process, technology, materials);
Ø Digital – being more digital, including the dynamic digital twinning of all aspects the built environment.

Each of these themes impact on the desired and required competences for our graduates. The assessment of the associated competences are more likely to be different to the traditional paper-
based examinations papers. The lessons learned from Covid and the associated enforced step-change in the use of Technology Enhanced Learning (TEL) are having a profound impact. The greater flexibility in achieving learning outcomes (MLOs and PLOs) should be maintained and increased for the benefit of the students and, hopefully, the programme teams and individual teachers/'facilitators'.

This includes more innovative approaches to assessments with the appropriate blend of generic (all in the class/group) and bespoke (teams and individuals). It is interesting to note that Engineers Ireland have included 'Software and Information Systems 'and 'Sustainability 'among the expected 7 'Programme Areas 'in their updated Accreditation Criteria.
(https://www.engineersireland.ie/listings/resource/519)

5.5. Paolo Villani, University of Salerno, Italy

Research question #1: "compare your current program(s) with the levels 6 and 7 and identify gaps in terms of Learning Outcomes"

EQF Level 6: Degree in Civil and Environmental Engineering

· 3 years/6 semesters 180 ECTS
· 29 modules ranging from 3 to 12 ECTS, mainly ‘Mandatory’ with limited ‘Electives’
· The overall Programme has 5 Programme Learning Outcomes (PLOs) following the Dublin
Descriptors
· These PLOs have been mapped against the AVA system from the National Agency for the
Evaluation of Universities and Research Institutes (ANVUR) and its 3 required Programme Outcomes (https://www.universitaly.it/index.php/scheda/sua/48128, in Italian, see A4a-c frameworks)
· These PLOs have also been mapped against the Engineer’s Italian Accreditation Agency (QUACING) and its 6 required Programme Outcomes (https://www.quacing.it/en/learning-
outcomes/). A comparison between ANVUR and QUACING requirements is also in the A4a-c
frameworks

The PLOs were mapped against the Level 6 and there were no significant gaps for all the 9 Dimensions. Mapping against each of the Sub-Dimensions has not been completed as this analysis would require a level of detail extended to the individual modules.

EQF Level 7: Master degree in Civil Engineering
· 2 year/4 semesters 120 ECTS
· 18 modules, ranging from 3 to 12 ECTS, mixed between ‘Mandatory’ and ‘Electives’
· The overall Programme has 5 Programme Learning Outcomes (PLOs) following the Dublin
Descriptors
· These PLOs have been mapped against the AVA system from the National Agency for the
Evaluation of Universities and Research Institutes (ANVUR) and its 3 required Programme Outcomes (https://www.universitaly.it/index.php/scheda/sua/47241, in Italian, see A4a-c frameworks)
· These PLOs have also been mapped against the Engineer’s Italian Accreditation Agency (QUACING) and its 6 required Programme Outcomes (https://www.quacing.it/en/learning-
outcomes/). A comparison between ANVUR and QUACING requirements is also in the A4a-c
frameworks
The PLOs were mapped against the Level 6 and there were no significant gaps for all the 9 Dimensions. Mapping against each of the Sub-Dimensions has not been completed as this analysis would require a level of detail extended to the individual modules.

Research question #2: “try to identify new competences like sustainability or digital”

The new challenges that Civil Engineering graduates will have to be able to face are mainly linked to Climate Change and all the UN Sustainable Development Goals. This requires new approaches and new tools both in the teaching phase and in the evaluation phase. Furthermore, the digital tools and skills acquired during the phase linked to the pandemic must also be enhanced in normal times, even if the close relationship with the design approach remains fundamental for the student engineer.

5.6. Asli Ackamet, Middle East Technical University, Turkey

The first research question was to (1) compare the Programme Learning Outcomes of the current first and second cycle programmes offered by the university in Civil Engineering with the Reference Framework, (2) share your thoughts about any changes/modifications in the desired graduate profile we might want to consider introducing taking into account the current pandemic experience and the societal/professional needs it has brought to the forefront.

Why/what for: The aim of this exercise is to identify existing configurations of study programmes in terms of their intended programme learning outcomes (if applicable). As mentioned repeatedly throughout, not all HE study programmes might seek to develop their students' competences to the highest level in every dimension/sub-dimension. Certain HEIs/programmes might aim for higher levels in some (sub-)dimensions and lower levels in others.

It is important to be clear about the intentions of each study programme – about the desired graduate profile – and to jointly identify the differences and commonalities across different higher education programmes/countries/types of HEIs in Civil Engineering. Due to the Corona-crisis, we would also like to use this 'reality check' as an opportunity to have a fresh look at the Civil Engineering Reference Frameworks.
Procedure:
1. Identify a first-cycle (Bachelors) programme and a second-cycle (Masters) programme offered by your University in Civil Engineering. If you have more than one such programme at each level, please choose those that fit best (e.g. disciplinary rather than interdisciplinary programmes, and those where the Master is 'building on' the Bachelor, rather than being a completely independent programme).
2. Provide the following basic information about each programme chosen

Degree Programme title: Bachelor of Science in Civil Engineering
❖ Level: First Cycle / Bachelor
❖ Duration:
- Expressed in academic years: 4;
4 Academic Years
2 Semesters per Academic Year (September-January and February-June)
- Expressed in ECTS credit points: 240 ECTS (30 ECTS per Semester)
❖ Graduate profile description:
The curriculum of the METU Civil Engineering Department is planned to provide a sound professional education for the students. After completing their first-year courses in basic sciences, students are offered courses in Applied Mechanics, Hydraulics, Hydromechanics, Coastal and Ocean Engineering, Geotechnical Engineering, Structures, Earthquake Engineering, Geodesy, Transportation Engineering, Materials, Construction Engineering and Management fields. Courses in mathematics, computer programming and non-technical subjects are also obligatory in the program. Throughout their studies, students are encouraged to take part in applied and theoretical research, as well as in practical professional training.

Mission of Department of Civil Engineering
-To provide the most high quality undergraduate and graduate education in the area of Civil Engineering in our country so as to turn students possessing high potential into graduates with maximum added value.

-Without neglecting the international standard and dimension, to conduct high level research projects giving priority to the needs of Turkish industry, providing mobility to intellectual capital and to merge them with graduate educational activities.
-To share and disseminate accumulated expert knowledge for use in the solution of problems faced by institutions in the relevant sector and by society.
-To ensure the continuous provision of quality both in necessary physical conditions and in human resources in order to fulfill educational, research and public service duties.

Vision of METU Department of Civil Engineering
-Being conscious of the necessity of efficiency, to continuously review, starting from within the University, our responsibilities to society, to the country, to our profession, to science and to humanity.
-To create required methods and mechanisms for the swift and effective transfer into the curriculum and research topics of the latest developments in technology, knowledge access and information processing.
-To take account of the ethical, social, cultural, environmental and economic aspects of the profession as much as to the technical dimension in all educational and research activities.
-To plan for the future and to adapt to innovation.
-To uphold the positive traditional qualities that have undeniably contributed to the present successful position.
-To equip students with the knowledge, ability and creative thinking required for the identification, solution, synthesis and design of civil engineering problems.
-To exert attention so that research activities in addition to being suitable for the needs of the country should also be pioneering studies that contribute to the profession and to science.
-To transfer and share the accumulation of knowledge firstly for the benefit of the country and in general for the benefit and development of all humanity.
-To always improve and develop the required physical environment for education and research.
-In short, in all areas of endeavor, with students, faculty, administrative staff and graduates to be always the pioneer, the leader and to strive for perfection The following program educational objectives are career and professional accomplishments that our graduates are expected to achieve within a few years after graduation:
● Graduates come to the forefront in their careers in leading companies and institutions.
● Graduates have successful research identities and academic careers in both national and international universities and research institutions.
● Graduates are preferred in international projects due to their strong engineering background and communication skills.

Program Outcomes (Student Outcomes):

1. An ability to apply knowledge of mathematics, science, and engineering.
2. An ability to design and conduct experiments, as well as to analyze and interpret data.
3. An ability to design a system, component, or process to meet desired needs.
4. An ability to function on multi-disciplinary teams.
5. An ability to identify, formulate and solve engineering problems.
6. An understanding of professional and ethical responsibility.
7. An ability to communicate effectively.
8. The broad education necessary to understand the impact of engineering solutions in a global and societal context.
9. Recognition of the need for and an ability to engage in life-long learning.
10. Knowledge on contemporary issues.

11. An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

The Civil Engineering undergraduate program was accredited by the Engineering Accreditation
Commission of ABET, http://www.abet.org. Students successfully completing their fourth year
are entitled to the degree of Bachelor of Science in Civil Engineering. Practical experience is
required for the degree therefore, students are required to go into summer practice at the end of
their second and third years and have a satisfactory record of their summer employment
approved by the Department of METU. During the fourth year, technical elective courses are
offered to enable the students to advance their knowledge in specific fields.
(https://catalog.metu.edu.tr/program.php?fac_prog=562)

Mapping of Programme Learning Outcomes onto the Level 6 and 7 of Reference Framework CALOHEE

In our BS program, Program Educational Objectives (PEOs) are mapped to ABET Program Criteria – Student. Outcomes (SOs) and Course Learning Outcomes (CLOs) are mapped to these Student Outcomes (SOs). Program-Student Outcomes are listed and mapped to CALOHEE Reference Framework. Sub-level SOs shows the level of cognitive achievement (which is the part that changes from bachelor to master).

In the Master of Science Degree in Civil Engineering (Second Cycle) Sub-levels shows the level of cognitive achievement (which is the part that changes from bachelor to master). Sub-disciplines in the MS program can have differences in the learning outcomes, therefore common objectives are taken mostly into consideration.

Main comments are that the PLOs are addressed by the nine CALOHEE Reference Framework Dimensions. Programs are structured to represent the learning outcomes mapped to ABET Program Criteria Outcomes, which is at a higher level description than the CALOHEE Reference Framework dimensions. However, there is a recent version of ABET BOK, where level of cognitive achievement under these program outcomes are also defined for BS and MS degrees. It was used this more detailed information while mapping First-Cycle and Second-Cycle programme in order to show the difference. Alternatively, a more detailed study can be done where Course Learning Outcomes, which are mapped to Program/Student Outcomes and shows the level of cognitive achievements, are used to do the mapping against sub-dimensions of the CALOHEE Reference Framework. The CALOHEE Reference Framework is very detailed and hence is capable of covering most of the PLOs of different programs in Civil Engineering. Regarding the impact of COVID19 and other potential future pandemics, the inclusion of digital learning and assessment modes were a concern. It is believed this will not change the PLOs, but the level of achievement might be changed due to limitations of online teaching methods. This is because students need to be present for conducting or observing experiments in the laboratories, they need to do internships at construction sites, and they need to be able to interact more with the instructors and peers in a campus environment. Some of the LOs cannot be provided just through classroom instruction (such as teamwork, leadership, and communication skills). Therefore, solely online education will not be sufficient in supporting all of the learning outcomes of the program required for the Civil Engineering profession.

5.7. Ivica Zavrski, University of Zagreb, Croatia

Examples of assessment tasks, approaches, criteria that have been used:

Example No 1:

- Description
o Students create teams of two or three on their own choice
o Each team pick one of topic proposal from the pool prepared by educator
o Students in team organise their own activities, share tasks
o Tasks include literature review, study of phenomenon, data collection, site visit, data analysis, model creating, making conclusions, text creation, preparing of presentation in PP and oral, giving presentation, answering questions put from other students
o Partial results of work on tasks are controlled by educator successively

- Analysis
o Creating teams on students choice build responsibility and integrity but is many times right opposite from real practice when teams are created by employer, boss
o Previously by educator prepared topics direct work but limit choice of students
o Activities organised by students build their managerial skills but put them in dangerous of mistake, some of students can be overloaded and some idle
o Work on tasks build skills and successive control make sure process is progressing well. Implementation is being monitored by senior staff members that is always not available.

Example No 2:

- Description
o Students are grouped in pairs and directed to spend a day a week during semester at a construction site by an industrial partner.
o Site management give real tasks to students to do. Tasks include participation in site inspection and quality control, participating at meetings, taking notes, quantity control, paperwork.
o Students take a notes on own activities and prepare written reports on their work.

- Analysis
o Grouping of students in pairs limits ability to create own teams but is similar to situation to be meet in practice.
o Site management behave with students similar like with own stuff but pedagogical approach is up of individual decision.
o Dedicated tasks are real but there is lack of continuity since students are in process just once a week.
o Written report is a part of work assessment but limited in reliability and time consumptive for students write and educators to proof.

5.8. Nicolaos Theodossiou, Aristotle University of Thessaloniki, Greece.

Changing assessment for an active learning in an Environmental course

The course “Environmental impact Assessment” is offered to postgraduate students following the program “Protection of the environment and sustainable development”. This program is offered by the Department of Civil Engineering of the Aristotle University of Thessaloniki. Each year, about thirty students from various disciplines, who are related to the environment, follow this postgraduate program.

The course “Environmental impact Assessment” is offered during the first semester, twice a week, with two-hour lectures each time. The lecturers are coming from various background and different discipline in order to provide to the students an overall approach on environmental impacts.

During the first years, the students were asked to answer to some questions, in written exams at the end of the semester. These questions were related to the identification of the environmental impacts of structures or activities and to propose measures to reduce the negative impacts and enhance the positive ones.

The assessment of the students was positive, but we realized that their ability to face other problems, apart from those introduced during the lectures, was limited. Then it was decided to change the format of teaching, introducing a project that the students needed to develop. This extensive project referred to a complete environmental impact Assessment study that the students were asked to develop during the semester. In order to take advantage of the multi-disciplinarity of the students, it was formed small groups of 3 to 4 students originating from different backgrounds.
This gave the opportunity to the students to introduce their own knowledge and experience from their previous studies to the group and thus the students became teachers of their fellow students. This significantly increased their understanding of the different aspects and approaches of the environment.

5.9. Rui Gonçalves, Universidade do Porto, Portugal

Changing assessment for an active learning in an Algebra course of Civil Engineering.

The course takes place in a Civil Engineering Integrated Master program. It has three hours of theoretical classes and two hours of practical classes each week. Thediscipline responds to needs to develop a scientifically based logical reasoning, to foster the capacity of logical thinking, to enable the competences of communication in scientific and technical approaches. The contents are fundamental concepts of linear algebra and matrices, applying algebraic calculus, formulate and solve explicit algebraic problems and acquire basic notions of analytical geometry.

The assessment method used in previous years were composed by two quizzes during the semester followed by exams to improve final grades or to have the chance to replace the any of the failing grades. The percentage of success in the previous years was between 50% and 60%. Several reasons were presented as causes for these low rates of success. The primary obstacle were the weeks when the students had other quizzes in the other making the follow-up of Algebra studies a secondary task. Algebra is a learning subject that is based on a constructivist approach and an ineffective learning of previous subjects has the consequence of a permanent divorce of the following subjects.

For this reason, it was decided to innovate the assessment while trying to involve students along the semester. The upgrade consisted in including an evaluation of each student along the semester that was 15% of the final grade. Each student was called at least two times to solve on the blackboard the problems assigned on a random basis for each class. That allowed to detect understanding problems of students, to motivate students to be prepared for each class and to value the work done along the semester besides the quizzes. A statistical analysis of the marks does show a improvement in terms of the distribution of final grades of about 5%.

5.10. Émilien Azema, Université de Montpellier, France

Example of assessment method for a "Practical Work": Measuring the moment of inertia of an
arbitrary solid.

- Course unit: Solid Dynamics for 5 ECTS
- Mechanical Engineering Bachelor
- Second year, last semester
- 15h of theory, 22h of exercises, 3h of practical work

Summary of the course unit:
Kinematics and dynamics of the material point. Fundamental Principle of Dynamics (Newton's
second law) for a material system. Kinetics and mass geometry. Force modeling. Elementary
oscillator and 1-degree of freedom oscillating systems

Learning outcomes:
LO1) Assessing the forces acting on a given system
LO2) Parameterizing a system and applying the second Newton's Law
LO3) Estimating the moment of inertia of any an idealized object (e.g., beam)
LO4) Estimating the moment of inertia of any mass

Aim of the practical work, see attached .pdf file (in French):
For solids having simple geometrical shape (plate, disc, beam, cylinder, sphere, …), provided that one can calculate a multiple integral, it is easy to determine the inertia operator with respect to a preferred axes of the system. On the other hand, in the case of more complex geometric solids (crankshaft, camshaft, …), it is necessary to have a numerical calculation software, or geometric modeling software to perform the integral calculations.

In this practical work, we propose an experimental method to measure the moment of inertia of a
solid rotating around an axis that passes through its center of gravity. We will first study a solid of
simple geometrical shape to validate the method by comparing the experimental values found with those obtained by the calculation. We will then be able to apply the method to a more complex geometrical solid.

The practical work contributes to obtain the LO4 and to verify that all others LO are well obtained.

Evaluation of the practical work
- Groups of, maximum, 3 students

- Writing a report
- Involvement in the group and in the practical work

Link with the Program Outcomes (competencies):
The assessment method used for the practical work will contribute to the following competencies:

Specific competencies:
- Use the concepts of forces, displacement, velocity, deformation and stress to solve and conduct a critical analysis of the result.
- Validate a model by comparing its predictions to experimental results and assess its limits of validity.

General competencies:
- Ability to work in a team as well as independently and be responsible of a project.
- To develop an argumentation with a critical mind.

Link with CALOHEE Qualifications Reference Framework of General Descriptors of a Bachelor Programme &
Evaluation
Knowledge: LO1 evaluated through the theoretical part of the report given at the end of the practical work to SAQ;
Skills: LO2 evaluated through the theoretical part of the report given at the end of the practical work to SAQ;
Attitudes: evaluated through the experimental/lab part of the work
LO3 SAQ for the explicit solution
LO3 Practical work (approximated solution for idealized solid)
LO4 Practical work (approximated solution for a given complex shape)

5.11. Thibaut Skyrzpek, École des Ponts, France

Based on a publication from the “pédagothèque de l’ENPC”
(https://pedagotheque.enpc.fr/2016/11/04/un-jeu-pour-comprendre-les-enjeux-en-situation-de-crise-et-les-ajustements-de-la-cooperation-entre-les-acteurs/)
Ref to Assessment Framework Template First Cycle
Dimension: Team-working / N15
Knowledge Descriptor: Ability to function effectively in national and international contexts as a member of a team that may be composed of engineers and non-engineers

Summary
Through a course given as part of a Specialist Master's degree (“Mastère Spécialisé”) in urban railway engineering in an engineering school, the École nationale des Ponts et Chaussées (ENPC) on crisis management, a day of crisis management exercise was set up since 2009 in ENPC classrooms. This day presents a real pedagogical interest for the students thanks to a scenario. This is a train derailment at a site located at the entrance to an average city. The freight train carries dangerous materials and derails at an hour of great affluence. The day of crisis is anchored in a one-week course devoted entirely to crisis management, and is the acme of it. This is a derailment of a freight train carrying propane wagons.

This exercise requires, in order to approach as closely as possible real situations, an important framework with very varied stakeholders, coming from very different horizons.

The Subject Area Group of Civil Engineering followed a double policy. As stated, it linked one-to-one modes of learning, teaching and assessment (LTA) to the different sub-dimensions/sub-descriptors. These modes were the outcome of the inventory of the CALOHEE questionnaire on assessment and on desktop research. The selection of modes for each of the sub-descriptors was the result of intense debate and exchange of opinions. The appropriate assessments methods were found by using the model Alignment of Learning Outcomes and Assessment (ALOA) using the webtool Time to Assess Learning Outcomes in E-learning (TALOE) which makes a proposal for each sub-descriptor formulated as a learning outcome statement: http://taloetool.up.pt.

The second policy was to identify examples of 'good practices' focussing on particular (sub)dimensions / (sub-)descriptors in more detail. Included here is one example proposed by Thibaut Skrzypek (École des Ponts ParisTech), member of the subject area group for Civil Engineering. The example of 'good practice' combines the dimension 6'Decision making' and dimension 7 'team-work' and for the second cycle (bachelor) / level 7 EQF. For this dimension the following descriptors were defined:

Decision making
K7_6
Demonstrate critical awareness of the key aspects of professional, ethical and social responsibilities linked to management of work contexts, decision making and judgment formulation in civil engineering subject area.
S7_6
Manage work contexts in civil engineering subject area and within broader or multidisciplinary contexts that may be unpredictable and require new strategic approaches, take decisions and formulate judgments.
C7_6
Identify and justify appropriate and relevant strategic approaches and analyse professional, ethical and social responsibilities linked to the management of work contexts in civil engineering subject area and within broader or multidisciplinary contexts, taking coherent decisions and formulating coherent judgments.

K7_6.1
S7_6.1
Manage work contexts in civil engineering subject area and within broader or multidisciplinary contexts that may be unpredictable and require new strategic approaches, identify, locate, obtain, organize and evaluate information and data, take decisions and formulate judgments.
C7_6.1
Describe and explain key aspects of professional, ethical and social responsibilities linked to management, decision making and judgment formulation of work contexts in civil engineering subject area.
Identify and justify appropriate and relevant strategic approaches to manage work contexts in Civil Engineering subject area and within broader or multidisciplinary contexts, identify and analyse situations involving multiple conflicting professional, ethical and social interests to determine an appropriate course of action, take coherent decisions and formulate coherent judgments also with incomplete or limited information and data.

Teamwork

The ‘example of good practice’ offers a learning and teaching method to develop named. ‘A game to understand challenges in a crisis situation and cooperation between stakeholders’, based on a publication from the “pédagothèque de l’ENPC”: (https://pedagotheque.enpc.fr/2016/11/04/un-jeu-pour- comprendre-les-enjeux-en-situation-de-crise-et-les-ajustements-de-la-cooperation-entre-les-acteurs/).

Through a course given as part of a Specialist Master's degree (“Mastère Spécialisé”) in urban railway engineering in an engineering school, the École Nationale des Ponts et Chaussées (ENPC) on crisis management, a day of crisis management exercise was set up since 2009 in ENPC classrooms.

Actually it presents a real pedagogical interest for the students thanks to a scenario. This is a train derailment at a site located at the entrance to an average city. The freight train carries dangerous materials and derails at an hour of great affluence. The day of crisis is anchored in a one-week course devoted entirely to crisis management, and is the acme of it. This is a derailment of a freight train carrying propane wagons.

This exercise requires, in order to approach as closely as possible a real situation, an important framework with very varied stakeholders, coming from very different horizons.

1. Aim of the exercise

The aim of the exercise is - beyond the application of the theoretical knowledge on railway operations and operational management in disturbed situations - to train students to improve their individual and collective behaviour under stress and face the media pressure. Another objective is to learn the care of travellers and customers during a crisis of great extent (called "Corporate crisis"). For the overwhelming majority of the students who follow the programme, they are engineers, and therefore more familiar with technological responses than with managerial know-how. The "crisis management" module is, in this sense, one of the few dedicated to the human factor. Finally, this exercise illustrates the complexity underlying the problems of the operational management of disturbed situations. It also brings to light the limits of a supposed-deductive approach, usually dominant in higher French academic education.

2. The pedagogical integration of the course

This course takes place at the end of the year, while the majority of the lessons on safety are at the beginning of the year. The first introductory safety course (Walter Schön, UTC professor) includes a course on safety management delivered by Hubert Blanc (EPSF: French institution for railway safety) and several courses on safety definitions and demonstrations.

The Courses Upstream:

1. A first sequence is based on the viewing of an episode of an American series “West Wing” on a major crisis of a nuclear power plant in California where the leak of a reactor occurs. We see the President of the United States and his advisers gathered to deal with the crisis, take decisions to evacuate the population and intervene with nuclear experts, all in a pre-electoral context that gives communication a major weight.

This film allows students to grasp, as the events unfold, the intense temporal succession and the multiplicity of stakeholders. After the viewing of the episode, we ask them to trace the chronology of the events, to identify the decisions, to call them "good or bad", to identify the objectives of the different groups of stakeholders and their respective stakes.

As Salem Brahimi wrote in an article devoted to the crisis in cinema, the series "West Wing sticks to the historical reality of crisis management, magnifies its characters by brilliant dialogues but succeeds in instilling a sense of complexity of the crisis thanks to a character who constantly reminds us that nothing is ever clear in the crisis ... " And it is of course a destabilizing situation for students that they will live in a quasi-real situation during the crisis exercise!

2. Catherine Piednoël, specialized journalist, teaches crisis communication. She teaches students how to build a press release, make situation points, prepare language elements and do a breathless interview. It also teaches them the basic rules of communication in crisis management: trust - consideration of victims - empathy - coherence - partnership logic - thanks - surveys, etc. To communicate with action verbs and "zero jargon" and put into practice the flowing rule: short, concise, clear and concrete!

3. Pascale Rieu, in charge of the pole of exercises and experience feedback in the Directorate of Civil Security of the French Ministry of the Interior, presents the provisions of the ORSEC ("Organisation des Secours") plan whose main objective is to prepare in advance an organization solid and roamed to respond urgently to events.

4. One of the educational biases being the comparative approach, a three-hour sequence is devoted to the presentation of the procedures implemented by each company based on their duplicate benchmark by the RATP (Parisian urban transportation company) and the SNCF (French railway national company) provided by Emmanuel Teboul and Pascal Halko.

5. The last sequence relates to the return of experience of the Eurotunnel crisis of 19 December 2009. Several Eurostar found themselves stranded under the tunnel following damage to equipment due to snow with hundreds of passengers on board. The REX puts a focus on the "Disney train" where the difficulties were concentrated (many young children returning from a stay at Disneyland Paris, English travellers and French commercial agents following an English agents strike, proximity of Christmas with lots of suitcases containing gifts that travellers did not want to get rid of, etc.).

The Educational mechanism

The means necessary for these 5 hours of exercise: 3 rooms, maps of the sites (station, agglomeration, region and national), a team of animators. The exercise requires an upstream preparation with a distribution of the different roles to each student according to their profile, skills, etc. Particular attention is paid to the choice of the technical director and the strategic director. Each student wears a badge with his function, his room and knows the telephone numbers of the other actors of the game.

The Equipment

Usually this type of training dedicated to professionals is carried out within the companies which have in their premises the dedicated installations that they use; none of this exists at the École des Ponts, where 3 computing rooms are requisitioned. The computer services department of ENPC gives about 20 telephones and internet access (students are not allowed to use their laptop). All rooms are equipped with large whiteboards and several paperboards.

The Framework

These 5 hours of exercise require considerable supervision. The module manager is an expert in crisis management who has trained many SNCF managers. In the animation room, are simulated more than fifteen actors played by at least 6 animators: a representative of local elected representatives, The Civil Protection Department, a journalist, several speakers from the Operational Centre for Infrastructure, train drivers, the customer relation department of the Dijon station, the SNCF Presidency, the Minister of Transportation, etc.

The organization of the exercise revolves around the relationships between three groups of actors divided into three rooms, which communicate between them only by telephone or by means of an intermediary (fax, email, tweet, etc.):

1. Technical crisis room with the technical director and all the activities (regional trains, Freight, train circulation and maintenance, and the meeting secretary).

2. Strategic room (also known as communication room or corporate room) with the crisis manager - responsible for security and safety - institutional relations, communication - responsible for communication etc.

3. Animation room with the teacher and the animators. The crisis leader who is the local incident leader is next to the public security representative.

The Scenario

1. A freight train of 17 Total cars carrying propane gas derailed at Dijon station at 9:47.
2. The Local Incident Correspondent (CIL) is promptly notified by the Exercise Director that there is a serious incident but no more information and that he must go to the site (in the animation room). More than a dozen trains are impacted. The director of the technical room is also informed of the incident by the COGC (operational centre for circulation management) of Dijon.
3. The students (except CIL) are distributed in the other 2 rooms. From this moment on, a series of information is sent to the CIL or to the Operational Centre by the facilitators, who play alternatively the drivers of the stopped trains, the traffic operations centre, etc.
4. At 11:40 a gas leak is detected in one of the damaged tank wagons. It is at this point that the organization switches with the setting up by the firemen of a perimeter of safety ... No train no longer circulates, trams are stopped ... The Plan Orsec (rescue organisation) is triggered soon after by the Prefect who takes the direction of rescue operations. The Prime Minister travels with the regional prefect...
5. The exercise ends after a press conference - 5 hours after the start. A one-hour debriefing session ends the day.

This exercise brings students to three points of operational exploitation:
The first is information management since facilitators literally drown students under phone calls or written information. As the two rooms can only communicate with each other over the telephone, an imbalance is rapidly established between the crisis room, which has a crucial need for concrete information to inform and communicate. And the technical room alone in contact with the place of the accident - too busy to manage the avalanche of information received by the animation room and the multitude of operational decisions to be taken in a very short time (to evaluate the risk of explosion, to identify impacted trains, stop (or not) traffic, evacuate travellers, find alternative buses, transportation plan to set up, etc.). In addition, the students were instructed to make situations points to maintain

control over the exercise and to work collectively. The two rooms can become so fierce that sometimes the exercise had to be suspended for a moment.

The second apprenticeship concerns the care of travellers, with very varied expectations. For example, taking over an 88-year-old man who broke his collarbone at the Beaune station; Of a pregnant woman of 8 months and a half in an arrested regional train ... The director of the mayor's office is worried about several classes of children on school trip, and awaited by their parents, etc. In the second part of the exercise, travellers descend onto the lanes.

The third apprenticeship is the construction of a transport plan (for D + 1) in particular for Burgundy regional trains because many travellers are students who pass baccalaureate examinations. In some years, students too concentrated on the emptying of gas tanks or the search for lifting gear or replacement coaches, either fail to do so or fail to adopt a constructive common position.

Main lessons

Some quotes from post-exercise debriefing sessions of the 2016 and 2014 class.
• "CIL (local incident correspondent) is very lonely on the ground. In addition, he receives injunctions all the time; they make very violent remarks. He gets screwed! ".

• "The fact that there is no relationship between the technical room and the Com room is very disturbing. So it was really difficult to build a common strategy».

• "I had no comprehensive and clear information on the position of all the trains and yet I had to make decisions to establish a transport plan".

• "During the exercise of the crisis, one learns more about oneself than during tens of hours of course"
• "At first the crisis is manageable but very quickly we lose ground - it is a real job of resistance to stress".

• "We did not have directories up to date, some phone numbers were wrong!".

• "I remember that it is always necessary to have a paper and a pen to take notes including on site".

What Do the Students Learn about the Professional Aspects of the Crisis?

1. In decision-making, there is no "absolute rationality" in a crisis situation. A crisis manager who takes his responsibilities and who often has to decide with his team between two bad solutions based on piecemeal information is needed. He musts weigh the risks, reflects, implements the decision and its consequences (the "So what"). It is not enough to apply standards or norms. You also need to know how to make a decision and apply it once it's taken, and sometimes it's harder than to make the decision; changing transportation plans during a crisis can be catastrophic, especially for travellers. But you must always have 2 scenarios - work on both plan A and plan B - and work on the 2 concomitantly (example of the diesel locomotive expected to do the lift during the derailment that breaks down).

2. Uncertainty: In crisis, we never have exhaustive information about the situation; Uncertainty and lack of information must be managed. Students are taught, for example, to tell journalists even if it is difficult - that "we do not have the information".

3. The posture of questioning is vital. It is necessary to constantly reformulate the raw information transmitted by the site in particular. In crisis, there is a distortion of information; Hence the necessity of always recalculating the facts and having the interlocutor to repeat the information given by telephone in particular.

4. Anticipation. One of the biggest difficulties in crisis management is time management. "Crisis management means taking precedence over events". We go into crisis management mode when we decide to take charge of the events: it is not when we are in panic: We must not let ourselves be driven by events. Crisis management; It is also knowing how to anticipate and keep one's common sense. This is especially true for the media, there is a need to communicate quickly and take the lead on the media: the first tweets in the exercise are launched 10 minutes after the incident.

5. A rigorous school: in crisis management, it is necessary to establish an exact chronology of the facts and to learn to hold a "handrail" to share the information between the different stakeholders. It is a new exercise for students.

6. The primacy of organizational robustness over technology. There is no "deus ex machina" that can take charge of a complex crisis situation. Technology, especially with new media, remains a tool for decision- making. SNCF and RATP developed robust transport plans in limited numbers that all the players (from the crisis manager to the local agents) know perfectly.

7. Pressure and stress. Human limits are reached very quickly; it is unthinkable to handle two crises at the same time. Often, during a crisis, there are clashes; the crisis is often violent! The crisis, as Salem Brahami writes, "is first of all a train of emotions".

8. Some crisis communication rules: never lie when you give information to travellers, do not discard, never justify yourself.

9. The complexity of the stakeholders' game: the objectives diverge, are not reconcilable; It is necessary to reconcile different interests: national interest vs the interest of the regions (Burgundy); Those of the Infrastructure Manager (restoring the tracks to resume circulations) and those of the Railway Company (taking care of passengers). As an illustration, a facilitator playing the role of the train conductor refuses to extend his service and exercises his right of withdrawal even if several hundred passengers are blocked.

Teaching feedback

Teachers know that game is one of the most effective methods of learning; and this applies to safety learning in a crisis situation. Thanks to a simulation, this day presents a real pedagogical interest; it asks for behavioural know-how, particularly in terms of communication, decision-making and coordination. 1.Referring to an article by the CEFES of the University of Montreal: the exercise of crisis as practiced at the Ecole des Ponts is clearly a simulation and not a simple role play.

Simulation is defined as "a reproduction of a situation that constitutes a simplified but correct model of a reality" (Chamberland, Lavoie and Marquis 2000, p.81). This

pedagogical method aims to recreate a situation representing the reality in an objective way and to which the student could be confronted. .... In a simulation, the student plays his own role by projecting himself into a realistic professional situation, while in a role-playing game he plays a role or a character. The exercise was designed to be as close as possible to a real situation. The scenario is quite plausible. The exercise is starting at 10 am and ending at 3 pm; there is no lunch break and the students are not warned. They do not know the place or the incident before the beginning of the exercise.
This pedagogical practice is time-consuming and requires a consistent teaching team as described - and therefore financial means (this course is the most expensive of the programme except the study trip) - "The time available represents an important challenge. In most cases, the teacher covers the three phases (preparation, delivery and activity feedback) during the same session. This choice limits the number of objectives and requires good coaching. "

Philippe Meirieu correctly points out that "when students are made to work as a group," we encounter a pitfall which is the division of labour ... The students divide the work between the missions of designers, performers, Unemployed, and do not learn much ".

In the crisis management exercise, by allocating roles upstream of the exercise (and in an authoritarian way) by the pedagogical managers and by the strong obligation of collective production, no student is in a situation of unemployed "underground passenger". The counterparty, however, is that the group of students cannot exceed twenty.

Finally, one of the basic pedagogical option of this exercise is the belief that students will learn more in a destabilizing posture: destabilization of the posture of students who practice the lessons of their teachers but also Destabilization in relation to their posture of engineer (confirmed or future) who apply after the analysis of a given problem, procedures, corrective actions conforming to referential or other normative system.

During the exercise, the students do not implement the actions described in the repositories, whether SNCF, RATP or Plan Orsec (presented at the beginning of the module): they must "invent" and not apply ... It demands Adaptability to an unprecedented situation (definition of the crisis par excellence), "getting wet" and taking collective decisions in a stressful situation.

6. OUTPUTS

Given the research undertaken it is proposed that each university with a Civil Engineering program to adopt a set of learning outcomes/competences required for the Civil Engineering professionals. It may be the existing CALOHEE or the EUR-ACE standards or the International Engineering Alliance attributes or any other recognised by society in general and by professional organizations, by companies and by accreditation agencies. According to the choice made the Civil Engineering program outcomes should comply with the adopted framework.

Most programs of Civil Engineering (Bachelor or Master) do not comply with the CALOHEE indicators. Most do not enough any type of references to the Civic, Social and Cultural Engagement descriptors. Concerning the qualification framework of CALOHEE some examples of missing exact compliance are related with the wording presented and described in the programs descriptions. To be noted the general similarity in terms of intended learning outcomes of all the programs analysed either for level 6 (bachelor) or level 7 (master). Nevertheless it seems impossible to obtain a common training framework due to the words used and the concepts addressed by each institution. Comparability is possible with the evaluation of the intended learning outcomes using the CALOHEE as terms of reference.

Following step to address proper management of engineering students assessment should be to define assessment methods for each of the learning outcomes of the Civil Engineering program. Choice of assessment method is generally a personal prerogative without preliminary verification by any colleague or academic body. Therefore either clear rules within each institution about how to conduct proper assessment of students. Continuing Professional Development (CPD) training should be mandatory and periodic for teachers of Civil Engineering.

Considering past and recent research the use of machine learning to assess students should also be considered to clarify the procedures in global terms without individualising by each teacher the assessment for each competence. Another conclusion from the this study is that choice of assessment is controversial among the academics. Following a Chinese proverb "You find 1000 teachers and you will find 1000 different ways of assessing". It is recommended that either there is an institutional body to evaluate a priori the appropriateness of each proposed assessment or there is proper teacher training to administer assessment or if there are transparent and effective rules to design the assessment methods.

It should be taken into account that education assessment of Civil Engineering students learning is an ongoing and evolutionary process. New and updated forms of assessment are needed to keep in line with society requirements and with the development of digital tools available for academic and administrative staff and for students. Validity, reliability and standards are aspects that should be a constant concern for academics and for students. The digital context may allow for more appropriate, more fair, more authentic and more acessible modes for assessing Civil Engineering students achievements in terms of competences.

Finally, the assessment should consider that "one size does not all" either in terms of the diversity of learning outcomes or related with the learning styles of each student. Therefore a diversity of assessment methods should be considered for each learning outcome in Engineering programs. Also it should be considered that a student is not number and is a person. Assess derives from Latin "assidere" that means to "sit with". It is probably the best assessment choice if teachers could sit with each student and verify individually the learning. Digital tools will certainly help this individualisation of assessment either through e-portfolios or though verification of evidences of learning in an automatic way like machine learning algorithms.

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