Tuning CALOHEE

# Transnational Comparative Assessments in European Higher Education

# CIVIL ENGINEERING

## Measuring and Comparing Achievements of Learning Outcomes in Higher Education in Europe

2023

# Measuring and Comparing Achievements of Learning Outcomes in Higher Education in Europe CALOHEE Phase 2

The CALOHEE Phase 2 Project has been supported by the European Commission through the Erasmus+ Programme, Action Forward Looking Projects, 2020-2023. Project number: 2019-612892



**Tuning Educational Structures in the World**

The name TUNING was chosen for higher education projects and initiatives to reflect the idea that universities do not look for uniformity in their degree programmes or any sort of unified, prescriptive or definitive curricula but simply for points of reference, convergence and common understanding. The protection of the rich diversity of higher education in Europe and the world has been paramount in the Tuning initiative from its start in 2001 and in no way seeks to restrict the independence of academic and subject specialists, or undermine local and national academic authority.

Co-funded by the European Union

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Education and Culture Executive Agency (EACEA). Neither the European Union nor EACEA can be held responsible for them.

Publisher: International Tuning Academy, Universities of Deusto and Groningen
Bilbao and Groningen, 2023

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# Table of Contents

# Introduction

The context of higher education has been changing during the last 25 years, as a result of rapid advances in digitalization and methods of communication, job market disruption, politics and recently COVID-19, disruptive conflicts and inflation. The need for change of higher education learning has become even more imperative. Awareness of these challenges go back to the 1990s and resulted in EU initiatives and the Sorbonne/Bologna Declarations. This led to the call for developing a European Higher Education Area (EHEA).

A cornerstone of developing a EHEA is trust and confidence. The Area was launched in the context of the Bologna Process. This was thought necessary to enhance the quality and relevance of higher education for individual development, employment opportunities, societal needs. Another aspect was and is to have instruments in place to facilitate large scale credit mobility and recognition. Towards this end four key instruments have been developed: the *European Standards and Guidelines for Quality Assurance*, the *European Credit Transfer and Accumulation System* and the *Lisbon Recognition Convention* as well as two parallel and overlapping qualifications frameworks, the *Qualifications Framework for the European Higher Education Area* (QF for the EHEA) and the *European Qualifications Framework for Lifelong Learning* (EQF). The first defined in the context of the Bologna Process and the second initiated by the European Commission. Both have been endorsed by national authorities.

Qualifications frameworks are the foundations of the other instruments. They offer the reference point for the academic structure (curriculum design and credentials), quality assurance and accreditation as well as recognition of (period of) studies. Qualifications Frameworks encompass all three cycles of higher education learning.

In parallel, two major initiatives were taken, namely, the development of the QAA-UK Benchmark papers and the *Tuning Guidelines and Reference points* at subject area (discipline) level. These proved to be pivotal for giving substance to develop and enhance degrees and to move from expert driven education toward student-centred and active learning. Both initiatives were developed by groups of academics, however, many academics have found it difficult to deal with this fundamental change of the learning paradigm. Lack of initial training and continuing professional development have continued to hinder large scale change. This has been exacerbated by the over-complex structures in place. That is having two European overarching frameworks and subject ones which are not fully aligned. This might have drained away full adoption of the instruments available.

To respond to this concern, a proposal has been made by the Tuning initiative, called *Measuring and Comparing Achievements of Learning Outcomes in Europe* (CALOHEE), to make a deep analysis of the strength and weaknesses of the existing models. This has resulted in *General Tuning-CALOHEE Qualifications Reference Frameworks* for all three cycles, as well as aligned reference frameworks on the level of subject areas. An important driver for developing these frameworks has been to make the implicit explicit.

These much more detailed frameworks, building on the existing ones, offer the opportunity to encompass present and future challenges. In addition, ten subject areas have been, and are, developing Subject Area Learning Outcomes Reference Frameworks. These offer a template and menu as to what can be learned in the context of a degree programme.

This resulting set of reference frameworks will reduce complexity, offer greater clarity and guidance for programme design, delivery and quality assurance.

However, qualifications reference frameworks are only part of process of change. As fundamental and as a consequence of the change of the paradigm of learning, is revisiting the way learning, teaching and assessment is designed and undertaken. This has been done too in the context of the CALOHEE initiative, supported by the European Commission.

## Preparing international comparative assessments

Mutual recognition and mobility go hand in hand and therefore need evidence of comparability of learning and teaching, but in particular assessment, which should obviously be aligned.

Although General Qualifications Reference Frameworks, Subject Area Qualifications Frameworks and related Subject Area Learning Outcomes / Assessment Reference Frameworks offer clarity regarding the levels of learning, they do not offer the evidence whether the related learning is actually achieved. To achieve the latter some form of assessment must take place, primarily to assure that across the spectrum of countries and institutions comparable learning in terms of its outcomes is taking place.

On the level of achievement, it is possible to make a distinction between the individual learner, the subject, the programme, the HE institution and the country (system level). The aim of the CALOHEE project has been to develop diagnostic international comparative assessments for five disciplinary fields, that is civil engineering, history, nursing, physics and teacher education.

These assessments provide a diagnostic tool to allow for a comparison to be made regarding the level of achievements of the different descriptors as included in the frameworks. The focus is here on the degree programmes in the context of the subject area. The results of the exercise will provide valuable evidence-based information for academic staff responsible for delivering the programme to allow for further enhancement.

The discussions among international groups of subject area experts show us that disciplines have their own requirements. There are obviously specific contextual settings, cultural and national conditions. For example, the field of history only allows for a high level of abstraction, whereas nursing, civil engineering and teacher education are usually regulated professions with all that that entails.

Assessment of students is perceived as a highly sensitive issue and the prime responsibility of the academic when the programme is purely theoretical. However, in professional and regulated programmes assessment of performance, the responsibility is shared with responsible professionals. Similarly, while academics are responsible for implementing a programme, they are required to involve relevant stakeholders. This requires coordination regarding programme design, delivery, evaluation and student-assessment and grading. This may influence academic freedom for regulated professions. Although all programmes will have their own profile, there should be common standards meeting international reference points. This approach intends to do justice to the EU motto, introduced in 2000, 'unity in diversity' which is clearly not standardisation.

In this context, the relation should be highlighted between the graduate profile and the learning outcomes of an individual programme and its units. This reflects the different missions of institutions and programmes, covering the full spectrum from research driven programmes to applied ones. This can be visualised in a spider web in which individual degree profiles, programme and unit learning outcomes are matched with the CALOHEE subject area qualifications refence frameworks for all three cycles, representing the graduate profile. These spiderwebs show varieties, which are both system and programme related.

Regarding the system level, although pursuing the EHEA, it has to be fully understood that we are dealing with national states which historically have their own educational philosophies, cultures and traditions. Regarding general philosophies we can make a distinction between the Anglo-Saxon, Humboldtian, Napoleonic and Soviet models. These traditions are deeply rooted and have an ongoing impact on the way learning, teaching and assessments is constituted, although convergence is taking place. This convergence – implying international alignment at subject area / disciplinary level - is commended by global societal developments and needs, to which the higher education sector and its degree programmes are expected to respond.

At programme level, countries might still define conditions which have to be met and/or set limits regarding the autonomy of the professional. This has implications for the (transnational) assessments to design.

As a consequence, in valid transnational comparative assessment both communalities and differences should be taken into account, as they have been detailed above. In this setting, lessons have been learned from the OECD *Assessment of Higher Education Learning Outcomes* (AHELO) feasibility study, implemented in the period 2010-2013, which obtained severe criticism from policy makers as well as academics, because it did insufficiently recognise the wide range of system and programme differentiations.

The disciplinary experts, involved in this CALOHEE project, are fully aware of the diversity in the way learning, teaching and assessment is modelled, although at the same time agreeing on the descriptors as defined in their subject area qualifications reference frameworks and far more detailed learning outcomes / assessment reference frameworks. Finding common ground - doing justice to the differences - has taken considerable time, but proved to be conditional for developing useful (transnational) assessments.

Departing from the objectives of the Bologna Process and the EHEA that programmes should be outcome based, the assessments developed, intend to cover high level generic and subject specific competences, that is applying knowledge and skills in real life situations – work place and society – requiring ‘autonomy’ and ‘authority’. Authority reflecting self-confidence to take position and act accordingly. In other words, the assessments should allow for evidencing a critical mindset in the context of a particular academic field by focussing on ‘measuring’ high level skills and competences in the context of the subject area and its domain of knowledge, such as critical thinking, analyzing and synthesizing, making and criticizing an argument, problem solving, observing and analyzing behavior, operating in conjunction with others. All perceived from two angles: the academic field involved and active societal participation. Relating to present and future needs of society, a much wider scope and approach than ‘disciplinary knowledge and skills’ and ‘critical thinking’ as had been tested in the global OECD-AHELO feasibility study.

This requires taking into account ‘burning societal issues’, for which in the context of the CALOHEE projects separate initial reference qualifications frameworks were prepared, meant to serve as sources of information and inspiration. Based on academic literature and policy documents, it identified five current topical issues, that is:

- Societies and Cultures: Interculturalism
- Processes of information and communication
- Processes of governance and decision making
- Ethics, norms, values and professional standards
- Sustainable development (climate change)

These topical issues should be integrated in the actual learning, teaching and assessment processes doing justice to the academic field involved and avoiding overload of learning.

From the start of the CALOHEE project to develop transnational assessments and testing, the aim has been mutual. The outcomes should allow for real testing to be applicable in different contexts, ranging from an individual HE education programme to transnational testing. Intended to be inspirational – offering new models of assessment – they should also be aspirational by covering topical issues.

As has been indicated already a distinction is made between the development of models of assessment and actual assessments and testing. Testing is defined here as the application of the assessments prepared, by asking groups of students to take a test. According to the project aim, actual testing was not foreseen in this phase. This project focussed instead on preparing the groundwork for testing whether of theory or in the workplace where this is relevant to the student programme.

In the context of the CALOHEE Phase 2 project assessment models and assessments have been prepared for the following five subject areas: Civil Engineering, History, Nursing, Physics and Teacher Education, nearly covering the full range of academic fields.

The assessments have been developed to measure the achievements of generic and subject specific competences at the end of the bachelor / first cycle.

## Structure of the assessments

The five subject area groups have followed a comparable model and approach to implement their tasks. Due to the COVID-19 pandemic initially the meetings took place online. Because more fundamental discussions were needed to define common ground requiring deep intensive reflection over a longer time span, only limited results could be obtained. Three multi day face-to-face meetings were needed to come up with actual results. These meetings took place in the period April – September 2022 and were supported by an additional set of online meetings.

A first step has been to match individual degree programmes with the subject area qualifications reference framework published in 2018. A follow-up has been to re-visit their academic field making use of the 2018 edition of the brochure *Tuning Guidelines and*

*Reference Points for the Design and Delivery of Degree Programmes* for their subject area. This proved to be a learning process in itself, developing partly new insights requiring accommodations of the materials prepared earlier.

The third step was to identify the (sub) descriptors included in the qualifications reference framework and learning outcomes / assessment reference framework, best suitable for developing transnational assessments, but also key to the subject area. This again required fundamental and deep reflections. The next step was to identify the most appropriate mode(s) of assessment and to decide on its feasibility. Independently of the mode of teaching and learning - class room, online, hybrid - different assessment formats were suggested to apply, e.g. scenario testing, observation, critically responding to arguments / texts, analyzing a problem and coming up with possible solutions, etc. This to be followed by describing / documenting the overview of items and approaches (independent of existing individual degree programmes) and the choices made. In practice, to:

- identify for each of these items the modalities for assessment: learning/teaching required, the best ways of assessment and the criteria for assessment.
- document the rational for selecting a particular competence; describe the actual test
- constitute a set of assessments reflecting a key part of the descriptors as included in the qualifications reference framework. The result should be a variety of assessment formats for the competences identified.

The outcomes of the work established by the five subject area groups are presented in separate publications for each of the five subject areas involved in the CALOHEE Phase 2 project: Civil Engineering, History, Nursing, Physics and Teacher Education. The reports of these five disciplinary groups follow a comparable format, but each group has taken the freedom to make its own choices in presenting its findings in doing justice to the process of reflection and discussion. This brochure presents the work established by the Subject Area Group of Civil Engineering, coordinated by prof. Alfredo Soeiro, University of Porto, Portugal and prof. Ken Thomas, South East Technological University, Ireland.

CALOHEE Project Team
Groningen, 2023

# 0. The Tuning–CALOHE2 Civil Engineering Subject Area Group (2020-2022)

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# 1. Introduction to the subject area of Civil Engineering

## 1.1 Overview

Engineering has classically been defined as the profession that deals with the application of mathematical, scientific and technical knowledge in order to use natural laws and physical resources to help design and implement materials, structures, machines, devices, systems and processes that safely accomplish a desired objective. As such, engineering is the interface between mathematical and scientific knowledge and human society.

The primary activity of engineers is to conceive, design, implement, and operate innovative solutions – apparatus, process, and systems – to improve the quality of life, address social needs or problems, and improve the competitiveness and commercial success of society.

The original formal use of the term engineer applied to the constructor of military engines such as catapults. Later, as the design of civilian structures such as buildings and bridges evolved as a technical discipline, the term civil engineering entered the lexicon as a way to distinguish between those specialising in the construction of such non-military projects and those involved in the older discipline of military engineering. As technology advanced, other specialty fields such as mechanical, chemical, electrical and electronic engineering emerged.

In recent years, branches such as biological engineering, food engineering, environmental engineering, and even financial engineering have been added to the specialisations. Interestingly, as these new branches were emerging, the complex future challenges are demanding more interdisciplinary knowledge of all engineers hence breaking down the barriers between different areas of engineering.

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.

## 1.2 Education and Professional Context: complexity of the field

Engineering education basically deals with the transfer or theoretically knowledge to engineering applications.

With engineers facing challenging expectations, including the ability to address complex societal problems, engineering education must be carefully planned and executed so that the student obtains the necessary competencies to be a successful professional engineer.

This education must include a strong grounding in mathematics and basic science, as well as training in the specialty-specific engineering sciences. Curriculum developments are a delicate balance between keeping up the necessary 'fundamentals', represented by mathematics, basic sciences and core engineering subjects, and their application in engineering design projects and products.

Design problems are increasingly complex and comprise input and assessment over a broad range of fields, combined to product an 'optimal' solution that will be acceptable for all parties involved.

The complexity of modern challenges facing engineers also requires that the education include sound foundation in topics such as economics, communications, team skills, and the current global geo-political environment.

Technical developments and the growing complexity of activities have generated strong pressure on the number of subjects to be given in civil engineering programmes and on the volume/content in each of their components. This has encouraged an increased focus on the concept of lifelong learning in education. It becomes imperative 'to learn how to learn', the 'need to know' is being replaced by the 'need to know where to find'.

Furthermore, engineering has a direct and vital impact on people's quality of life. Accordingly, the services provided by engineers require honesty, impartiality, fairness and equity. Engineers must be dedicated in particular to the protection of public health, safety and welfare. They must uphold a standard of professional behaviour, adhering to the highest principles of ethical conduct.

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 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 toprepare 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.

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;
c) 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, cannot 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 by questionnaire 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.

## 1.3 The Future Graduate – Degree, Masters, Doctorate

Graduates with a degree in one of the engineering fields may enter in many different types of organisations. There are also many graduates of engineering programmes who choose to enter fields such as financial services, sales, or non-engineering management where their engineering skills can help them in their success.

In some cases, graduates choose to form new companies or go into their own private consulting practice. While their technical preparation may be valuable in this case, the graduates' skills in other professional areas may be equally important.

The investigation by questionnaire carried out in the framework of the CALOHEE project has shown that the type of sectors where civil engineering graduates find employment are Private Enterprise, Government (including departments, statutory authorities and government owned businesses), Local Government and Public Company.

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.

Furthermore, due to the civil and criminal responsibility of civil engineering activities, the profession of civil engineer 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.

Employment sectors of engineering graduates are mainly Engineering manufacturing and production, Property and construction, Energy and utilities, Environment and agriculture, Government and public administration, Business and management, Banking finance and insurance, Further or higher education or research, but also Charities and voluntary work, IT information services and telecommunication, Physical resources (mining, quarrying, oil, gas, …) and Armed forces and emergency services, Creative arts and culture, Hospitality and social care, Media and publishing, Retail and sales.

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 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 CALOHEE 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.

For Doctoral graduates the tasks expected are related with specialization in topics of relevant research. Most graduates get involved in academic or research life working in areas of research and teaching. This happens in universities and in higher education institutions and in research in Civil Engineering. The competences of programs comply with the European Qualification Framework. In terms of knowledge, it is expected to be at the most advanced frontier of Civil Engineering. Considering skills, it is expected that graduates have the most advanced and specialised skills and techniques, including synthesis and evaluation, required to solve critical problems in research and/or innovation and to extend and redefine existing knowledge or professional practice in Civil Engineering. In terms of autonomy and responsibility (attitudes) graduates should demonstrate substantial authority, innovation, autonomy, scholarly and professional integrity and sustained commitment to the development of new ideas or processes at the forefront of Civil Engineering.

# 2. Assessments – Definitions and Options

## 2.1 Models of assessment identified

There have been initiatives to find proper assessment methods for the different types of LOs. The more recent is the TALOE project (http://taloe.up.pt), which has delivered a web-tool that advises about proper methods of assessment aligned with the different types of LOs to be verified. The tool is applicable to all areas of knowledge as long as there is a definition of LOs. The web-tool was the implementation made of the ALOA model that is based on the revised Bloom's taxonomy and on the work of alignment of Anderson et al. The ALOA model was developed for engineering courses and the web-tool was afterwards extended to all fields of knowledge.

Discussion among the members of the SAG t evidenced 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 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.

LOs, 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 'successes of the education experiences.

## 2.2 Testing and Assessment

### 2.2.1 University of Montpellier

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 masters 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 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.

# CIVIL ENGINEERING

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 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)

### 2.2.2. SETU

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 assessments 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 cases 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).

### 2.2.3. UNISA

EQF Level 6: Degree in Civil Engineering

3 years/6 semesters 180 ECTS

29 modules ranging from 3 to 12 ECTS, mainly ‘Mandatory’ with limited ‘Electives’

Vast majority of Assessment Methods are Summative (End-of-term or midterm exams)

27 ‘Traditional’ Exams – typically 2 hours written paper held on campus + 1 hour interview

Mostly include or are integrated by Projects, Reports, Presentations, Practicals, Fieldwork and Dissertation

Since about 85% of 1st level graduates continue their education by enrolling in a master´s degree program, it is quite difficult to obtain meaningful feedback from the world of work. An increase in formative assessments is currently under study, especially in basic subjects (mathematics, physics, ...)

Among the key modules on the programme are:

Order of the Engineer Training (OET) in Year 3 (3 ECTS - students typically do an internship in public and private offices, with a range of assessments, including employer input).

Dissertation in Year 3 (3 ECTS with a variety of summative assessments, including individual Presentations, Reports and final Dissertation)

EQF Level 7: Master´s degree in Civil Engineering

2 year/4 semesters 120 ECTS

18 modules, ranging from 3 to 12 ECTS, mixed between 'Mandatory' and 'Electives'

Vast majority of Assessment Methods are Summative (End-of-term or midterm exams)

16 "Traditional" exams - typically an interview with a discussion of the project

Since most of the modules in this program are design-based classes, the assessment methodologies can be more flexible. As an example, a peer review-like assessment model is shown: the student must demonstrate the achievement of a series of Learning Objectives by writing a paper in the form of a scientific article and the teacher evaluates it through the criteria of the scientific peer review.

Some examples are among the key modules on the programme are:

Order of the Engineer Training (OET) in Year 2 (6 ECTS - students typically do an internship in public and private offices, with a range of assessments, including employer input).

Dissertation in Year 2 (9 ECTS with a variety of summative assessments, including individual Presentations, Reports, mostly related to the internship activity, and final Dissertation)

### 2.2.4. UP

EQF Level 6: Licenciatura em Engenharia Civil (Licentiate in Civil Engineering)

3 years/6 semesters full-time 180 credits ECTS.

33 modules ranging from 1,5 to 7,5 credits ECTS, mostly with 6 credits.

There are Electives courses during 3 rd year.

Mix of Assessment Methods, majority are mixed with formative and summative assessments,

some are summative and some are formative.

Written and Midterms Exams – typically 2 hours held on campus.

Other assessments include Projects, Reports, Group work, Presentations and Midterms.

There are two modules addressing transversal skills with 1,5 credits ECTS each and one module consisting of group work about a project in Engineering in the first semester worth 1,5 credits ECTS.

There is a requirement that there is at least one module per semester without final exam.

The choice of formative and summative assessments are decided by the leading teacher and approved by the academic dean. All assessment methods are in the group of traditional assessment methods. Information about evaluation in each module are presented in the respective webpage.

There are six credits allotted to a module in the last semester called "Projecto Integrador – Capstone Project". It is a multidisciplinary project involving professional components. In the third-year students can choose two elective modules of six credits ECTS from seven scientific areas.

EQF Level 7: Mestrado em Engenharia Civill (Master in Civil Engineering)

Two years/four semesters full-time 120 credits ECTS.

15 modules, with six credits ECTS each, in a total of nine credits ECTS plus a dissertation in the las t semester with thirty credits ECTS.

Program has a mixture of assessment methods, formative and summative.

Final exams, reports, midterm exams, home works and oral presentations are distributed almost equally in the 15 modules.

Evaluation of each dissertation module is made by a jury of three teachers (president, external member and supervisor) during one hour and in a public event.

The fifteen modules of each specialization are available for a specialization certificate in each of the four scientific areas.

This programme was created provide competences in each of the four scientific areas. The assessment has remained traditional with some modules having use of personal and individualized evaluation. One of these is based on the e-portfolio evaluation and another is the individual formative assessment based on case study analysis. Most students are full time participants and options are also prepared for students that work and are part time students. There is flexibility in the assessments translated into a wider choice of options and into all modules having at least two opportunities for students to show evidences of the competences acquired. Some dissertations are developed with companies allowing the students to work in a professional setting and with participation of the companies tutors in an informal evaluation of competences acquired.

## 2.3 Updated Framework and Topical Issues

Amendments to the Reference Framework linked to the 5 topics:

**Ethics** (orange) **Sustainability** (blue) **Information & Communication** (green)

**Governance & Decision Making** (yellow) **Intercultural** (purple)

**TUNING Qualifications Reference Framework (Meta-Profile) of General Descriptors of a Bachelor Programme in the Subject Area of CIVIL ENGINEERING (LEVEL 6)**

| QF EHEA<br>1st cycle descriptors | SQF domain dimensions<br>Level 6<br>(BACHELOR) | EQF descriptor Knowledge<br>Level 6<br>*Advanced knowledge of a field of work or study, involving a critical understanding of theories and principles* | EQF descriptor Skills<br>Level 6<br>*Advanced skills, demonstrating mastery and innovation, required to solve complex and unpredictable problems in a specialised field of work or study* | EQF descriptor Autonomy and Responsibility (Wider Competences)<br>Level 6<br>*- Manage complex technical or professional activities or projects, taking responsibility for decision-making in unpredictable work or study contexts*<br>*- Take responsibility for managing professional development of individuals and groups* |
|---|---|---|---|---|
| **Special feature degree programme** | | Demonstrate knowledge and understanding of the disciplinary, professional, personal and interpersonal requirements necessary to solve / design / investigate / conduct complex civil engineering problems / products, processes and systems / issues / activities. | Apply knowledge and understanding to solve / design / investigate / conduct complex civil engineering problems / products, processes and systems / issues / activities | Identify appropriate and relevant established method to solve / design / investigate / conduct complex civil engineering problems / products, processes and systems / issues / activities and be aware of professional, ethical and social responsibilities. |
| *I. Have demonstrated knowledge and understanding in a field of study that builds upon their general secondary education, and is typically at a level that, whilst supported by advanced* | **DIMENSION 1. Knowledge and Understanding** | **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.** | **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.** | **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.** |

# CIVIL ENGINEERING

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| *textbooks, includes some aspects that will be informed by knowledge of the forefront of their field of study* | **SUB-DIMENSION 1.1 MATHEMATICS** | Define and describe key factual information and problem-solving processes related to mathematics through differential equations | Solve / design / investigate / conduct civil engineering problems / products, processes and systems / issues / activities using and applying knowledge and understanding of mathematics through differential equations | Identify knowledge and understanding of mathematics necessary to solve / design / investigate / conduct civil engineering problems / products, processes and systems / issues / activities through differential equations |
| | **SUB-DIMENSION 1.2 SCIENCES UNDERLYING CIVIL ENGINEERING SPECIALISATION** | Define and describe key factual information and problem-solving processes related to calculus-based physics and chemistry | 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 | 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 |
| | **SUB-DIMENSION 1.3 ENGINEERING DISCIPLINES UNDERLYING CIVIL ENGINEERING SPECIALISATION** | 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 and significant societal impact context of civil engineering | 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 | 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. |
| *II. Can apply their knowledge and understanding in a manner that indicates a professional approach to their work or vocation, and have competences typically demonstrated through devising and sustaining arguments and solving problems within their field of study* | **DIMENSION 2. ANALYSIS AND PROBLEM SOLVING** | **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, including relevant ethical considerations.** | **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.** | **Identify ethically appropriate and relevant established methods of analysis / solution of complex civil engineering issues (products, processes, systems, situations) / engineering problems.** |
| | **SUB-DIMENSION 2.1 ANALYSIS OF CIVIL ENGINEERING ISSUES** | 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, including relevant ethical considerations, and how analysis methods are applied | Analyse complex civil engineering issues (products, processes, systems, situations) by applying ethically appropriate and relevant established analysis methods and report the results of the analysis process | Identify ethically 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 |

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| | SUB-DIMENSION 2.2 SOLUTION OF CIVIL ENGINEERING PROBLEMS | Define and describe key factual information related to civil engineering problem recognition, applicable processes and established methods of solution and their limitations, including relevant ethical considerations, and how solution methods are applied | Solve complex civil engineering problems by applying ethically appropriate and relevant established solution methods and report the results of the solution process | Identify ethically appropriate and relevant established solution methods of complex civil engineering problems and present recommendations for necessary measures taking requirements and constraints into account |
| | SUB-DIMENSION 2.3 SAFE, SUSTAINABLE AND OF LOW IMPACT SOLUTIONS | 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. Knows that sustainability problems must be tackled by combining different disciplines, knowledge cultures and divergent views to initiate systemic change. | 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. Can synthesise sustainability-related information and data from different disciplines. | 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. Is committed to considering sustainability challenges and opportunities from different angles. |
| | **DIMENSION 3. DESIGN** | **Demonstrate knowledge and understanding of the process and established methods of design in civil engineering subject area and of their limitations, including relevant ethical considerations.** | **Design complex civil engineering products (devices, artefacts, etc.), processes and systems by applying ethically appropriate and relevant established design methods.** | **Identify ethically appropriate and relevant established design methods of complex civil engineering products (devices, artefacts, etc.), processes and systems.** |
| | SUB-DIMENSION 3.1 DESIGN OF CIVIL ENGINEERING PRODUCTS, PROCESSES AND SYSTEMS | 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 ethically and define and describe constraints that affect the process and results of engineering designs | Design complex civil engineering products (devices, artefacts, etc.), processes and systems by applying ethically appropriate and relevant established design methods and report the results of the design process | Identify ethically 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 |

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| | **SUB-DIMENSION 3.2 SAFE, SUSTAINABLE AND OF LOW IMPACT DESIGNS** | 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 | 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 | 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 |
| | **DIMENSION 4. INVESTIGATIONS** | **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.** | **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.** | **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.** |
| | **SUB-DIMENSION 4.1 CODES OF PRACTICE AND SAFETY REGULATIONS** | 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 | 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 | 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 |

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| | **Sub-Dimension 4.2 Consultation of sources of information** | 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.<br>Understand the criteria for assessing the quality, reliability and credibility of sources. | 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.<br>Be able to critically evaluate the quality, credibility, reliability and relevance of information sources and information<br>Identify the context in which specific information was created and disseminated. | Identify appropriate and relevant source of information (literature sources, databases and other<br>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.<br>Reflect critically on different perspectives and context of information judgement. Be capable to responsibly and critically use information coming from diverse sources. |
| | **Sub-Dimension 4.3 Simulations** | 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.<br>Identify the digital tools for/methods for managing information required for or generated as a result of simulations. | Conduct simulations in order to pursue detailed<br>investigations and research of technical issues in civil engineering subject area in order to meet specified needs and report the simulation results.<br>Conduct simulations using the digital tools necessary for achieving required simulation results. | Identify appropriate and relevant simulation methods<br>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.<br>Identify appropriate and relevant simulation tools<br>in civil engineering subject area to conduct the simulations and analyse and interpret the simulation results. |
| | **Sub-Dimension 4.4 Experimental methods** | 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, including relevant ethical considerations, also with respect to other investigation approaches | Provide evidence of laboratory/workshop skills and design and conduct experiments ethically according to established procedures in order to meet specified needs and report the experiment results | Identify ethically appropriate and relevant experiments to be conducted, analyse and interpret the experiment results with respect to the needs to be met and draw conclusions |

# CIVIL ENGINEERING

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| | **Dimension 5. Practice** | **Demonstrate practical knowledge and understanding of materials, equipment and tools, processes and technologies in civil engineering subject area and of their limitations, including relevant ethical considerations** | **Conduct complex engineering activities in civil engineering subject area, using and applying ethically the practical knowledge and understanding of materials, equipment and tools, processes and technologies.** | **Identify practical knowledge and understanding of materials, equipment and tools, processes and technologies necessary to conduct complex engineering activities in civil engineering subject area.** |
| | **Sub-Dimension 5.1 Materials, equipment and tools, technologies and processes** | 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 | 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 | 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 |
| | **Sub-Dimension 5.2 Societal, health and safety, environmental implications and risks** | Define and describe societal, health and safety, environmental implications and risks in conducting complex civil engineering activities | Conduct complex engineering activities in civil engineering subject area having awareness of societal, health and safety, environmental impact and risks | 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 |
| | **Sub-Dimension 5.3 Economic, industrial and managerial implications** | 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 | Conduct complex engineering activities in civil engineering subject area awareness of economic, industrial and managerial implications | Act appropriately, by meeting deliverable, schedule and budget requirements, while fulfilling all legal and regulatory requirements, reflecting on economic, industrial and managerial implications |
| III. *Have the ability to gather and interpret relevant data (usually within their field of study) to inform judgements that include reflection on relevant social, scientific or ethical issues* | **Dimension 6. Decision making** | **Demonstrate awareness of the key aspects of professional, ethical and social responsibilities linked to management of civil engineering activities, decision making and judgment formulation.** | **Manage work contexts in civil engineering subject area, take decisions and formulate judgments.** | **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.** |

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| | **SUB-DIMENSION 6.1 MANAGING COMPLEX WORK CONTEXTS, TAKING DECISIONS AND FORMULATING JUDGMENTS** | 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 | Manage work contexts in civil engineering subject area, gather and interpret information and data, take decisions and formulate judgments | Identify ethically 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 |
| *IV. Can communicate information, ideas, problems and solutions to both specialist and non-specialist audiences* | **DIMENSION 7. TEAM-WORKING** | **Demonstrate knowledge and understanding of functioning methods of teams that may be composed of different disciplines and levels.** | **Function effectively and ethically 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.** | **Identify appropriate functioning methods and relevant management strategies of teams that may be composed of different disciplines and levels and elements of successful teamwork.** |
| | **SUB-DIMENSION 7.1 TEAM FUNCTIONING** | Define and describe key characteristics and functioning methods of effective teams that may be composed of different disciplines and levels. Know how to handle cultural diversity in teams. | 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 andbudget requirements. Being able to apply different team management techniques in accordance with different cultural contexts. | Take responsibility for contributing to professional development of individuals and teams in to meet deliverable, schedule and budget requirements. Treat every member team in accordance with respective cultural characteristics. |
| | **DIMENSION 8. COMMUNICATION** | **Demonstrate knowledge and understanding of established communication methods and tools and of their limitations, including relevant ethical considerations.** | **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.** | **Identify appropriate and relevant established communication methods and tools.** |

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| | **SUB-DIMENSION 8.1 COMMUNICATION STRATEGIES, METHODS AND TOOLS** | 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 | 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 | 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 |
| *V. Have developed those learning skills that are necessary for them to continue to undertake further study with a high degree of autonomy* | **DIMENSION 9. LIFELONG LEARNING** | **Demonstrate knowledge and understanding of the learning methods necessary to follow developments in science and technology in civil engineering subject area.** | **Engage in independent lifelong learning and follow developments in science and technology in civil engineering subject area autonomously.** | **Identify ethically appropriate learning methods in independent lifelong learning to follow developments in science and technology in civil engineering subject area.** |
| | **SUB-DIMENSION 9.1 LIFELONG LEARNING STRATEGIES AND METHODS** | **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** | **Engage in independent lifelong learning to follow developments in science and technology in civil engineering subject area autonomously** | **Identify ethically appropriate learning methods in independent lifelong learning to follow developments in science and technology in civil engineering subject area** |

# 3. Exploration Process

## 3.1 Stakeholder Perspectives

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 progressing 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 Framework of Qualifications for European Higher Education Area (QF-EHEA) or of the level 7 of the European Qualifications Framework for Lifelong Learning (QF for LLL) than to the ones of FQ-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 attitudes. 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 that were consulted 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.

## 3.2 SAG Discussions

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.

## Common Assessments for Civil Engineering Reference Framework in an International Context?

| Dimension | Knowledge | Skills | Autonomy & Responsibility |
|---|---|---|---|
| Knowledge and Understanding | | | |
| Analysis and Problem Solving | | | |
| Design | | | |
| Investigations | | | |
| Practice | | | |
| Decision Making | | | |
| Team Working | | | |
| Communication | | | |
| Lifelong Learning | | | |

**How many and which Assessments for CALOHE2?**

| Requirements for each Stakeholder? | Issues and Actions for CALOHE2 Assessments? |
|---|---|
| **Student Perspective**<br>• *Student-Centred*<br>• *Clear Purpose*<br>• *Suitable Digital Format*<br>• *Good Timing and Sequencing*<br>• *Fair* | ➢ Clarify the purpose, rules and expectations for the tests, including: whether Formative (Voluntary?) and/or Summative (Mandatory?); the timing/sequencing in each semester with all other tests; and the potential for 'co-creation'.<br>➢ Clarify also the extent of allowed access to reference materials (Open vs Closed?) and time restrictions; 'live' in a limited time-frame or a longer time–period (e.g. a 2 hour 'exam') or a longer time–period with a given deadline (e.g. a project over 4 weeks)<br>➢ **Ensure easy to access and submit using the appropriate Digital Technologies (online/remote)**<br>➢ Consider different Individual Tests - Bespoke (unique) or General (same for 'all' students in the class group)<br>➢ For Group Tests, explore potential to include some recognition for individual contributions<br>➢ Ensure quick feedback (especially for Formative)<br>➢ Consider Quality vs Quantity (avoid over–assessing?)<br>➢ Explore potential Multi-Purpose Tests (1 submission to address 2+ Competences – e.g. Design and Communication |
| **University, Professional Accreditation and Employer Perspective**<br>• *Authenticity*<br>• *Demonstration of Competences*<br>• *Standards*<br>• *QA Processes* | ➢ Ensure the ID of each student and source/'originality' of their submission (i.e. no plagiarism)<br>➢ **Ensure direct alignment with CALOHE2 Framework Competences (using/developing the TALOE Model)**<br>➢ Consider how best to have objectivity and consistency of the Assessors (human and/or use of automation?)<br>➢ Multi-Purpose Assessment challenge (e.g. different Assessors for different Competences)<br>➢ Consider the actual results to be generated (Graded or Pass/Fail), their use for specific Modules as well as a 'Micro-credential' (e.g. Skills) and how to(potentially) compare across universities<br>➢ Consider the actual/potential role of independent reviews (internal and external) |

# 4. Actual Assessments

## 4.1 Aligning Updated Framework with the model(s) identified

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 (http://taloe.up.pt).

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.

Table 1. ALOA model assessment methods (TALOE).

| **Assessment Methods** | **Sub-categories** |
|---|---|
| **Multiple Choice Questions (MCQ)** | A) Remember<br>B) Understand<br>C) Apply<br>D) Analyse<br>E) Evaluate<br>F) Create |

| | |
|---|---|
| **Essays** | 3.1. Essay – Speculative essay<br>3.2. Essay – Quote to discuss<br>3.3. Essay – Assertion<br>3.4. Essay – Write on<br>3.5. Essay – Describe/Explain<br>3.6. Essay – Discuss<br>3.7. Essay – Compare<br>3.8. Essay – Evaluate<br>3.9. Essay – Problem |
| **Problem solving** | 4.1. Problem solving – Routines<br>4.2. Problem solving – Diagnosis<br>4.3. Problem solving – Strategy<br>4.4. Problem solving – Interpretation<br>4.5. Problem solving – Generation |
| **Practical work** | 5.1. Practical work – Demonstration<br>5.2. Practical work – Exercise<br>5.3. Practical work – Structured enquiry<br>5.4. Practical work – Open ended enquiry<br>5.5. Practical work – Project |

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

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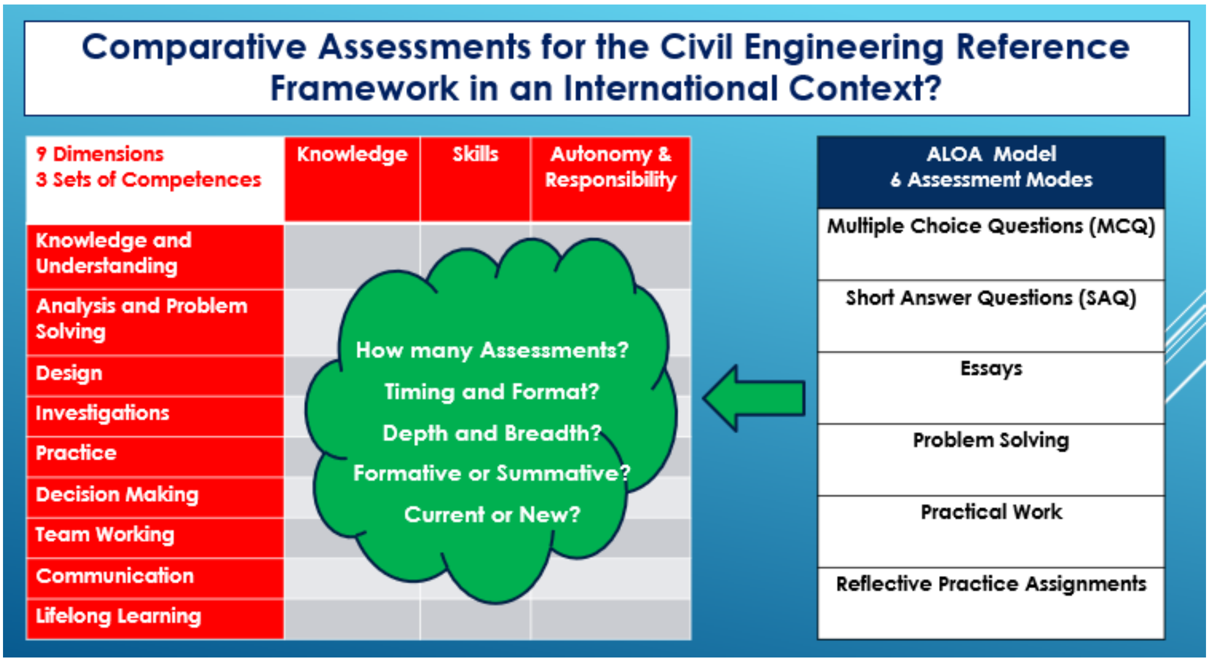


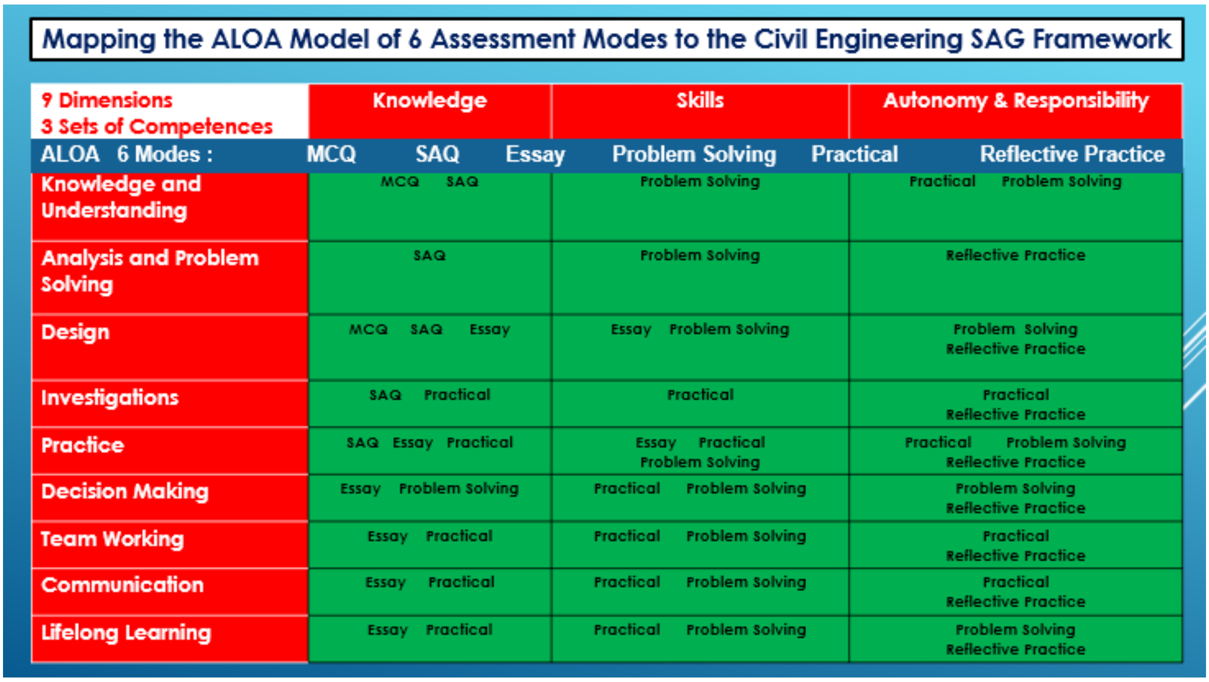

Mapping the ALOA Model of 6 Assessment Modes to the Civil Engineering SAG Framework

| 9 Dimensions<br>3 Sets of Competences | Knowledge | Skills | Autonomy & Responsibility |
|---|---|---|---|
| ALOA 6 Modes : | MCQ SAQ Essay | Problem Solving Practical | Reflective Practice |
| Knowledge and Understanding | MCQ SAQ | Problem Solving | Practical Problem Solving |
| Analysis and Problem Solving | SAQ | Problem Solving | Reflective Practice |
| Design | MCQ SAQ Essay | Essay Problem Solving | Problem Solving<br>Reflective Practice |
| Investigations | SAQ Practical | Practical | Practical<br>Reflective Practice |
| Practice | SAQ Essay Practical | Essay Practical<br>Problem Solving | Practical Problem Solving<br>Reflective Practice |
| Decision Making | Essay Problem Solving | Practical Problem Solving | Problem Solving<br>Reflective Practice |
| Team Working | Essay Practical | Practical Problem Solving | Practical<br>Reflective Practice |
| Communication | Essay Practical | Practical Problem Solving | Practical<br>Reflective Practice |
| Lifelong Learning | Essay Practical | Practical Problem Solving | Problem Solving<br>Reflective Practice |

# CIVIL ENGINEERING

## 4.2 Detailed Examples of Actual Assessments

### 4.2.1. AUT

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, 30 students from various disciplines, who are related to the environment, follow this postgraduate programme.

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 we 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, we 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.

### 4.2.2. UP

Changing assessment for an active learning in an Algebra course

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. The discipline 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 not show a significant improvement in terms of the distribution of final grades, but clearly points out gender as a significant factor behind the variation in grades, with female students exhibiting a modest increase in final grades in 2020/21 when compared to the previous year.

#### 4.2.3. METU

4th year Building Information Modelling (BIM) course

The course involves learning the basic terminology of BIM and current and future use of BIM in the AEC industry. The skills that will be gained through BIM applications includes software usage to do model based cost estimation, planning/4D simulation, and clash detection. Assessment involves short answer quizzes throughout the semester for evaluating knowledge and understanding (which adopted MCQ during pandemic for automated digital grading), homeworks for demonstrating software usage skills (which includes submission of models as well as a reflective paper answering questions regarding the implementation as well as a group presentation), and a final report exploring a topic of interest related to BIM usage which could be a literature review paper or a different software implementation practice based on the students' preference.

Course Learning Outcomes
Student, who passed the course satisfactorily will be able to:
● identify the basic terminology of Building Information Modelling (BIM)
● explore the value, benefits, and levels of adoption of BIM
● discuss the implementation of BIM concepts throughout the lifecycle of a facility
● demonstrate skills in using several BIM applications (such as BIM-based cost estimation, 4D simulation, and clash detection)
● examine BIM implementation outcomes and illustrate those through a presentation
● explore and report on a contemporary BIM topic

Assessment
Grade components will be weighted as follows in the computation of the final course grade:
Homework Assignments (3) 45%
Presentation (1) 15%
Final Project 30%
Participation & Quizzes 10%

SAQ examples from quizzes:

Knowledge and Understanding
Q. How would you define BIM in your own words? Use at least three features of BIM in your explanation.

Understanding of software usage skills
Q. Explain the differences in the 4D modelling (linking the model and the schedule and creating a simulation) process of Synchro 4D tool from Navisworks 4D feature by giving two examples.
Q. The model-based quantity take off has advantages and disadvantages compared to the manual quantity take off. To support this idea, give one example for its advantage and one for the disadvantage. Explain the reasons for both cases.

MCQ examples from quizzes:
Q. In a BIM model, a window can be placed into a wall after its hosting wall has been modelled.
As the modeler replaces the window with a larger one, its hosting wall understands that the window area is expanded and keeps its boundaries the same but reduces the hosting wall surface area. This exemplifies the parametric intelligence of BIM objects.

Select one: True False
Q. Tick the checkbox if the explanation about a model you generated in a BIM tool is True. Please select all that apply.
a. BIM objects know how they should behave when an analysis is performed with the model (such as quantity take-off, energy analysis etc.).
b. Each object knows what it is, such as a wall or a beam.
c. Manual efforts are required to update each view separately when an element in the model is modified.
d. It defines both geometrical and functional properties.

Discussion question example from software implementation homework:
Q. Can you be sure that the model based quantity take-off is correct? (1 pt) What considerations you should make while using Autodesk Navisworks Quantification to estimate? (2 pts) Do you think this method covers all the cost items you should include in a construction cost estimate? (2 pts)

### 4.2.4. UNISA
Revision of existing assessment methods

The CALOHEE questionnaire did not foresee any question about assessment of the level of achievement of the established LOs. There have been initiatives to find proper assessment methods for the different types of LOs. The more recent is the TALOE project [14], which has delivered a webtool that advises about proper methods of assessment aligned with the different types of LOs to be verified. The tool is applicable to all areas of knowledge as long as there is a definition of LOs. The webtool was the implementation made of the ALOA model that is based on the revised Bloom's taxonomy and on the work of alignment of Anderson et al. [15]. The ALOA model was developed for engineering courses and the webtool was afterwards extended to all fields of knowledge.

Discussion among the members of the SAG t evidenced 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 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.

LOs, 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 'successes' of the education experiences.

### 4.2.5. UM

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 modelling. 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:
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 axis 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 modelling 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 centre 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.

# 5. Improved Future Assessments: where can we go from here

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 recognized 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 programmes' 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 may be 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, clear rules within each institution about how to conduct proper assessment of students have to be set. Continuing Professional Development (CPD) training should be mandatory and periodic for teachers of Civil Engineering.

## 6. Actual Testing – Practical Implications

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 accessible 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.