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CALOHEE PROJECT AND CIVIL ENGINEERING: ANALYSIS OF RESULTS

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Abstract. Paper describes the experience of leading the group dedicated to Civil Engineering of the project Comparing Achievement of Learning Outcomes in Higher Education in Europe (www.calohee.eu). There were four other subjects that were analyzed: History, Physics, Teacher Education and Nursing. The rationale for this project was built with the goal of searching for a more reliable model for evidence based learning and quality assurance and enhancement of the assessment of learning outcomes. When civil engineers enter the labour market with sets of competences based on their personal experiences and their studies are they really prepared for the jobs they go after? What are the demands of employers? Are they equipped to fully engage with their civic responsibilities? Are students trained to cope with the many uncertainties that life and work will bring to them? Do existing quality assurance instruments offer sufficient evidence to answer those questions?

Existing approaches to assess quality of learning tend to look at processes and not at achieved learning by civil engineering students. CALOHEE applied a forward looking approach, focusing on what a graduate should know and be able to do in order to function successfully in life and contribute to society (learning outcomes perspective). The chosen approach brought evidence-based accountability into the teaching and learning role of HE institutions by focusing on competences acquired by students, which meet the needs of society and the graduates. The assessment framework included four strands: 1) Knowledge (theory and methodology); 2) Applying knowledge and skills; 3) Preparing for employability and 4) Civic, social and cultural engagement. CALOHEE also developed a set of reference points at 1st and 2nd cycles levels. The sets of learning outcomes' descriptors were prepared by teams from the respective academic communities, in close consultation with stakeholders and open to public scrutiny.

1 INTRODUCTION AND TUNING APPROACH

It is presented in this paper the summary of two documents [1], [2] that builds on documents published in the past, in particular the publication A Tuning-AHELO Conceptual Framework of Expected Desired/Learning Outcomes in Engineering, documents of the European Civil

Engineering Education and Training (EUCEET) Association and the EUR-ACE Framework Standards and Guidelines (EAFSG).

This work done in the subject area of Civil Engineering concern degree profiles and the tasks and societal roles graduates will take on, but also show how different degrees fit into the wider context of overarching qualifications frameworks. In other words, which are the essential elements that constitute a particular subject area in higher education? Among other aspects, the guidelines include general descriptors for the first and the second cycle, the bachelor and master, presented in easy-to-read tables, and are meant to be used as reference points for the design and delivery of individual degree programmes. According to the Tuning philosophy, each degree programme has its own unique profile, based on the mission of the institution and taking into account its social-cultural setting, its student body, and the strengths of its academic staff [3].

The Guidelines and Reference Points [1] are the outcome of a long and intense collaboration, starting in 2001, in conjunction with the early phases of the Bologna Process, which has now come to include 48 European countries. They are a result of the grassroots university-driven initiative called Tuning Educational Structures in Europe, or simply 'Tuning', that aims to offer a universally useful approach to the modernisation of higher education at the level of institutions and subject areas. The Tuning initiative has developed a methodology to (re-) design, develop, implement and evaluate study programmes for each of the Bologna cycles.

The Tuning methodology is based on student-centred and active learning approaches it has promoted since its very launch. Tuning's mission is to offer a platform for debate and reflection which leads to higher education models able to ensure that graduates are well prepared for their societal role, both in terms of employability and as citizens. Graduates need to have obtained as the outcome of their learning process the optimum set of competences required to execute their future tasks and take on their expected roles. As part of their education graduates should have developed levels of critical thinking and awareness that foster civic, social and cultural engagement.

Using the Tuning reference points makes study programmes comparable, compatible and transparent. They are expressed in terms of learning outcomes and competences. Learning outcomes are statements of what a learner is expected to know, understand and be able to demonstrate after completion of a learning experience. According to Tuning, learning outcomes are expressed in terms of the level of competence to be obtained by the learner. Competences represent a dynamic combination of cognitive and meta-cognitive skills, knowledge and understanding, interpersonal, intellectual and practical skills, and ethical values. Fostering these competences is the object of all educational programmes. Competences are developed in all course units and assessed at many different stages of a programme. Some competences are subject-area related (specific to a subject area), others are generic (relevant for many or all in degree programmes). According to the Tuning philosophy, subject specific competences and generic competences or general academic skills should be developed together. Normally competence development proceeds in an integrated and cyclical manner throughout a programme.

The initial core competences of the subject area were identified in a consultation process involving four stakeholder groups - academics, graduates, students and employers - during the period 2001-2008. Since then similar consultation processes have been organised in many other parts of the world: these have been taken into consideration in developing this new edition. This

edition has been elaborated as part of the CALOHEE project (Measuring and Comparing Achievements of Learning Outcomes in Higher Education in Europe), co-financed and strongly supported by the European Commission as part of its Action Programmes for Higher Education. CALOHEE project aims to develop an infrastructure which allows for comparing and measuring learning in a (trans)national perspective. Besides updating and enhancing the reference points brochures it has also developed Assessment Frameworks which offer even more detailed descriptors than those presented in this document. The Assessment Frameworks are published separately.

To make levels of learning measurable, comparable and compatible across Europe academics from the single subject areas have developed cycle (level) descriptors expressed in terms of learning outcomes statements. In this edition, for the first time these are related one-to-one to the two overarching European qualifications frameworks, the 'Bologna' Qualifications Framework for the EHEA (QF for the EHEA) and the EU European Qualifications Framework for Lifelong Learning (EQF for LLL). In the CALOHEE project these two meta-frameworks have been merged into one model to combine 'the best of two worlds'. While the EQF for LLL is focused on the application of knowledge and skills in society, the focus of the QF for the EHEA is more related to the learning process itself: it applies descriptors which cover different areas or 'dimensions' of learning: knowledge and understanding, application of knowledge and understanding in relation to problem solving, making judgments, communicating information and conclusions, and finally, knowing how to learn.

In developing the CALOHEE Tuning model, it was concluded that 'dimensions' are an indispensable tool, because they make it possible to distinguish the principal aspects that constitute the subject area. Dimensions help give structure to a particular sector or subject area and also make its basic characteristics more transparent. Furthermore, the 'dimension approach' is complementary to the categories included in the EQF for LLL, which uses the categories of knowledge, skills and wider competences to structure its descriptors. Thus, in CALOHEE terms, the three columns correspond to a 'knowledge framework', a 'skills framework' and a 'wider competency framework', linked by level. The last column, the 'wider competency framework', refers to the wider world of work and society and identifies the competences required to operate successfully in the work place and as a citizen. It builds on the first two elements: knowledge and understanding and the skills necessary to develop and apply this knowledge.

The use of the learning outcomes and competences approach implies changes regarding the teaching, learning and assessment methods. Tuning has identified approaches and best practices to form the key generic and subject specific competences. Some examples of good practice are included in this brochure. More detailed examples can be found in the subject area based Assessment Frameworks.

Finally, Tuning has drawn attention to the role of quality in the process of (re-)designing, developing and implementing study programmes. It has developed an approach for quality enhancement which involves all elements of the learning chain. It has also developed a number of tools and identified examples of good practice which can help institutions to improve the quality of their degree programmes.

The outcomes of the work done by the Subject Area Group (SAG) in Civil Engineering, which was established in the context of the CALOHEE project, are presented in a template to

facilitate readability and rapid comparison across the subject areas. The summary aims to provide, in a very succinct manner, the basic elements for a quick introduction into the subject area. It shows in synthesis the consensus reached by a subject area group after intense and lively discussions in the group [1].

2 TERMS OF REFERENCE IN CALOHEE PROJECT

In order to develop the sectoral and the subject area frameworks, the SAG started from the EUR-ACE programme (learning) outcomes recently re-defined by the European Network for Accreditation of Engineering Education (ENAEE) in the document EUR-ACE Framework Standards and Guidelines (EAFSG), approved by the Administrative Council of the European Network for the Accreditation of Engineering Education (ENAEE) on March 2016. The EUR-ACE programme outcomes (POs) are the basis for a European mutual recognition agreement, currently developed under the framework of ENAEE.

EUR-ACE programme outcomes (POs) and corresponding accreditation criteria have been integrated into national learning outcomes and accreditation requirements of thirteen European countries: Finland, France, Germany, Great Britain, Ireland, Italy, Poland, Portugal, Romania, Russia, Spain, Switzerland and Turkey. In addition, FEANI, the European Federation of Engineering Societies in 30 European Countries, recognises the EUR-ACE POs and accreditation results for their own index of accredited engineering programmes and the European engineering register of professional engineers.

EUR-ACE POs describe the knowledge, understanding and skills that an accredited engineering degree programme must enable a graduate to demonstrate. They are described separately for both Bachelor and Master degree programmes, with reference to the following eight ‘learning areas’:

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

First of all, the SAG has verified the capacity of the EUR-ACE learning areas to include the learning outcomes (LOs) established in the most influential LOs frameworks in the engineering field. In fact, that there is a common understanding throughout the world of what an engineer is supposed to know and be able to do is most striking and probably differentiates engineering from many other disciplines.

The frameworks that have been considered are:

- the Tuning-AHELO framework [4];
- the EUCEET framework [5];
- the International Engineering Alliance (IEA) - Washington Accord framework [6];
- the ABET framework [7];
- the Conceiving, Designing, Implementing, Operating (CDIO) Initiative framework [8];

- the National Society of Professional Engineers framework [9];
- the American Society of Civil Engineering (ASCE) framework [10].

Consequently, the SAG has assumed the EUR-ACE learning areas as 'dimensions' for constructing the sectoral qualifications framework (SQF) for the engineering domain, renaming them as follows:

- Knowledge and understanding;
- Analysis and Problem Solving;
- Design;
- Investigations;
- Practice;
- Decision Making;
- Team-working;
- Communication;
- Lifelong Learning.

Then, the SAG has checked the correspondence of the EUR-ACE POs with the LOs established in the considered frameworks. The members of the SAGS quickly came to the conclusion that, in spite of a different ordering, the EUR-ACE POs and the LOs established in the considered frameworks were highly compatible, but also that two major revisions of the EUR-ACE POs were necessary in order to improve the compatibility:

- the introduction of a PO regarding the ability to implement and conduct engineering activities;
- the necessity to provide better evidence to the social responsibility associated to the outcomes.

Finally, the EUR-ACE POs have been redefined, according to the template suggested in the context of the CALOHEE project, as described and shown in the next paragraph.

3 ASSESSMENT FRAMEWORK FOR CIVIL ENGINEERS

The Tuning-CALOHEE Assessment Frameworks for Civil Engineering offers an important and novel tool for understanding, defining and visualising the requirements for any degree programme in the Subject Area or closely related to it. It shows, in a detailed but also general and flexible way, which competences should be developed by such a programme (the AF for Civil Engineering does not shows competences), giving useful indications about the relevant learning areas: not only core knowledge content, including theories and methodologies, but also skills for developing and applying that content, as well as the level at which the graduate will be able to operate meaningfully in his or her profession and, more broadly, in society. It distinguishes between the first and second cycle degree (Bachelor and Master) in the Subject Area, clarifying the progressive nature of the learning process, and showing the connections between levels of learning to be developed.

The CALOHEE Assessment Framework comprises easily read reference tables containing descriptors covering knowledge, skills and wider competences [2]. These tables are an integral part of the Tuning Guidelines and Reference Points 2018 for the Design and Delivery of Degree Programmes [1].

The advantages of being able to refer to an Assessment Framework are numerous. Such a framework provides:

- a widely accepted comprehensive overview of the key learning topics a degree programme can include, developed by an international group of experts, and validated by peers and other stakeholders;
- a range of up-to-date strategies, methodologies and approaches to learn, teach and assess the topics of learning, formulated in terms of learning outcomes.
- different stakeholder groups' insight into what could be usually covered in terms of learning in a particular subject area and a particular degree programme. Stakeholders include disciplinary experts, teaching staff, university and faculty management, professional organisations, employers, and (potential) students;
- a menu through which an individual degree programme at bachelor or master level can be composed and defined on the basis of motivated and articulated choices and a transparent decision-making process;
- a fair indicator of the completeness and quality of a degree programme which allows for different institutional missions and profiles;
- a reliable mechanism for quality assurance based on a robust reference framework based on well-defined sets of measurable learning outcomes;
- a format for comparing different degree programmes in terms of profile, content and approach;
- a robust and articulated framework for developing comparable diagnostic assessments which offer reliable evidence regarding the strengths and weaknesses of a particular degree programme benchmarked against programmes with comparable missions and profiles.

CALOHEE's Assessment Framework can be seen as a general table providing a complete overview of the Civil Engineering in terms of measurable learning outcomes statements [2]. These statements, taken together, are much more precise than the more general Reference Points descriptors of Civil Engineering [1]. The focus in the framework is not only on 'what' to learn, but also on 'how' this 'what' can be learned. It represents the lowest, but at the same time most detailed level in the hierarchy of qualifications frameworks. This hierarchy starts with the overarching European frameworks, followed by national, sectoral and the subject area frameworks. As in the case of the subject area frameworks, the Assessment Framework organises its descriptors according to the categories knowledge, skills and competences distributed among the 'dimensions', which are seen as the main building blocks of the subject area. The descriptors, formulated in this way, provide structure and transparency: a general way to look at Civil Engineering through which specific programmes can be formulated.

While the general descriptors have the primary purpose of indicating the type and level of learning, in an Assessment Framework these are broken down using 'sub-descriptors' or 'subsets' which describe the key elements and topics that constitute each descriptor in greater detail. Although the general descriptors are often called learning outcomes, in practice they are much more competence statements. The real, utilizable, learning outcomes of a subject area are the sub-descriptors, because they meet the condition of being measurable, indicating not only a subject, but also context and complexity. The dimensions, sub-dimensions, descriptors and sub-descriptors together make an assessment framework which is complimented by an overview of the most appropriate learning, teaching and assessment strategies and approaches to achieve the intended learning outcomes. These can be formulated per sub dimension but are more often formulated for several related sub descriptors in order to avoid repetition.

According to the Tuning and CALOHEE philosophy, learning, teaching and assessment –

in that order - should be fully aligned. A specific body of learning (knowledge, skills and wider competences), identified by the intended learning outcomes, is split into modules or units spread over the available learning period (e.g. academic years) in such a way that progression routes are established. Appropriate modes of learning, teaching and assessment are linked to each unit or module. These, of course, should fit the level of learning identified.

An Assessment Framework should first and most of all be understood as a source of reference - inspiration and guidance - for modernising, revising and enhancing existing degree programmes and constructing new ones to meet the needs of the learners, preparing them appropriately for their role in society, in terms both of employability and as citizens. For this reason, CALOHEE has developed a model in which the different aspects of the learning process are defined. The 'knowledge set of descriptors' is expected not only to cover core knowledge of the subject area but also related theories and methodologies. The 'skills set of descriptors' focusses on the skills/competences – generic and subject specific – which are relevant for applying knowledge. With regard to the generic skills /competences one normally thinks of such abilities as critical thinking, analysing and synthesising, creativity and originality and written and oral communication, but it is important to remember also value related competences such as ethical commitment.

4 BACHELOR AND MASTER LEVELS 6 AND 7 OF EQF

The two levels of the European Qualification Framework, 6 and 7, represent the academic qualifications of the majority of civil engineers working as professionals. These two levels are generally known as qualifications denominated bachelor and master. For each one of these levels an example is presented with the indication of the dimension, the learning outcome (knowledge, skill or wider competence), the teaching approach, the learning approach and assessment methods proposed.

The teaching and learning approaches are proposals arising from the consultation among the project partners, targeted surveys and contribution of stakeholders. The proposal of assessment methods was obtained using a web-tool TALOE. This tool is the result of the application of the ALOA model that aligns the assessment methods with the different types of learning outcomes using revised Bloom´s taxonomy and Biggs alignment model [11].

For level 6, first Bologna cycle or bachelor, an example is Analysis and problem solving. In this case for the knowledge dimension one of the learning outcomes is "Demonstrate knowledge and understanding of the process and established methods of analysis of civil engineering issues (products, processes, systems, situations) and of their limitations, of the process and established methods of solving civil engineering problems and of their limitations and demonstrate also awareness of the importance of non-technical, societal, health and safety, environmental, economic and industrial considerations in solving civil engineering problems. The teaching approaches proposed are lectures, seminars, tutorials, flipped classroom, blended teaching and problem-based classes. For the same learning outcome it is proposed in terms of learning attending lectures, attending seminars, attending tutorials, participating in flipped classroom, blended learning and problem-based learning. The assessment methods proposed are short answer questions, multiple choice questions and essays.

For level 7, second Bologna cycle or master, an example is Lifelong Learning. For this dimension the wider competences are defined as Identify the most appropriate learning strategy

and method in independent lifelong learning and to follow developments in science and technology and undertake further studies in new and emerging technologies in civil engineering subject area and within broader or multidisciplinary contexts. For this learning outcome the teaching approaches proposed are problem-based classes, design-based classes, work-based practice and individual supervision. The learning approaches are problem-based learning, design-based learning, practicing professional skills and individual supervision. The assessment methods proposed are problem solving, practical work and reflective practice assignments.

5 CONCLUSIONS

The ultimate ambition of the CALOHEE for Civil Engineering initiative is to develop a transnational multi-dimensional assessment model which allows for actual measuring and comparing of learning, taking into account the specific mission and profile of each degree programme, within its cultural and academic context. This model should offer sets of consistent test formats and items which make it possible the assessment of deep knowledge and understanding as well as high level skills. One could think of, for example, critical awareness, analysing and composition skills.

An Assessment Framework is a key tool in this case because it offers a basis for identifying and developing the items to be tested. Although students' achievements will be individually assessed, the outcomes of the assessments will be generated at degree programme level (not at the individual student level), because the intention is – in line with traditional quality assurance systems – to diagnose whether the intended learning outcomes are actually achieved. In other words, does the programme offer what it has promised and does it meet the standards which have been agreed by the academic community? The Assessment Framework presented here should be understood as a planning tool, but also as a tool for answering this question.

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