INQUIRIES INTO EUROPEAN HIGHER EDUCATION IN CIVIL ENGINEERING

SOCRATES - ERASMUS
THEMATIC NETWORK PROJECT

EUROPEAN CIVIL ENGINEERING EDUCATION AND TRAINING

EUCEET

FIFTH EUCEET VOLUME

Edited by
Iacint Manoliu

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FOREWORD

This is the fifth of a series of volumes to be published within the Thematic Network Project EUCEET (European Civil Engineering Education and Training) run on the basis of a grant of the European Commission under the auspices of the Erasmus component of the SOCRATES programme.

The volume comprises the Reports pertaining to two, out of the total of six, themes undertaken under EUCEET II:

- Theme A "*Curricula issues and developments in civil engineering education*" (coordinator: professor Iacint Manoliu, Technical University of Civil Engineering of Bucharest, Romania).
- Theme E "*Recognition of academic and professional civil engineering qualification*" (coordinator: professor Laurie Boswell, City University London).

There are six reports prepared by the Working Groups in charge with four Specific Projects under the theme A and two Specific Projects under the theme E.

In addition, the volume includes the Report of the EUCEET-Tuning Task Force on the cooperation as a Synergy Group of the Thematic Network EUCEET with the EC supported Project Tuning.

Due to space limitations, annexes to various reports could not be printed. However, the CD attached to the volume contains the reports in full extent, including annexes.

The editor expresses his gratitude to the authors of the Reports and to all active partners of EUCEET Consortium for their contribution and support.

Professor Iacint MANOLIU

Chairman of EUCEET II Management Committee

Table of Contents

Report of the **Working Group** for the Specific Project 1

Studies and recommendation on core curricula for civil engineering

STUDIES AND RECOMMENDATIONS ON CORE CURRICULA FOR CIVIL ENGINEERING

Stanisław Majewski[1]

PREFACE

The specific project 1 (SP1) entitled ***“Studies and Recommendations on Core Curricula for Civil Engineering”*** was carried out within the Thematic Network EUCEET. The special team was organized to develop the project. At the launching meeting during the EUCEET General Assembly in Athens (February 2003) 40 delegates declared their participation in this team. Later on some of them didn’t respond for any correspondence and didn’t undertake any work within the project. Finally the official list of SP1 group (Appendix 1) comprises 31 persons who were more or less active in the project. On the other hand many persons, who are not included at the SP1 team list and officially didn’t declare their engagement in this project responded for the questionnaires and contributed significantly to the work. This entitles me, as the chairman of the SP1 team, to express my conviction, that contents of this Report represents the average opinion of European academicians and professionals directly involved in Civil Engineering. Simultaneously I feel obliged to express my thanks and acknowledgments to all colleagues from many countries, whose proficiency and engagement created the basis for this elaboration.

Glossary

Core subject

A compact part of teaching material, which should be present in every course curriculum within a particular discipline irrespectively to the specialization.

Core Curriculum

List of subjects, which should be taught at every course within a particular discipline irrespectively to the specialization.

Frame Syllabus

A list of topics, which should be taught within a particular subject.

1. INTRODUCTION

1.1 Engineering Education.

Education is a crucial human activity, which conditions the growth and development of an individual, society and the whole world. Considering the

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Professor, Silesian University of Technology, Gliwice

leading role of engineers in the society, the engineering education plays a very responsible role in the contemporary world. This refers not only to the professional competencies but also to the personal, interpersonal and most general human skills and attitudes. We must be aware of that if we plan and organize any educational activity, which is aimed not only at education and training of a well qualified professional, but of a responsible human person as well.

The project entitled *"Studies and Recommendations on Core Curricula for Civil Engineering"* carried out within the Thematic Network EUCEET deals just with one engineering discipline and touches only some aspects of the educational activity within this discipline. However considering, the role of the Civil Engineering profession in every society, as well as importance of the undertaken issues we dare consider, that the opinions presented herein can be of interest and benefit for those who deal with educational activity.

1.2 Scope of the SP1

While planning any educational activity we must consider three basic questions [1]:

- What should be taught?
- How should it be taught and learned?
- Who should teach and learn it?

The scope of the SP1 project is limited to the first question. However in the engineering education this question does not refer only to the domain of pure knowledge only. The graduate of an engineering faculty besides the scientific basis must be trained in skills, which make effective and creative application of his knowledge possible, as well as formed in attitudes which assure honest and responsible performance and approach to his work during all his professional life. Thus, the first question: 'what should be taught?' includes the range of knowledge which should be taught, skills which should be trained and attitudes which should be formed. All these attributes determine the competencies of a civil engineering professional. The first, general answer to the question: 'what should be taught' will be given in terms of competencies.

More detailed answer referring particularly to the scope of knowledge, which should be known by every graduate of a civil engineering faculty must be given in terms of subjects which should be taught. This leads to the definition of a Core Curriculum. Considering that the Civil Engineering is a very broad profession and consists of numerous specializations we must determine a set of Core Subjects, which must be known to every graduate of any Civil Engineering faculty irrespectively to her/his specialization.

Thus, within the first Specific Project (SP1) entitled *"Studies and Recommendations on Core Curricula for Civil Engineering"* the answer for the question: what should be taught? will be given both in terms of ***competencies*** of each civil engineering graduate, as well as ***core subjects***, which should be included in every civil engineering course curriculum.

2. OUTCOMES OF THE EDUCATION

2.1 Outcomes and Competencies versus Subjects and Curricula

Although the title of the first Specific Project: *"Studies and Recommendations on Core Curricula for Civil Engineering"* emphasizes the role of subjects, which create every curriculum, thus the Core Curriculum as well, we must univocally declare that the proficiency in any particular subject, even the most important one, cannot be considered as the final outcome of the education. Subjects are only the indispensable means to reach more general outcomes of the education. Therefore, the essential part of this report will begin with the presentation of outcomes of the Civil Engineering Education.

Every education is aimed at shaping a competent professional. Thus, the quality of education should be measured by the competencies of graduates.

Numerous Engineering Organizations have determined the set of outcomes of the education usually in form of competencies, which every graduate of a BSc or MSc course should achieve. Let us mention here some of them.

The Thematic Network TUNING has divided the competencies into generic and subject specific ones. The generic list (table 1) includes 17 competencies, which are important for every graduate of any higher education. Authors of this list assume, that the importance of competencies on this list will be arranged according to the results of wide inquiry among the academics, graduates and employers dealing with every single profession.

The lists of subject specific competencies were proposed by the E4[**] TN, Engineering Professors Council, QAA, Engineering Council and probably the most complete by the Body of Knowledge Committee of the American Society of Civil Engineers. In the EUCEET Specific Project 1 all these accomplishments were regarded, but majority of outcomes have been formulated in terms used by ASCE BOK Committee.

In October 2001 The American Society of Civil Engineers (ASCE) created the Task Committee on Academic Prerequisites for Professional Practice (TCAP3) which in turn founded the Body of Knowledge (BOK) Committee.

This Committee was in charge of defining the BOK needed to enter the practice of civil engineering at the professional level (licensure) in the 21st Century. The Final Report of the Committee [1] includes the comprehensive answer to all above mentioned questions referring to the education (what, how and who). Although we are aware, that all these questions are of great

[**] Enhancing European Engineering Education

importance to the education, just the first of them is within the area of interest of SP1.

Table 1. Generic competencies by TUNING

1.	Basic knowledge of the field of study
2.	Basic knowledge of the profession
3.	Ethical commitment
4.	Capacity for generating new ideas (creativity)
5.	Oral and written communication in your native language
6.	Elementary computing skills (word processing, database, other utilities)
7.	Knowledge of a second language
8.	Capacity to learn
9.	Capacity for applying knowledge in practice
10.	Capacity for analysis and synthesis
11.	Ability to work in an interdisciplinary team
12.	Research skills
13.	Capacity to adapt to new situations
14.	Interpersonal skills
15.	Decision-making
16.	Critical and self-critical abilities
17.	Appreciation of diversity and multiculturalism

2.2 Outcomes of the Civil Engineering Education expressed by the competencies of a graduate

The ASCE Body of Knowledge Committee has included 11 outcomes currently used by The Accreditation Board for Engineering and Technology (ABET) and added 4 others connected with the attitudes, that is the manner in which one approaches his or her work. The important feature of this elaboration is determining 3 levels of competency, which are required for particular outcomes.

The SP1 group has expressed the outcomes of the education in terms of competencies (table 2), which every Civil Engineering graduate should reach during her/his studies. Speaking solely about Civil Engineering we didn’t distinguish generic and subject specific competencies. We based mainly on the ASCE outcomes, taking into account the above mentioned elaborations (p. 2.1) as well. To each competency a brief commentary was added. The ASCE levels of competency were maintained.

Table 2. Outcomes of the education measured by Competencies of a Civil Engineering graduate

Scientific Basis: Knowledge Competencies
1. An ability to apply knowledge of mathematics and other basic subjects *Commentary*: Knowledge of Mathematics, Applied Physics, Applied Chemistry, forms the basis for the good understanding of the engineering sciences and provides graduates of civil engineering programs with intellectual tools.
2. An ability to use knowledge of mechanics, applied mechanics and of other core subjects relevant to civil engineering *Commentary*. Mechanics, applied mechanics (strength of materials, structural mechanics, soil mechanics, fluid mechanics & hydraulics) reinforced concrete, steel structures, engineering surveying, building materials, computer science and computational methods, construction technology & organization, buildings construction, transportation engineering, water structures and water management, environmental engineering are among the core subjects for civil engineering programs, as established within EUCEET Thematic Network on the base of a wide inquiry among European civil engineering faculties[***]. The core subjects are subjects common to all degree courses in the civil engineering field, regardless of the specialization.
3. An ability to apply knowledge in a specialized area related to civil engineering *Commentary*: Examples of specialized technical areas related to civil engineering are: structural engineering, water resources engineering, transportation engineering, geotechnical engineering, environmental engineering, construction engineering and management.
Professional Skills
4. An ability to identify, formulate and solve civil engineering problems *Commentary*: Assessing situations in order to identify problems, formulate alternatives and recommend feasible solutions is an important aspect of the professional responsibilities of the graduate of a civil engineering programme. Solving complex civil engineering problems, would require from the graduate, in addition to the ability to identify and formulate the problem, experience in performing numerical analysis and parametric analysis by using adequate computer codes, in assessing critically the results, in assessing risks, selecting constructions methods etc.
5. An ability to design a system or a component to meet desired needs *Commentary*: Design is at the heart of civil engineering and is where

[***] See point 3

graduates of civil engineering programs demonstrate their creative thinking and depth and breadth of knowledge and skills. The creative engineer must be able to recognise human, social and technical needs within his discipline and design the means to satisfy these needs. Design methodology includes problem definition, analysis, risk assessment, environmental impact, creativity, synthesizing alternatives, safety, security, constructability, sustainability, estimating engineering costs; interaction between planning, design and construction; and life-cycle assessment.
6. An ability to design and conduct experiments, as well as analyse and interpret data *Commentary*: Solving complex civil engineering problems sometimes requires using non-conventional methods among them design and conduct field and laboratory studies, gather data, analyze and interpret the results. The graduate of a civil engineering programme should be able to do this in at least one major civil engineering areas, such as structural engineering, geotechnics, transportation, water resources etc.
7. An ability to identify research needs and necessary resources *Commentary*: Complex civil engineering projects often require undertaking research activities to support the design. The graduate should be able to identify the appropriate area of research.
8. An ability to use the techniques, skills and modern engineering tools, including IT, necessary for engineering practice *Commentary*: This includes the role and use of appropriate information technology, contemporary analysis and design methods, and applicable design codes and standards as practical problem solving tools to complement knowledge of fundamental concepts.
9. An understanding of the elements of project and construction management *Commentary*: Important elements of the constructions activity involve constructions processes, methods, systems; equipment; planning; safety; cost analysis and cost control; labour issues. Projects management essentials include project manager responsibilities, defining and meeting client requirements. In the case of complex civil engineering works other elements are of relevance, such as owner-engineer-contractor relationship; project delivery systems; estimating construction costs; bidding by contractors; labour management issues etc. Project management essentials include project manager responsibilities, defining and meeting client requirements, risk assessment and management, contract negotiations, preparation and monitoring etc.
Personal, Interpersonal and Professional Attitudes and Skills
10. An understanding of ethical commitment and professional responsibility of civil engineers *Commentary*. Ethical commitment is one of basic factors of human

reliability. The graduates of civil engineering programmes should be also aware of the responsibility of the civil engineer for the public safety, health and welfare. They need to understand and be committed to apply the codes of conduct adopted by professional associations.
11. An understanding of the interaction between technical and environmental issues and ability to design and construct environmentally friendly civil engineering works *Commentary:* Civil engineers must be aware that the built environment they create always interferes with the natural environment. The changes introduced by their activity cannot damage this environment, should be friendly not only to people but to the whole wildlife, as well. This refers to the aesthetic aspects, too.
12. An understanding of the impact of solutions for civil engineering works in a global and societal context *Commentary*. Graduates of civil engineering programmes need to appreciate, from historical and contemporary perspectives, the technical, environmental, social, political, legal, aesthetic, economic and financial implications of civil engineering projects.
13. An ability to communicate effectively *Commentary*. The graduates of civil engineering programmes should prove abilities in reading, speaking and writing, not only in their native language, but also in at least one foreign language. They should be able to present and communicate technical information to a range of audience and be versatile with graphics, the worldwide web and other communication tools.

14. An ability to function in multi-disciplinary teams *Commentary*. Graduates of civil engineering programmes should be able to participate as a member of a team or to become eventually the leader of a team, which requires understanding team formation and evolution, collaboration with various personalities, co-operation among diverse disciplines etc.
15. An understanding of the role of the leader and leadership principles and attitudes *Commentary*. Graduates of civil engineering programmes, who might well, during their professional career, reach positions of leadership, should be aware of the attitudes conducive to such positions and of the desirable behaviour of leaders.
16. A recognition of the need for, and the ability to engage in, life-long learning *Commentary*. Graduates of civil engineering programmes should recognize that after getting an academic degree at University, they must strive for personal and professional development, through formal education,

continuous education, professional experience, active involvement in professional societies etc.

The above set of competencies can be considered as outcomes of the education at the MSc level both for two-tiers system (4+1.5÷2 years) and the integrated course (5 years). The words: *recognition*, *understanding* and *ability* indicate the levels of competency, which should be achieved during the study period. Their importance differs depending not only on the level of education (BSc or BEng, MSc), but also within one level. We adopted here the following levels of competency and their definitions according to the proposal of the ASCE BOK Committee [1].

- Level 1 (**Recognition**) represents a reasonable level of familiarity with a concept. At this level, the engineer is familiar with a concept, but lacks the knowledge to specify and procure solutions without additional expertise. For example, an engineer might recognize that a particular architectural plan poses significant construction difficulties without having the expertise to devise improved construction or design alternatives.
- Level 2 (**Understanding**) implies a thorough mental grasp and comprehension of a concept or topic. Understanding requires more than abstract knowledge and is the basis for creative developing and practical applying this knowledge. Understanding refers not only to the scientific and technical aspects, but to the ethical consequences and responsibility as well.
- Level 3 (**Ability**) is a capability to perform with competence. An engineer with the ability to design a particular system can take responsibility for the system, identifying all the necessary aspects of the design, and match objectives with appropriate technological solutions. As an engineer develops, the engineer's abilities also develop so that more challenging and difficult problems can be solved.

Achieving the highest level of competency means, that the graduate is able to perform with competency, yet it does not mean that he reached the excellence or even proficiency of his performance. This should be reached due to life long learning (individual studies and postgraduate courses) as well as due to the professional work experience (fig. 1).

The vertical axis in figure 1 represents the level of particular competency in percentage. Let us emphasise that the Specific Project 1 is entitled *"Studies and Recommendations on Core Curricula for Civil Engineering"*. Just "*recommendations*" as the result of studies not obligatory rules. And so the values of "percentage of competency" should be understood.

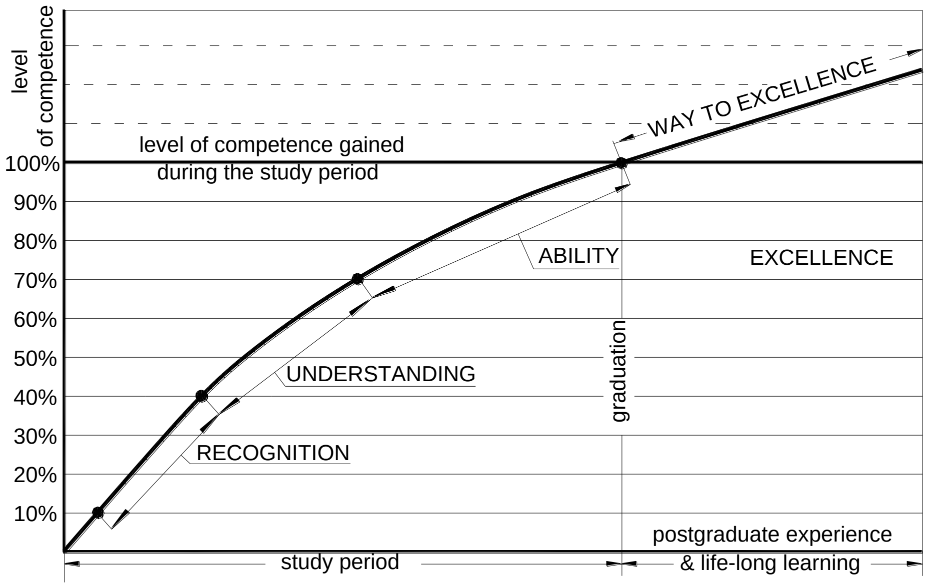

Figure 1. Life-long increase of the professional competency level

Assuming that the highest competency, assessed during the study period corresponds to 100% we propose the following intervals of competency percentage:

- Recognition 10-40%,
- Understanding 40-70%,
- Ability 70-100%.

This means that if our student reached for example 65% of the competency within a particular outcome, in which understanding level is required, we can evaluate his effort with highest possible mark. On the other hand this level of competency is insufficient if the ability level is required for this outcome.

The overall assessment of the graduate competency can be represented in the circular diagram (fig. 2). The filled area in this diagram represents the total competence of a graduate. According to the above assumptions the levels of competency for all outcomes satisfy the requirements presented in table 2, but not always at the highest possible level.

Discussing required competencies of a graduate, we must just mention two very important issues, though they exceed the area of interest of the reported project SP1. First of them is the question how to teach and train the above competencies and the second is: how to assess students' level within these competencies? More or less we know (or at least we believe that we know) how to teach particular subjects and how to evaluate the students' knowledge within these subjects.

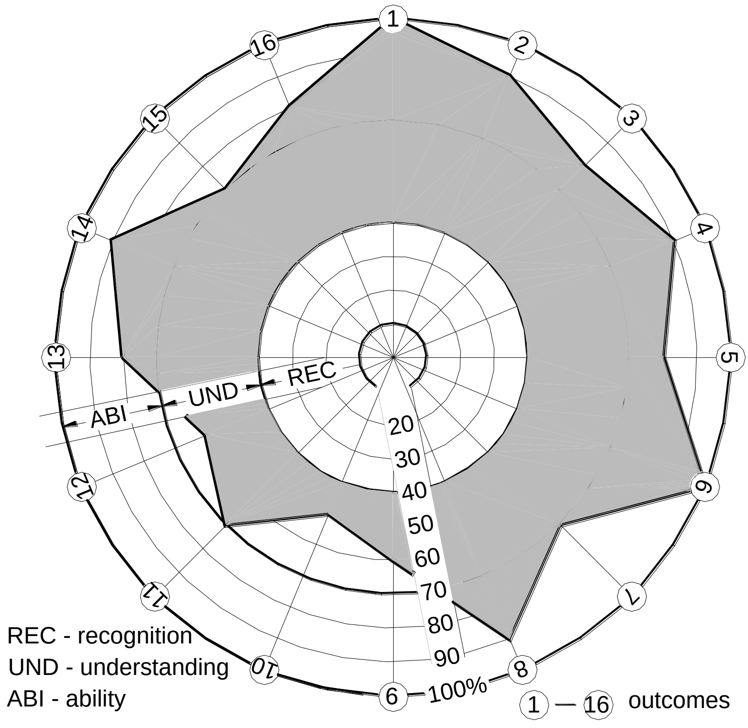

Figure 2. Circular diagram of the graduate's competency

Teaching and training competencies as well as evaluating the achieved level of competency is much more difficult and requires abandoning traditional educational scheme (chalk-talk-examining) and moving towards problem oriented education with solving design tasks, seminars with students' presentations, team work and other educational techniques. It is worthy of thinking about next EUCEET project to study and discuss these problems.

3. CORE CURRICULA

3.1 Core Subjects and their crediting

The SP1 was launched at the General Assembly in Athens in February 2003. There was one workshop of the group in Louvain la Neuve in June 2003. The meeting of the group took place during the General Assembly on Malta in May 2004. The Final Report was elaborated at the end of January and beginning of February 2005. In the meantime all the work was performed by electronic correspondence. The work was carried out in the following stages:

1. Determining the list of Core Subjects on the basis of first questionnaire since March 2003 to the workshop in Belgium on the 13th and 14th of June 2003. The list was discussed and agreed during the workshop. Later on just the slight changes of some subject names have been introduced. The list of core subjects was established on the basis of 22 answers to the first questionnaire, some of them expressed the opinion of a few people from particular universities. In the final discussion on the list of core subjects during the workshop in Louvain la Neuve participated 16 persons.
2. Assigning credits to the particular core subjects on the basis of the second questionnaire since June 2003 practically to the February 2004. Finally, the mean values of credits have been calculated on the base of 29 responses. Some of them expressed the opinion of more than one person. The list of credits for 25 core subjects was approved during the open SP1 group meeting on Malta in May 2004.
3. Elaboration of frame syllabuses for 25 core subjects.

All questionnaires were elaborated and data processing was carried out by Prof. S. Majewski, the SP1 chairman. The average credits have been calculated as the weighted average with use of a the specially designed iterative procedure, which automatically increased the weight of the data, close to the average value and decreased the weight of those strongly differing from this average. The procedure is explained in the Appendix 2.

The average credits rounded to 0.5 for core subjects are given in table 3. The possible intervals of credits are given in table 4. Using these intervals one should maintain the total sum of credits for core subjects on the constant level (140). This means that if we give more credits for one subject, we should decrease them for another one.

Core Curriculum

Credits represent the student's workload per subject. This work consists of:

- contact hours at school,
- student's individual studying (library, discussions),
- homework (project and design work),
- training before tests and exams.

Table 3. Core Subjects with Credits for basic types of courses Mean values rounded to 0.5

No	CORE SUBJECTS IN CURRICULA FOR CIVIL ENGINEERING	Credits for course:		
		Integrated	Two-tier system	
		10 sem	1st cycle 8 sem	2nd cycle 2 sem
1.	Mathematics and Applied Mathematics	23.0	16.0	6.0
2.	Applied Chemistry	3.5	3.0	
3.	Applied Physics	6.5	5.5	
4.	Computer Science and Computational Methods in C.E.	8.0	6.5	2.0
5.	Drawing and Descriptive Geometry	5.0	4.0	
6.	Mechanics	6.5	5.5	1.0
7.	Mechanics of Materials	9.5	7.5	2.0
8.	Structural Mechanics	11.0	8.5	2.0
9.	Fluid Mechanics & Hydraulics	6.0	5.5	1.0
10.	Engineering Surveying	5.5	5.0	1.0
11.	Building Materials	6.5	5.5	1.0
12.	Buildings	4.5	4.0	
13.	Basis of Structural Design	4.5	4.5	
14.	Engineering Geology	4.0	3.5	
15.	Soil Mechanics and Geotechnical Engineering	9.0	6.5	2.0
16.	Structural Concrete	9.5	7.5	2.0
17.	Steel structures	8.0	6.0	2.0
18.	Timber, Masonry and Composite Structures	4.5	3.5	
19.	Transportation Infrastructure	4.5	4.0	
20.	Urban and Regional Infrastructure	3.0	3.0	
21.	Water Structure and Water Management	4.5	3.5	1.0
22.	Construction Technology & Organisation	7.0	3.5	2.0
23.	Economics and Management	7.5	6.0	2.0
24.	Environmental Engineering	4.5	4.0	
25.	Non-technical subjects	9.0	6.0	3.0
Core subjects total		**175.0**	**140.0**	**30.0**
Specialization subjects total		**125.0**	**100.0**	**30.0**
Total		**300.0**	**240.0**	**60.0**

These parts differ for particular subjects, anyway we can assume that approximately 50-60% should be reserved for contact (teaching) hours. Assuming that the total student's workload should not surpass 40 hours per week we obtain 20-24 teaching hours per week. On the other hand we usually assume 30 credits and 15 weeks per semester, thus 2 credits correspond with 20-24 teaching hours. Constructing the Core Curriculum we assumed that 1 credit corresponds to 10-12 teaching hours. Regarding that we have 15 weeks in a semester we additionally assumed, that the total number of hours per subject should be a multiplicity of 15.

The recommended contact hours for core subjects in curricula for basic types of courses are presented in table 5.

Table 4. Recommended intervals of Credits for Core Subjects in basic types of courses

No	CORE SUBJECTS IN CURRICULA FOR CIVIL ENGINEERING	Credits for course:		
		Integrated	Two-tier system	
		10 sem	1st cycle 8 sem	2nd cycle 2 sem
1.	Mathematics and Applied Mathematics	19.0-27.0	13.0-19.0	5.0-7.0
2.	Applied Chemistry	3.0-4.0	2.5-3.5	
3.	Applied Physics	5.5-7.5	4.5-6.5	
4.	Computer Science and Computational Methods in C.E.	7.0-9.0	5.5-7.5	1.5-2.5
5.	Drawing and Descriptive Geometry	4.0-6.0	3.5-4.5	
6.	Mechanics	5.5-7.5	4.5-5.5	1.0
7.	Mechanics of Materials	8.0-11.0	6.5-8.5	1.5-2.5
8.	Structural Mechanics	9.0-13.0	7.0-10.0	1.5-2.5
9.	Fluid Mechanics & Hydraulics	5.0-7.0	4.5-6.5	1.0
10.	Engineering Surveying	4.5-6.5	4.0-6.0	1.0
11.	Building Materials	5.5-7.5	4.5-6.5	1.0
12.	Buildings	3.5-5.5	3.5-4.5	
13.	Basis of Structural Design	3.5-5.5	3.5-5.5	
14.	Engineering Geology	3.5-4.5	3.0-4.0	
15.	Soil Mechanics and Geotechnical Engineering	7.5-10.5	5.5-7.5	1.5-2.5
16.	Structural Concrete	8.0-11.0	6.0-9.0	1.5-2.5
17.	Steel structures	6.5-9.5	5.0-7.0	1.5-2.5
18.	Timber, Masonry and Composite Structures	3.5-5.5	3.0-4.0	
19.	Transportation Infrastructure	3.5-5.5	3.5-4.5	
20.	Urban and Regional Infrastructure	2.5-3.5	2.5-3.5	
21.	Water Structure and Water Management	3.5-5.5	3.0-4.0	
22.	Construction Technology & Organisation	6.0-8.0	4.5-6.5	1.5-2.5
23.	Economics and Management	6.0-9.0	5.0-7.0	1.5-2.5
24.	Environmental Engineering	3.5-5.5	3.5-4.5	
25.	Non-technical subjects	7.5-10.5	5.0-7.0	2.0-4.0
Core subjects total		**175.0**	**140.0**	**30.0**
Specialization subjects total		**125.0**	**100.0**	**30.0**
Total		**300.0**	**240.0**	**60.0**

The exemplary curriculum with core subjects for the 1st BSc stage of a two-tiers 8 semesters course is presented in table 6. That is just an example, which proves that on the basis of above accomplishments core subject can be easily and reasonably scheduled over 6 semesters. Let us observe that during initial 4 semesters all students of a civil engineering faculty are involved in core subjects only. Specialization subjects appear at the 3rd and 4th year of study, when students are prepared to choose what they are interested in and predestined to.

Frame Syllabi for Core Subjects

To determine unequivocally what is meant by a particular core subject frame syllabuses have been elaborated for each of them. The frame syllabus is a brief list of topics which should be known to every graduate of any civil engineering faculty irrespective to her/his specialization and the place of study. The topics are split into parts. The required level of competency* has been determined for each part of the teaching material.

The syllabi were determined on the basis of wide European survey. Altogether, 32 universities sent nearly 200 syllabuses. Some of them could not be used mainly because of the improper format or the use of a mother tongue. Finally, the frame syllabi for core subjects have been elaborated on the basis of 169 syllabuses from 23 universities. The list of these universities is given in table 7.

Table 5. Recommended contact hours in Core Curriculum for basic types of courses

No	CORE SUBJECTS IN CURRICULA FOR CIVIL ENGINEERING	Credits for course:		
		Integrated	Two-tier system	
		10 sem	1st cycle 8 sem	2nd cycle 2 sem
1.	Mathematics and Applied Mathematics	195-305	135-225	60-75
2.	Applied Chemistry	30-45	30-45	
3.	Applied Physics	60-75	45-75	
4.	Computer Science and Computational Methods in C.E.	75-105	60-90	30
5.	Drawing and Descriptive Geometry	45-75	45	
6.	Mechanics	60-90	45-60	15
7.	Mechanics of Materials	90-120	75-90	13-30
8.	Structural Mechanics	90-150	75-105	15-30
9.	Fluid Mechanics & Hydraulics	60-75	45-75	15
10.	Engineering Surveying	45-75	45-75	15
11.	Building Materials	60-75	45-75	15
12.	Buildings	45-60	45	
13.	Basis of Structural Design	45-60	45-60	
14.	Engineering Geology	45	30-45	
15.	Soil Mechanics and Geotechnical Engineering	75-120	60-75	15-30
16.	Structural Concrete	90-120	60-105	15-30
17.	Steel structures	75-105	60-75	15-30
18.	Timber, Masonry and Composite Structures	45-60	30-45	
19.	Transportation Infrastructure	45-60	45	
20.	Urban and Regional Infrastructure	30-45	30-45	
21.	Water Structure and Water Management	45-60	30-45	
22.	Construction Technology & Organisation	60-90	45-75	15-30
23.	Economics and Management	60-105	60-75	15-30
24.	Environmental Engineering	45-60	45	
25.	Non-technical subjects	75-120	60-75	15-45
Total hours for Core subjects not more than		**1750-2100**	**1400-1680**	**300-360**
Total hours for Specialization Subjects not more than		**1250-1500**	**1000-1200**	**300-360**
Total contact hours per course not more than		**3000-3600**	**2400-2880**	**600-720**

* 3 levels of competency used previously to determine the outcomes of education (point 2.2) have been applied to the teaching material as well

Table 6. Exemplary Curriculum with Core Subjects for 8 semester BSc course

First stage - Four years BSc Course	Schedule of teaching hours								Total hours
	1	2	3	4	5	6	7	8	
Mathematics and Applied Mathematics	75	60	30						165
Applied Chemistry	45								45
Applied Physics	45	30							75
Computer Science and Comp. Methods in C.E.	30	30		15					75
Drawing and Descriptive Geometry	45								45
Mechanics	60								60
Mechanics of Materials		60	30						90
Structural Mechanics			60	60					120
Fluid Mechanics & Hydraulics		45							45
Engineering Surveying		60							60
Building Materials	60								60
Buildings		45	15						60
Bases of Structural Design			60						60
Engineering Geology		30							30
Soil Mechanics and Geotechnical Engineering			45	30					75
Structural Concrete			45	45	30				120
Steel Structures				45	30				75
Timber, Masonry and Composite Structures				45					45
Transportation Infrastructure			30	30					60
Urban and Regional Infrastructure					30				30
Water Structures and Water Management						45			45
Construction Technology & Organisation			15	45					60
Economics and Management				15	30				45
Environmental Engineering					30	15			45
Non-technical subjects			30	30	30	30			120
Core subjects total	360	360	360	360	180	90	0	0	1710
Specialization subjects total	0	0	0	0	180	270	360	360	1170
Total	360	360	360	360	360	360	360	360	2880

Table 7. List of universities and number of sent syllabuses

No	***Country***	***University from City***	***Number of programs***
1	Poland	Gliwice	18
2		Bialystok	14
3		Lodz	4
4		Rzeszow	2
5		Wroclaw	1
6	Czech Republic	Brno	7
7		Ostrava	25**
8		Pardubice	2
9		Prague	5
10	Greece	Thessaloniki	18
11		Athens	4
12	Slovak Republic	Bratislava	5
13		Zilina	9
14	Spain	Cantabria	10
15		La Coruna	3
16	Lithuania	Vilnius	18
17	Romania	Bucharest	6
18	Estonia	Talinn	4
19	Germany	Oldenburg	4
20	Latvia	Riga	3
21	Portugal	Covilha	3
22	Ireland	Dublin	3
23	Sweden	Chalmers Univ.	1
Total			**169**

1. MATHEMATICS AND APPLIED MATHEMATICS *	13.0-19.0 credit points
Course contents	
MA1. *The course deals with basic knowledge and calculus of the matrix algebra, solving systems of equations and function analysis, graphing and approximation.* Matrices, elements of matrix algebra. Square matrices, regularity, singularity, determinants, inverse matrices. Methods for solving systems of linear equations. Cramer’s rule and Frobenius theorem. Sequences of real numbers and their properties. Limits of sequences. Elementary functions, their properties and graphs. Compositions of functions, inverse functions.	

** Elaborated in the final stage as the “summary” of previously sent syllabuses

* Based on the syllabus from Bratislava and includes the topics from other 6 universities

Continuity and limits of functions. Basic methods for evaluation of limits. Derivative of a function. Geometric applications of derivatives. Tangent line and normal line to a graph of a function. Higher order derivatives. Mean value theorems and their application. Monotonicity for functions, concavity. Graphing a function, local and global extrema. Approximation of functions by polynomials, Taylor's theorem.

***MA2.** The course deals with basic knowledge and calculus of integrals, analysis o functions of several variables, geometric and physical application.*

Antiderivative – primitive function, indefinite integral. Methods of integration of functions. Definite integral – definition, methods of computation. Improper integrals. Applications in geometry and physics. Basics of multivariable calculus, functions of two and three variables, determination of areas and volumes. Partial derivatives and gradient. Local and global extrema of functions of several variables. Infinite series of functions, power series, Fourier series. Double and triple integrals – basic concepts and computation. Line integral in a vector field. Analysis of function of several variables. Definite, multiple, and curvilinear integrals. Elements of field theory. Elements of differential geometry, moving trihedral, curvature, torsion, first quadratic form of surface.

***MA3**. The course deals with basic knowledge and calculus of ordinary and partial differential equations, systems of differential equations.*

Fundamental elements of differential equations. Ordinary differential equations of first order. Applications of differential equations of first order. Ordinary differential equations of higher order. Linear differential equations of higher order. Methods of the solution of differential equations. Fundamental elements of system of differential equations. Methods of solution of differential equations systems. Linear systems of differential equations. Fundamental elements of partial differential equations. Linear partial differential equations. Special cases of partial differential equations. Linear partial differential equations.

***MA4**. The course deals in first part with basic knowledge and calculus of statistics and probability in general and in engineering, in second part with numerical methods and techniques used in mathematics and engineering*

Introduction to Probability, One-Dimensional Random Variables and Distributions, Distributions for Discrete Random Variables, Distributions for Continuous Random Variables, Estimation of Parameters, Confidence Intervals for Mean Value, Correlation Analysis, Regression Models, Estimation of Regression Parameters, Prediction and Forecasting, Statistical Applications in Civil Engineering Problems.

Numerical solutions of equations with one variable and non-linear systems. Linear operators, interpolation, extrapolation. Numerical approximation, orthogonal polynomials. Numerical differentiation and integration. Numerical linear algebra, matrix computations. Numerical solution of: systems of linear equations, differential equations, partial differential equations. Examples of

applications for Civil Engineering.	
Level of competence	Ability in MA1 and MA2, Understanding in MA3, MA4.
Skills achieved	Proficiency in calculation of matrices, derivatives, integrals, solving of systems of equations, differential equations including systems as well as familiarity with statistics and probability, numerical methods and their use in engineering practice.

2. APPLIED CHEMISTRY *	2.5-3.5 credit points
Course contents	
CH1. *General Chemistry.* Atomic Theory. The Periodic Table and Periodic Trends in Atomic Properties. Chemical Bonds. Elements of the Gaseous, Liquid and Solid State Chemistry (Band theory and Electrical properties). Chemical Kinetics and Chemical Equilibrium. ***CH2.*** *Water and Air Chemistry.* **Water chemistry:** Hydrologic Cycle. Properties of water. Composition and Types of Natural Waters. Water Pollution. Drinking Water. Industrial Water. Desalination. **Atmospheric chemistry:** Composition and Regions of the atmosphere. Nitrogen and Carbon Cycles. The Ozon Layer. Air Pollution. ***CH3***. *Building Chemistry.* **Corrosion and Protection of Metals:** Electrochemical Corrosion. Galvanic Cells. Pourbaix Diagrams. Corrosion Rate. Uniform and Selective attack. The Corrosion Protection of Metals. ***CH4***. *Building Chemistry.* **Chemistry of Cement:** Raw materials. Types of Cement. Cement Properties. Hydration of Portland Cement.The role of Pozolans in cements. **Chemistry of Concrete:** Definition. Specifications. Durability of Concrete. Aggregates and Admixtures. Chemical attack of concrete and methods of confrontation.	
Level of competence	Understanding in CH2, CH3, CH4, Recognition in CH1.
Skills achieved	Students will get basic knowledge in general and physical chemistry required for better understanding of building materials. Deeper understanding of water chemistry and building chemistry is presupposed.

* Based on the syllabus from NTUA Athens and includes the topics from other 5 universities

3. APPLIED PHYSICS *	4.5-6.5 credit points
Course contents	
<u>Ph1. Heat</u> Fundamentals of heat conduction, thermal convection and heat radiation thermal properties of building materials, thermal characteristics. Thermal bridges: heat losses and characteristics, indoor surface temperatures, thermal and hygrical effects. Ventilation. Heat Balance: building components balance, room balance. Non-Steady State Thermal Behaviour of Buildings: heat transfer in building components, mechanism of heat storage, heating and overheating effects, passive solar energy utilization, sun spaces made of glass, thermal insulation in summer. Measures for Saving Heating and Cooling Energy: structural measures to reduce heat losses, energy-saving concepts, improvement of thermal insulation in old and new buildings, management of solar energy, balance of buildings. Thermal Load of Building Components. Thermal stresses and deformations. ***<u>Ph2 .Moisture</u>*** Fundamentals: relative air humidity, water vapour content in the air, characteristic water content of building materials, water vapour partial pressure, dew temperature, diffusion resistance, transport of liquid, water sorption. Moisture Storage: sorption and capillary condensation, moisture storage function, hygrical characterisation of pores, hygroscopic balance. Moisture Transport: diffusion, capillary suction and air flow, steady and non-steady state moisture transport, other mechanisms. Hygrical Load of Building Components: swelling and shrinking of building materials, hygrical dilatation and bending of multi-layer structures, selection of building materials under severe impact of moisture. Moisture Protection in Buildings: protection against driving rain on horizontal, inclined and vertical areas, protection against condensation or domestic hot water, protection against water in the soil, measures against moisture damage in new buildings. **<u>Ph3.Sound</u>** Fundamental Terms: sound field characteristics, wave propagation, perception and measurement of sound, calculations with sound levels. Room Acoustics: sound absorption and reflection, absorber types, reverberation time, principles of room acoustic planning, sound control, echoic criteria, room geometry. Airborne Sound Insulation: sound reduction coefficient and parameters derived from measurement, mono-layer building components, influence of area-related mass, stiffness, coincidence effect, two- or multi-layer building components, resonance, flanking transmission, resulting sound insulation, measures for airborne sound insulation. Impact Sound Insulation: impact sound level and transmission, impact sound insulation of characteristic building components, measures for impact sound reduction. Flanking Sound and Vibration: attenuation, water installations and technical systems, flanking sound attenuation and vibration insulation.	

* Based on the MEMORANDUM prepared by the members of the Permanent Conference of University Professors of Building Physics [4]

Environmental Noise Control: characteristic sound levels, sound radiation, punctual sources, linear sources, aerial sources, sound propagation in the open air and in urban areas, sound shields.
Ph4. Fire. Fire Protection Fundamentals: emergence of fire, fire load, ventilation, course and spread of fire. Fire Behaviour and Smoke Emission of Building Materials. Behaviour of Building Components and Dimensioning: concrete building components, heating processes and fire water effects, courses of temperature, stress peaks, calculation methods, design features to increase fire resistance, dimensioning of building components, specific problems of fireproof constructions masonry, steel building components, fire behaviour of timber, dimensioning of timber constructions, measures to increase the fire resistance of timber building parts. Pipes, Stacks, Tubes, Ducts. Equivalent Fire Loads, Rescue Provisions. ***Ph5. Climate.*** Climatological Fundamentals: Seasonal and day-time fluctuations of air temperature and air humidity, radiation intensity. Heat and Material Balance in the Open Air and in Urban Areas. Building Aero-Dynamics: wind profile over open air and urban areas, distribution of pressure in the boundary layers of buildings. Energy saving by urban area management, supply of fresh air in urban districts, generation of barriers, micro-climate design, especially in metropolises. Climate-Adjusted Construction ***Ph6. Light.*** Daylight: daylight in the open air and indoors, daylight ratio, distribution of lighting intensity. Artificial Lighting: daylight complementary lighting, operating hours, artificial light sources (lamps, tubes, radiators), electrical performance, efficiency, total energy balance.

Level of competence	Ability in Ph1-Ph4, Understanding in Ph5, Recognition in Ph6
Skills achieved	Proficiency to understand the methodology used in Physics and knowledge of the most important theorems and postulates as well as familiarity with the development of the analytic-synthetic capacity in the resolution of problems.

4. COMPUTER SCIENCE AND COMPUTATIONAL METHODS IN CE *	5.5-7.5 credit points
Course contents	
CS1. *The course regards to introduction to the computer science: theory of information, computer systems, hardware and software, operating systems, computer networks, computer security, software packages.* Basic notations of the information theory. Computer systems structure. General information of basic hardware and software. Operating systems	

* Based on the syllabus from Wroclaw

(review: DOS, Windows, Linux, etc.). Exchanging information by internet, ftp, e-mail (working groups), etc. Basis of computer and system security. Knowledge of software packages with application to solving engineering problems: word processor, spreadsheets presentation programme and data bases, .pdf files.
***CS2.** The course regards to the basic knowledge of programming: algorithms, flow charts, programming languages (for example: Pascal, Fortran, C++, Basic etc.).* Definition of algorithms, elements of flow charts. Programming language elements: variables, statements, expressions, functions and sub-programmes. Writing, editing, running and debugging of programmes. Libraries. Ability of writing and running simple programmes for engineering purposes.
***CS3.** The course regards to the computer aided graphics in civil engineering (for example AutoCAD, RoboCAD, Microstation, ArchiCAD etc.)* Presentation and instruction of CAD interface. Commands. Blocks and libraries. Import and export of drawings. Basis of CAD program macros. Plotting. Full 2-D drawing ability and 3-D drawing basis.
***CS4.** The course regards to the basis of computational methods in engineering: FEM, BEM, optimisation methods, structural analysis and CAE (for example: Abaqus, Ansys, Cosmos, Diana, Lusas etc., for example: Robot, Sofistic, etc.).* Structural modelling. Numerical methods (numerical methods errors, systems of equations, interpolation and approximation methods, numerical derivation and integrals, etc.). Basis of computational mechanics. Computational formulation of FEM and BEM. Structural analysis: static & dynamic of different engineering structures. Basis of structural optimisation: mathematical model, programming, application to simple design programmes (for example using Solver application). ***CS5.** The course regards to the basis of GIS* System outline and its field of application. Data vs. information; geometric, temporal and ENGINEERING components of spatially related data; data models and structures; metadata. Spatial and spatial-temporal analyses. Spatial statistics, Spatial Decision Support System (SDSS). GIS vs map vs digital map. Review of possibilities of different GIS software. Data input and edition. Database navigation. Simple and complex requests to the database. Vector and raster data composition. Design of output documents. Design of application packages.

Level of competence	Ability in CS1, CS3 and CS4, Understanding in CS2 and CS5.
Skills achieved	Proficiency in using computers to solve different engineering problems by using standard software packages. Proficiency in using computer graphics software (drawing) and exploitation of structural analysis and design programmes. Familiarity with programming languages.

5. DRAWING AND DESCRIPTIVE GEOMETRY *	3.4-4.5 credit points
Course contents	
***DG1. In this course student gets general knowledge and ability in technical drawing both by hand and* using computer programs** • Introduction to technical drawing. Basic equipment for technical drawing. Kinds of drawing-lines and their usefulness in technical drawing. Kinds of lettering for technical drawing. Scales and dimensions in technical drawing. Architecture and building construction drawings: plans, elevations, sections. Civil engineering drawings. • Bases of Computer Aided Design programs (CAD). Logics of graphic editor on example of AutoCAD system. Creation of 2D and 3D drawings. Cover plate for standard program CAD in engineering designing. Spatial modeling, formation and modeling of curves and surfaces. Designing of residential building applying the graphical editor - dimensioning in CAD program. Lay-out applying the computer program. Principles of structural designing using CAD program on a project.	
DG2. *In this course student gets general knowledge and ability in constructive techniques used in technical praxis, especially in 2-D and 3-D projection.* Parallel (and orthogonal) projection and its properties. Affinity in 2-D and 3-D. Monge´s projection – definition, point, line and a plane, principal and steepest lines, intersection of simple geometric objects. Length of a line segment. Revolution of a plane into a projection plane. Image of a circle. Auxiliary views – side view and a third projection plane. Prisms and cylinders. Axonometry – definition, various sorts of axonometry. Transformation of an object from Monge´s projection into the axonometry. Orthogonal axonometry. Revolution of coordinate planes. Intersection of single geometric objects. Projective geometry – definition, elements, point, line and plane, interval, calibration and the slope, intersection of single geometric objects, revolution of a plane into a projection plane. Topographic (land) surfaces and roofs. Parallel shading – definition, main applications in	

* Based on the syllabus from Bratislava and includes the topics from other 6 universities

Monge´s projection and axonometry.	
Level of competence	Ability in DG1 and DG2.
Skills achieved	Proficiency in technical drawing both by hand and using computer programs, basic projection techniques as well as familiarity with some advanced projection and constructional methods.

6. MECHANICS *	4.5-5.5 credit points
Course contents	
ME1. *Basic concepts and methodology of Statics* **1.** The concept of a particle and a rigid body**.** The concept of a concentrated force, couple and distributed forces. The essence of the vectorial approach to Mechanics **2. Statics of a particle**: Forces acting on a particle. Resultant of concurrent forces. Equilibrium of a particle in plane and in space**.** Free-body diagram concept. **3. Statics of a rigid body and systems of rigid bodies**: Moment of a force about a point. Varignon's theorem. Moment of a force about an axis. A couple. Moment of a couple. Reduction of a system of forces to one force and one couple. Equivalent systems of forces. Equations of equilibrium of a rigid body in two dimensions (2D). Constraints imposed on a 2D rigid body by links and hinges. Statical determinacy and indeterminacy. Kinematic stability. Systems of 2D rigid bodies and related problems (equations of equilibrium, constraints, statical determinacy and kinematic stability). Equilibrium of a rigid body in three dimensions (3D). Systems of rigid bodies in 3D. **4. Principle of virtual work for rigid bodies:**The concept of a virtual work. Application of the Principle to determining support reactions and forces transmitted by links of systems of 2D rigid bodies. **5. Centroids and centres of gravity:** Centre of gravity of a 2D rigid body. Centroid of an area. Centre of gravity of a 3D rigid body. Centroid of a volume. **6. Moments of inertia of areas:** Second moment of an area. Polar moment of inertia. Product of inertia. Parallel-axis theorem. Principal axes and principal moments of inertia. Moments and products of inertia of composite areas. **7.Moments of inertia of masses:** Definition of a moment of inertia of mass**.** Mass product of inertia. Parallel-axis theorem**.** Moments of inertia of selected rigid bodies.	
Recommended texts to ME1 1. Beer F.P., Johnston E.R. Jr: Vector Mechanics for Engineers. Statics . Mc Graw Hill.	
ME2. *Kinematics of particles:* **1.** Rectilinear motion of particles**.** Curvilinear motion of particles**. 2 Kinetics**	

* Elaborated in UBI, Covilha on the base of own experience as well as the syllabi from other 7 universities

of particles: Linear and angular momentum of a particle**.** Newton's Second Law. Equations of motion of a particle: a/ in terms of rectangular components, b/ in terms of normal and tangential components, c/ in terms of radial and transverse components**.** Kinetic and potential energy of a particle**.** Principle of work and energy. Conservation of energy**.** Motion of a particle under a central force**.** Principle of impulse and momentum**.** Direct and oblique central impact**. 3. Kinematics and kinetics of a system of particles:** Linear and angular momentum of a system of particles**.** Motion of a the centre of mass of a system of particles**.** Kinetic and potential energy of a system of particles**.** Principle of work and energy. Conservation of energy for a system of particles**.** Principle of impulse and momentum for a system of particles**. 4. Kinematics of rigid bodies:** Translation and rotation of a rigid body about a fixed axis**.** General plane motion of a rigid body: absolute and relative velocity of a point belonging to a rigid body**,** instantaneous centre of rotation**,** absolute and relative acceleration of a point belonging to a rigid body. Equation of motion for a rigid body. D'Alembert's principle. Kinetic and potential energy of a rigid body. Principle of work and energy. Conservation of energy for a rigid body. Principle of impulse and momentum for a rigid body. Eccentric impact.
Recommended textbooks for ME2 1. Beer F.P., Johnston E.R. Jr: Vector Mechanics for Engineers. Dynamics . Mc Graw Hill. 2. Soutas-Little R., Inman D.J.: Engineering Mechanics. Dynamics. Prentice Hall

Level of competence	Ability, in M1 and M2.
Skills achieved	Proficiency in applying equations of equilibrium for solving simple statically determinate problems. Ability of applying principles of dynamics for the analysis of motion of particles and rigid bodies.

7. MECHANICS OF MATERIALS *	6.5-8.5 credit points
Course contents	
MM1. *Internal forces in simple structural elements.* **1.** The concept of an internal force and its diagram**.** Normal forces in struts subjected to axial loads. Diagrams of normal forces in struts**.** Twisting moments in shafts subjected to torques. Diagrams of twisting moments in shafts. Bending moments in beams subjected to couples. Diagrams of bending moments in beams. Bending moments and shear forces in beams subjected to transverse loads: diagrams of bending moments and shear forces,	

* Elaborated in UBI, Covilha on the base of own experience as well as the syllabi from other 8 universities

differential relationships between bending moment, shear force and distributed load **2. Stresses and strains in simple structural elements:** The elementary concept of a stress and strain**.** Stresses and strains produced by axial tension or compression in straight elements. Stresses and strains in shafts. Stresses and strains in beams subjected to pure bending. Stresses and strains in beams of solid and thin-walled sections subjected to bending and shear. Stresses in elements subjected to eccentric loads and other combined actions **3. Stresses in connector:** Stresses in connecting bolts and rivets. Stresses in welded connections. **4. Deflection lines for beams:** Differential equation of deflection line. Solution of the differential equation of deflection line. Direct integration method. Finite difference method **5. Plane state of stress and strain:** Review of cases where a plane state of stress and plane state of strain predominate. Transformation of plane stresses and strains. Principal values and principal directions for strains and stresses. Mohr's circle for stresses and strains. **6. 3-D state of stress and strain:** Differential equations of equilibrium for an infinitesimal internal part of a body. Equations of equilibrium for an infinitesimal boundary part of a body. Stresses on an oblique plane. Cauchy's stress tensor. Principal values and directions of the stress tensor. Mohr's circle for a 3D state of stress. Three dimensional state of strain. Infinitesimal stain tensor. Principal values and directions of the strain tensor. Compatibility equations**.** Strain energy. **7. Constitutive equations:** Various types of material behaviour**.** Material constants and their determination**.** Constitutive equations for isotropic materials. Constitutive equations for orthotropic materials. **8. Failure criteria for isotropic materials:** The onset of failure**.** Yield criteria: Huber-Mises-Hencky criterion. Tresca criterion. Fracture criterion of Coulomb- Mohr. **9. Stability of struts:** Stable and instable states of equilibrium**.** Stability of spring-rigid rod systems**.** Stability of elastic rods: Euler's formula. Geometrical and load imperfections. Generalization of the Euler formula. Stability of rods in elasto-plastic range **10. Introduction to design of simple structural elements:** Allowable stress versus limit states design philosophy. Dimensioning of simple structural elements (tension elements, shafts, beams and columns).	
Recommended textbooks for MM1: Beer F.P., Johnston E.R. Jr : Mechanics of Materials. Mc Graw Hill.	
Level of competence	Ability in MM.
Skills achieved	Proficiency in plotting diagrams of shear forces and bending moments in beams. Proficiency in calculating stresses and strains in struts and beams subjected to simple and combined actions. Proficiency in calculating displacements in beams. Ability to design a section of an element subjected to simple actions.

8. STRUCTURAL MECHANICS *	7.0-10.0 credit points
Course contents	

SM.1

1. Review of the basic concepts: Types of structures. Modelling of supports. Statical determinacy and indeterminacy. Kinematic stability and instability External actions—dead and live loads, change in temperature, settlements of supports. The concept of internal forces. Plotting the internal forces diagrams for statically determinate beams. **2. Displacements in statically determinate structures:** The Principle of Virtual Work for elastic bodies. Determination of the displacement of a point in a structure by the Principle of Virtual Work: Effect of external loads. Effect of change in temperature. Effect of support settlements. Determination of the deflected shapes of various structures. Deflected lines for beams (review of the material given by a Mechanics of Materials), Deflection of frames. Deflection of arches. Deflection of upper and lower chords of trusses. **3. Influence lines for statically determinate structures:** The concept of an influence line. Determination of the influence lines by the static method. Influence lines for beams. influence lines for frames. Influence lines for trusses. Influence lines for arches. **4. Static analysis of statically indeterminate structures:** Force method: basic concept of the method, application of the force method for the analysis of statically indeterminate trusses, beams, frames and arches. Displacement method: basic concept of the method, classical version of the method – application of the method for the analysis of statically indeterminate beams and frames. Matrix version of the method - application of the method for the analysis of statically indeterminate trusses, beams and frames. Moment distribution method: basic concepts of the method, iteration process for non-sway frames, iteration process for sway frames, effect of settlements of supports and changes in temperature. Frames with non-prismatic members.

SM.2

***5.* Displacements in statically indeterminate structures:** Determination of the linear displacements of points and angular displacements of sections: effect of external loads, effect of settlements of supports, effect of changes in temperature. Determination of the deflected shapes of structures: simple one-span beams, continuous beams, frames, trusses. **6. Influence lines for statically indeterminate structures:** Static approach: influence lines for one-span beams, influence lines for continuous beams, influence lines for frames, influence lines for trusses. Kinematic approach: influence lines for beams, influence lines for frames, influence lines for trusses. **7. Plastic analysis of structures.** Basic concepts: plastic moment of resistance,

* Elaborated in UBI, Covilha on the base of own experience as well as the syllabi from other 4 universities.

ultimate load and collapse mechanisms. Theorems of plastic collapse: static or lower bound theorem, kinematics or upper bound theorem, uniqueness theorem. Methods of plastic analysis: static method, method of mechanisms. **8. Stability of structures:** Stability criteria: energy criterion, stiffness criterion. Stability of simple systems with one degree of freedom: bifurcation of the equilibrium path, snap-troug phenomenon. Stability of complex struts: struts with complex support conditions, struts with stepped moments of inertia. Stability of plane frames: stability functions, numerical methods for determining the critical loads for frames. **9. Dynamics of structures:** Dynamics of SDOF systems: free vibrations, forced vibrations, response to harmonic loading, response to arbitrary loading, response to ground excitation. Dynamics of MDOF systems: free vibrations, forced vibrations. ***SM.3.*** **10 Plates and shells:** Thin plates subjected to in-plane loads. Bending of thin plates: internal forces and moments in thin plates, displacement-strain relations, equilibrium equations. Differential equation of deflected plate, some particular thin plate solutions. Basics of thin shell theory: internal forces and moments in thin shells, displacement - strain relations, equilibrium equations, some particular thin shell solutions. **11. Finite element method:** General idea of the method, Idealisation of structures. Analysis of two- dimensional elements: triangular element, rectangular element. Analysis of an entire structure: assembly of the structure stiffness matrix, determination of the nodal displacements and the element stresses.
Recommended books: 1. Chajes A.: STRUCTURAL ANALYSIS. Prentice Hall

Level of competence	Ability in SM.1, understanding in SM 2, recognition in SM 3
Skills achieved	Proficiency in calculation of inner forces as well as displacements in statically indeterminate structures, familiarity with numerical methods used in analysis of structures, knowledge of fundamentals of theory of plates and shells and of FEM.

9. FLUID MECHANICS AND HYDRAULICS *	4.5-6.5 credit points
Course contents	
FMH1. ***Fluids Mechanics***	
Basic principles. Properties of fluids. Hydrostatics. Pressure and its measurement. Forces on surfaces. Buoyancy and stability. Kinematics of	

* Based on syllabus from Aristotle University Thessaloniki and includes the topics from other 6 universities

fluids. Streamlines. Acceleration. Ideal fluids. Stream function and Potential. Bernoulli equation. Dynamics of real fluids. Mass conservation. Equations of momentum and energy. Navier-Stokes equations. Laminar and Turbulent flows. Characteristics of Turbulence and turbulence models. Friction losses. Laminar and turbulent flow in a pipe. Boundary layers.
FMH2. ***Hydraulics*** Steady flow in closed conduits. Friction losses. Moody diagram. Secondary losses. Energy and piezometric lines. Pipes in series. Parallel Pipes. Equivalent Pipe. Reservoirs and basic problems. Pumps and turbines. Siphons. Cavitatjon. Steady flow in open channels. Uniform flow. Manning's equation. Compound sections. Efficient hydraulic section. Specific energy and force. Critical depth. Control sections. Gradually varied flow. Profiles. Computations. Rapidly varied flow. Hydraulic jump. Jump in a horizontal bed. Location of jump. Weirs and orifices.
FMH3. ***Groundwater Hydraulics and Hydrology*** Darcy's law. Continuity equation. The mathematical model. Boundary conditions. Computations by means of the finite-difference method. Ditches and wells. Method of images. Infiltration force and the phenomenon of piping. Anisotropic and non-homogeneous aquifers. Analogue and physical models. Hydrologic cycle and balances. Measurement and analysis of precipitation and overland flow. Hydrologic parameters for engineering works. Floods and droughts. Simulation of watersheds.

Level of competence	Ability in FMH1, FMH2, FMH3.
Skills achieved	Proficiency in theory of Hydraulics and Fluid Mechanics

10. ENGINEERING SURVEYING *	4.0-6.0 credit points
Course contents	
S1. Principles Introduction. Units of measurement of geodetic parameters. Theory of errors. Concepts of the operation of classic and modern geodetic instruments. Geodetic instruments and methods for the measurement and computation of lengths, angles and height differences. Instruments and methods for the control of high structures. Systems of geodetic projections. Fundamental geodetic problems. Trigonometric determination of points. Polygonometric determination of points. Calibration, adjustment and maintenance of geodetic instruments	
S2. Geodesy Introduction. Surveying of small and big land areas. Digital terrain models. Surveying of buildings, monuments and archaeological sites. Area and volume	

* Based on the syllabus from Aristotle University Thessaloniki and includes the topics from other 6 universities

computations. Setting out of land properties and buildings. Setting out of roads and transportation works, tunnels and bridges. Setting out of port, hydraulic and drainage works. Setting out of dams. Cadastral and technical projects. Setting out of city plans. Expropriation and compulsory purchases. Recent developments in Geodesy.	
S3. Photogrametry and Geoinformation Systems Introduction. Fundamentals of mathematics and physics (for Photogrammetry). Stereoscopy, photography and other kinds of images. Photogrammetric takings, equipment, organisation. Photogrammetric instrumentation. Automated systems. Rectification, orthophotography, aerotriangulation. Close range, terrestrial, satellite and other kinds of Photogrammetry. Photogrammetry and digital terrain models, cartography. Geoinformatjon systems. Photogrammetry and Geoinformatjon systems (GIS). Photogrammetry and Remote Sensing. Applications.	
Level of competence	Understanding in S1, S2, S3
Skills achieved	Proficiency in capture and exploitation of the geographical information as well as in topographic and photogrammetric methods. Familiarity with the use of topographic instruments

11. BUILDING MATERIALS *	4.5-6.5 credit points
Course contents	
BM1. History of evolution of technology of building Materials. Criteria of the selection of building materials. Physicochemical, mechanical thermal and acoustic properties of materials. Quality control and standardization. Specifications. Stones. Classification mineralogical composition. Testing the properties of rocks. Marble. Causes of deterioration. Protection of stones and marble. Crushing of rocks. Aggregates. Origin, production, treatment. Properties of aggregate, sieve analysis. Specifications. Tests for suitability of aggregates for concrete and road construction. Modulus of elasticity of sand and fine aggregates. Ceramics. Raw materials, manufacture, ceramic bricks and roof tiles. Expanded clay - light aggregate for concrete. Properties. Binders. Classification, production, mechanisms of setting and hardening. Regulations. Lime. Sorel binder. Anhydrite Resins. Cement. Manufacture, mechanism of setting and hardening. Testing of properties of cement. Standards. Categories of cement. Mortars. Classification. Synthesis. Properties characteristics. Criteria for suitability of mortars. Specifications. Laboratory	

* Elaborated on the base of syllabi from Aristotle University Thessaloniki and includes the topics from other 6 universities

exercises: Sieve analysis of aggregates. Apparent specific density of coarse aggregate. Bulk density. Granulometric synthesis of aggregates. Measurement of fineness of cement by blaine: Manufacture and test of cement mortars.
BM2. Concrete. Categories of concrete. Binders. Aggregates. Properties of fresh concrete. Workability. Tests of workability of concrete. Ready mixed concrete. Design of concrete mixtures. Properties of hardened concrete, compressive, flexure, tensile and biaxial actions. Lightweight concrete materials. Concrete bond by pull out test. Composition. Applications.
BM3. Metallic building materials. Classification. Structure. Steel for reinforcement of concrete. Manufacture tests of steel quality. Corrosion of steel. Laboratory exercises: Design of concrete mixture. Manufacture of the designed concrete mixture. Testing of compressive and flexural strength measurement of steel. Stress strain curve and measurement of modulus of elasticity. Test of steel in tension. Yield point and ultimate elongation. Timber and manufactured boards – properties, durability, protection, products and their application. Thermal and acoustical insulating materials – properties, application. Bituminous materials: asphalt's, tars, mastics. Properties and application.

Level of competence	Ability in BM1, BM2 and BM3
Skills achieved	Good knowledge of basic building materials' properties and application

12. BUILDINGS *	3.5-4.5 credit points
Course contents	
BC1. System concept and performance applied to domestic, industrial and commercial buildings. Modular coordination in building construction. Basic concepts in building design. Functional process and space planning. Buildings presentation in technical drawings: scale and conventions. Actions on buildings. Loads: permanent loads, live loads, climatic loads. Seismic action. Agents acting on buildings.	
BC2. Design fundamentals. Design codes. Structural planning and typical solutions. Dimensioning methods for structural elements. Seismic analysis. Typical solutions for ductility enhancement.	
BC3. Building infrastructure: basements and foundations. Geotechnical conditions and foundations depth. Typical foundation solutions. Waterproofing of	

* Based on the syllabus from TUCE Bucharest and includes the topics from other 5 universities

basements and foundations. Buildings with cast-in-place and precast concrete structure: shear-wall structures and dual structures. Buildings with masonry structural walls: layout, materials. Buildings with frame structures. Seismic behaviour. Typical solutions. Principles of design. Structural solutions for concrete and steel floor plates. Principles of design. Arches, vaults, domes. Vertical transport: stairs, ramps. ***BC4*** Types of roofs. Roofing works. General characteristic of wood and wooden structures. Cold and warm roofs. Thermal insulation of roofs. Attics and roof lights. Rainwater discharge. Openings and shutters in structural and partitioning walls. Floors: tasks, layout. Floor finishing. Suspended ceilings Partitions walls. Plastering and walls finishing
BC5 Energy saving in the buildings. Thermal insulation of partitions. Water insulations. Hygrothermal comfort. Acoustical comfort and protection. Fire protection of buildings. Basic concepts for building services. Water supply, drainage and sanitary systems. Electromechanical installation. Heating systems.

Level of competence	Ability in BC3 and BC4. Understanding in BC1, BC2 and BC5.
Skills achieved	Conception of a building structure. Design components and requirements. Design coordination. Building project layout.

13. BASIS OF STRUCTURAL DESIGN *	3.5-5.5 credit points
Course contents	
***BSD1**. The course presents the role and objectives of structural design within a process of civil and building design as well as the general rules of structural design.* Designing as a creative human activity. Project elements: architectural project - structural project - sanitary systems - construction - cost calculation. Aims and parts of a structural design. Modelling of a structural bearing system in 3D space of a building. Basic information about bearing systems. Partition of a building into independent segments; dilatation. Three dimensional, plane and linear structural systems. Subdivision of a structural system into structural elements. Structural stability and stiffness with reference to different types of structures (reinforced concrete cast in situ and precast, steel,	

* Elaborated on the base of syllabi from Rzeszow and Gliwice

timber, masonry).	
BSD2. *The course regards to the theoretical basis of the reliable structural design.* General principles of structural design: basic requirements, limit state design. Uncertainties in the building process. Basic variables. Structural reliability analysis: geometrical and behavioural idealization of structures. Development of the structural reliability concepts: deterministic, semi-probabilistic (the Partial Factor Method), simplified probabilistic (Reliability Index Method), full probabilistic. Reliability measures. Models of structural loads: classification of loads, statistical parameters, methods of loads combination. Models of structural resistance: statistical parameters of materials and structural elements, references for models of resistance. Definitions of failure. Analytical, numerical integration and simulation methods in structural reliability and safety analysis. Reliability index: general, mean value, Hasofer-Lind. Uncorrelated and correlated basic random variables. Reliability analysis using simulation. Target values of reliability measures. Calibration of partial safety factors. Probabilistic design of structural elements and simple structures. National Standards and Euro-Codes. Examples of calculations.	
BSD3*. The course regards to structural systems reliability, special problems and advanced methods of structural reliability assessment.* Elements and systems reliability. Series, parallel and mixed systems. Reliability bounds for structural systems. Time-variant reliability methods: transfer into independent systems, out-crossing approach, spectral analysis. Design and assessment of deteriorating structures. Life-cycle probabilistic design. Testing based design. Illustrative examples. Development of reliability-based design codes: European standards. Human errors: classification, error surveys, approach to errors. Advanced versions of simulation procedures. Stochastic Finite Element Method – brief introduction.	
Level of competence	Ability in BSD1, Understanding in BSD2, Recognition in BSD3
Skills achieved	Proficiency in the knowledge of the behaviour of the most habitual structures as well as familiarity with the methods of conventional analysis.

14. ENGINEERING GEOLOGY *	3.0-4.0 credit points
Course contents	
G1. The course provides an introduction to fundamentals of Geology. The Earth zones. Geological processes of internal and external origin. Absolute and relative age of rocks. Geological time table. Tectonic	

* Elaborated on the base of syllabi from Riga, Aristotle University Thessaloniki, Cantabria and NTUA Athens

movements of Earth crust. Folding and faulting. Earthquakes. Seismic zoning and micro zoning. Weathering. Geological activities of wind. Eolian deposits. Water erosion. Sheet erosion. Gullies. Geological work of rivers. Alluvial deposits Glaciers. Glacial till, fluvioglacial and limnoglacial deposits. Coastal environment, marine erosion and deposition. Longshore drift. Swamps. Peat depositions. Origin of subsurface water. Aquifers, aquicludes. Ground water, capillary fringe, perched water, confined water. Water aggressiveness. Groundwater regime. Groundwater motion. Darcy's law. Determination of the coefficient of permeability. Inflow to foundation pits, trenches and wells. Geological activities of groundwater: karst, piping, landslides, frost heave. Rock-falls, talus, creep. Man-made geological process.	
G2. *Geology and Geotechnics* Engineering geological and geotechnical investigations. Engineering geology and geotechnics. Geotechnical problems in design. Engineering geological conditions of building site. Geotechnical design requirements of Eurocode. Geotechnical supervision. Field exploration: boring, sampling. In situ tests: cone penetration tests, standard penetration test, dynamic propping test, pressure meter test, field vane tests, plate loading test etc. Geophysical methods of investigation.	
G3. *The course includes the study of advanced problems in engineering geology.* Aspects of dam geology. Geology and tunnelling. Geology and surface excavations. Case studies of failures of civil constructions due to geological factors. Aspects of Environmental Engineering Geology. Practical exercises- Engineering applications.	
Level of competence	Understanding in G1, G2, Recognition in G3.
Skills achieved	Proficiency in application of geology to civil engineering problems as well as familiarity with geological fundamentals.

15. SOIL MECHANICS AND GEOTECHNICAL ENGINEERING *	5.5-7.5 credit points
Course contents	
SMG1. ***Geotechnics*** Soil and Rock identification. Soil classification (including geotechnical categories). Nature, physical and mechanical properties of soil. Ground water – appearance and phenomenon connected with it. Properties of dry and saturated soil. Laboratory and in-situ tests. Basic soil models. Bearing capacity of soils and foundations. Allowable pressure. Limit states. Stress distribution in the subsoil (total and effective stresses). Theory of consolidation and rheology of soil. Soil settlements. Slope stability.	

* Based on the syllabus from Gliwice and includes the topics from other 7 universities

SMG1. ***Foundations*** Definitions, models and types of foundations. Limit states. Partial safety factors (Eurocode 7). Shallow foundations (including design). Deep foundations (especially pile foundations, including design). Excavations and protecting deep excavations. Dewatering of excavations.
SMG3. *Special foundations and ground improvement techniques* ***Special Foundations*** **-** Wells and caissons. Diaphragm walls. Retaining structures. Structures of reinforced soil. ***Ground Improvement Techniques*** **-** Surface strengthening (mechanically stabilization, binder sealing), soil replacement, static and dynamic compaction, vibro systems (vibrocompaction, stone columns), grouting, micropiles, jet grouting method, vertical wick drains, lightweight fill materials, geotextiles, slope stability: anchoring, nailing.
SMG4. *Advanced problems in geotechnics* Geotechnical problems in environmental protection. Seismic and para-seismic influences on soil behaviour. Numerical soil models.

Bibliography:

[1] Atkinson J.H., Bransby P.L. (1978): The mechanics of soil. An introduction to critical state soil mechanics. McGHRAW-HILL Book Company (UK) Limited, London, New York, St Louis, San Francisco, Auckland, Bogota, Düsseldorf, Johannesburg, Madrit, Mexico, Montreal, New Delhi, Panama, Paris, São Paulo, Singapore, Sydney, Tokyo, Toronto.
[2] Foundation Engineering Handbook Edited by Hans F. Winterkorn and Hsai-Yang Fang (1975). Van Nostrand Reinhold Company, New York, Cincinnati, Toronto, London, Melbourne.
[3] Head K.H. (1992): Manual of soil laboratory testing. Volume 1, Soil classification and compaction tests. Volume 2, Permeability, shear strength and compressibility tests. Volume 3, Effective stress tests. Second Edition. Halsted Press: an Imprint of JOHN WILEY & SONS, INC. New York – Toronto.

Level of competence	Ability in SMG1 and SMG2, Understanding in SMG3, Recognition in SMG4.
Skills achieved	Proficiency in basic knowledge on identification and classification of soil and ability in designing shallow and deep foundations, familiarity with the knowledge of advanced problems in geotechnics such seismic and para-seismic activity, numerical soil models and application of Finite Elements Method in geotechnics.

16. STRUCTURAL CONCRETE *	6.0-9.0 credit points

Course contents

RC1. ***The course regards to the design of RC beams, one way slabs and columns, comprising the dimensioning rules under bending, shear and torsion (beams) as well as simultaneous action of bending, and axial force (columns) with regard to ultimate load and serviceability limit states.***

Concept and idea of concrete reinforcement. Historical background. Material properties - concrete and steel. General characteristic of RC design principles

(limit state approach), EC2 and national version. Design of beams(rectangular and T section) with regard to ultimate load limit state under bending, shear and torsion. Single- and multi-span one-way slabs and beams. Design of columns subjected to axial force and bending. Compression: general rules, slenderness and stability. Design with regard to ultimate load limit state for rectangular section. M-N interaction diagrams. Confined columns. Tension: design with regard to ultimate load limit state for rectangular section. Limit states of serviceability - deflection of RC beams, cracking in reinforced concrete.

RC2.*The course regards to principals of RC elements design. These principals will be presented at simple and popular in constructional practice elements such as floor structures (beam-and-slab, flat slab), stairs, frames, and retaining walls.*

Beam-and-slab floors. Two-way slabs: calculation in elastic stadium and by critical load method; reinforcement distribution. Reinforced concrete stairs. Reinforced concrete frame structures. Approximate methods of frame analysis under vertical and horizontal load. Computational methods of frame analysis. Reinforcing rules for frame structures. Reinforced concrete spot footings and strip foundations. Spot footings for pre-cast columns. Retaining walls: calculation and rules of reinforcing.

RC3. *The course regards to principals of pre-stressed concrete.*

Concept of pre-stressing of structural concrete members. Materials and techniques for pre-stressed concrete. High strength concrete and steel for pre-stressing. Pre-tensioning and post-tensioning techniques. Losses of pre-stressing force – short time and long term effects. Basic assumptions and procedures for design of prestressed concrete members subjected to bending for serviceability limit state and ultimate limit state methods Verification of limit states in prestressed members.

* Based on the syllabus from Gliwice and includes the topics from other 6 universities

RC4.
Brief presentation of advanced reinforced concrete and pre-stressed structures proving the possibilities and advantages of structural concrete.

Level of competence	Ability in RC1 and RC2, Understanding in RC3, Recognition in RC4.
Skills achieved	Proficiency in calculation of reinforcement and loading capacity of beams, slabs and columns subjected to bending moment, shear and axial force as well as familiarity with reinforcing rules for elements discussed within RC2.

17. STEEL STRUCTURES *	5.0-7.0 credit points
Course contents	
SS1. ***The course regards to the design of SS beams, slabs and columns, comprising the dimensioning rules under bending, shear and torsion as well as simultaneous action of bending, and axial force with regard to ultimate load and serviceability limit states.*** Concept and idea of steel structures. Historical background. Materials (material properties, ductility, fracture toughness, production tolerances design, values of material coefficient). Basis of design (Principles of limit states design, design actions, design resistance, design codes, environmental influences).Structural analysis (structural modelling, global and local structural analysis, imperfections, material and geometrical non-linearity, elastic and plastic global analysis, cross section classification). Limit state evaluation. Resistance of cross sections (tension, compression, shear and bending resistance of members, torsion, combination of basic resistances). Buckling resistance of members (uniform compression members, built-up compression members, lateral- torsional buckling of beams). Buckling of plates (column type buckling behaviour, single plate elements with longitudinal stiffeners, resistance to shear, resistance to transfer loads, interactions of shear force, bending moment and axial force on web stability). Design of joints (welded connections, bolts, rivets, pins, analysis and modelling). Beams. Trusses. Design and detailing of beams and trusses' joints and nodes. Fragile breaking and fatigue. Laboratory-practices in welding, flexion, buckling, screws and extensometers.	

* Elaborated on the base of syllabi from Pardubice and Rzeszow

SS2. *The course regards to principles of popular SS design.* Types of steel structures, industrial structures and buildings. General arrangement and analysis of structural system. Modelling of structures. Space rigidity of steel structures Evaluation of internal forces. Design of multi-storey buildings. Roofs. Roof trusses, Flooring systems. Design of column base plates. Design particularities of crane girders. Tubular constructions. Structural details and their static models, application of computer technique. Design for fire. Design particularities of prestressed girders. Fabrication of steel structures. Erection. Corrosion protection.	
SS3. *The course regards to principles of advanced SS design.* Steel bridges: Types of bridges (railroads bridges, highways, bridges). Structural detailing (Deck plates, main girders). Plate girders truss bridges, arch, suspended and cable-stayed bridges. Introduction to the design of bridges. Cold-formed steel structures: corrugated steel sheets, thin-walled structural elements - design rules and application. Aluminium and stainless steel as structural materials, basis of design, EC9 approach, implementation. Design of multi-storey buildings. Industrial steel structures: tanks for oil and water, containers for granular materials (bins and silos), steel lattice towers and guyed masts, steel chimneys, steel and composite bridges. Strengthening of steel structures.	
SS4. Brief presentation of advanced steel structures proving the possibilities and advantages of steel structures.	
Level of competence	Ability in SS1 Understanding in SS3 and SS3, Recognition in SS4.
Skills achieved	Proficiency in calculation of loading capacity of beams, slabs and columns subjected to bending moment, shear and axial force as well as familiarity with design rules for elements, ability to utilize theirs knowledge in building praxis.

18. TIMBER – MASONRY – COMPOSITE STRUCTURES *	3.0-4.0 credit points
Course contents	
TMC1**.** ***Timber structures.*** Wood as a building material. Timber in construction. Solid timber, glued laminated timber, wood-based materials. Material properties. Limit states and design situations – design requirements, ultimate limit states, and serviceability limit states. Stress-strain relations. Calculation models. Tension, compression, bending, shear, torsion, combined bending and axial	

* Elaborated on the base of syllabi from Brno, Pardubice, Zilina, Gliwice and Vilnius

tension, combined bending and axial compression. Columns and beams. Trusses – general analysis, trusses with punched metal plate fasteners. Roof and floor diaphragms. Bracing of beam or truss systems. Joints – timber-to-timber joints, steel-to-timber joints, joints made with punched metal plate fasteners. Structural detailing and control. Structural systems – plane frames and arches, timber frame houses, timber concrete composite structures, round-wood structures, spatial frames and domes.
TMC2. *Masonry structures* The course regards to the design of widely comprehended un-reinforced masonry structures in addition to simplified cases of masonry walls and columns subjected to compressive loads acted with eccentricity, in-plane bending walls and walls subjected to lateral loads. Materials for masonry structures. Specific of design and workmanship of masonry structures. Influence of some factors on mechanical properties of masonry. Theoretical model of failure of masonry elements under compression (Hilsdorf criterion). Mechanical properties of masonry: σ - ε relationship, compressive strength, bending strength, shear strength, modulus of elasticity, shear modulus, deformation of masonry (non-dilatational strain angle). Design masonry elements under compressive loads. Design of external walls subjected to lateral loads. Reinforced and prestressed masonry. Masonry arches.
TMC3. *Composite structures* Steel-concrete composite structures: slabs, beams, columns, beam-columns - design and application. Timber-concrete composite structures. Concrete-masonry structures: floor structures, walls and columns.

Level of competence	Ability in TMC1, TMC2 and in TMC3
Skills achieved	Proficiency in calculation and familiarity with basic rules of design of timber, masonry and composite structural elements,.

19. TRANSPORTATION INFRASTRUCTURE *	3.5-4.5 credit points
Course contents	
T1. *The course regards to the design* to principals *of transportation engineering* Traffic engineering documentation, planning process in transportation engineering. Methodology, types and census organisation. Traffic forecast. Public transport. Network, Integrated Transport Systems. Traffic accidents. Reasons, statistical evaluation, arrangements to accident risk decreasing. Capacity calculation of the roads and intersections. Traffic management Provision/encouragement of non-motorised traffic modes (cycling, pedestrians). Introduction to the transport prognosis	

* Based on the syllabus from Pardubice and includes the topics from other 7 universities

T2. *The course regards to principals of* railway lines. Railway construction history and development of railway lines. Main characteristic of rail types. Principles of track and construction design. The basis of organisation and protection of railway traffic. Alignment of lines inside and outside towns. Solution of interconnections, switch junctions and embranchments, renovation of railway substructure and superstructure, reconstruction and maintenance of rail tracks. Principles of drainage of a line and a station Mechanisation used in track works in railway superstructure and substructure, diagnostics of geometric track position
T3. *The course regards of* road, road constructions and urban planning: Road user and vehicle characteristics. Road junctions - non-signalised, traffic signals, roundabouts, multilevel junctions. Introduction to the traffic flow theory.. Highway and roads planning and location. Basic design principles. Environmental protection measures in road construction process. Categorisation of the roads and highways. Traditional and modern sub-base construction components. Soil improvement and stabilisation. Mechanization of earth work. Technology of construction of typical subgrade. Earth work designing. Construction of road surfaces. Elements of pavement design: materials, types, analysis. Methods and equipment of pavement construction. Roads and streets dewatering. Basis of building organization, management and planning. Investment processes, Costs and design. Maintenance works. Modern materials and technologies used in roads maintenance.

Level of competence	Ability in T1 Understanding in T2 and T3.
Skills achieved	The students should achieve the skills in designing and evaluation of road route and road construction, transport system in towns, urban traffic, urban road network, traffic flow theory, organisation of traffic.

20. URBAN AND REGIONAL INFRASTRUCTURE *	2.5-3.5 credit points
Course contents	
UP1*. The course provides a comprehensive introduction to the urban and regional science.* City and Urbanism: conceptual aspects. History and models of urban development. Principles and theories of urban structure and regional organization. Social, economic and environmental context in which planning issues arise.	
UP2.*The course focus on theories, methods and techniques of Urban and Regional Planning.*	

* Based on the syllabi from Cantabria and Aristotle University Thessaloniki

Theoretical underpinnings of past and contemporary approaches to planning. Institutional context and legal framework within which planning operates. Types of plans: Regional, master and site plans. Planning process: How to formulate & implement Plans. Planning Analysis: Database systems, information resources, elements and techniques. Discovering and exploring alternatives. Urban design problems and methods. Instruments for urban and regional management.	
***UP3**. The course regards to principals of infrastructures, community facilities and services.* Types of infrastructure systems (water, sewer, storm water, solid waste and transportation) and facilities (parks, schools, libraries, police, fire…). Standards to meet citizens´ needs. Location criteria.	
***UP4**. The course approaches aspects of professional planning practice.* The course includes a report and the completion of a dissertation by groups related to a planning project.	
Level of competence	Ability in UP1 and UP2, Understanding in UP3, Recognition in UP4.
Skills achieved	Proficiency in conceptual framework, analysis and planning methods as well as familiarity with graphic expression techniques and urban design.

21. WATER STRUCTURES AND WATER MANAGEMENT *	3.0-4.0 credit points
Course contents	
WS1. ***Introduction into Hydraulic engineering*****.** Introduction, circulation of water, definitions. Precipitation, evaporation, discharge. Analysis of discharge measurements, design flood. Design flood, catchment area. Ecology of surface water bodies. River training. Hydraulic constructions on rivers. Flood protection and hydropower (overview). Ships and waterway channels. Navigational structures. Locks. Ports. Coastal engineering. Legal foundations of water related projects. Preparation of examination	
WS2. *Introduction into hydrology, ecology of surface water bodies, river training, coastal engineering (overview), waterway channels, locks (overview).* Introduction, circulation of water, definitions. Precipitation, evaporation, discharge. Evaluation of discharge measurements, design flood. Appraisal of design flood, catchment area, SCS-equations. Appraisal of discharge, when precipitation is known. Ecology of surface water bodies, valuation systems for the ecological status. Open channel hydraulics, sediment transport. Design and realisation of River training. Design and construction of weirs and dams.	

* Elaborated on the base of syllabi from Oldenburg, Prague and other 5 universities

Design and construction of outlets, inlets, culverts. Flood protection (overview), drainage. Navigational structures (overview). Coastal engineering (overview). Legal foundations of water related projects.
WS3. *Water Structures.* Water Supply and Structures for Water Supply, Waste Water Treatment and Structures. Stream – channel Regulation and Revitalization. Irrigation and Drainage. Ponds, Water Reservoirs, Dams. Hydro Power – Low and High Head Water Power Plants. Weirs and Navigation.
WS4. *Water Management.* Water Balance, Water Resources and their Protection. Legal Foundation in Water management and Planning.

Level of competence	Understanding in WS1,WS2, WS3, Recognition in WS4
Skills achieved	Proficiency in the design of water structures as well as familiarity with water management techniques.

22. CONSTRUCTION TECHNOLOGY AND ORGANISATION [*]	4.5-6.5 credit points
Course contents	
CTO1. *Construction Technology* Characteristic of building production. Principles of building processes design. Comprehensive mechanization. Machinery and equipment used in building. Technology of building transport, materials handling, long-distance transport, horizontal transport, vertical transport. Technology of earth work, land leveling, excavations, backfilling, compaction of earth works. Technology of concrete and reinforcing works. Technology of assembling, selection of assembling equipment, types of lifting sling, technology of assembling of basic structural elements. Economic means and their sources. Basic principles of accountancy. Specific attributes of building accountancy. Fillings of enterprise activity. Finance accountancy and analysis of account of results. Analysis of enterprise activity and evaluation of finance situation. Application of finance activity in recording of economic operation.	
CTO2. *Organization and Management* Essentiality of network method. CPM method. Building graphic schedules. Basic principles of site organization. Methods of organization of the site (deterministic approach). Progress of the site-work management. Compensation of perturbations in building engineering processes. Principles of design of site planning. Elements of design of site road access. Designing of stockyards. Equipment on the site. Designing: Selected elements of designing of organization and site planning (for small and not complicated	

[*] Based on the syllabus from Bialystok and includes the topics from other 4 universities.

building project). Network design according to CPM method; analysis of network dependence time; basic building time schedules; conceptual lay-out of the building site. Basic organizational structures of building engineering tasks and processes. Methodology of technology and organization processes designing. Formulation of criteria and methods of selection of building processes models.	
***CTO3**. Organization and Management* Time-costs analysis of building engineering tasks. Methods of selection of equipment and production plants. Problems and methods in designing of interior transport roads. Conditions for storing of basic building materials. Deterministic evaluation of building materials reserves. Methodology in determining of surfaces and front of storage area. Location of production plant and material back-up on the site. Bases of optimal realization of building processes Formulation of extreme tasks in building engineering processes. Criteria, decisive variables and limitations in formulation of tasks. Classifications of optimization problems and methods their solving. Transportation problems as the task of linear programming. Methods of solving in non-linear tasks from Kuhn-Tucker's conditions. Problems of building processes optimization in assumptions of theory of random variable function , application in tasks of theory of mass service. Problems of optimization of graphic schedules - realization of construction works on lots in operational sequence ensuring the shortest construction period.	
Level of competence	Ability in CTO1 and CTO2, Understanding in CTO3
Skills achieved	Proficiency in calculation and scheduling of different resources needed for a building process and familiarity with building technology and technological order of main construction works.

23. ECONOMICS AND MANAGEMENT *	5.0-7.0 credit points
Course contents	
***EM1.** Building Economics* *Building cost calculations - resource cost:* Management and control. Estimate cost. Tendering planning. Calculation of unit rates. Calculation of preliminary and temporary works. Cost classification. Cost monitoring and cost control on site. Cost analysis. Estimate of profit, risk, and inflation. Economics, human and resources. Investment policy.	
Finance resources of investments: Working capital. Credits and save deposits. Performance efficiency. Planning methods of building works.	

* Elaborated on the base of syllabi from Gliwice, Prague other 4 universities.

Building - invest market. Building contractor - organisation form commercial activity: Structure, function of building construction company. Investment analysis. Introduction to marketing. Participants of investment process: investor, contractor, bank, designer, etc. *Licence and duties*: architect, surveyor, and site manager. Planning methods of building works. Hardware and software and their practical application within organisations. Schedules networks. Business presentations using various software packages for work processing, financial mobility databases spreadsheet, graphics and project management packages. Aims of: business, invest, investment. Establishment and its connections with market of: work, outlet, equipment, capital, human environment. Project and cost documentation of investment. Processing dimension and types of building process. Assignation conditions, methods and manners making building process. Estimate resources to realising process. Assignation orders and times to realise building process. Production and market planning. Building marketing. Market strategy. Cost counting. Supply and demand. Function of the invest -building market. Procurement studies - alternative tendering/ contractual arrangements. Application and consideration - case studies. Function and format of procedure systems, tendering and contractual arrangement. Financial control of pre and post contract. Valuation of progress and the variations in work. Application of computer software in the administration	
EM2. *Project Management* Management of life cycle of construction projects. Analysis of project phases. Types of construction contracts. General Conditions of Construction Contracts including Design/Build. Principles of estimating. Time scheduling. Cost control. Contruction Operations Manual - policies and procedures. Contract documents management. Project engineering. Controlling	
EM3. *Special Topics of Construction Management* Preparing bids for international projects and general approach to international constructing. Risk management systems for construction projects. Management of equipment and other capital investment. Procurement in construction firm and projects, Information technologies for project management.	
EM4. *Management of Construction Firms*: Strategic corporate management, organizational strategy, business management, company operations handbook, corporate financing, financial analysis and performance benchmarking, management accounting and internal market, capital investment, controlling, auditing, valuation of firms, crisis management, litigation and claiming.	
Level of competence	Ability in EM1 Understanding in EM2, Recognition in EM3 and EM4.
Skills achieved	Proficiency in project planning, project

	management, familiarity with management basis of construction firms

24. ENVIRONMENTAL ENGINEERING *	3.5-4.5 credit points
Course contents	
EE1. *Ecology*. Environment, biosphere, natural resources. Elements of ecology: ecosystems, symbiotic and antagonistic relationship, ecological niche, biocenosis and biotop. The turnover of materials and energy in ecosystems. Point and non-point sources of pollutants. Fate of pollutants in environment. Effects caused by environmental pollutants in various ecosystems. Acidification and eutrophication of terrestrial and aquatic ecosystems. The essence of critical load approach. Toxicology, uptake of toxic pollutants, effects in individuals and ecosystems. Technical means for improving environmental quality. Air cleaning methods. Wastewater treatment practice. Solid waste, sources and categories. Handling of solid waste. Environmental monitoring, main aim and objectives. Implementation of environmental monitoring. Subprogrammes of integrated monitoring. Physical pollution: ionizing and non-ionizing electromagnetic radiation, noise, vibrations and thermal pollution. Effects on humans and means of protection from physical pollution. How much the environment should be improved? Value of our environment. Policy instruments used for reduction of environmental pollution. International environmental programmes.	
EE2. *Soil, air and water pollution*. Pollution sources (point, non-point sources), air pollution, soil contamination.	
EE3 *Waste treatment, remediation*. Waste water treatment, methods of sludge treatment, dumping, incineration, composting, wetlands. Toxicology. Policy instruments for reduction of environmental pollution.	
EE4. *Basic information about building services*. Water supply. Heating. Sewage systems. Air condition systems. Wiring.	
Level of competence	Recognition in EE1, Understanding in EE2, EE3, EE4.
Skills achieved	Understanding of the basic environmental processes, soil, air and water pollution and treatment methods. Familiarity with basic ecological principles and functions. Familiarity of building services.

* Based on the syllabi from Prague and Vilnius with additional part EE4.

25. NON-TECHNICAL SUBJECTS	5.0-7.0 credit points
Course contents	
NT1. **English language**	
NT2. *Building Law* Building law in National and European Law System. Terminology used in building law. Principle of design, construction and maintenance accordance with regulations. Rights in disposing of real estate for building purposes. Protection of individual interest in Building Law. Building technical regulations and principles of building technical knowledge. Proceeding principles of administrative building engineering supervision and technical architectural management. Conditions in obtaining permission for construction. Construction and operational commissioning of building. Exploitation of buildings. Building catastrophe. Individual technical function in building engineering - amenability to law and technical.	
NT3. *History of Civil Engineering and Architecture* Beginning of civil engineering and architecture in prehistoric and ancient age. Ancient Greek and Rome. Early Christian and Medieval C.E. and Architecture. Renaissance, Baroque and Rococo. C.E. and Architecture from 19th and beginning 20th century. Contemporary C.E and Architecture.	
NT4. *Aesthetics. The aim of the course is to define the object and content of aesthetics as a field of science. To learn how to find and perceive beauty by the way of cultural heritage.* Aesthetics as a field of science about beauty and art; object and tasks of aesthetics, aesthetic categories; categories of aesthetics, aesthetic experience. 2. Prehistoric art. 3. Ancient art. 4. Art of Middle Ages. 5. Renaissance art. 6. Art of Baroque and Rococo. 7. Art of Classicism. 8. - 9. Art forms of the 19th century. 10. – 11. Art forms of the 20th century. 12. National Art.	
NT4. *Ethics* The course is focused on acquisition of the fundamentals of ethics. It seeks to understand morality as a social phenomenon, its origin, development and role in society. Basic human values and social norms. It also examines many dimensions of the term "meaning of life". An analysis of interpersonal relationships in contemporary society is also included.	
NT5. *Philosophy* The aim of this subject is to provide the students with a survey of cardinal problems of individual philosophical disciplines (ontology, epistemology, philosophical logic, methodology, philosophical anthropology, social philosophy, aesthetics, axiology and ethics). The intention is a transfer of problems solved in the range of history of philosophy to modern language and updating of the demand of clear explications of fundamental scientific categories as an inevitable condition for a reasonable dialogue between sciences (physics) and philosophy.	

NT6. *Psychology* This course aims to give the student knowledge on the object, system, content, goal and development of psychology with an accent on academic psychology. To explain some basic conceptions and categories. General psychology offers knowledge which can be used as a foundation for extended psychological themes.	
NT7. *Economics* Market, its' equilibrium, elasticity, costs and profits differentiation, perfect competition, calculation of gross national product, money demand and supply, regulation of exchange rates, prices stabilisation means. Object of economics science in market conditions. Behaviour and market consumer. Costs and profits. Competition, its model and economic effect. National product and its calculation. Cyclic fluctuations. Fiscal policy. Money, banks and monetary policy. Inflation and economic stabilisation. Currency courses and the international financial system.	
Level of competence	Ability in NT1, Understanding in NT2, Recognition in at least one from among NT3-NT7.
Skills achieved	General Education

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[3] MANOLIU Iacint et al. (editor): **Inquiries into European Higher Education in Civil Engineering. EUCEET volumes 1, 2, 3 & 4**, Bucharest, 2001, 2003.

[4] MANOLIU Iacint (editor): ***Challenges to the Civil Engineering Profession in Europe at the beginning of the third millennium.*** Proceedings of the EUCEET-ECCE International Conference, Sinaia, Romania, 13-17 July 2001, EUCEET volume 2, Bucharest, 2002.

[5] Permanent Conference of University Professors of Building Physics: **MEMORANDUM on teaching of Building Physics for Universities and Scientific Colleges,** Bauphysik, 21 (1999), issue 4, p 171-175.

Appendix 1

List of the SP1 group

No	Name/Surname	University	City	Country
1	BARANSKI Wojciech	Technical University of Lodz	Lodz	Poland
2	BERKOWSKI Piotr	Technical University of Wroclaw	Wroclaw	Poland
3	BREABAN Virgil	Ovidius University Constantza	Constantza	Romania
4	BUGNARIU Tudor	Technical University of Civil Eng.Bucharest	Bucharest	Romania
5	COKCA Erdal	Middle East Techn. University Ankara	Ankara	Turkey
6	DICKY Josef	Slovak Univ. of Technology	Bratislava	Slovak Rep.
7	ESPINO Manuel	Technical University of Catalonia	Barcelona	Spain
8	FANNING Paul	University of Dublin	Dublin	Ireland
9	JUTILA Aarne	Helsinki University of Technology	Espoo	Finland
10	KLEMCZAK Barbara	Silesian University of Technology	Gliwice	Poland
11	KOWALCZYK Ryszard	University of Beira Interior	Covilha	Portugal
12	KURAZ Vaclav	Czech Technical University Prague	Prague	Czech Rep.
13	LAPKO Andrzej	Technical University of Bialystok	Bialystok	Poland
14	LAUR Toomas	Tallin Technical University	Tallin	Estonia
15	LERAU Jacues	Inst. National des Sciences. Appliqueés INSA	Toulouse	France
16	LINHARTOWA Yveta	University of Pardubice	Pardubice	Czech Rep.
17	LOVAS Antal	Budapest Univ. of Techn. and Economics	Budapest	Hungary
18	MAJEWSKI Stanislaw **(chairman)**	Silesian University of Technology	Gliwice	Poland
19	MANOLIU Iacint	Technical Univ. of Civil Eng. Bucharest	Bucharest	Romania
20	MATERNA Alois	Technical University of Ostrava	Ostrava	Czech Rep.
21	NOGUES LINARES Soledad	Technical University of Cantabria	Cantabria	Spain
22	PAPANICOLAU Panos	University of Tessaly		Greece
23	PRETORIAN Alexandrina	Technical Univ. of Civil Eng. Bucharest	Bucharest	Romania
24	SERTLER Hynek	University of Pardubice	Pardubice	Czech Rep.
25	SMIRNOVS Juris	University of Riga	Riga	Latvia
26	STEPANEK Petr	University of Technology Brno	Brno	Czech Rep.
27	STRAGYS Vincentas	Vilnius Gediminas University	Vilnius	Lithuania
28	THIMUS Jean Francois	Catholic University of Louvain	Louvain	Belgium
29	VELLANDO Pablo	University of La Coruna	La Coruna	Spain
30	VILA Xavier Sanchez	Technical University of Catalunya	Barcelona	Spain
31	WOLINSKI Szczepan	Technical University of Rzeszow	Rzeszow	Poland

Weighted Average Algorithm

The average value of credits for the core subjects was calculated according to the following algorithm:

1. In the first iteration the wage coefficients are assumed as $w_i = 1$.
2. The average value is calculated with assumed wage coefficients $c_{sr} = \sum_{i=1}^{n} w_i c_i \left(\sum_{i=1}^{n} w_i \right)^{-1}$
3. For every data the deviation c_i is calculated as $\Delta_i = |c_i - c_{śr}|$
4. New wage coefficients are calculated in dependence on the above deviation from the formula: $w_i = b^{-\Delta_i / c_{sr}}$.
5. Return to point 2.

The variation of average values for selected subjects is presented in figure 1. Quick convergence towards the weighted average can be observed. The coefficient *b* effects only on the rate of the convergence without any influence on the final average value.

The algorithm effectively eliminates these data, which strongly differ from the average value. Let us observe, that in the subsequent iterations we don't remove any results only correct the wage coefficients, adjusting them to their deviation from the average value.

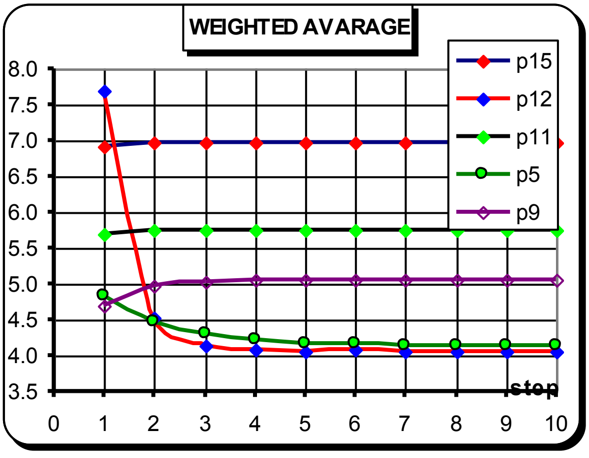


Figure 1. Variation of weighted average in the subsequent steps of iteration.

The calculations were carried out in the following Excel spread sheet.

iter	c_1	c_i	c_n	$c_{sr}=\sum_{i=1}^{n} w_i c_i \left(\sum_{i=1}^{n} w_i\right)^{-1}$
1		$\Delta_{i,1}=\left\|c_i-c_{\acute{s}r}\right\|$		
		$w_{i,1}=b^{-\Delta_{i,1}/c_{sr}}$		$\sum_{i=1}^{n} w_{i,1}$
		$c_{i,1}=w_{i,1}c_i\left(\sum_{i=1}^{n} w_{i,1}\right)^{-1}$		$c_{sr,1}=\sum_{i=1}^{n} w_{i,1}c_{i,1}\left(\sum_{i=1}^{n} w_{i,1}\right)^{-1}$
2		$\Delta_{i,2}=\left\|c_i-c_{\acute{s}r,1}\right\|$		
		$w_{i,2}=b^{-\Delta_{i,2}/c_{sr,1}}$		$\sum_{i=1}^{n} w_{i,2}$
		$c_{i,2}=w_{i,2}c_i\left(\sum_{i=1}^{n} w_{i,2}\right)^{-1}$		$c_{sr,2}=\sum_{i=1}^{n} w_{i,2}c_{i,2}\left(\sum_{i=1}^{n} w_{i,2}\right)^{-1}$
k		$\Delta_{i,k}=\left\|c_i-c_{\acute{s}r,k-1}\right\|$		
		$w_{i,k}=b^{-\Delta_{i,2}/c_{sr,k-1}}$		$\sum_{i=1}^{n} w_{i,k}$
		$c_{i,k}=w_{i,k}c_{i,k}\left(\sum_{i=1}^{n} w_{i,k}\right)^{-1}$		$c_{sr,k}=\sum_{i=1}^{n} w_{i,k}c_{i,k}\left(\sum_{i=1}^{n} w_{i,k}\right)^{-1}$

Report of the
Working Group for the
Specific Project 2

Practical placements as part of the civil engineering curricula

PRACTICAL PLACEMENTS AS PART OF THE CIVIL ENGINEERING CURRICULA

Antal LOVAS[1]

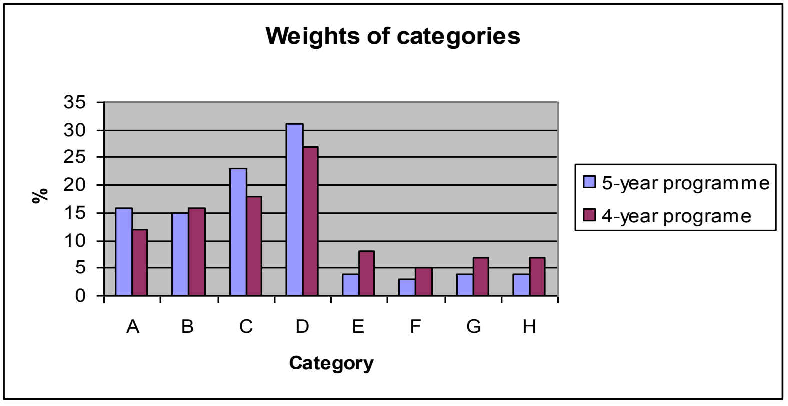
1. OBJECTIVES OF THE SPECIFIC PROJECT SP2

In the Glossary joining the first EUCEET questionnaire „About Civil Engineering Education at Undergraduate Level in Europe" is given the following definition of the practical placement or fieldwork: "*Period of several weeks to months spent by students working at a construction company, design office, research institute or other organization outside the normal university environment*".

The second EUCEET questionnaire contained the assignment of the course units to categories A to H, as follows:

A: Basic Sciences,
B: Engineering Sciences
C: Core Civil Engineering Subjects
D: Engineering Specialisation
E: Economics and Management Subjects
F: Humanities, Social Sciences, Languages and Physical Education
G: Fieldwork
H: Final project

The relative weights of each category as of the total contact hours were presented and can be seen in the figure below:



In the 5-year programme and in the 4-year programme the category G reached 4% and 7% respectively. It is important to know that this category has

[1] Chairman of the WG for SP 2
Professor, Dean of Faculty of Civil Engineering, Budapest University of Technology and Economics, Hungary

higher percentage in the shorter programme.

Note, that fieldwork is not always present in the curricula. Some institutions from DE, ES, FI, FR, GR, IT, PT did not assign any compulsory or optional fieldwork.

Certainly, the lack of data is caused by the incompleteness of the answers and in some cases fieldwork was allocated to another category. Probably the data set doesn't include the longer and "real practical placements"; it only contains some day long fieldwork such as Geodesy Fieldwork, Hydraulic Fieldwork etc. organised by university staff.

In summary, the curricula in 22 European countries show a great diversity of disciplines and corresponding contact hours.

The EUCEET database expresses the situation in the academic year 1998-99. Due to the Bologna Declaration a lot of change was done during the past 4-5 years.

The initial objective of the Task Force SP2 is to gather a survey on the civil engineering curricula focusing on the practical placements and fieldworks. The main goal is to define the role of the practical placements in the curricula.

2. WORKING METHODS

First of all, it was created a questionnaire in order to get the updated information from all institutions by e-mail, as follows:

Dear EUCEET Member,

please fill this short SP2 Questionnaire in English, change the INSTITUTION in the file name to the name of your institution and send back to Prof. A. LOVAS via email until 29th of May 2004 the latest. E-mail address: alovas@mail.bme.hu

Glossary for the SP2 Questionnaire:

FIELDWORK: period of several days to weeks spent by the student working in laboratory, or field generally organised by the institution mainly in summer period. PRACTICAL PLACEMENT: period of several weeks to months spent by the student working at a construction company, design office, research institute or other organisation out of the normal university environment.

GENERAL INFORMATION	
Name of the Institution	
City	
Country	
Contact person	
E-mail of the contact person	

Date of fulfillment			
STUDY INFORMATION			
Formal duration	years		
Total number of ECTS credits	credits		
Total number of contact hours	hours		
Entry number of students 2002/03	students		
FIELDWORK			
Total number of contact hours	hours		
Total number of ECTS credits	credits		
Name of the course unit/total contact hours/credits			
1. Course unit		hours	credits
2. Course unit		hours	credits
3. Course unit		hours	credits
4. Course unit		hours	credits
i. Course unit		hours	credits
PRACTICAL PLACEMENT			
Total number of days	days		
Total number of ECTS credits	credits		
Name of the course unit/number of days/credits			
1. Course unit		days	credits
i. Course unit		days	credits

If you organize practical placement, please share your experience and any useful information:

1. How do you define the role of the course?
2. Is the practical placement compulsory or can it be replaced by university subjects?
3. Who chooses the workplace; the student or the tutor?
4. What is the typical size of the company?
5. What is the typical profile of the company; construction or design?
6. Is the typical company domestic or foreign?
7. What motivates the companies to employ students?
8. Is there a particular industrial tutor?
9. Do the students and tutors get compensation for their works?
10. Does the student write a report or a study about the practical placement?
11. How is the student's practical placement accepted and marked?
12. What are the shortcomings and weaknesses of this kind of course?
13. Any other useful information are also appreciated

3. OUTCOMES

43 answers were received:

- BE University of Liege
- BE University Catholic of Leuven
- CH Swiss Federal Institute of Technology
- CZ Czech Technical University in Prague
- EE Tallinn Technical University
- ES University of Cantabria
- ES Universitat Politechnica de Catalunya, Barcelona
- ES University of Coruna
- ES University of Castilla La Mancha
- DE Technical University of Berlin
- DE Technical University of Darmstadt
- DE Technical University of Dresden
- DE Technical University of Munich
- DE FH Oldenburg, University of Applied Sciences
- DK The Engineering College of Odense
- FI Helsinki University of Technology
- FR University of Marseille
- FR ENPC Paris
- FR INSA Lyon
- GR University of Patras
- GR National Technical University of Athens
- GR Technological Educational Institution of Piraeus
- HU Budapest University of Technology and Economics
- IT Politecnico di Torino
- IT Politecnico di Milano
- LT Technical University of Vilnius
- LV Technical University of Riga
- NL Delft University of Technology
- NO Norwegian University of Science and Technology Trondheim
- PL Bialystok Technical University
- PL Silesian University of Technology Gliwice
- PL Technical University of Lodz
- PL Technical University of Szczecin
- PT University of Beira Interior Covilha
- PT Technical University of Lisbon
- PT University of Porto
- RO Technical University of Civil Engineering Bucharest
- RO Technical University of Timisoara
- SK Technical University of Bratislava
- TR Istanbul University
- UK City University of London

- UK Imperial College of Science, Technology and Medicine London
- UK Heriot-Watt University Edinburgh

The answers were shared between the partners, comments or corrections were appreciated. There was a very strong connection with SP1, therefore no SP2 meetings were organized. Between the SP1 Task Force Meetings and the Management Committee Meetings the communication was done via e-mails.

4. SUMMARY OF THE ANSWERS

The received datasheets in table format can be found in the annex, at the end of this report. As a conclusion, the edited version of the given answers is summarized below.

How do you define the role of the course?

It's very important part of the curricula. The practical placement is very useful, sometimes necessary for students to find professional direction. It is the first contact with construction industry. The students will get familiar with the practical side of the construction works; it is a good opportunity to give professional experience to the students before their graduation.

Is the practical placement compulsory or can it be replaced by university subjects?

In most cases it is compulsory and it can't be replaced by other subjects. When it is not compulsory, in some curricula it can be replaced by one-semester project.

Who chooses the workplace: the student or the tutor?

The student chooses the workplace with the approval of the professor. The student chooses from a list of companies contacted by the university. Sometimes, the tutor decides if the practical placement is organized by the faculty.

What is the typical size of the company?

It varies in large scale from small consultant firms to international construction companies.

What is the typical profile of the company; construction or design?

All types of companies are involved.

Is the typical company domestic or foreign?

Both, but mainly domestic. The foreign students work in their home countries during their summer vacation.

0 What motivates the companies to employ students?

The students are the potential future staff members of the companies. The companies are able to choose from the students considering their skills. Most companies aim to support the universities in training the students.

Is there a particular industrial tutor?

Generally not, officially the company manager is the tutor, but practically one of the experienced engineers is the actual one.

Do the students and tutors get compensation for their works?

Most of the students are paid and insured by the companies. Generally there is no compensation for the tutor.

Does the student write a report or a study about the practical placement?

Yes, the students have to write a report or study and fill a questionnaire after the internship.

How is the student's practical placement accepted and marked?

It is based on the written report, sometimes a presentation is also required or the final mark is discussed by the tutor and the representative of the company. Sometimes it is not marked, only accepted by the universities.

What are the shortcomings and weaknesses of this kind of course?

Sometimes the students have difficulties finding a job. There are difficulties to check the students working in site. This kind of courses can be easily organized only if the number of the students is small. It needs a lot of work for the university people to list the potential companies.

Any other useful information are also appreciated:

There is considerable evidence that practical placements during a course improve the eventual student performance. The practical placement in foreign countries would be very productive and beneficial for the students. Year by year the practical placements become more popular.

5. COMMENTS

The SP2 Task Force produced a survey of the present situation and gave suggestions about the role of the practical placements for the new European Civil Engineering Curricula.

The total process for the formation of a professional civil engineer must include education, training and practice. Facilities should exist for all civil engineering students to have periods of industrial training or work experience during their academic course. These courses introduce students to industrial practices and increase student motivation during the academic parts of the programme.

If possible, such training should be integrated with the academic studies. The “sandwich-type” courses were very popular to the university, to the industry and to the students when first introduced, but organizing this type of courses became sometimes unrealistic.

Generally, it becomes increasingly difficult to find enough training places for the students in most countries, especially in Central and Eastern Europe, where the large state-controlled construction companies and design offices were divided on many parts. In small and medium sized companies the student might “shadow” one engineer in his work.

Summer practical placements or one-semester-long trainings of students are useful only if taken seriously by both parties. Therefore we need a strong cooperation between academia and industry.

6. CONCLUSIONS

Universities alone can educate engineers, but to form engineers, universities must co-operate with industry. Close co-operation between academia and industry is required.

The total formation process for a professional civil engineer must include education, training and practice. Training should be integrated with the academic studies. They also tend to increase the motivation of students for engineering studies. However, there can be major difficulties in obtaining a sufficient number of training placements.

National governments should be aware of their responsibilities for improving the provision of industrial training places and they can greatly aid the situation by: providing training grants to industrial companies and/or providing incentives to industry in the form of tax allowances for training.

No.	Part.	Participant organisations	Formal duration ys/cr	Fieldwork	1. Course unit	Practical placement	1. Course unit
			Total contact hours	*Contact hours*	*2. Course unit*	*Days*	*2. Course unit*
		Location	*Entry number of stds*	*ECTS credits*	*3. Course unit*	*ECTS credits*	*3. Course unit*
1	No 1	ENPC Paris	3years/300credits		Project 1st year 20h/2cr		Practical pl.I. 30d/0cr
		Ecole Nation. des Ponts et Chaussées	1800hours	20hours		230-510days	Pr.pl.II. 60-340d/10-60cr
		FR PARIS	104students	2credits		40-70credits	
2	No 2	University of Liege	5years/300credits				
		Universite de Liege	3336hours	120hours		72days	
		BE LIEGE	30students	0credit		22credits	
3	No 3	University Catholic of Leuven	5years/300credits				Industrial pl. 100days
		Katholieke Universiteit Leuven	hours	0hour		20days	
		BE LEUVEN	students	0credit		3credits	
4	No 6	The Engineering College of Odense	3,5years/210credits		Surveying 5hours/0,2cr		Industrial pl. 20days/3cr
		Ingeniorhojskolen Odense Teknikum	3000hours	5hours	Costruction materials 10h	100days	
		DK ODENSE	100students	0,2credit	Geotechnical 44hours	30credits	
5	No 8	Technical University of Dresden	5years/300credits		Advenced topics 40h/5cr		
		Technische Universitat Dresden	3000hours	40hours	Project /25cr	60days	
		DE DRESDEN	180students	30credits		0credit	
6	No 9	Technical University of Darmstadt	5years/292credits				
		Technische Universitat Darmstadt	3080hours	0hour		60days	
		DE DARMSTADT	158students	0credit		0credit	
7	No 10	Technical University of Berlin	5years		Surveying 88hours		
		Technische Universitat Berlin	4000hours	30hours	Costruction materials 10h	90days	
		DE BERLIN	60students		Geotechnical 44hours		
8	No 11	Technical University of Munich	5years/280,5credits		Surveying 30hours/2cr		
		Technische Universitat München	2730hours	30hours		60days	
		DE MÜNCHEN	131students	2credits		0credit	
9	No 13	Univ. of Applied Sciences Oldenburg	4years/240credits		Advenced topics 40h/5cr		Practical pl.I. 90d/30cr
		Fachhochschule Oldenburg	3360hours	0hour	Project /25cr	180days	Practical pl.II. 90d/30cr
		DE OLDENBURG	150students	0credit		60credits	
10	No 16	University of Patras	5years/300credits				
		Panepistimio Patron	2790hours	0hour		0day	
		GR PATRAS	230students	0credit		0credit	
11	No 17	National Technical University of Athens	5years/300credits		Surveying 20hours/3cr		Technical Appl. 30d/2cr
		National Technical University of Athens	3280hours	20hours		30days	
		GR ATHENS	313students	3credits		2credits	
12	No 23	Techn. Educational Inst. of Piraeus	3,5years/4150credits				Working as designer 90d
		Technological Institut in Piraeus	4500hours	300hours		180days	Working as contract. 90d
		GR ATHENS	250students	0credit		0credit	

No.	Part.	Participant organisations	Formal duration ys/cr	Fieldwork	1. Course unit	Practical placement	1. Course unit
			Total contact hours	Contact hours	2. Course unit	Days	2. Course unit
		Location	Entry number of stds	ECTS credits	3. Course unit	ECTS credits	3. Course unit
13	No 25	University Politechnics Cataluna	5years/300credits				Optional Practical pl.
		Universitat Politecéchnica de Cataluna	4130hours			66days	
		ES BARCELONA	175students			9,5credits	
14	No 27	University of Castilla La Mancha	5years/300credits		Land surveying 60h/0cr		Practical pl. 60days/6cr
		Universidad de Castilla-La Mancha	3800hours	50hours	Geotech.ical 60hours/0cr	60days	
		ES CIUDAD REAL	50students	4credits		6credits	
15	No 28	University of Cantabria	5years/316credits		Optional fw. 20h/1,6cr		Practical pl. I. 20days/8cr
		Universidad de Cantabria	3950hours	50hours	Optional fw. 30h/2,4cr	50days	Practical pl. I I. 30d/12cr
		ES SANTANDER	125students	4credits		20credits	
16	No 31	University of Coruna	5years/300credits				Industrial pl. 15days
		Universidad de Coruna	4200hours			45days	
		ES LA CORUNA	100students			4credits	
17	No 34	INSA Lyon	5years/300credits		Surveying 24hours/1.5cr		Training I. 20-50d/2,5cr
		Inst. National des Sci. Appl. de Lyon	4500hours	24hours		100-150days	Training II. 80-100d/15cr
		FR LYON	120students	1,5credits		17,5credits	
18	No 35	University of Marseille	1year/60credits		Buildings proj. 120h/3cr		
		Inst. Sup. du Beton Arme ESIM	1506hours	400hours	Bridges 120hours/3cr	90days	
		FR MARSEILLE CEDEX 20	26students	11credits	CE structures 120h/3cr	21credits	
19	No 44	Politechnic of Torino	3years/60credits				
		Politecnico di Torino	1800hours			32days	
		IT TORINO	242students			10credits	
20	No 51	Politechnic of Milano	3years/60credits				
		Politecnico di Milano	1800hours			30-60days	
		IT MILANO	200students			10credits	
21	No 52	Delft University of Techology	5years/300credits				
		Technische Universiteit Delft	3500hours			40days	
		NL DELFT	150students			11credits	
22	No 55	University of Porto	5years/300credits				
		Universidade de Porto	3500hours	0hour		0day	
		PT PORTO	239students	0credit		0credit	
23	No 60	Technical University of Lisboa	5years/300credits				
		Instituto Superior Tecnico Lisboa	3675hours			0day	
		PT LISBOA	200students			0credit	
24	No 61	University of Beira Interior					
		Universidade de Beira Interior				0day	
		PT COVILHA				0credit	

No.	Part.	Participant organisations Location	Formal duration ys/cr Total contact hours Entry number of stds	Fieldwork Contact hours ECTS credits	1. Course unit 2. Course unit 3. Course unit	Practical placement Days ECTS credits	1. Course unit 2. Course unit 3. Course unit
36	No 101	Technical University of Lodz	5years/300credits		Geodesy 60hours/6cr		Constr. pl. I. 15days/0cr
		Politechnika Lodzka	3600hours	120hours	Soil Mech. 60h/3cr	40days	Constr. pl. II. 25days/0cr
		PL LODZ	150students	0credit		0credit	
37	No 107	Silesian University of Technology	4years/240credits				Practical pl. 84days/20cr
		Politechnika Slaska	2680hours	0hour		84days	
		PL GLIWICE	240students	0credit		20credits	
38	No 109	Bialystok Technical University	3,5years/210credits		Land surveying 60h/0cr		Industrial pl. 15days
		Politechnika Bialostocka	1900hours	160hours	Geotechn. 60hours/0cr	21days	
		PL BIALYSTOK	320students	0credit		0credit	
39	No 111	Tech. Univ. of Civil Eng. Bucharest	5years/300credits		Surveying 90hours/3cr		Practical pl. 30days/5cr
		Univ. Tehnica de Constructii Bucuresti	3640hours	90hours		30days	
		RO BUCHAREST	225students	6credits		5credits	
40	No 112	Technical University of Timisoara	5years/300credits		Surveying 90hours/4cr		Surveying 15days/4cr
		Universitatea Politehnica din Timisoara	3776hours	360hours	Pract.l act. I.-II 180h/8cr	60days	Practical act. I.-II 30d/8cr
		RO TIMISOARA	750students	16credits	Pract.l act. I.-II 180h/8cr	16credits	Practical act. III. 15d/4cr
41	No 126	Technical University of Bratislava	5years/300credits				Surveying 5days/1cr
		Slovenská Techn. Univ. v Bratislave	3280hours			15days	Special. pl. 10days/2cr
		SK BRATISLAVA				3credits	
42	No 131	Istanbul University Dept. Of CE	4years		Topogr.42hours/2.5cr		Industrial pl. 45days
		Istanbul University Dept. Of CE	4480hours	42hours		70days	Office pl. 25days
		TR ISTANBUL	65students	4credits		0credit	
43		Swiss Federal Institute of Technology	4,5years				Industrial pl. 30days
		Swiss Federal Institute of Technology	6720hours			30days	
		CH Lausanne	60students			2credits	

Report of the
Working Group for the
Specific Project 3

Environmental and sustainable development matters in civil engineering education

ENVIRONMENTAL AND SUSTAINABLE DEVELOPMENT MATTERS IN CIVIL ENGINEERING EDUCATION

Peter Ruge[1]

1. INTRODUCTION

"Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs."

This is a fundamental objective under the Treaty on European Union (Art. 2) and the Constitution. It is an overarching concept which underpins all Union policies, actions and strategies in order to achieve a correct balance between

Environment
Society
Economy

The thinking on environmental issues has progressed from end-of-pipe treatment (e.g., waste water treatment), to pollution prevention (waste reduction, recycling) to pro-active design for the environment (e.g., replacing toxic raw materials with environment-friendly compounds) and finally to sustainable development (Mihelcic et al., 2003[20]). This is a progression that does not imply that more recent concepts and approaches are necessarily better, but rather that each stage is appropriate depending on the scale and the complexity of the problem at hand. The present report presupposes this understanding and hence uses the term sustainable development in a manner that encompasses environmental engineering.

In 2005, the Commission of the European Communities confirmed the relevance of its core strategic objectives of prosperity, solidarity and security to sustainable development. The EU first set out its commitment to sustainable development in June 2001. At this time the Gothenburg European Council adopted the EU Sustainable Development Strategy (SDS) on the basis of a Commission Communication, see Appendix [A]. In 2002, the Commission presented a second Communication focussing on the external dimension of sustainable development, which was endorsed by the European Council in Barcelona. These texts together form the basis of the comprehensive EU Sustainable Development Strategy. The Commission has committed to review the Strategy at the start of each new Commissions term in office.

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This will be done in the course of 2005 on the basis of experience over the past four years. The revised Sustainable Development Strategy will need to adopt a broader approach highlighting the structural changes in the economy needed to move towards more sustainable production and consumption patterns and covering unsustainable trends. With a further strengthening of the new approach to policymaking, the revised strategy will reaffirm its three dimensional (prosperity, solidarity and security) approach and also ensure the full integration and reinforcement of the external aspects of sustainable development. It will furthermore confirm the commitment made in the proposal on the financial perspectives 2007-2013 that sustainable development will be a guiding principle for EU policies.

In the 2005 review the Union's approach to sustainable development is described. Some aspects are:

Investing in science and technology

Advances in knowledge and technological progress are key to achieving a balance between economic growth and social and environmental sustainability. There are many synergies to exploit between innovation for quality and performance and innovation to optimise energy use, waste and safety. More energy-efficient machines, for example, consume fewer natural resources and lead to lower emissions.

Investments in new technology will also create jobs and growth. EU action in this field includes the sustainable development activities of the 6th Framework Programme for Research and Technology Development. The Environmental Technologies Action Plan promotes technology platforms on hydrogen and fuel cells, photovoltaics, sustainable chemistry, water supply and sanitation. The EU is also supporting the development of technologies having an impact on our social systems, for example, healthcare systems.

Communicating and mobilising citizens and business

Civil society and the private sector play important roles in sustainable development. Several initiatives have been taken at EU level to encourage active involvement of these groups, and to improve the consultation processes and the mobilisation of stakeholders. Among other things the Commission has adopted minimum standards for stakeholder consultation and improved information on and participation in environmental decision making. It has also taken various initiatives to promote Corporate Social Responsibility.

Management of natural resources

Rapid global population growth means that by 2010 there will already be 400 million more people on Earth compared to now, essentially located in urban areas. In a world of growing \interdependence" we cannot continue to produce and consume as we are doing today. Bio-diversity is under threat. Worldwide, there are 15 500 species of plants and animals which face a high risk of extinction. Recent decades have already seen very significant losses in virtually all types of eco-systems and species (animals, plants, forests, fresh water, fertile land, etc). Fresh water is another precious natural resource under pressure.

Overall, the global water crisis threatens lives, sustainable development and ultimately peace and security.

In the period from 2000-2006, the European Union is also deploying large amount of money from the Structural and Cohesion Funds to co-finance investments in favour of environmental infrastructures and the rehabilitation and maintenance of industrial, urban and natural sites. International initiatives include the EU Water Initiative \Water for Life" - as a follow up to the World Summit on Sustainable Development. The EU is also taking a leading role both in the Convention on Biodiversity and in the work to establish a ten-year framework of programmes on sustainable consumption and production.

Land use and transport

Despite the aim to decouple transport from GDP growth, the volume of transport continues to rise faster than GDP. This has impacts in a variety of areas, ranging from traffic congestion and health problems caused by air pollutants, to increased CO2 emissions affecting the EUs targets on climate change. The EU has initiated a number of policy initiatives to limit the negative effects of this trend in the growth in transport. It encourages a shift from road transport to modes with lower environmental impacts, such as clean buses, shipping and rail. The Commission has also proposed that Member States introduce infrastructure charging to influence transport demand, by moving towards a situation where prices paid by transport users reflect the full costs to society (e.g. the Euro vignette directive), but implementation remains limited. Moreover, significant progress, albeit offset by increase in demand and volume of transport, has been made in vehicle and fuel technology, driven by EU legislation and initiatives. Finally, actions are being pursued to improve the urban environment and land-use management, for example through the EU Structural Funds programme "Urban II" and the Research Framework Programme.

The Commission is also preparing a Thematic Strategy on the Urban Environment which is due to be published in 2005.

2. CIVIL ENGINEERING AND SUSTAINABLE DEVELOPMENT

Obviously, sustainable development touches on almost every sector of society and thus presents new challenges to the role of engineers. Especially the role of civil engineers is touched by this development because traditionally they care for the technology and means which make societies develop.

The aim of the specific project 3 (SP3) is to make a contribution in promoting education on matters of sustainable development (SD) and environmental engineering (EE) in Europe and to discuss the position of civil engineers in these fields.

The active members of the working group:

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tried to achieve an overview of the many contributions from governments (national and supernational), bodies, non-governmental organisations, engineering councils, universities, conferences and similar sources.

We agreed to produce a report showing typical efforts in Europe in order to incorporate environmental and sustainable development matters in civil engineering education.

Consequently, our report contains much information. All courses, websites etc. mentioned are only a collection from a huge number of sources. These are not being recommended or endorsed; the only aim is to show what exists.

In a keynote paper, A.D. Cortese [5] summarizes the contribution of civil engineers to modern life:

Civil engineers played a critical role in increasing the health and quality of life in the last decades.

From developing better water supplies, municipal sewer systems, wastewater treatment plants to the design of buildings to protect us from natural hazards and provide health care, to improved agriculture through water resource development and distribution projects to rapid and dramatic changes in transportation systems, civil engineers have developed the basic infrastructure on which modern society depends.

Civil engineers were the first engineers and continue to be dedicated to technology development for the common good and the general public.

Our work has helped reducing the death rate dramatically which is one of the principal reasons that population has been able to grow so dramatically in the last 150 years. And in addition, the improvements in transportation alone have enabled rapid migration of large numbers of people all over the world and increased the volume of raw materials and finished products in international trade 800 times compared to the last century. Economic output has increased over 20 times, fossil fuel 30 times and industrial production 100 times compared to the last century.

Along with this growth has come some undesirable environmental, health and social impacts, particularly in the last half century: the population of the world has more than doubled to the current level of 5.9 billion people and the world's economic output has increased fivefold.

This unprecedented growth is altering the face of the earth and the composition of the atmosphere. Pollution of air and water, accumulation of *wastes, destruction of forests, erosion of soils, depletion of fishery and damage to the stratospheric ozone layer threaten the survival of humans and thousands of other living species. Humans are conducting an uncontrolled experiment unprecedented in scope and scale that represents the reversal of the natural evolution which produced clean air and water and increasingly complex and diverse ecosystems; systems which made human evolution possible.*

These changes, a result of unsustainable and inequitable patterns of production and consumption, are likely to accelerate with the addition of 81 million people to the planet earth each year.

These trends prompted a UN conference on Environment and Development in Rio in 1992 from which emerged a declaration of action, Agenda 21, and some treaties and conventions to move society on a sustainable path. Scientists around the globe, including 102 Nobel laureates, signed the World Scientists' Warning to Humanity in 1992, which reads in parts:

Human beings and the natural environment are on a collision course. Human activities iflict harsh and often irreversible damage on the environment and on critical resources. If not checked, many of our current practices put at serious risk the future that we wish for human society and the plant and animal kingdoms, and may so alter the living world that it will be unable to sustain life in the manner that we know. Fundamental changes are urgent if we are to avoid the collision our present course will bring about.

However, despite these warnings all Earth's living systems have continued to decline:

Current strategies to meet human needs are not sustainable. Eighty percent of the world's resources are being consumed by 20 percent of the world's population. For 30 percent of the world's population, poor sanitation, malnutrition and air pollution are still the major causes of illness and death. The rural poor will increasingly migrate and be transformed into an urban poor, and environmental health and social problems will multiply.

There is increasing social and political instability worldwide despite the end of the Cold War or perhaps because of it. In addition, there is a worldwide migration due to the increased globalization of the economy.

Obviously we have a societal problem caused by today's economic and social system which lives off its support system in a degrading, unhealthy and unsustainable manner.

We will need a paradigm shift in the relationship of humans to the environment and each other. It seems of that we can not achieve these results with our current thinking. Significant problems in a system cannot be solved at the same level of thinking we were at when we created them.

However, we are fixed in an old way of thinking: The current ideology of growth has captured our imagination to the degree that we continue to believe that more of the same resource intensive and pollution creating economic growth remains the best way to serve the common good. In principle, the earth and all its living organisms supply all raw materials for human activities. All *economic, social and community systems derive resources from, and are a part of, the biophysical system we call the bioshere.*

There is no inherent conflict between protecting the environment and a strong human economy since the environment is the support system for all human activity.

Nevertheless, new directions in the civil engineers' careers can be seen in search of a better understanding of technology-environment-socio-economic affairs and they are willing to merge their careers with areas of study which are complementary to classical fields of civil engineering.

Civil engineers become conscious that their role in society is changing:

from a construction engineer to a multi-field server who cares for a built world worth living in leaving as much space to nature as possible and using a minimum of natural resources.

Thus, aspects of planning, assessing, risk management, hazard, business, law, public health, policy and others should be added to classical curricula.

On the other hand, the tasks to be fulfilled in the construction sector continue to be of importance and are far from becoming smaller and simpler. Bridges and tunnels become longer, buildings higher, sound and vibrations are more and more important in living and production areas, constructions are set up in hazardous regions effected by earthquakes, tornados, flood disasters, mining etc.

Therefore we must ask if and how a civil engineer can be educated in such a way as to enable him/her to take the leadership role in this complex field.

The following report presents an overview on activities, reports, programs and information on sustainable development (SD) matters in general, and to education in civil engineering in particular.

- First a definition or description of SD will be given.
- Quotations devoted to SD and EE will be cited from literature.
- A summary will be given on websites dedicated to education in EE and SD issues in universities in Europe and institutions worldwide.
- Typical key reports on SD and EE published by civil engineering societies will be cited.
- Some examples will we presented on how teaching and learning activities in academic courses can be organized and evaluated.
- A catalogue of subjects will be created which seem to be important for EE and SD study programs. European and international programs concerning SD and EE will be reviewed in order to find needs for additional subjects in civil engineering curricula.

3. ENVIRONMENTAL ENGINEERING AND SUSTAINABLE DEVELOPMENT. DEFINITIONS, INTERPRETATIONS

3.1 Principles

Concerning the environment there seems to be a general agreement. However, sustainable development (SD) is a difficult concept to define; it is also continually evolving, which makes it doubly difficult to define.

Many governments, bodies and individuals have pondered on what SD means beyond a simple one-sentence definition. Some examples of theses are summarized in the next section.

The *Rio Declaration on Environment and Development* fleshes out the definition by listing 17 principles of sustainability.

- People are entitled to a healthy and productive life in harmony with nature.
- Development today must not undermine the development and environment needs of present and future generations.
- Nations have the sovereign right to exploit their own resources, but without causing environmental damage beyond their borders.
- Nations shall develop international laws to provide compensation for damage that activities under their control cause to areas beyond their borders.
- Nations shall use the precautionary approach to protect the environment. Where there are threats of serious or irreversible damage, scientific uncertainty shall not be used to postpone cost-effective measures to prevent environmental degradation.
- In order to achieve sustainable development, environmental protection shall constitute an integral part of the development process, and cannot be considered in isolation from it. Eradicating poverty and reducing disparities in living standards in different parts of the world are essential to achieve sustainable development and meet the needs of the majority of people.
- Nations shall cooperate to conserve, protect and restore the health and integrity of the Earth's ecosystem. The developed countries acknowledge the responsibility that they bear in the international pursuit of sustainable development in view of the pressures their societies place on the global environment and of the technologies and financial resources they command.
- Nations should reduce and eliminate unsustainable patterns of production and consumption, and promote appropriate demographic policies.
- Environmental issues are best handled with the participation of all concerned citizens. Nations shall facilitate and encourage public awareness and participation by making environmental information widely available.
- Nations shall enact effective environmental laws, and develop national law regarding liability for the victims of pollution and other environmental damage. Where they have authority, nations shall assess the environmental

impact of proposed activities that are likely to have a significant adverse impact.

- Nations should cooperate to promote an open international economic system that will lead to economic growth and sustainable development in all countries. Environmental policies should not be used as an unjustifiable means of restricting international trade.
- The polluter should, in principle, bear the cost of pollution.
- Nations shall warn one another of natural disasters or activities that may have harmful transboundary impacts.
- Sustainable development requires better scientific understanding of the problems. Nations should share knowledge and innovative technologies to achieve the goal of sustainability.
- The full participation of women is essential to achieve sustainable development. The creativity, ideals and courage of youth and the knowledge of indigenous people are needed too. Nations should recognize and support the identity, culture and interests of indigenous people.
- Warfare is inherently destructive of sustainable development, and Nations shall respect international laws protecting the environment in times of armed conflict, and shall cooperate in their further establishment.
- Peace, development and environmental protection are interdependent and indivisible.

3.2 Quotations from the literature

Brundtland report: [27]

A sustainable development is defined as the development that provides for the needs of the present generation without endangering the possibilities for future generations to provide for their needs.

Essex Report (Second Nature): [28]

In the next 20 to 40 years, society must adopt new strategies that allow the needs of an expanding population to be met in an environmentally sustainable and equitable manner. Higher education will play a critical role in determining whether we succeed or fail.

Designing a sustainable human future requires a paradigm shift towards a systemic perspective which encompasses the complex interdependence of individual, social, cultural, economic and political activities and the biosphere. This shift emphasizes collaboration and cooperation.

Sustainable development is not an ideology or religion.

Cortese: [5]

Environmental engineers will be the interdisciplinary, systems specialists who will bring together, coordinate and manage all the specialists to solve the complex environmental problems and promote sustainable development.

There is no inherent conflict between protecting the environment and a strong human economy since the environment is the support system for all human activity.

McDonough mentioned by Cortese: [5]

Waste is not simply an unwanted and sometimes harmful byproduct of life; it is a raw material out of place.

A sustainable economy would mirror nature's circular method of using matter and employ the concepts of design through which all waste would be food for another process.

UN: Outlook 2000: [21], [26]

Two over-riding trends characterise the beginning of the third millennium. First, the global ecosystem is threatened by grave imbalances in productivity and in the distribution of goods and services. A significant proportion of humanity still lives in dire poverty, and projected trends are for an increasing divergence between those that benefit from economic and technological development, and those that do not. This unsustainable progression of extremes of wealth and poverty threatens the stability of society as a whole, and with it the global environment.

Secondly, the world is undergoing accelerating change, with internationally coordinated environmental stewardship lagging behind economic and social development. Environmental gains from new technology and policies are being growth and economic development. The processes of globalisation that are so strongly influencing social evolution need to be directed towards resolving, rather than aggravating, the serious imbalances that divide the world today.

Travers: [24]

Engineers are seen as the problem and also as the solution to the environmental problems. Today they are pressured and encouraged to think and practice along the path of sustainable development, cleaner production, greener technology, ecological design, waste prevention and recycling, energy efficiency, resource conservation and environmental protection.

Smith; Biswas: [23]

The environmental engineering educational system must be vigilant to avoid the movement toward more and more practical and example driven teaching, which, because of limited classroom time, could lead to sacrifices in the study of fundamentals.

Latinopoulos: [17], [18]

For ages, numerous engineers were, and still are, too focused on the technical part of their work so that, although they know that they have a significant role to play, eventually they fail to fully understand their place in society.

Horkfiy: [10]

Under the pressure of more and more specialized advanced building technologies, civil engineering itself fragmented into a number of rather independent professions and lost its original close and integrating relation to Architecture and planning.

Angelides: [1]

Nowadays, environmental protection no longer constitutes only constraints, but also business opportunities for civil engineers. This trend is expected to continue into the future.

Phumpiu; Gustafsson: [22]

Civil engineering graduates foresee new directions in their careers in their search for better understanding of technology-environment-socio-economic and are willing to merge their careers with areas, which are not purely engineering specialities, rather areas associated to the carrying out and operation of technology.

ICE Council (UK): [6]

Sustainable development is now absolutely central to civil engineering and we must organize ourselves accordingly.

Students might come to see engineering as a more attractive option, and one which started to address more vividly their real world issues in a more balanced way.

Kunz; Levitt; Fischer: [16]

Sustainability is the ability of developers, users, communities and societies to continue engaging in current behaviours and practices, given predicted rates of change in the demographics, economic and social costs of resources, objectives of developers, the community and society, and the carrying capacities of ecosystems.

Without political, economic and social sustainability, the creations of civil engineers will fall into disuse, or worse, become hazardous to their occupants and stakeholders.

Civil engineering educators should teach leadership in sustainable development of the built environment using new integrated, multi-disciplinary computer-based virtual performance models.

Mangan; Doherty: [19]

Higher education institutions bear a profound moral responsibility to increase the awareness, knowledge, skills and values needed to create a just and sustainable society.

The development of education and training, which facilitates internalisation of the principles of sustainable development, is superior to traditional education. It provides the student with norms and values, which will guide decision-making along a sustainable path, rather than towards economic wealth only.

Most of us do not lack a philosophical commitment for sustainability, we lack the knowledge necessary to make decisions for sustainable actions. Therein lie some of the challenges for our academic and research institutions and our education systems.

4. KEY REPORTS

This chapter starts with a general view on SD published by Cortese and continues with actions which have been set into action by ECCE (European Council of Civil Engineers) and the Institution of Civil Engineers in UK.

4.1 General view on SD-education

In a conference on "Engineering Education and Training for Sustainable Development: Towards Improved Performance", Anthony D. Cortese gave a general view on Education in SD:

"Universities have departments while society has complex problems" he states and asks for a content of learning, that embraces an interdisciplinary, systemic approach to address environmentally sustainable development on local, regional and global scales over short-, medium- and inter-generational time periods.

All engineers must learn a number of concepts and skills in order to be prepared for a complex world to act in:

- Systems thinking
- Knowledge of how the natural world evolved and works
- Interdependence of humans and the environment, including relationship of population, consumption, culture, social equity, health and the environment.
- Knowledge of how to assess and minimize the ecological footprint of human economic activity.
- Technical, design, scientific and institutional strategies and techniques that foster sustainable development, promote energy and natural resource efficiency and conservation, mirror natural system resource use and recycling, remediate environmental problems, and preserve biological diversity.
- Social, cultural, legal, market and governmental frameworks for guiding sustainable development.
- Strategies to motivate environmentally just and sustainable behaviour by individuals and institutions.

4.2 ECCE-report

The European Council of Civil Engineers recently asked it's national members for short comments on "Environmental training within civil engineering education".

The results were published in 2005 under www.eccenet.org and are added here as Appendix D with some national supplements. Furthermore ECCE published an Ethical Commitment to Sustainable Civil Engineering added, too, as Appendix E.

Additional information for France prepared by the national council of engineers called "Conseil National des Ingenieurs et des Scientifiques de France" follows closely the European approach towards Sustainable

Development as can be seen by visiting "www.cnisf.org". Furthermore in June 2003 a ministerial conference on Sustainable Development adopted the European issues and set up a national strategy towards sustainable development; see "www.sd21000.org".

Some academic activities in Estonia are described in more detail in Appendix G.

In Spain significant activities of engineering bodies and the government are reported by the Universidad de Cantabria at Santander:

In 2002, the National Council of Civil Engineers (Colegio de Ingenieros de Caminos) set up the strategy on Civil Engineering activities and Sustainable Development (SD) by means of the so called Declaration of Mofrague (see Appendix J or www.ciccp.es).

The guiding principle of this Declaration is that the activities of civil engineers have to contribute to sustainable development. In the same way the Spanish Institute of Engineering (Instituto de la Ingeniera de Espa~na), pursues similar objectives establishing a general policy on the role of civil engineers in sustainable development. In this case, the Declaration of Spanish Engineering on Sustainable Development 2005 (see www.iies.es) includes an extensive discussion about the following aspects:

- The definition of SD in terms of economic, social and environmental sustainability.
- The principles of sustainability, that follow the Rio Declaration on Environment and Development.
- The application of those principles to civil engineering practice.

There are other documents (i.e. those of the Minister of Environment about strategies for the conservation and sustainable use of biodiversity, that can be seen in www.mma.es) related to some aspects of SD that involve similar concepts and, in some terms, are related to Civil Engineers activities.

The Barcelona Declaration (see Appendix K or www.congress.cimne.upc.es/eesd2004/frontal/default.asp) summarizes the work carried out during the international conference in Engineering Education and Sustainable Development (Barcelona, October 2004).

Details can be found in the website mentioned.

4.3 The Situation in the UK

4.3.1 Institution of Civil Engineers in UK

Professor Ian M. May from Heriot Watt University, Edinburgh, communicated results from the 2004 International Engineering Education Conference (EE 2004). In this conference, A. Crudgington and P. Jowitt [6] presented results of an ICE task group on **Sustainability in Education, Training and Continuous Professional Development**.

The Institution of Civil Engineers in UK (ICE) passed a resolution on sustainable development as a guiding principle:

"Sustainable development is now absolutely central to civil engineering and we must organise ourselves accordingly".

A task group was charged with addressing 7 key assertions:

1. Civil engineering (CE) is changing and needs to change more and Sustainable Development is at the heart of it.

2. CE is increasingly about managing complexity as opposed to things which are just complicated.

For example, finite element analysis is complicated, urban development is complex.

3. CE as practised is increasingly issues/process driven, not technique driven. Issues such as Quality of Life, EU Legislation Transport/Travel.

4. CE as taught has been largely driven by techniques and not by processes or issues.

5. If Sustainable Development (SD) is to be embedded into CE education then it needs

- to be generic
- to encourage a questioning of perceived wisdom
- to be open ended and encourage out of the-box-thinking.
- to be team focussed
- to embrace new approaches to learning and teaching.

6. Barriers to embedding SD in Engineering Education/Professional Formation include the traditional approach of the profession at large, most of whom are products of technique driven education and training.

7. The barriers are higher in Higher Education where different commercial/economic drivers compete eg. research deliverables vs teaching requirements.

These principles will be best met by a teaching and learning process that

- provides an interdisciplinary perspective on the problems that engineers will tackle in practice;
- develops an understanding of the interaction between engineering, the environment and society;
- develops an ability to use technical engineering knowledge to help solve complex problems

4.3.2 The UK approach to the introduction of Sustainable Development

This report, prepared by Prof. Ian May, too, describes the approach to Sustainable Development that it is expected will be adopted by UK Universities which are accredited by the Joint Board of Moderators (JBM). The JBM is responsible for accrediting civil and structural engineering degree courses, in UK Universities, for the Academic requirements for corporate membership of the Institution of Civil Engineers and the Institution of Structural Engineers. They issue a series of guidelines that can be found at http://www.jbm.org.uk. The three sets guidelines that are most relevant are the Guidelines for Design Learning [11], Guidelines for the Teaching of Health and Safety Risk Management Issues to Undergraduates [12] and The Guidelines for Sustainable Development Issues [13]. Much of this section is taken from the third of the above documents.

The guidelines for Design and Sustainable Development both encourage the use of team working and project working. For Sustainable Development "The JBM believes that Sustainable Development should be integrated into existing teaching and learning and ideally should be pervasive throughout the engineering education programme". There is an appreciation that Sustainable Development should include environmental societal and economic issues. This embedding of Sustainable Development is similar to the approach the JBM recommends for Health and Safety Risk Management. The guidelines imply that Sustainable Development should be more than just the transfer of a body of knowledge.

"It therefore requires that (...) degree courses for which accreditation is sought from the Joint Board of Moderators (JBM) are expected to contain elements which provide a good understanding of a broad range of inter-related social, economic and environmental issues. An understanding of how core technical skills can be utilised to deal with them should back up these elements. This will be best-achieved by a teaching and learning process that:

- Provides an interdisciplinary perspective on the problems that engineers will tackle in practice
- Develops an understanding of the interaction between engineering, the environment and society
- Develops an ability to use technical engineering knowledge to help solve complex problems as described above" [13].

As described above it is envisaged that Sustainable Development, as with Design, would form a thread running throughout the Undergraduate curriculum. The key aim should be to ensure that engineers have appropriate:

Attitudes, which include "an overarching approach to engineering problems in the context of environmental, economic and social issues, and other dimensions including ethics and environmental justice" [13].

Skills, for example the "ability to work with complex/ill-defined problems, team work and communication skills, and the ability to evaluate the merits and demerits of options/feasibility assessment" [13].

Knowledge, which would be both "broad and deep, of technical processes, the environment, social processes and the legal framework" [13].

However, it might be necessary to include lectures, particularly to cover some aspects of the knowledge requirement, and project work to develop attitudes and skills in the early part of the curriculum. This would give students some of the required tools that could then be used as, for example, a component of design to ensure that the particular proposed design was sustainable. Some suggestions are made elsewhere in the report to topics that could be covered in the early part of a civil engineering to degree to introduce students to sustainable development.

In a paper which gives some of the background to the JBM approach to Sustainable Development, Jowitt [15] draws parallels to design, where teaching by University staff is supplemented by input from practitioners. It was also recognised that there is often no right answer and that this can cause tensions within a system where there has been a tendency to set problems that lead to a uniquely definitive answer.

In the paper there is also discussion of the need to implement Sustainable Development within continuing professional development, CPD.

4.4 The Situation in new EU member state

A typical situation in one of the new EU member states is shown by describing academic activities in Estonia with respect to Environmental Engineering and Sustainable Development matters in education and training. Details of these activities are presented in Appendix G.

4.5 Essex-Report [28]

Profound ideas and proposals concerning principles and topics for higher education in SD are offered in the Essex-Report, held under the auspices of the President's Council on SD and sponsored by Second Nature, 1995 in Essex, Massachusetts:

Rather than being isolated in its own academic discipline, education in SD must become an integral part of the normal teaching in all the disciplines. This will avoid adding new requirements to already crowded curricula. Educated graduates must understand:

- how the natural world works;
- the interdependence of humans and the environment;
- how to assess the effects on humans and on the biosphere of human population dynamics; energy extraction, production and use; and other human activities such as agriculture, manufacturing, transportation, building and recreation;
- the relationship of population, consumption, culture, social equity and the environment;
- the interdependence of human health and the environment;
- how to apply principles of sustainable development in the context of their professional activities;

- technical, design, scientific and institutional strategies and techniques that foster sustainable development, promote energy and natural resource efficiency and conservation, prevent and control the generation of pollution and waste, remediate environmental problems, and preserve biological diversity;
- social, cultural, legal and governmental frameworks for guiding environmental management and sustainable development;
- environmental and health risk assessment, communication, perception and management;
- strategies to motivate environmentally just and sustainable behaviour by individuals and institutions.

The educational foundations should be realized by innovative pedagogical approaches. First of all by

System Thinking.

System thinking provides understanding rather than explanation and emphasizes:

- wholes over parts
- relationship over objects
- contextual over objective definitions
- pattern over contents
- quality over quantity
- process over structure
- dynamic equilibrium over stability
- development over growth
- inclusiveness over exclusiveness
- non-linear dynamics
- complex cause-effect relationships

How the Biophysical World Works

is essential in SD education, because the biophysical world is the basis for life. This understanding includes:

- fundamental natural laws
- ecosystems as communities with hierachies of relationships
- all energy is derived from the sun
- tendencies toward dynamic equilibrium
- limits and boundaries
- material cycles are circular: closed loops and waste as a resource
- interdependence and holism: e.g., if part of the system is sick, the whole system is sick
- flexibility, adaptation and resilience through feedback
- diversity and complexity
- development, evolution and self-organization
- partnership, cooperation and competition

- co-evolution of species including humans
- short and long time scales
- synergy

Sustainabilty in Human Activity

is possible only if system integrity is maintained:

- Human population size
- Physical and natural resources are used no faster than they can be replenished.
- The assimilative capacity of natural systems is not exceeded.
- Global life support systems are maintained, including biological diversity, clean air and water, food production capacity, and sufficient open space.
- Efficiency and equity characterize use of all natural resources, including exposure to environmental hazards.

Sustainability emerges from the appropriate integration of economic and ecological systems. Students must understand the basic principles that underlie this interaction, and the implications of these principles:

- Economic systems are organized around and sustained by the ow of energy and matter.
- Economic systems are open subsystems nested within and dependent on a closed global biogeochemical system and its cycles.
- Limitations exist in the rate at which economic systems can utilize natural resources and the earth's capacity to assimilate waste or provide other environmental services.
- Economic activity should be designed to mimic and live within natural systems.
- A sustainable economy should provide for basic material requirements and a healthy quality of life.
- A sustainable economy will cause no net loss of social and human capital (our current system doesnot do this).
- Economic "progress" must be encouraged, measured and gauged in terms of quality of life and development of human potential, not solely in quantitative terms.
- Economic activity must be subject to a true cost accounting, which will entail new approaches such as exploring economic value as a function of energy ows, ecological processes preserved and maintained, or resilience of systems to collapse.
- A sustainable economy, in addition to emphasizing eficiency and adaptability, should provide work that is meaningful, valued and biophysically compatible for every individual.
- Economic systems are a subset of the socio-political structure, including its moral structure; people are citizens first and consumers second.
- The behaviour of economic systems today should not diminish the potential enjoyment of life for future generations.

- Appropriate market incentives (e.g., full cost accounting) are essential to achieve biophysical and economic sustainability, and subsidies for unsustainable practices should be eliminated.

Enhancing and sustaining human health is dependent on a healthy, productive and biologically diverse environment. To achieve sustainability, students need to understand:

- The productivity and health of the physical and natural environment is one of the most important determinants of human health since the environment provides all the resources that make life possible.
- Protection of the environment and preservation of biologically diverse ecosystems are, in public health terms, the most fundamental forms of primary prevention of human illness.
- How to assess the impact on human health of economic and other human activities which impact the biophysical environment.
- How to design economic activities, food production, transportation, communities and building structures which enhance and sustain human health.
- Human activity always takes place in a cultural context. The changes necessary to bring about a sustainable future are intrinsically linked to that cultural context. Students need to understand that:
- Human cultures are built around spiritual, social, philosophical and political beliefs that determine societal values.
- Values change at certain times, especially when cultural and political systems are in ux; we are now in a constructive period when values can change.
- Not all values can be accommodated simultaneously.
- There is a biological basis for some values.
- Human rationality is bounded.
- Beauty and aesthetics as well as immediate self-interest can motivate behaviour.
- Cultural diversity must be recognized and respected; we need to examine issues from a variety of cultural perspectives.
- Sustainable development is not an ideology or religion.
- Sustainable development must be inclusive and not alienate.
- The question of what is a good life must be considered from a cultural perspective; sustainable development must serve cultural as well as physical needs.

Communities and institutions play a critical role in sustainable development. Students must understand the principles by which communities and institutions operate and can contribute to bringing about a sustainable future. Students should be especially guided to discover and understand the focus and operations of the communities and institutions to which they themselves belong or which impact significantly on them, and to participate in these communities and institutions in order to assure their contribution to a sustainable future. Students should be made aware that:

- The natural and physical environment is the platform which supports all communities and institutions.
- Sustainability depends on ecological design inside and outside communities.
- Feedback loops operate in different time frames in intra-person, intra-company, intra-industry and intra-society situations; short feedback loops are key to effective change and must be designed into institutions.
- Environmental management must be decompartmentalized { e.g., it should be a function distributed throughout government, not solely delegated to the EPA; and consideration of environment/ sustainability issues should be a normal part of government programs and those of communitybased organizations.
- Institutions must upgrade their understanding of their relationship to the planet.
- Institutions should encourage empowerment through incentives, such as reorganizing for optimal outcomes, increasing access to community resources, and symbiotic local relationship building.
- Decentralization and exibility are generally desirable.
- Students should also explore and debate the relationships between environmental justice and sustainability hat are contained in the following proposals:
- Sustainable development with environmental justice ensures that no community, group, people or gender is required to accept socially condoned and/or legally sanctioned negative environmental consequences.
- Sustainable development with environmental justice redresses past, present, and future maldistribution of resources, privileges and rights of endangered communities, of poor people, and of communities of color.
- Sustainable development with environmental justice eliminates the necessity to choose between sources of income versus health and safety, especially for poor people and people of color.
- Sustainable development with environmental justice ensures the widest stakeholder participation possible in relevant decision making needed to avert inequitable and unjust environmental conditions.
- Fossil fuel energy ows should be not only be decreased, but more equitably distributed among all people regardless of their differences { sustainable and equitable energy ows foster structural interdependence rather than structural dependence.
- Sustainable communities cannot be maintained unless biodiversity and cultural diversity are highly revered.
- A sustainable society produces a public policy process which is cyclical rather than linear.

Better learning strategies might include:

- developing new performance indicators
- identifying new tools and mental models
- balancing emphasis of breadth and depth
- developing a sense of place of the campus in the local environment
- diversifying student's learning strategies

Interdisciplinary learning can be encouraged by bridging, uniting, or even "dissolving" currently separate disciplines. Possibilities include:

- starting new schools (and letting old ones die)
- creating special sustainability courses, such as a single basic natural science or basic social science course
- modifying existing courses
- creating a unified, team-taught science course on the biosphere
- creating an institute for ecological design arts
- funding research on applied sustainability and justice

Students should get outside and do something real. This could be accomplished by:

- using the campus as a laboratory for environmental management and sustainability
- creating biological reserves on campus
- confronting actual, real-world problems
- internships in government, industry, communities, K-12 schools and NGOs
- capstone courses oriented toward solving environment and development problems of communities, government and industry
- finding opportunities and giving credit for off-campus work in communities
- encouraging students to work in groups so that they will be able to effectively collaborate as future managers and leaders

Finally, higher education must be open to the lifelong learning necessary to support the continuing evolution of sustainable development.

Almost all of the aspects mentioned above can be found, too, in

Rosalyn McKeown: Education for Sustainable Development. Toolkit.

http://www.esdtoolkit.org

Generally speaking, issues, subjects, demands and programs published in reports and proceedings do not differ too much. Obviously, the demands are so clear and strong, that there exists a worldwide agreement on these issues; a fact, which is confirmed in Rio in 1992 by the UN Agenda 21.

5. TEACHING, LEARNING, ASSESSING

5.1 Teaching

Sustainable development should be an integrated part of teaching and learning and should be pervasive throughout the civil engineering education. It is more than just transfer of a body of knowledge; it is in some ways an attitude of mind. It needs a teaching and learning process that:

- provides an interdisciplinary perspective on the problems that engineers will tackle in practice
- develops an understanding of the interaction between engineering, the environment and society
- develops an ability to use technical engineering knowledge to help solve complex problems.

Active members of SP 3 believe that it is useful to include some lectures or modules on Sustainable Development in an existing semester-long course on a related subject or interspersed in several such courses.

Examples for sustainable topics are shown in the following list.

- Demand for cost efficiency
- National and international declarations
- EU programs and guidelines
- Landscape protection
- Protection against pollution
- Mitigation of natural disaster effects
- Life-cycle analysis
- Waste: secondary raw material
- Transformation of societies
- Water demand is doubling every 21 years
- Over 70 % of water is used for irrigation; limits on irrigation lead to limits on food production
- Limits on food production in poor countries lead to imports, higher prices and political instability
- Water tables are falling (caused by excessive pumping and leading to permanent damage to aquifers)
- National and european laws and regulations dealing with SD
- Obligations for civil engineers resulting from national and european laws

There is no doubt that matters of SD play a key role and are strongly promoted by the European Commission [7], [8]. In order to compare any involvement in SD education means are needed in order to measure and to compare activities in SD matters and final results of these activities.

The following two sections, contributed by Prof. Marina Pantazidou, describe an approach that can be used to quantify the environmental engineering component of a civil engineering curriculum (with suitable changes it can also be used for the SD component of a CE curriculum) and a summary of a paper on assessing students' understanding of sustainability.

5.2 An approach to assess the environmental component of civil engineering curricula

This section describes the approach adopted by the School of Civil Engineering at the National Technical University of Athens (NTUA) for the assessment of the Environmental Education offered to its students. NTUA has five Departments: (1) Structural Engineering, (2) Water Resources, Hydraulic and Maritime Engineering (3) Geotechnical Engineering, (4) Transportation Planning, and (5) Engineering Construction and Management. NTUA has been awarding diplomas with three specializations: (I) Structural Engineer, (II) Hydraulic Engineer and (III) Transportation Engineer. From the academic year 2005-2006 onward, it will add a fourth specialization, that of a (IV) Geotechnical Engineer. The term "Environmental" does not appear in the name of any specialization or sub-unit of the School. However, many courses with an environmental component are taught in the School, in increasing numbers in recent years.

At the beginning of the 2003-2004 academic year, the President of the School of Civil Engineering at

NTUA formed a task force, with members from all Departments, with the charge to assess comprehensively the environmental training the School offers to its graduates. The task force evaluated all courses taught at the School based on the description of the courses in the school catalogue and tentatively identified 43 courses with an environmental component. The task force then sent e-mail messages to the instructors of these courses asking them (i) whether their course had indeed an environmental component and, if yes, (ii) to give an estimate of this component as a percentage of the entire content of the course, in three ranges: < 20% (small), 20 - 50% (adequate), or > 50% (large).

The total number of courses with some environmental component is 36, according to the instructors' responses. However, of these 36 courses, only 10 courses have a large environmental component (>50% of the course subject matter). What is more, only two of these courses (Ecology for Engineers and Environmental Engineering) are core courses, i.e., required courses for all students, the remaining eight being elective courses open to all students or only to students that follow one of the three specializations. Hence, depending on a student's choice of specialization and courses, the total number of courses with an environmental component can vary appreciably. [It should be noted that the differences among the curricula of the three specializations amount to only 17% of the 66 courses needed for graduation.]

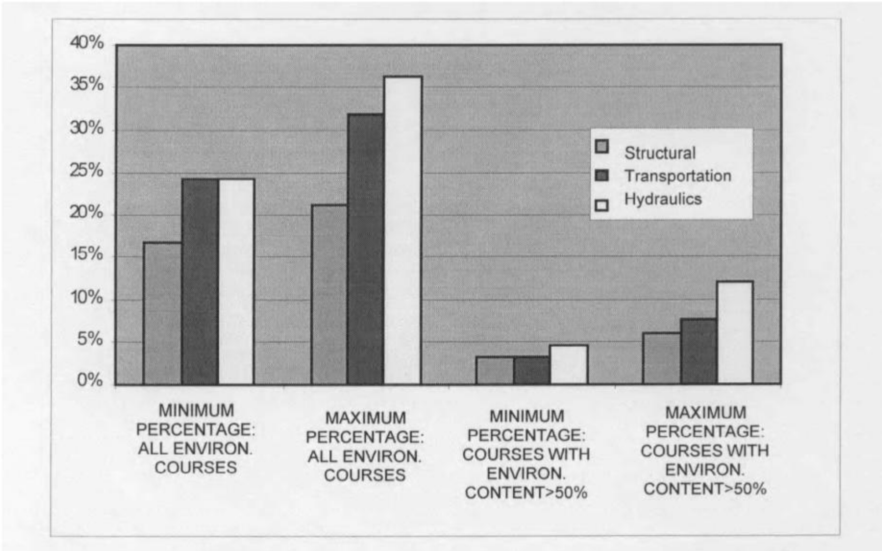

Figure 1. Percentage of courses with environmental content, with reference to the 66 courses required for a civil engineering diploma at NTUA.

Figure 1 shows the minimum and the maximum possible percentage of courses with an environmental component in a student's record (out of a total of 66), depending on the chosen specialization. These numbers drop significantly when only courses with a large environmental component (> 50%) are considered. In terms of number of courses with an environmental theme, for a student with Structural Engineer specialization it varies between 11 and 15, and drops to 2 - 4 courses, when only courses with a large environmental component (> 50%) are considered. For a student with Transportation Engineer specialization, the respective ranges are 16 - 21 (all courses) and 2 - 5 (courses with an environmental component > 50%). Finally, for a student with Hydraulic Engineer specialization, the respective ranges are 16 - 24 (all courses) and 3 - 8 (courses with an environmental component > 50%).

The task force further assessed the type of environmental competences developed in each course, again by studying the detailed descriptions of these courses in the school catalogue. For this purpose, it distinguished four categories of environmental competences:

- Awareness that civil engineering (CE) projects may have adverse environmental impacts
- Ability to perform engineering calculations and to carry out design for the environmental components of CE projects

- Ability to perform assessments of the environmental impacts of specific CE projects
- Ability to formulate personal positions for environmental problems related to CE projects and to enunciate an environmental philosophy.

Considering the four types of environmental competences, it was clear that most of the courses cultivated awareness, whereas few involved quantitative aspects of environmental calculations and design, as shown in Figure 2.

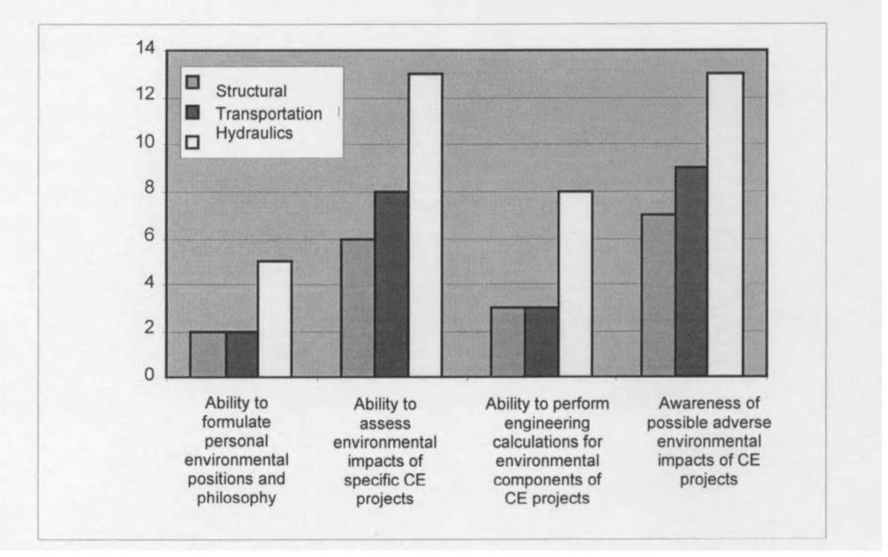

Figure 2. Number of courses contributing to the development of four environmental competences, out of the 36 courses with an environmental component in the civil engineering curriculum at NTUA.

Based on the data above, the task force recommended the following:

- The School can guide students having interests in environmental issues to select among courses with environmental component so as to strengthen the environmental dimension of their education.
- This was accomplished by preparing a pamphlet that was distributed to all incoming students.
- In the short term, environmental training in the School can be enhanced by creating an environmental component or enlarging an existing one in suitable core courses (e.g., Chemistry, Building Materials, Law, Engineering Geology).
- In the long term, environmental training can be enhanced further by (i) modifying courses to reinforce the development of the more complex environmental competences and (ii) restructuring course syllabi in order to

close knowledge gaps both technical (e.g., thermodynamics) and non technical (e.g., landscape protection).

In the academic year 2004-2005, a new university-wide course was added at NTUA with the title "Environment and Development". The aim of the course is to highlight the conflicts between engineered economic development and protection of the environment and to stress that interdisciplinary teams are needed for effective conflict resolution. The course was developed by department members from all Schools of NTUA, co-funded by the European Social Fund and the Greek Ministry of Education. Currently, the course is being taught by instructors and attended by students from seven of the nine Schools at NTUA. The course is structured with an introductory series of five lectures (weeks) dedicated to the principles and theories (e.g., sustainable development) and tools (e.g., environmental economics) available for management of environmental issues, followed by seven lectures on specific cases (e.g., alternative energy sources, brownfield development, refrigeration processes, construction of dams for hydroelectric power). Students are graded on the basis of debates on specific contested environmental cases (e.g., redevelopment of a brownfield site in Athens), which they prepare in teams under the supervision of one of the 14 department members involved with course delivery.

5.3 The student perspective on sustainability

It is important to distinguish what students should know from what students end up knowing about sustainability. Recent research carried out by Carew and Mitchell [3] provides insights on the student's understanding of sustainability. This section summarizes the main points of their approach and findings.

After noting the variability of the concepts of sustainability, Carew and Mitchell compile a list with the principles of sustainability that systematically appear in the relevant literature. They then present an analysis of the term \understanding", which, when it comes to expert understanding, includes both content knowledge and structural knowledge. Content knowledge is the factual knowledge that is relevant for each discipline (e.g., familiarity with the principles of sustainability). Structural knowledge refers to applying theories and principles, deciding when it is appropriate to use a principle for a particular situation and judging the quality of decision outcomes. Turning to students, Carew and Mitchell propose a 5-level gradation (or competence hierarchy) for analyzing the answers of 52 chemical engineering students to the question \in your words, what is sustainability"? The first and lowest level corresponded to a vague or incomplete answer (6 responses). Students who responded by providing one specific example for an answer were at the second level; these formed the majority (29 responses). The middle level included answers with multiple examples relevant to sustainability (9 responses). The fourth level corresponded to answers that started to give relationships between examples or statements related to sustainability (7 responses). Finally, the fifth and highest level included internally consistent statements on sustainability and provided evidence of critical or creative thinking or ethical judgement on sustainability-related issues (2 responses).

Considering that these 52 students were in their third year of a 4-year engineering degree program and had completed a unit of study focused on sustainability, the authors express concern that 65% of these third-year engineering students have a rudimentary understanding of sustainability (corresponding to the lowest two levels of the aforementioned gradation). They recommend that instructors should focus not only on deciding the content of sustainability instruction but also on specifying what understanding of sustainability means at various educational levels, in order to tailor instruction and assessment accordingly.

Another more recent and extensive study conducted by Azapagic et al. [2] investigated students' knowledge of both environmental and sustainability issues. The study covered several engineering faculties, including chemical, civil and mechanical engineering, from 40 universities based in the Americas, Asia, Australia and Europe. The results of the study showed that the students had a fairly good knowledge of environmental issues. On the contrary, the study identified several knowledge gaps with respect to sustainable development. To remedy these gaps, the authors make reference to sources and initiatives dedicated to the teaching of sustainability to engineering students.

6. TYPICAL COURSES AND SUBJECTS

6.1 Degree programs at Democritus University Thrace

Complete curricula in SD are hardly available in the internet. A typical one has been communicated by V.A. Tsihrintzis and D. Panagiotakopoulos [25] from Democritus University of Thrace (http://www.duth.gr).

They give a report on how to establish a SD Master program within an existing academic structure.

To be successful, they mention 10 needs:

1. General environmental policy or agreement within university
2. A committee or a person or an office dealing with environmental policy and issues and addressing compliance with environmental laws or regulations on the campus.
3. Curricula containing environmental courses in science, engineering, politics, economics, etc.
4. Educational programs for the personnel and applied policy on pollution prevention, waste minimization and recycling.
5. Educational programs for the personnel and applied policy on energy and resources conservation.

6. Programs to raise environmental awareness.
7. Environmentally friendly transportation within campus.
8. Environmental purchasing policy.
9. Environmental auditing system.
10. Policies related to smoking and public health, occupational health and safety, equity and justice between employees, harassment of women, minorities, disabled, students, etc.

The main subjects of the 5-years diploma course are summarized in the following table of content. It is emphasized, that in addition to the titles the contents and teaching philosophy have to be adjusted in order of realize a multidisciplinary approach.

In order to show the strong correspondence with the Agenda 21 in Appendix H, the corresponding chapters are marked in table 1.

Besides complete curricula different sources of SD-subjects are available in the internet and in international literature.

6.2 Degree programs at Kungl Tekniska H • ogskolan (KTH)

Nine months course on SD and EE at KTH Stockholm [14]

Environmental Engineering & Sustainable Infrastructure

General information

There is an ever-increasing demand for people trained to handle global and local problems related to the environment and infrastructure. This programme, which provides students with a knowledge of how to analyse, plan, communicate and manage environmental projects, is designed for those who want to find solutions to these kinds of problems.

The programme has a truly international focus and is co-financed by KTH, SIDA (Swedish International Development Cooperation) and STINT (Swedish foundation for International Cooperation in Research and Higher Education).

The programme comprises two terms (nine months) of course work. All courses carry 5 credits and apart from two compulsory introduction courses, there are several possibilities to combine courses quite freely.

Term I

Environmental Impact Assessment - compulsory
Political Economy for Environmental Planners - compulsory
Environmental Dynamics/Physics
Environmental Dynamics/Chemistry
Sustainable Urban and Rural Development
Human Settlements and Housing
Theory of Science, Research Methodology and Excursion

Table 1

No.	Course	Chapter of agenda 21
1	Environmental Biology, Environmental Ecology	11,12,13,15,17,18
2	Environmental Ethics	2,3,4,5,6,7,8
3	Environmental Geology	12,13,18
4	Introduction to Environmental Engineering	All
5	Systems Theory	All
6	Fluid Mechanics / Applied Hydraulics	7,13,14,17,18
7	Environmental Economics	2,3,4,5
8	Engineering Biochemistry	16
9	Social Science	2,3,4,5,6,7,8
10	Technical and Environmental Law	All
11	Environmental Microbiology	6,17,18
12	Hydrology and Groundwater	7,10,11,12,13,14,15,17,18
13	Sociology /Risk Assessment	2,3,4,5,6,7,8
14	Air Pollution and Control Technology	6,9
15	Physical, Chemical, Biochemical Processes	4,5,6,7,19,20,21,22
16	Public Health / Occupational Health	5,6,7,8
17	People Management and Communication	All
18	Industrial Production, Environmental Impacts	4,6,7,19,20,21,22
19	Renewable Energy	4
20	Solid Waste Management	6,7,21
21	Wastewater Management	4,5,6,7
22	Engineering Economics	2,3,4
23	Theory of Sustainable Development	All
24	Ecological Engineering/Ecosystem Management	All
25	Environmental Auditing	4,9,19,20,21,22
26	Bioclimatic Design of Buildings	4,7
27	Environmental Impact Assessment	All
28	Solid Treatment / Toxic Waste Management	6,19,20,21
29	Analysis and Mangagement of Env. Systems	All
30	Environmental Engineering Design Project	All
31	Diploma Thesis	All

Term II

Environmental Data
Water and Waste Handling
Applied Hydrology
Sustainable Project Management
Natural Resources Management
Quantitative Hydrology
Environmental Geology
Urban Infrastructure
Management of Land and Water

The studies are carried out in the form of seminars, group work and individual projects. Subject to funding availability, a one-week excursion to one of the Baltic countries will be also arranged.

Final Degree Project/Master's Thesis

The third term is devoted to a Final Degree Project/Master's Thesis, which should preferably be carried out in the student's home country.

Degree

Students who have successfully completed the programme will be awarded a "Degree of Master of Environmental Engineering and Sustainable Infrastructure".

6.3 Matters of SD in urban development

Concerning matters of SD in urban regions a typical summary has been used by a report on the 12 new EU-candidates:

Overall situation and problem complexes in urban areas
- administrative and legal structure
- major problem areas
- national and supra-national programmes
- restrictions and barriers

Sustainable urban management
- key problem areas and issues
- administrative and legal structure
- innovative instruments, projects and programmes
- public information and participation
- role of NGOs and stakeholders
- main barriers

Sustainable urban transport
- basic information
- key problem areas
- urban traffic and transport planning
- public passenger transport
- political agenda
- pilot and model projects
- main barriers

Sustainable urban design
- basic information
- planning issues
- key issues and problems
- political agenda
- pilot and model projects

- main barriers

Sustainable construction methods and techniques
- legislation and key issues
- construction in urban areas
- political agenda
- pilot and model projects
- main barriers

6.4 Sustainability education: examples from the literature and the Internet

A design course on sustainability issues entitled "Sustainable Problem Solving Lab" was designed by Dr. Annie Pearce, the Director of the Sustainable Facilities and Infrastructure (SFI) Program at the Georgia Tech Research Institute (GTRI), and taught to a mixed audience of senior-level and graduate civil engineering students. The web site of the course, http://maven.gtri.gatech.edu/sfi/gradcourses/courses.html, gives a detailed course syllabus, a course outline with weekly activities, and required/recommended reading. The course focuses on evaluating alternative designs with tools such as environmental impact assessment and life cycle analysis and assessing whether sustainability considerations are taken into account during the design stage (i.e., design for disassembly). Hence, students leave the course with a clear idea of how sustainability issues changed problem solving.

Another researcher and educator active in the area of sustainability, Professor Jorge Vanegas of Texas A&M University, has published cases of sustainability suitable for instruction (Hmelo et al. [9]; Vanegas [29]). These cases can be drawn either from particular incidents, such as the accident at Bhopal, India, or from industrial practices, such as chlorine use. For civil engineering students in particular, civil infrastructure systems provide opportunities to discuss sustainability issues in the classroom or design an entire course with this theme.

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Appendix A

GOTHENBURG DECLARATION - AN EUROPEAN UNION STRATEGIES FOR SUSTAINABLE DEVELOPMENT

A strategy for sustainable development

1. Sustainable development to meet the needs of the present generation without compromising those of future generations is a fundamental objective under the Treaties. That requires dealing with economic, social and environmental policies in a mutually reinforcing way. Failure to reverse trends that threaten future quality of life will steeply increase the costs to society or make those trends irreversible. The European Council welcomes the submission of the Commissions communication on sustainable development which includes important proposals for curbing such trends.

2. The European Council agrees a strategy for sustainable development which completes the Union's political commitment to economic and social renewal, adds a third, environmental dimension to the Lisbon strategy and establishes a new approach to policy-making. The arrangements for implementing this strategy will be developed by the Council.

3. Clear and stable objectives for sustainable development will present significant economic opportunities.

This has the potential to unleash a new wave of technological innovation and investment, generating growth and employment. The European Council invites industry to take part in the development and wider use of new environmentally friendly technologies in sectors such as energy and transport. In this context the European Council stresses the importance of decoupling economic growth from resource use.

A new approach to policy-making

4. The Union's sustainable development strategy is based on the principle that the economic, social and environmental effects of all policies should be examined in a coordinated way and taken into account in decision making. "Getting prices right" so that they better reflect the true costs to society of different activities would provide a better incentive for consumers and producers in everyday decisions about which goods and services to make or buy.

5. To improve policy coordination at the level of the Member States, the European Council:

- invites Member States to draw up their own national sustainable development strategies;
- underscores the importance of consulting widely with all relevant stakeholders and invites

Member States to establish appropriate national consultative processes.

6. To achieve better policy coordination in the Union, the European Council:

- will at its annual spring meetings give policy guidance, as necessary, to promote sustainable development in the Union;

- invites the Union institutions to improve internal policy coordination between different sectors; the horizontal preparation of the sustainable development strategy will be coordinated by the General Affairs Council;

- notes that the Commission will include in its action plan for better regulation to be presented to the Laeken European Council mechanisms to ensure that all major policy proposals include a sustainability impact assessment covering their potential economic, social and environmental consequences.

7. To build an effective review of the sustainable development strategy, the European Council:

- invites the Council to examine, for the purposes of implementing the strategy, the proposals in the Commission communication, in particular its proposals for headline objectives and measures, as well as the sixth environmental action programme and the sector strategies for environmental integration;

- will review progress in developing and implementing the strategy at its annual spring meetings, in line with the conclusions of the Stockholm European Council;

- notes that the Commission will evaluate implementation of the sustainable development strategy in its annual synthesis report, on the basis of a number of headline indicators, to be agreed by the Council in time for the spring European Council 2002; at the same time, the Commission will present a report assessing how environment technology can promote growth and employment;

- supports the Commissions work on a draft on labelling and traceability of GMOs;

- asks the Council to take due account of energy, transport and environment in the sixth framework programme for research and development.

The global dimension

8. Sustainable development requires global solutions. The Union will seek to make sustainable development an objective in bilateral development cooperation and in all international organisations and specialised agencies. In particular, the EU should promote issues of global environmental governance and ensure that trade and environment policies are mutually supportive. The Union's sustainable development strategy forms part of the preparations for the 2002 World Summit on Sustainable Development. The Union will seek to achieve a \global deal" on sustainable development at the summit. The Commission undertakes to present a communication no later than January 2002 on how the Union is contributing and should further contribute to global sustainable development. In this context, the Union has reaffirmed its commitment to reach the UN target for official development assistance of 0.7 %

of GDP as soon as possible and to achieve concrete progress towards reaching this target before the World Summit on Sustainable Development in Johannesburg in 2002.

Targeting environmental priorities for sustainability

9. Building on the Commission communication on sustainable development, the sixth environmental action programme and the sector strategies for environmental integration, the European Council has, as a first step, singled out a number of objectives and measures as general guidance for future policy development in four priority areas: climate change, transport, public health and natural resources, thus complementing decisions on social and economic issues taken by the European Council in Stockholm.

Combating climate change

10. Emissions of greenhouse gases from human activity are contributing to global warming with repercussions on the world's climate. Therefore, the conference of the parties in mid-July in Bonn must be a success. The Community and the Member States are determined to meet their own commitments under the Kyoto Protocol. The Commission will prepare a proposal for ratification before the end of 2001 making it possible for the Union and its Member States to fulfil their commitment to rapidly ratify the Kyoto Protocol. The European Union will work to ensure the widest possible participation of industrialised countries in an effort to ensure the entry into force of the protocol by 2002. To enhance the Union's efforts in this area, the European Council:

- reaffirms its commitment to delivering on Kyoto targets and the realisation by 2005 of demonstrable progress in achieving these commitments; recognising that the Kyoto Protocol is only a first step, it endorses the objectives set out in the sixth environmental action programme;
- furthermore reaffirms its determination to meet the indicative target for the contribution of electricity produced from renewable energy sources to gross electricity consumption by 2010 of 22 % at Community level as set out in the directive on renewable energy;
- invites the European Investment Bank to promote the sustainable development strategy and to cooperate with the Commission in implementing the EU policy on climate change.

Ensuring sustainable transport

11. A sustainable transport policy should tackle rising volumes of traffic and levels of congestion, noise and pollution and encourage the use of environment-friendly modes of transport as well as the full internalisation of social and environmental costs. Action is needed to bring about a significant decoupling of transport growth and GDP growth, in particular by a shift from road to rail, water and public passenger transport. To achieve this, the European Council:

- invites the European Parliament and the Council to adopt by 2003 revised guidelines for trans-European transport networks on the basis of a forthcoming Commission proposal, with a view to giving priority, where appropriate, to infrastructure investment for public transport and for railways, inland waterways, short sea shipping, intermodal operations and effective interconnection;

- notes that the Commission will propose a framework to ensure that by 2004 the price of using different modes of transport better reflects costs to society.

Addressing threats to public health

12. The European Union must respond to citizens' concerns about the safety and quality of food, use of chemicals and issues related to outbreaks of infectious diseases and resistance to antibiotics. To this end, the European Council:

- notes the Commission's intention to present formal proposals, and invites the Council and the European Parliament to adopt them, so that the chemicals policy is in place by 2004, thereby ensuring that within a generation chemicals are only produced and used in ways which do not lead to a significant impact on health and the environment;

- notes the Commissions intention to present by the end of 2001 action plans for tackling issues related to outbreaks of infectious diseases and resistance to antibiotics;

- urges the European Parliament and the Council to profit from the substantial progress achieved and rapidly agree on the final adoption of the European Food Authority and food law regulation in order to comply with the time frame agreed at the Nice and Stockholm European Councils;

- asks that the possibility of the creation of a European surveillance and early warning network on health issues be examined.

Managing natural resources more responsibly

13. The relationship between economic growth, consumption of natural resources and the generation of waste must change. Strong economic performance must go hand in hand with sustainable use of natural resources and levels of waste, maintaining biodiversity, preserving ecosystems and avoiding desertification. To meet these challenges, the European Council agrees:

- that the common agricultural policy and its future development should, among its objectives, contribute to achieving sustainable development by increasing its emphasis on encouraging healthy, high- quality products, environmentally sustainable production methods, including organic production, renewable raw materials and the protection of biodiversity;

- that the review of the common fisheries policy in 2002 should, based on a broad political debate, address the overall fishing pressure by adapting the EU fishing effort to the level of available resources, taking into account the social impact and the need to avoid over-fishing;

- that the EU integrated product policy aimed at reducing resource use and the environmental impact of waste should be implemented in cooperation with business;
- halting biodiversity decline with the aim to reach this objective by 2010 as set out in the sixth environmental action programme.

Integrating environment into Community policies

14. The Council is invited to finalise and further develop sector strategies for integrating environment into all relevant Community policy areas with a view to implementing them as soon as possible and present the results of this work before the spring European Council in 2002. Relevant objectives set out in the forthcoming sixth environmental action programme and the sustainable development strategy should be taken into account.

[...]

Appendix B

WEBSITES DEDICATED TO EE AND SD
(from http://www.esdtoolkit.org/)

I Information on Sustainability

1) The International Institute for Sustainable Development (IISD)
   http://www.iisd.org/
2) World Bank - Home Page for Environmentally and Socially Sustainable Development Network (ESSD)
   http://worldbank.org/environment
3) Organization of American States (OAS)
   http://www.oas.org/
4) World Resources Institute (WRI)
   http://www.wri.org/
5) Jetzt und Morgen
   http://www.sbjum.de/
6) The Natural Step
   http://www.detnaturligasteget.se/

II Education for Sustainable Development

1) Teaching and Learning for a Sustainable Future (A UNESCO site)
   http://www.unesco.org/education/tlsf/
2) Second Nature
   http://www.secondnature.org
3) Learning for a Sustainable Future
   http://www.schoolnet.ca/future
4) Campus Ecology
   http://www.nwf.org/campusecology/
5) University Leaders for a Sustainable Future (ULSF)
   http://www.ulsf.org/
6) Sustainable Development on Campus: Tools for Campus Decision Makers
   http://iisd1.iisd.ca/educate/
7) Sustainability Education
   http://www.urbanoptions.org
8) Green Teacher
   http://www.greenteacher.com
9) Global Learning, Inc.
   http://www.globallearningnj.org/
10) The Sustainability Education Center
    http://www.sustainabilityed.org/
11) Southwestern Ecoliteracy Project

http://www.ecoliteracy.org/

12) World Resources Institute (WRI) Education Center
http://www.wri.org/wri/enved/

I Information on Sustainability

1) The International Institute for Sustainable Development (IISD) has developed an interactive toolkit to introduce some of the basic concepts of sustainable development and ways these concepts are put into practice in institutions. This tool kit was developed primarily for the higher education community, but the learning modules will be of interest to many. The set of learning modules is aimed at providing a more complete understanding of the concept of sustainable development and its relevance to personal lives as well as to institutions. These modules help to identify direct application of this concept to the community and to jobs and professions. The modules then suggest next steps, contacts, and networks to keep users involved and informed in their efforts to create a sustainable society.

The site also features a chronology of the concept of sustainable development. Its timeline tracks key events, from the publication of Rachel Carson's Silent Spring in 1962 to the Earth Summit in 1992 and beyond. The site links to a data bank of sustainable development principles, which illustrates the evolution and ownership of the concepts of sustainable development.

This site provides the definition of sustainable development prepared by the World Commission on Environment and Development (the Brundtland Commission), taken from the report Our Common Future (Oxford University Press, 1987). A section on indicators and measurement shows how to track progress to sustainability.

http://www.iisd.org/

2) World Bank - Home Page for Environmentally and Socially Sustainable Development Network (ESSD)

This site has three main sections:

(a) **Social Development** focuses on development that is equitable, socially inclusive, and therefore sustainable. This section promotes local, national and global institutions that are responsive, accountable, and inclusive; it empowers poor and vulnerable people to participate effectively in development processes. The Web page features links to such key topics as conflict prevention, indigenous peoples, participation, and poverty. Links are also provided to resources, projects and policies, news and events, related partnerships, and information on sustainable development issues in different world regions.

(b) **Environment** describes how the World Bank is focusing on finding ways to ensure that economic growth does not come at the expense of the world's physical and economic systems, or the world's poor. This section features links to learning and knowledge resources, projects, publications, data, related partnerships, information on world regions, and such key topics as biodiversity, climate change, environmental economics, and pollution management.

(c) **Rural Development and Agriculture** links to such key issues as gender and rural development, information and communication, water resource management, agriculture, and the WTO negotiations.

Also included are features on key topics (e.g., reducing poverty in villages), policies, reports, projects, and links to the development community (conferences, discussions, and partnerships).

http://worldbank.org/environment

3) Organization of American States (OAS) [click on Sustainable Development in the pull-down "Search" menu at top of page]

The Unit for Sustainable Development and Environment (USDE) responds to the needs of member states on issues relating to sustainable development within an economic development context. Technical issues addressed by the USDE include management of water resources, biodiversity, reduction of vulnerability to natural hazards, public participation in decision making, climate change/sea-level rise, coastal-zone management, and renewable energy planning. Each category contains links to groups working on related initiatives.

Among the various goals of the USDE is the facilitation of exchanges of information related to sustainable development in the region, to build a basis for the participation of civil society in environmental management decision processes.

http://www.oas.org/

4) World Resources Institute (WRI) provides information and ideas about global environmental problems for the purpose of catalyzing public and private action to meet global challenges. WRI aims to move human society to live in ways that protect Earth's environment for current and future generations, by \tying together the threads of natural resource use and conservation, economic development, and social equity through research, capacity building, and institutional change."

The Spanish/English site features:

- Global topics;
- A "Newsroom" which offers useful resources for the media [media kits, etc.] and timely information on global environmental issues;
- A calendar of events focused on sustainability;
- Review of books and other resources about sustainability;
- **The Environmental Information Portal (Earth Trends)**, which provides up-to-date information on 10 key environmental issues, including Coastal and Marine Ecosystems; Water Resources and Freshwater Ecosystems; Climate and Atmosphere; Population, Health, and Human Well-being;

Energy and Resources; Biodiversity and Protected Areas; Agriculture and Food; Forests and Grasslands; Environmental Governance and Institutions.

http://wri.org/

5) Jetzt und Morgen is an independent research group focusing on the transformation of social and economic systems at the structural level. Their Web site provides brief descriptions and definitions of major concepts associated with sustainability. The Jetzt und Morgen group is committed to the concepts of sustainability and intergenerational equity as well as to holistic approaches. Their studies aim to illustrate problems of economic as well as ecological indebtedness. They also work on developing ways to preserve natural and economical resources for future generations. Ecological, economical, and social aspects are consistently brought together with this approach.

[To reach the English version, click on "Homepage in English." To reach basic sustainability principles, click on "Studies." Then click on "Principles for Sustainable Policy and Behavior: Ecological, Economical, Social, Global" [from the study on "Sustainable Policy"]; click on \go to principles" [at "Principles for Sustainability: Summary"] for details of \Principles for Sustainable Policy and Sustainable Behavior."

http://www.sbjum.de/

7) The Natural Step is an international organization that uses a science-based systems framework to help organizations and communities understand and move toward sustainability. The Natural Step engages in training and consulting, research and development, and community outreach. Its purpose is to develop and share a common framework of easily understood scientific principles that act as a compass to guide society to a just and sustainable future. The site links to nine countries. Australia's Natural Step Web site is informative, with links to the Australian framework, including "back casting," the four system conditions, strategy for action, and basic science. The U.S. site also offers information on the U.S. framework, including the "funnel" and systems conditions. The U.S. site's "Strategy for action" discusses ways to implement the "system conditions" in an organization's everyday operations.

http://www.detnaturligasteget.se/

II Education for Sustainable Development

1) Teaching and Learning for a Sustainable Future (A UNESCO site) is a multimedia, interactive professional development program with materials, exercises, and links that help educators deepen their understanding of education for sustainability and its importance in addressing the economic, social, and environmental issues of the world.

This site presents key educational issues that form the rationale for Education for a Sustainable Future (ESF), including:

- A basic understanding of sustainable development;

- Help in understanding the range of social, economic, and environmental issues facing the world today; the interrelationships among these different types of issues; and the ways that education is key to the empowerment of people working for a sustainable future;
- "Future studies," which explore different ideas and perspectives about the future and include exercises designed to examine personal views as well as writings by futurists, consider probably versus preferable future scenarios, and incorporate these ideas into the curriculum;
- Various strategies for the education community to reorient education toward the broader process of building a sustainable future.

The exercises help develop an appreciation of the range of ESF objectives regarding knowledge, values, and skills, as well as an understanding of the broad scope of actions needed to reorient education. Key themes include the evolving nature of interdependence, citizenship/stewardship, rights of future generations, diversity; quality of life, uncertainty; and sustainability.

http://www.unesco.org/education/tlsf/

2) Second Nature offers guidance and assistance to institutions of higher education in their efforts to make sustainability an integral part of the institution and expand sustainability into personal and community life. The site is designed for a range of audiences and includes resource guides for department, administration, and students. These resource guides foster an understanding of sustainability issues and provide examples of how others are working together across traditional boundaries in both campus and community. Each guide includes on-line databases of bibliographies, contacts, calendars of workshops and other events, and links to descriptions of case studies of sustainability efforts at various higher education institutions. The site's Resource Centre section, originally known as Starfish, provides an extensive database of syllabi for courses that address environmental themes. The Alliance for Sustainability

Through Higher Education is a multi-institution effort to foster awareness and initiatives related to education for sustainability.

- The department Guide highlights department who are engaged in including the principles of sustainability in their teaching, learning, research, and practices. It also provides resources related to curriculum change and design, interdisciplinary course syllabi, innovative course projects, department development, and collaborative efforts for institutional change.
- The Student Guide is designed for college and university students who are actively promoting Education for Sustainability. It provides links to resources that can bolster efforts to initiate or continue effective and collaborative change for sustainability on campus, in the curriculum, in research, and in surrounding communities.
- The Administrator Guide provides tools and resources to help institutions reflect on their role in the future of the planet, learn more about

incorporating sustainability into the institution's agenda, and link to other institutions and administrators who are implementing sustainability goals.

http://www.secondnature.org

3) Learning for a Sustainable Future is a non-profit organization in Canada that helps educators and students integrate concepts of sustainability into the curriculum. This multi-lingual site includes:

- Teacher Documentation Center, which provides dozens of classroom and on-line activities for educators, including a pedagogical guide for activities, a calendar of related workshops, and a resource list of books and organizations focused on such sustainability issues as energy efficiency, international understanding, international development, and science education;
- Hurley Island, which teaches sustainability concepts to grade 12 students via the Internet, for two hours credit;
- Top of the World, which links to organizations working on sustainable development issues in arctic countries;
- International Youth Magazine, which helps students understand economic, environmental, and social issues in the world; provides links to organizations working on these issues; and features an interactive \youth exchange" for learning with others through various on-line activities.

http://www.schoolnet.ca/future

4) Campus Ecology, a National Wildlife Federation (NWF) program, Campus Ecology is a conservation initiative in higher education that aims to transform the nation's college campuses into living models of an ecologically sustainable society. The Campus Ecology program is working to train a new generation of environmental leaders and ensure a strong future for America's environmental movement.

The resources of this NWF program include Campus Ecology fellowships, technical assistance, publications, conference information, and a "Campus Ecology Action Toolkit."

http://www.nwf.org/campusecology/index.cfm

5) University Leaders for a Sustainable Future (ULSF) provides information and resource referrals, facilitates communication, offers technical assistance, and conducts training workshops that support institutional initiatives to engender environmentally responsible decision making and action through education. ULSF works in partnership with over 275 signatories of the Talloires Declaration and other colleges and universities pursuing sustainability. ULSF fosters institutional capacity to develop ecologically sound policies and practices and strives to make sustainability a major focus of curriculum, research, operations, and outreach at higher education institutions worldwide.

http://www.ulsf.org/

6) Sustainable Development on Campus: Tools for Campus Decision Makers includes learning modules, case studies, action plans, environmental policies, resources, forums, and contacts - all designed to help administration, students, or department implement sustainable development on campus - and also includes links to a \bookshelf" of key reports and guides covering university leadership, green campus administration, curriculum issues, and student actions.

http://iisd1.iisd.ca/educate/

7) Sustainability Education Handbook offers the \Multi-strand Approach," which gives teachers a way to customize current curricula to include sustainability concepts. This approach involves changing one's teaching structure from teaching discreet individual topics to choosing a theme and teaching all subjects from within this theme. "Mining a topic from all angles" is a standard style of teaching for K-5 enclosed classrooms, but can be adopted for all grade levels.

To customize current curricula, visitors to the site can link to a list of Sample Activities or consult the Criteria Evaluation to quickly interject varied concerns not included directly within the curriculum. The Criteria Evaluation provides basic guidelines to help teachers evaluate whether or not their curriculum embraces sustainability concepts. This tool is designed to simplify the complex process of incorporating sustainability content into the curricula by breaking down sustainability into its essential, but not inseparable, components.

http://www.urbanoptions.org

8) Green Teacher is a magazine by and for educators to enhance environmental and global education across the curriculum at all grade levels. Each issue contains:

- Perspective articles - ideas for rethinking education in light of environmental and global problems;
- Practical articles - reports of what successful teachers, parents, and schools are doing;
- Ready-to-use activities - cross-curricular activities for various grade levels;
- Resource listings and reviews - evaluations of dozens of new books, kits, games, and other resources;
- School news, announcements of all kinds

http://www.greenteacher.com

9) Global Learning, Inc. is a non-profit educational organization that translates the world's growing interdependence into educational activities for teachers, students, librarians, and educational systems, from elementary school through college and in community settings.

Its Sustainable Development Program is actively engaged in two major projects.

Libraries Build Sustainable Communities is a second national partnership with the American Library Association, with support from the US Agency for International Development.

The New Jersey Sustainable Schools Network is a growing consortium of schools and a wide variety of organizations committed to promoting education for a sustainable future in all schools in New Jersey.

Global Learning's approach to multicultural education is based on a commitment to increasing equity within the pluralistic society of the United States and on a vision of a healthy, inclusive human community. It stresses the development of cross-cultural attitudes and skills that help students and teachers interact positively with people who may appear different from themselves. Global Learning's services for schools, colleges, and professional associations include program presentations, in-service workshops, curriculum development consultations, conference planning, and professional networking. Global Learning also provides affirmative action workshops on cross-cultural awareness and conflict resolution for corporations.

Global Learning has developed several teacher resources (including sample lessons and more) focusing on the interrelated concepts of the environment, development, and equity, including:

- Sustaining the Future: Activities for Environmental Education in US History, for high schools;
- A Sustainable Development Curriculum Framework for World History & Cultures, for high schools;
- Making Global Connections in the Middle School: Lessons on the Environment, Development & Equity.

These books are available for a fee but are approved by New York City Board of Education for textbook purchase and have received favourable reviews from Green Teacher and Teachers Clearinghouse for Science and Society Education Newsletter.

- Also offered: The Conflict Mediators Program, which trains teachers and students in non-violent conflict resolution and mediation skills. This program helps teachers incorporate these concepts and skills within their existing curriculum and also helps set up student peer mediation programs in elementary, middle, and high schools. The Conflict Mediators Program is an approved program provider in the New Jersey Department of Education's Character Education Partnership Initiative.

http://www.globallearningnj.org/

10) The Sustainability Education Center of the American Forum for Global Education offers educational materials, professional development, and community education focused on sustainability. The Center builds on the American Forum's 28 years of program expertise in global and environmental education, technical assistance, and curriculum and professional development.

The Sustainability Education Center explores the relationships among economic systems, ecological systems, and justice in contexts ranging from local communities to global institutions. The goal of these explorations, and sustainability education in general, is to provide young people and citizens with the knowledge, skills, and attitudes that will enable them to meet their own needs without compromising the ability of future generations to meet their own. The Center pilots its programs and materials in the schools of its hometown of New York City before taking them on the road nationally and internationally.

The professional development programs and educational materials developed by the Center help community groups, educators, and young people understand the connections necessary for sustainability and provide them with the skills to find integrated solutions to environmental challenges.

The Center's overall goal is to increase knowledge and understanding of the concept and process of sustainability among pre-collegiate teachers, their students, administrators, teacher educators, and community members. The Center aims to achieve this goal by helping to improve and facilitate school and community relationships and collaborations using sustainability as the integrating force, while encouraging the schools themselves to become communities of learners. The Center also serves as an educational resource for the collection and dissemination of information about sustainability materials as well as about organizations, institutions, and individuals that are active in sustainability education initiatives.

http://www.sustainabilityed.org/

11) Southwestern Ecoliteracy Project takes the position that radical change is needed in our cultural relationship to the natural world. The Project seeks to advance an ecoliterate citizenry capable of perceiving and responding intelligently to the complexities and potential crises involved in this interrelationship.

The Project invites collaboration with interested individuals and other organizations toward this purpose. The Project offers educational programs to professionals, including professional development for college department and teachers, as well as public workshops and talks.

http://www.ecoliteracy.org/

12) World Resources Institute (WRI) Education Center is an unusual website in that it offers programs designed for environmental stewardship for business, with links to:

- "**Business-Environment Learning and Leadership Program**" **-** a WRI program offering curriculum resources aimed at filling in the gaps that exist in the business and environment teaching literature. To make management education "green," professors must address environmental issues across the entire spectrum of the curriculum's core courses. Furthermore, students and department must form partnerships with business leaders and surrounding communities to share knowledge and gain practical experience in creatively addressing environmental challenges.
- "**Beyond Gray Pinstripes: Preparing MBAs for Social and Environmental Steward-ship**" **-** a joint report of WRI and the Initiative for Social Innovation through Business (ISIB), a program of the Aspen Institute. As a rapidly growing number of businesses discover sources of competitive advantage in social and environmental stewardship, the report identifies the pioneering U.S. business schools and department dedicated to educating future managers to handle complex social issues and provide stewardship of fragile environmental resources.
- "**Exploring Sustainable Communities**."
- **Powerpoint slide shows -** WRI's powerpoint presentations are designed to make technical ideas and concepts tangible to a variety of audiences. Topics include climate and atmosphere; economics, business, and the environment; coastal and marine ecosystems; forests and grasslands; pilot analysis of global ecosystems (including maps and population statistics); and global trends.
- **Biodiversity Education -** "Building Biodiversity Awareness in Primary and Secondary Schools" (teaching activities, and links to related sites).

http://www.wri.org/wri/enved/

Appendix C

CATALOGUE OF UNIVERSITY COURSES

In what follows, a list of university courses on EE and SD is given in order find helpful hints from these sources.

- **Audubon Expedition Institute -** Graduate and undergraduate degrees with a focus on direct experience. Utilizes immersion techniques for teaching environmental topics.
- **Australian Natural Resource Study Programs -** Directory of links to natural resource and environmental management degree programs and short courses in Australian universities.
- **Boston University Center for Energy and Environmental Studies -** Conducts research and offers undergraduate and graduate degrees in the environment, including environmental policy, energy policy, energy and environmental modeling, environmental risk assessment, natural resource management, global climate change and sustainable development.
- **Cardiff University** - Geoenvironmental Research Centre - Describes research activities and graduate degree programs focused on topics such as remediation of contaminated land, pollution control, risk assessment, and waste disposal.
- **Centre for Arid Zone Studies -** A natural resource consultancy group based within the University of Wales, Bangor offering short courses on Environmental Management, Impact Assessment, Monitoring with GIS and Remote Sensing, Forest Resource Economics and Project Management.
- **Department of Environmental Resources Engineering, Humboldt State University -** Prepares engineers to identify, evaluate and solve complex problems involving the management of environmental resources.
- **Duke University** - Nicholas School of The Environment - Graduate education and research in environmental sciences, including resource ecology, coastal environmental management, resource economics and policy, forest resource management, ecotoxicology, risk assessment, water and air.
- **EnviroEducation.com** - The Environmental Education Directory - Searchable directory of undergraduate and graduate school and department listings in specialities including agriculture, air quality, ecology, and environmental law. Also has advice and other resources for prospective students.
- **Environmental and Water Resource Engineering, Imperial College, London -** Engineering program with a focus on water and wastewater

treatment and distribution, water reuse and sustainability, water resource modelling and solid waste management.

- **Environmental Applied Science and Management, Ryerson Polytechnic University -** Offers a Masters degree for graduate study in environmental science, technology, environmental management systems and decision making.
- **Environmental Science and Safety, Mt. Hood Community College -** One- and two-year programs leading to careers as environmental technicians, safety officers, or hazardous materials managers { or transfer to a 4-year institution.
- **Greenpeace Research Laboratories, Exeter University -** The Greenpeace Research Laboratories form part of the Science Unit of Greenpeace International. The Laboratories provide scientific advice and analytical support to Greenpeace offices worldwide, over a range of disciplines.
- **Hydroinformatics and Management Systems -** MSc, Diploma and Professional Development Courses offered through the Universities of Birmingham, Newcastle, and Shefield. IT distance learning and short courses for professionals in the water industry to improve technical and business decision making within that industry.
- **Imperial College, London -** Centre for Environmental Control and Waste Management, **-** Engineering program that focuses on waste treatment and disposal, environmental and health impacts of waste disposal, recycling and re-use of wastes, treatment of contaminated land, waste management policy and law, and waste minimization.
- **Imperial College, London -** 120 hours of teaching, projects and case studies in engineering for sustainable development, available as an integral part of existing Masters programmes in Geotechnics, Structural Engineering, Transport and Environment/Hydrology.
- **Lesley College's Audubon Environmental Education Program -** In partnership with Audubon Expedition Institute, Lesley College offers a Bachelor of Science degree in Environmental Studies, a Master of Science degree in Environmental Education and a Master of Science in Ecological Teaching and Learning.
- **Master of Energy and Environmental law, Katholieke Universiteit Leuven -** The programme offers a study of international, European and comparative (including US) energy and environmental law, with a strong emphasis on trade law and legal practice.
- National **Center of Excellence for Environmental Management, University of Findlay -** Graduate programs, in-service training and online resources for high school teachers, with emphasis on environmental safety and health.
- **Schumacher College (UK) -** An international centre for ecological studies which welcomes course participants from all over the world, from a wide

range of ages and backgrounds (e.g., university students, professionals, activists, teachers).

- **U.S. Department of Energy Global Change Education Program -** Information and application materials for several educational and research-experience opportunities offered to undergraduate and graduate students.
- **WASTE Program, University of Stuttgart -** New Master Degree Program in environmental engineering. "Air Quality Control, Solid Waste and Waste Water Process Engineering - WASTE"

Appendix D

EUROPEAN COUNCIL OF CIVIL ENGINEERS: CIVIL ENGINEERING PROFESSION IN EUROPE 2005

A review of the profession in Europe today from education to professional practice

Abstract dealing with environment teaching for Engineers

Croatia

Environmental training within civil engineering education

Modules are to be introduced at levels 2 and 3. These modules will be compulsory at level 2 and voluntary at level 3. Some environmental topics have recently been introduced in water engineering courses.

Environmental courses are offered at university-level inter-department postgraduate studies in chemistry, civil engineering, space planning, social sciences, as well as in health and law sciences.

Cyprus

Environmental training within civil engineering education

There are modules in environmental understanding as part of the undergraduate programme. Some of the modules are mandatory. Specific lectures and seminars are organized by the Cyprus Technical Chamber and the Civil Engineers Associations in order to educate civil engineers about the environmental implications of their work. The University of Cyprus has not yet fully adopted the system, but is in the process of adopting it. The University of Cyprus offers two civil engineering four year full time courses.

(a) BSc in civil engineering and

(b) BSc in civil engineering and environment

Postgraduate MSc and PhD research courses will soon be available in the University of Cyprus.

Czech Republic

Environmental training within civil engineering education. Concepts and trends

The environmental protection and sustainable development can be classified among very important topics for all three stages of civil engineering education in the Czech Republic (bachelor, master, doctor). A major target is to synthesise education the ecological and environmental knowledge with the gamut of civil engineering disciplines. Properly trained civil engineer must be able to protect the environment and effectively to use resources. All Czech Civil Engineering Faculties have approved new structured study programmes, branches of study and subjects curricula from the previous academic year. The programmes are design so that, after completion, the graduate will:

- acquire high-quality knowledge related to environmental protection and sustainable development;
- get familiar with legal regulations in the Czech Republic and EU (Planning and Building Law);
- be able to analyse, investigate and manage the projects in his branch of study also from point of environmental aspects;
- be able to develop environment-friendly policy with full responsibility towards the society.

The higher education institutions have prepared compulsory and elective courses devoted to environmental protection and sustainable development, for example Civil Engineering and Environment, Environmental Protection, Environmental Engineering, Air Pollution, Environmental Hydraulics, Environmental lmpacts, Water Quality and Pollution Control, Applied Ecology for Engineers, Ecology, Environmental lmpact Assessment, Environmental and Remote Sensing, Environmental Geology, Environmental Protection of Urban Area, Pollution Control of Urban Areas, Soil and Groundwater Protection, Waste Disposal, etc.

Some problems of this issues are embedded in subjects Building Construction, Building Physics, Maintenance and Rehabilitation of Buildings, Construction Quality, Building Services Systems, Sanitary Engineering, Water Supply and Sewer Systems, Water Treatment, Design of Buildings, Advanced Design in Building Construction, City Planning, Regional and Urban Planning, Analysis of Urban and Environmental Systems, Land Use Planning, Planning and Building Law, etc.

Due to Czech law on higher education all courses can be attended by the public and are also regularly offered by Czech Chamber of Chartered Engineers and Technicians as a part of the life-long system.

Estonia

Environmental training within civil engineering education

One of the Sections in the Department of Civil Engineering focusses on environmental engineering. Naturally, the modules of understanding are mandatory for the students of that department.

For the other students of the Department of Civil Engineering, environmental modules are included into the programs of general studies and so they are mandatory.

Finland

Environmental training within civil engineering education

Environmental training is an important part of the education in technical universities. There are mandatory modules concerning environmental impacts of technology and methods to minimise environmental burden. There are also specific courses concerning environmental issues such as water and wastewater engineering.

A new way of taking into account environmental aspects in civil engineering, called lifetime engineering, is also gradually becoming more important, both in universities and polytechnics. Lifetime engineering deals with optimising energy and material use including ecology and economics aspects and with methods for designing and maintaining structures (houses, bridges, roads, etc) that take into account environmental loads and the true behaviour of the structures as a function of time.

France

Environmental training within civil engineering education

In the schools of engineering, there are generally no specific environment studies. Nevertheless, the "Ecole Centrale de Nantes" includes a "Département de Génie Civil et Environnement" in which environment has an important place.

But, environment is a significant component in all main technical matters, then environment is part of the "basic culture" of students. For example, environment and sustainable development are treated in water supply, waste treatment (etc.) and they are major points taken in account by students at the time of the "designs".

Moreover, in some high schools, environment is effectively introduced as a specific option carried out a final step of studies.

Germany

Environmental training within civil engineering education

Nearly all universities offer modules connected with environmental topics. Some of these are mandatory for every student e.g. building/environmental physics, waste water treatment etc. In addition a number of universities offer specialisation programmes for civil engineers to work later as environmental civil engineers.

There are very few special modules targeting this very topic. One will find such questions and implications as part of the normal educational modules, but they are mostly more technically or legally treated.

Ethical aspects are a rather small part in the education and up to now special module on ethics in the built environment are rare Experience gained during practical placement semester are most appropriate to this question.

Hungary

Environmental training within civil engineering education

Modules in environmental understanding are available in Hungary as part of the undergraduate programme.

Such modules are not mandatory.

Latvia

Environmental training within civil engineering education

There are 2 professional bachelor programms with study length 4,5 years (180 CP) in Civil engineering offered by RTU:

- Building Construction and Reconstruction;
- Transportation Engineering (Roads, Trafic managament and Bridges)

and 2 academic bachelor programms with study length 3 years (120 CP):

- Land surveying and real estate management
- Heat, gas and water technology

and 4 programms (4-years) offered by Latvia University of Agriculture (LUA):

- Rural building
- Environmental and water resource management
- Land management
- Landshaft architecture and planning

Lithuania

Environmental training within civil engineering education

One of the faculties in Vilnius Gediminas Technical University is named as an Environmental Engineering Department. Modules of environmental understanding are mandatory for the students of that department.

For the rest of civil engineering students such modules are not mandatory. There are no special programmes of Environmental implications for civil engineering graduates in their work.

Poland

Environmental training within civil engineering education

Three kinds of studies relating to environmental education exist in Polish Universities of Technology:

(1) Ordinary studies in Departments of Environmental Engineering or Sanitary Engineering, e.g. in such disciplines as water supply, sewerage, central heating, water treatment.

(2) Obligatory subjects type of Environmental Engineering or Environmental Protection in all types of engineering specialities.

(3) Undergraduate studies relating to environmental protection directed to different kinds of engineering activity areas.

The common interest in environmental protection problems amongst civil engineers is reinforced by Polish Building Law which introduced an obligation to prepare special elaboration related to evaluation of influence of each type of new designed engineering construction on environment.

Portugal

Environmental training within civil engineering education

Modules in environmental understanding are available in Portugal as part of an undergraduate programme in courses approved by OE. They are mandatory. Civil engineers are taught about the environmental implications of their work through a mandatory course on environmental impacts in their undergraduate courses.

Romania

Environmental training within Civil Engineering Education

Faculties of Hydrotechnics from the Technical University of Civil Engineering Bucharest, University "Politehnica" Timisoara and Technical University "Gheorghe Asachi" lasi offer a specialization on "Sanitary Engineering and Environmental Protection" within the 5-year integrated programmes. The environmental implication of the civil engineering works are presented in all engineering disciplines, mainly through case studies and emphasis put on the ethical responsibility of civil engineers.

Russia

Environmental training within civil engineering education

Environmental training is a part of the undergraduate program as a special module and is mandatory for all students. The environmental implication of the civil engineering works are also presented in all engineering disciplines, mainly through case studies and emphasis put on the ethical responsibility of civil engineers. A special environmental block is compulsory in the Graduate "Diploma Design, but it's volume depends on the speciality (for instance, more detailed for hydrotechnical, ground engineering and water supply and waste water management).

Slovak Republic

Environmental training within civil engineering education

The goal of the Environmental Engineering Programme is to train specialists in environmental structures, environmental engineering of internal and external environment, waste management, landscape and urbanised territories, transport management and the longevity of structures. The programme also includes the environmental sciences, geo-informatics, project and personnel management, programming and automation of engineering and environmental land and commercial law.

The graduate is suitable for positions as an executive state administration employee in the field of environmental politics, local administration, environmental protection, water management, engineering networks, waste management and environmental management. Other possibilities include landscape planning designer, environmental structures designer and environmental project manager.

Generally, some modules in the environmental understanding are mandatory; some are voluntary, depending on the university/ the department/ the department. However, environmental training is often incorporated in specialised subjects. Furthermore, at the department of Civil Engineering of the Technical University of Kosice, students can choose specialisation "Environmental Engineering" that focuses on indoor building environment and outdoor environment of structures. The Department of Civil Engineering at the Slovak University of Technology offers the study programme Environmental Engineering.

Spain

Environmental training within civil engineering education

There are no mandatory modules in environmental understanding in the undergraduate programme.

However, there are some optional subjects related to environment which students can choose. There are subjects on Environmental lmpact Studies and the "End of Degree Project" must include an Environmental Impact Assessment.

Turkey

Environmental training as a part of civil engineering education

Environmental understanding has been part of the system since the beginning of civil engineering education in Turkey. The subject has become an individual departmental education, but also continued to be held in civil engineering training. The modules of environmental understanding are provided in undergraduate programmes as related courses.

The mandatory education in civil engineering departments in Turkey consists of environmental understanding, although they may not be dedicated to the issue completely. Most of the universities give the aspect as optional courses. The environmental implications of civil engineering are given as an essential fundamental of the discipline starting from introductory courses.

Structures, hydraulics, geotechnics, management, transportation, geodesy, study of materials and other areas provide the importance of the environmental viewpoint within related courses.

United Kingdom

Environmental training within civil engineering

Environmental engineering modules are now found in most accredited courses, both at BEng and MEng level. Degree courses for which accreditation is sought are expected to contain elements which engage students with the broad range of environmental issues that will later inform and influence their actions as professional engineers. The Joint Board of Moderators (JBM) does not seek to be prescriptive as to how these issues are covered in courses; they might, for example, be the subject of taught classes or could be integrated within project or design work.

Appendix E

ECCE - ETHICAL COMMITMENT TO SUSTAINABLE CIVIL ENGINEERING

RECOGNIZING:
The importance of conserving biodiversity
That Civil Engineering acts on the land
The fragility of natural ecosystems
The high complexity of the ecological systems
That Civil Engineering can cause environmental damage
The importance of efficient use of energy
ADMITTING:
Social differences between all countries
The need to equal their basic infrastructures
The right to achieve high quality of life
Years of human pressure
The novelty of the term environmental engineering
The interdisciplinary character of these studies
ASSUMING:
The need to take full account of our environmental impact
The existence of environmental conditions which can influence the technical solution
That technical reasons are not infallible
That we are altering the cycles of the biosphere
That we waste non-renewable products
That nothing can grow indefinitely
That it is essential to stabilize human activity
LET US ACQUIRE THE FOLLOWING ETHICAL COMMITMENT TO SUSTAINABLE CIVIL ENGINEERING

- We will put our professional activity at the disposal of Sustainable Development.
- We will claim a scientific method of assessing all factors concerned.
- We will make the effort of differentiating technical criteria from political criteria.
- We will increase our awareness when we take decisions that may affect the conservation of the natural ecosystems.
- We will employ our determination and professional influences for the benefit of the well being of future generations worldwide.
- We will increase our knowledge about land, ecosystems and ecological processes, as an environmental basis for improving our technical decisions.

- We will acknowledge the influence of our profession in Sustainable Development in Europe.
- The present Commitment will determine the public image of Civil Engineering in the 21st Century.

Appendix F

EUROPEAN CONSTRUCTION TECHNOLOGY PLATFORM: A NEW APPROACH FOR THE CONSTRUCTION SECTOR

The European Construction Technology Platform (ECTP) will raise the sector to a higher worldbeating level of performance and competitiveness. This will be achieved by analysing the major challenges that the sector faces in terms of society, sustainability and technological development. Research and innovation strategies will be developed to meet these challenges engaging with and mobilising the wide range of leading skills, expertise and talent available to us within our industry over the coming decades, in order to meet the needs of the Society.

The ECTP will have to overcome key challenges of the 21st century including:

- The industrialisation of the construction process to reduce significantly construction costs and increase quality;
- The creation of safe and healthy working and living environments for European citizens;
- Participation in the work to streamline national and European legislation to create a truly common market for construction products and services;
- Action to reduce the use of energy, materials, and other resources in construction and in the built environment;
- Enhancing the competitiveness of the European construction sector with respect to the USA and the low cost economies;
- Create an understanding that the construction sector is innovative and researchdriven;
- Contribute to the improvement of the quality of the built environment that will be accessible for all;
- Address the needs of ageing and disabled populations whose mobility and independence are reduced
- by the absence of accessible transport systems and built environments;
- Make construction become an advanced knowledge economy sector at all levels of the supply chain;
- Support integrated and sustainable development and maintenance of the European urban and
- rural environments diminishing conflicts of parties involved in interventions in immovable cultural heritage;
- Ensure our cultural and architectural heritage is preserved for the benefit of society and the richness of our cities;

- Strengthen relationships through the supply and procurement chains particularly with clients, citizens and the end- users of construction products;
- Shifting focus from products to services to the Society.

Appendix G

This appendix shows the academic activities in Estonia, a new member of EU, with respect to programs in SD and EE provided by Prof. Tiit Koppel, Tallinn University of Technology, Estonia.

General Information

The Republic of Estonia with its population of 1.4 million inhabiting the 45,000 sq. km territory on the eastern coast of the Baltic Sea is a small country. Its low population density leaves ample space for wilderness forests, wetlands, reedy coastal areas rich in nesting birds, and picturesque small islands.

The University of Tartu was founded in 1632 by the King of Sweden Gustav II Adolph under the name Academia Gustaviana or Universitas Dorpatensis. Following good academic traditions, this classical Estonian-language university offers research-based graduate and postgraduate degree programmes and deals with both fundamental and applied research.

The mission of Tallinn University of Technology (TUT) is to provide educational, research and innovation services in the fields of engineering and entrepreneurship. TUT is the only university in engineering and technology in Estonia.

The mission of the Estonian Agricultural University is to guarantee sustainable use of natural resources and enhance rural development. The Estonian Agricultural University is the only university in Estonia whose priorities in academic and research activities provide the sustainable development of natural resources necessary for the existence of Man as well as the preservation of heritage and habitat.

TALLINN UNIVERSITY OF TECHNOLOGY

Department of CIVIL ENGINEERING

Main Research Fields in the EE and SD Area

- Structural Design
- Energy saving renovation of building (50
- Design of lightweight structures
- Technologies of complex use and utilization of oil shale ash in the production of building materials
- Improvement of technology of waste water purification plants
- Energy efficiency renovation of building and HVAC systems Projects
- Estimation of building physics qualities on the basis of product indicators
- Actual problems of sustainable development in structural engineering
- Energy saving renovation of the 20th century stone buildings
- Investigation of timber dwelling houses, their renovation and development of timber frame and bridge structures

- Elaboration of the composition of Portland cements with increased durability, using industrial residue
- Evaluation of housing and neighbourhood initiatives to improve the quality of life in deprived urban neighbourhoods (EC, (NEHOM) FW5)
- Properties and usage of burnt oil shale from fluidized bed as main constituent of cement
- Lifetime engineering of buildings and civil infrastructures (EC, FW5)

EDUCATION OF CIVIL ENGINEERING SPECIALISTS. Today's new building design and renovation of old buildings, which may prove more complex than new constructions, are targeted to improved living environment, with emphasis on local features. Civil engineers are faced with new challenges, which offer more opportunities. Young engineers equipped with updated knowledge and skills are required in the building sector. The department has a reputation for high-quality study programs, which have been offered from 1918.

In the civil engineering programs, in addition to basic courses (mathematics, physics, technical mechanics, geodesy, building materials), students gain knowledge in general engineering, economics-related and other subjects. Students perform their practice in the accredited building materials, structural engineering, water analysis, strength, road and hydromechanics as well as geodesy laboratory.

Degree Programs in Estonian

Level	TUT code	Study program	Capacity of the program	Nominal period of studies
Bachelor	EALB02	Logistics	120 CP	3 years
Engineering studies	EAKI02	Environmental Engineering	200 CP	5 years
Engineering studies	EATI02	Transport Engineering	200 CP	5 years
Engineering studies	EAEI02	Civil and Building Engineering	200 CP	5 years
Master	EABM03	Environmental Management and Cleaner Production	80 CP	2 years
Master	EALM02	Logistics	80 CP	2 years
Doctor	EAED02	Civil and Environmental Eng.	160 CP	4 years

CREDIT UNITS 1 credit unit in Estonia = 1.5 ECTS credits

Full academic year 40 credit units in Estonia = 60 ECTS credits

One semester 20 credit units in Estonia = 30 ECTS credits

The **Environmental Engineering** speciality has differentiation in specialization:

1. Water Engineering
2. Heating and Ventilation
3. Environmental Management

Degree Programs in English

Level	TUT code	Study program	Capacity of the program	Nominal period of studies
Master	EABM03	Environmental Management and Cleaner Production	80 CP	2 years

Environmental Management and Cleaner Production

Stage of studies: **Master's studies**
Programme capacity: 80 credit points (120 ECTS credits)
Nominal time of studies: 2 years
Language of instruction: English
Degree awarded: Master of Science in Engineering (M.Sc.)

This programme is suitable for graduates with qualification in different engineering fields, such as Chemical Engineering, Civil Engineering, Environmental Engineering, Material Technology, Mechanical Engineering and others. The goal of the programme is to educate managers who not only understand all aspects of the environmental industry, but are also skilled in critical thinking, problem solving and are able to plan, implement and control all facets of environmental management.

INSTITUTE OF SUSTAINABLE TECHNOLOGY AT TUT

In Tartu the Institute of Sustainable Technology at Tallinn University of Technology has been opened this year. The main task of the Institute is to contribute to the development of the economy of South Estonia. The Institute is engaged in next areas:

1. Industrial ecology
2. Nature protection
3. Landscape ecology and architecture
4. Sustainable environment and quality of life
5. Technique and technology of urban environment
6. Reuse of natural resources

Starting from autumn 2005 the Institute will start to educate students on the basis of curricula of the department of Civil Engineering of TUT. Next specializations are planned: waste treatment technique, environmental protection and planning of surface.

TARTU UNIVERSITY
Department of BIOLOGY AND GEOGRAPHY and
Department of PHYSICS AND CHEMISTRY

The Tartu University has the 3 years Bachelor Degree and 2 years Master Degree study program in Environmental Technology.

Environmental Technology is interdisciplinary speciality covering studies in natural sciences as chemistry, biology, geography and physics, and in engineering branch of study. The students will study environmental chemistry, environmental physics, methods of environmental analysis and monitoring technology, as well learn to know biotechnological processes, microbiology, ecology and processes of chemical industry.

The realization of environmental projects needs the competence in the field of legislation and economy, corresponding juridical and economic disciplines are included to the curricula of the environmental technology.

At the level of Master studies there are different specialization options: **technology of ecosystems, technology of wastes, technology of microbic processes, geotechnology, ecotechnology or technology of environmental monitoring**.

The another study program directly connected with the environment protection in Tartu University is the **Protection of Ecology and Biological Diversity**. The studies are coordinated by the department of Biology and Geography. There are three specializations on master level: **mainland ecology, ecology of waters and biology of nature protection**.

ESTONIAN AGRICULTURAL UNIVERSITY

Estonian Agricultural University in Tartu has the 3 years Bachelor Degree and 2 years Master Degree study program in **Environmental Protection**. There are two specializations after finishing bachelor studies: landscape architecture and landscape protection and management.

EUROUNIVERSITY (EUROLIKOOL)

Department of ENVIRONMENTAL CONSERVATION

Environmental conservation and protection is an area in which many traditional fields of study are closely interwoven. A professional engaged in environmental protection is supposed to have an equally good knowledge of the basics of natural sciences and economics, and be fluent in foreign languages. All these essentials have been considered in designing the curricula. Eurouniversity is a private university.

Bachelor programme

- Full-time Bachelor programme - 3 years (120 credit points)
- distance learning Bachelor programme - 4 years

The curriculum involves subjects related to classical **natural sciences** (General Biology, Zoology, Botany, Physics, Mathematics, General Chemistry, Environmental Chemistry, etc.), major subjects (Environmental Law, Management of Environmental Protection, Environmental Damages Monitoring, Ecological Security, etc.) as well as general subjects (Sociology, Basics of Economy, Philosophy, foreign languages, etc.). Much attention is also paid to practical classes.

Master program

- Length of studies 2 years (80 credit points)

Appendix H

UNITED NATIONS CONFERENCE ON ENVIRONMENT & DEVELOPMENT, AGENDA 21

1. Preamble

SECTION I. SOCIAL AND ECONOMIC DIMENSIONS

2. International cooperation to accelerate sustainable development in developing countries and related domestic policies
3. Combating poverty
4. Changing consumption patterns
5. Demographic dynamics and sustainability
6. Protecting and promoting human health conditions
7. Promoting sustainable human settlement development
8. Integrating environment and development in decision-making

SECTION II. CONSERVATION AND MANAGEMENT OF RESOURCES FOR DEVELOPMENT

9. Protection of the atmosphere
10. Integrated approach to the planning and management of land resources
11. Combating deforestation
12. Managing fragile ecosystems: combating desertification and drought
13. Managing fragile ecosystems: sustainable mountain development
14. Promoting sustainable agriculture and rural development
15. Conservation of biological diversity
16. Environmentally sound management of biotechnology
17. Protection of the oceans, all kinds of seas, including enclosed and semi-enclosed seas, and coastal areas and the protection, rational use and development of their living resources
18. Protection of the quality and supply of freshwater resources: application of integrated approaches to the development, management and use of water resources
19. Environmentally sound management of toxic chemicals, including prevention of illegal international traffic in toxic and dangerous products
20. Environmentally sound management of hazardous wastes, in hazardous wastes
21. Environmentally sound management of solid wastes and sewage-related issues
22. Safe and environmentally sound management of radioactive wastes

Appendix J

THE MONFRAGÜE DECLARATION, SEPTEMBER 2002

Drafted by the standing Environment Committee at the Colegio de Ingenieros de Caminos, Canales y Puertos, SPAIN

Preamble

The members of the standing Environment Committee at the Colegio de Ingenieros de Caminos, Canales y Puertos are meeting in Villareal de San Carlos placed within the Natural Park of Monfragüe located in the province of Cáceres, area to which the members feel closely bond as they contributed to its protection prior to the establishment of the area as a Natural Park, together with other institutions and organizations.

We feel persuaded by social and cultural criteria, many of which find their natural expression in the environment that surrounds us, encouraging the endeavour of a society based on human values and on social solidarity in harmony with environment. We identify the ideal welfare society with preserving and recovering the environment where man can encounter the adequate conditions for the achievement of human ideals of coexistence.

Also, taking into account that the Spanish Constitution recognizes everybody's right to benefit from an adequate environment as well as the duty to conserve it (Article 45.1) and the public administration's obligation to guard the correct use of natural resources in order to protect and improve quality of life and defend and restore environment, based on essential joint solidarity (Article 45.2) principles which should guide our activities.

According to these principles, the Committee shares the model of sustainable development as a strategy adopted by the majority of the 21st Century's modern society, being presently the most adequate formula in order to articulate actions and programmes oriented towards the achievement of the ideal of responsibility towards future generations and solidarity among current generations.

The conception of economic development calls for the adaptation of our professional activity within the frame of the Bruntland report "Our Common Future" and the International agreement reached during the Earth Summit celebrated in Rio de Janeiro in 1992, starting up the Agenda 21.

More recently, the Johannesburg Earth Summit on poverty and environment failed to reach the expected goals, nonetheless it served to renew the commitments contained in the Agenda 21 by establishing a Action Plan including areas such as: water, renewable energies, commerce and globalisation, fishing resources, development aid, health, biodiversity and natural resources.

To a smaller or larger extent all these areas of activity are related to civil engineering , hence we should assume the challenge contained in the Action

Plan as our contribution to sustainable development and make use of the new professional opportunities offered by the need of equate management of the environment.

The Earth is everybody's home

Being aware that:

The Earth has provided shelter, food and other necessary resources for survival to Humanity since thebeginning.

Man has developed capacities in order to take better advantage of these resources and to protect himself from adverse circumstances in nature.

Demographic pressure and inadequate use of technologies in certain areas have broken the equilibrium between man made actions and environment, resulting in overexploitation of resources, disorderly occupation

of the territory, soil, water and air pollution and depletion of the ecosystems. Now Man must apply his knowledge in order to encounter durable formulae which will allow social welfare coexisting in harmony with environment.

In order to design sustainable solutions able to deal with the need of infrastructures demanded by society, an adequate comprehension of the natural processes is required, thus permitting an evaluation of possible damage to the environment prior to the execution and facilitating if necessary proposals of protective measures.

In the economic analysis of the actions, apart from the direct and indirect costs, the correct internalisation of the environmental costs should be considered. In general, these costs are supported by the community without effects on the acting agents.

Therefore, Spanish civil engineers should incorporate into their professional sphere the necessary knowledge in a way that environmental criteria are included in the study and analysis of the selected solutions together with the traditional determining factors (economic, geomorphologic, geotechnical, hydrologic, structural etc..)

The land, in its natural state, apart from presenting natural risk factors (floods, natural fires, electrical storm, volcanic activity, storms on the sea and coastal areas, earthquakes, tidal waves, etc) has a limited capacity as a refuge; hence human development requires actions on the land which are to be studied and executed mainly by civil engineers.

Society, environment and engineering

Consequently, we as Spanish civil engineers are debating the role we should play as to transcend the challenges society are facing in order to reach full social and human development in harmony with the environment and we believe:

That the engineer, as a person immersed in society should above all base his action upon ethical, human and social values of our times.

That engineering should therefore develop its activity taking advantage of its technical knowledge in order to solve social problems concerning the territory.

That in consequence engineering as a professional activity, should be able to identify reachable goals in agreement with interests and problems and to employ and arrange for the necessary means and resources.

The relationship society-engineering implies a reciprocal commitment in which engineers assume the responsibility of serving society and society provides the necessary means.

On the other hand, the complexity of the natural processes, the importance of economic aspects and increasing globalization, is encouraging to a higher degree the constitution of interdisciplinary teams which are joined by specialists from other areas together with civil engineers.

Ideology

Support the content of the Ethical Compromise on Sustainable Development published by the Colegio de Ingenieros de Caminos, Canales y Puertos on February 13th 2002.

Emphasize the ethical compromise of civil engineers towards society above any other bonds which would damage the independency professional dignity.

Foster the links between civil engineering and society, by promoting a higher participation and compromise when facing environmental problems.

Reinforce the traditional education of Spanish civil engineers by extending their knowledge to subjects related to natural science and economic evaluations.

Facilitate continuing professional development and bringing up to date our knowledge in these areas.

Point out to society the importance of the role of civil engineers in the prevention of natural risks and in sustainable management of the land.

Promote I+D projects in the fields of interrelation between the actions upon the land using and conserving natural resources and the protection of the ecosystems, as well as follow-up programmes on the corrective and compensating measures which can facilitate the inclusion of real and experimental data into future actions.

Set in motion conferences, courses, encounters in order to foster, in the various areas of influence among civil engineers, the application of the principals of this Declaration.

Through this Declaration it is the wish of the Environment Commission of the Colegio de Ingenieros de Caminos to make clear to society en general and to civil engineers en particular the need to decidedly impulse the actions which relate to civil engineering on our way towards sustainability.

Appendix K

DECLARATION OF BARCELONA, OCTOBER 2004

International Conference on Engineering Education in Sustainable Development. Barcelona 27-28 October 2004

Preamble

We live in an increasingly complex world and we are at a critical juncture at which humanity must make some serious choices about the future. Our current model of development poses significant challenges when it comes to achieving a more just society based on respect for nature and human rights, and demands a fairer economy and greater solidarity towards different cultures and future generations.

Ignoring this reality when educating and informing future citizens, and therefore future professionals, could have severe consequences. It is undeniable that the world and its cultures need a different kind of engineer, one who has a long-term, systemic approach to decision-making, one who is guided by ethics, justice, equality and solidarity, and has a holistic understanding that goes beyond his or her own field of specialisation.

Education supports a process of self-discovery and learning about the world, encourages personal development, and helps individuals find their roles in society. However, education is also a commitment to improving society by strengthening communities and stimulating social progress. This reality forces us to reconsider the purpose of our role as social actors, in particular as educators, and to construct a way of responding to these challenges.

Education, and particularly higher education, is a vital tool to be used for facing today's challenges and for building a better world. Higher education is essential if we are to achieve sustainable development and therefore social progress. It also serves to strengthen cultural identity, maintain social cohesion, reduce poverty and promote peace and understanding.

Higher education institutions must not restrict themselves to generating disciplinary knowledge and developing skills. As part of a larger cultural system, their role is also to teach, foster and develop the moral and ethical values required by society. Universities need to prepare future professionals who should be able to use their expertise not only in a scientific or technological context, but equally for broader social, political and environmental needs. This is not simply a matter of adding another layer to the technical aspects of education, but rather addressing the whole educational process in a more holistic way, by considering how the student will interact with others in his or her professional life, directly or indirectly.

Engineering has responded to the needs of society and without a doubt, today's society requires a new kind of engineers.

We declare that

Today's engineers must be able to:

- Understand how their work interacts with society and the environment, locally and globally, in order to identify potential challenges, risks and impacts.
- Understand the contribution of their work in different cultural, social and political contexts and take those differences into account.
- Work in multidisciplinary teams, in order to adapt current technology to the demands imposed by sustainable lifestyles, resource efficiency, pollution prevention and waste management.
- Apply a holistic and systemic approach to solving problems and the ability to move beyond the tradition of breaking reality down into disconnected parts.
- Participate actively in the discussion and definition of economic, social and technological policies, to help redirect society towards more sustainable development.
- Apply professional knowledge according to deontological principles and universal values and ethics.
- Listen closely to the demands of citizens and other stakeholders and let them have a say in the development of new technologies and infrastructures.

Engineering education, with the support of the university community as well as the wider engineering and science community, must:

- Have an integrated approach to knowledge, attitudes, skills and values in teaching.
- Incorporate disciplines of the social sciences and humanities.
- Promote multidisciplinary teamwork.
- Stimulate creativity and critical thinking.
- Foster reflection and self-learning.
- Strengthen systemic thinking and a holistic approach.
- Train people who are motivated to participate and who are able to take responsible decisions.
- Raise awareness for the challenges posed by globalisation.

In order to achieve the above, the following aspects of the educational process must be reviewed:

- The links between all the different levels of the educational system.
- The content of courses.
- Teaching strategies in the classroom.
- Teaching and learning techniques.
- Research methods.

- Training of trainers.
- Evaluation and assessment techniques.
- The participation of external bodies in developing and evaluating the curriculum.
- Quality control systems.

These aspects cannot be reviewed in isolation. They need to be supported by an institutional commitment and all decision makers, in the form of:

- A redefinition of institutions' and universities' missions, so that they are adapted to new requirements in which sustainability is a leading concern.
- An institutional commitment to quality.
- An institutional support for changing educational paradigms and objectives research funding.

Universities must redirect the teaching-learning process in order to become real change agents who are capable of making significant contributions by creating a new model for society. Responding to change is a fundamental part of a university's role in society. There is evidence that sustainable development has already been incorporated in engineering education in a number of institutions around the world.

The United Nations Decade on Education for Sustainable Development (2005-2014) offers a great opportunity to consolidate and replicate this existing good practice across the international higher education community.

Universities now have the opportunity to re-orient the traditional functions of teaching and research, by generating alternative ideas and new knowledge. They must also be committed to responding creatively and imaginatively to social problems and in this way educate towards sustainable development.

Report of the
Working Group for the
Specific Project 4

The need for subjects complementing civil engineering technical studies in CE curricula

THE NEED FOR SUBJECTS COMPLEMENTING CIVIL ENGINEERING TECHNICAL STUDIES IN CE CURRICULA

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1. INTRODUCTION

1.1 Definitions

Up to now, no consensus has been reached about the competences, abilities and knowledge a generic Civil Engineer (CE) must have after graduation. It might even be argued whether such thing as a generic CE can really be defined. Some work has been done, initially by the American Society of Civil Engineers (ASCE), to define such competences, skills and abilities a professional CE must show in order to be able to perform professionally. It is arguable whether their conclusions can be applied at the European level.

It is quite clear in our opinion that EUCEET members would support the statement that every Civil Engineer must have a strong technical background, which would allow them to take technical decisions. It is debatable, though, how much scientific background a Civil Engineer must possess. But actually, a few years after graduation, most CE tend to develop a management profile. They become managers of a field construction site or become members of the Board of Directors of some company. Managerial, as well as team-work skills, not to mention foreign languages, become a need. To support this statement, the National Research Council of the U.S, published a report stating that little knowledge of economics and management issues as a very serious concern regarding engineering graduates.

Additionally, there is room for debate about the knowledge needed by a CE in economics, law, arts and humanistic studies, as well as ethical issues. More, a second issue is whether the skills related to such issues must be acquired in the Higher Education Institutions using formal education methods.

SP4 is strongly related to a number of specific projects within EUCEET-II. In particular, links can be established with those groups devoted to defining a

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core curricula for CE within the European Higher Education Area framework (SP1), to specify whether a student can learn using project-based learning (SP5), what is the plus added to a student's education by practical placement (SP2), the importance of including sustainable development in the curricula (SP3), and the full importance of lifelong learning (SP12). SP4 complements this comprehensive view of CE education. It is oriented towards the need for those subjects which would complement the more traditional civil engineering technical subjects and which could be considered for inclusion in CE curricula, either during undergraduate or graduate studies.

SP4 work is then extended to presenting a few ideas of the Working Group members regarding learning outside from the formal education institutions. This implies both the high school level, during the university years but outside from University, and finally, life-long learning (LLL)

1.2 Initial ideas

Learning is a holistic experience, so it should not be left only to University Professors. In words of María José Lemaitre, from the National Accreditation Board in Chile, "Higher education is too important to be left solely to Universities, too expensive to be the exclusive responsibility of the Estate, and too complex and strategic to be left as a private activity".

There are several times and several ways to approach learning. If we focus first on learning periods, through a lifetime span of a Civil Engineer covering from pre-adulthood to seniority, we can distinguish three periods:

1) High School

Some abilities can be acquired, and in some cases must, at this stage. During high school years young people start developing ethical concepts, might realize the need for environmental issues, get some interest in politics, could learn the benefits of teamwork, can learn foreign languages, is surrounded by new technologies, and so on

2) University

During the University period students can learn through:

- Regulated subjects with credits coming from exams, homework,…
- Incorporating ideas within the engineering subjects (examples: European Water Law, Communication, Team Work,…)
- Just as a consequence of aging and information (TV, newspapers, …)
- Develop a personal conscience on cultural diversity (Erasmus exchanges, conferences, traveling, ...)
- Co-curricular activities (getting involved in university politics, collaborating with the campus newspapers, ...)

3) Professional Life

While in professional life, learning can take place as:

- Professional enrichment, interaction with co-workers (not necessarily CE)

- Regulated learning: MBA, postgraduate courses
- Lifelong Learning
- Just by living in a real world and interacting with colleagues, traveling, or getting and analyzing critically information from the media

1.3 Objective

The **overall aim** of SP.4 in general, and this report in particular, is to contribute to the debate about the formation of a Civil Engineer in subjects that cannot be considered traditional engineering subjects. The starting point is to know the type of knowledgeable skills a professional CE must acquire during his/her life. A second group is formed by those skills that are desirable for any CE, but not a must.

The following step would be to define when and where those skills should be acquired. This is done by dividing the learning period into four cathegories: (1) learning prior to the university years; (2) undergraduate (Bachelor type) and graduate (Master type) formal study; (3) learning during the university years but not through formal learning; and (4) professional learning (post University).

In the report we use the term University for simplicity to account for Higher Education Institutions, whether they are actually universities or not.

2. LIST OF RELEVANT COMPETENCES

2.1. An overview

The first approach to the problem consists of finding the different skills a Civil Engineer is going to need through his/her professional life. This is already a formidable task in the sense that not all professionals actually end up doing the same type of work. Professional Civil Engineers might have very different profiles: site construction work, project design, site or project management, industry, administration, research, higher management, and so on.

As such, the very same concept of specifying competences that will be needed by **all** civil engineers becomes an impossible task by itself. Therefore the first stage is to find out which competences are mostly required by, let us say, a large number of engineers. Here it is important to listen to both the actual professionals, a subset of whom are the CE employers, who probably have the most clear ideas about what they look for in a young engineer. But further, it is also important to know what professors, who are responsible for their education, feel. Actually these two groups are linked in a quite subtle way: professionals where students some time ago, and were educated by professors, so that professors introduce some bias in the way of thinking in recent graduates. That is, most recent graduates will probably consider that the things to be taught are the ones they have been taught. This feeling will eventually evolve through the years.

Another important point is the geographical specificity. Employers in different countries need not necessarily look for the same competences. We believe that the big gaps existing at present between the different countries will progressively reduce in time, once the European Higher Education Area (EHEA) becomes an active reality, and therefore we look for generic competences that would apply all through Europe in the coming years.

With this prospective, in this section 2 we will take a look to the expectations of professionals, employers and professors. This general look will set up the framework for the work to be carried out in Section 3, which is basically devoted to see what is being done at present in Universities; that is, what are the different topics that are taught now. We will then give a critical view about how little can be achieved regarding formal learning only, and suggest a number of alternatives regarding non-formal University learning. Once established our general views we provide some views about When and Where (Section 4) and then How (Section 5) Civil Engineers might acquire the competences that seem to be appropriate for an average Civil Engineer all throughout Europe.

2.2. Expectations from the professionals (and prospective employers)

The project Tuning Educational Structures in Europe (Tuning Project), funded by the European Union, and launched in 2001 had, amongst others, the following objectives:

1) to define a number of generic competences that are potentially the objective of higher education, independent on the specific topic (that is, independent of the student major). Then, to ask to a number of people to rank those competences for a specific major.

2) to define a number of specific competences (that is, applicable to civil engineers, but not for students majoring in a different line), and again asking a number of people to grade them in terms of how these competences are really needed for future graduates, ranking from irrelevant to a total must.

The list of generic competences defined in the Tuning methodology is as follows:

1. Ability to work in an interdisciplinary team
2. Appreciation of diversity and multiculturalism
3. Basic knowledge of the field of study
4. Basic knowledge of the profession
5. Capacity for analysis and synthesis
6. Capacity for applying knowledge in practice
7. Capacity for generating new ideas (creativity)
8. Capacity to adapt to new situations
9. Capacity to learn

10. Critical and self-critical abilities
11. Decision-making
12. Elementary computing skills (word processing, database, other utilities)
13. Ethical commitment
14. Interpersonal skills
15. Knowledge of a second language
16. Oral and written communication in your native language
17. Research skills

The actual results of the ranking of these 17 competences can be found in the results of the EUCEET-TUNING Working Group. The relevant results with respect to our Working Group are that we can mark most of the 17 generic competences as complementary to the traditional technical-only engineering competences. In this sense, most employers find that it is as important for young graduates to know the technical aspects of civil engineering, as it is to being able to communicate their thoughts in a meeting, and also taking into account that their teammates are probably not (all) civil engineers and in some cases can have a very different cultural backgrounds.

Knowledge of a different language, interpersonal skills, decision making, and ethics are other non-technical competences that are highly ranked by some employers. Thus, there is a need for future graduates to learn some things apart from the traditional engineering subjects that **must** form the core of civil engineering studies (defining a list of those topics has been the subject of EUCEET-SP1).

2.3. How professors feel

Professors all through Europe were also asked to fill in the same questionnaire as that addressed to employers. A summary of results can be found again in the EUCEET-TUNING Task Force results. Even though the answers differ when compared to those of employers, which by itself is a very significant result, the global ideas obtained from the questionnaires are the same: University professors believe that students must acquire some competences that cannot be classified as either technical nor as scientific, but rather **humanistic** or **interpersonal**.

As explained before, the Tuning methodology incorporates a second analysis on the **specific** competences and abilities of a Civil Engineering graduate. A second questionnaire was designed and circulated amongst University professors to grasp their feeling regarding the following 18 competences and abilities of a prospect Civil Engineer.

1. An ability to apply knowledge of mathematics and other basic subjects
2. An ability to use knowledge of mechanics, applied mechanics and of other core subjects relevant to civil engineering

3. An ability to design (problem definition, analysis, risk assessment, environmental impact statements, safety, constructability, sustainability, cost evaluation) a system or a component to meet desired needs

4. An ability to identify, formulate and solve common civil engineering problems

5. An ability to identify, formulate and solve complex civil engineering problems

6. An understanding of the interaction between technical and environmental issues and ability to design and construct environmentally friendly civil engineering Works (including aesthetic aspects).

7. An ability to design and conduct experiments, as well as analyse and interpret data

8. An ability to identify research needs and necessary resources

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

10. An ability to apply knowledge in a specialized area related to civil engineering

11. An understanding of the elements of project and construction management of common civil engineering Works

12. An understanding of the elements of project and construction management of complex civil engineering Works

13. An understanding of professional and ethical responsibility of civil engineers

14. An understanding of the impact of solutions for civil engineering works in a global and societal context

15. An ability to communicate effectively

16. An understanding of the role of the leader and leadership principles and attitudes

17. A recognition of the need for, and the ability to engage in, life-long learning

18. An ability to function in multi-disciplinary teams

In this new questionnaire, professors were asked to classify these 18 competences from 0 to 4 according on whether they were found "irrelevant" to "of outmost importance". A summary of results can be found in the report of the EUCEET-TUNING Working Group. The most striking result in the opinion of the SP4 members is that all of them, even the a priori least connected to civil engineering "traditional" studies, were considered at least “somewhat important” for future civil engineers. We will come back to this point in the next subsection.

2.4. The view of EUCEET-SP4

Actually a large number of the competences presented in the previous sections include either completely or partly abilities that are traditionally not considered a typical engineering ability. Let us analyze them one by one, showing those in which the SP4 WG members believe these apparently non-engineering competences are relevant. The analysis is based on the additional information (commentaries) provided by the EUCEET - TUNING Task Force regarding each individual Specific Competence.

The main idea of this preliminary analysis is to allow us to get some ideas later about the need for the non-traditional engineering subjects in civil engineering education. In the following list we respect the numbering of specific competences given by the EUCEET-TUNING TF.

Specific Competence 3. The word "Design" includes not only the classical engineering technical topics, but also risk assessment, environmental impact statements, safety, sustainability. All these topics must be included when estimating engineering costs, including life-cycle assessment.

Specific Competence 6. Civil engineers must be aware of environmental as well as aesthetic aspects, and their related costs. Preserving cultural heritage can be included here.

Specific Competences 11 and 12. Include cost analysis and cost control, as well as labor issues. Projects management essentials include project manager responsibilities, defining and meeting client requirements, handling owner-engineer-contractor relationship, bidding and contract negotiations.

Specific Competence 13. Civil engineering graduates should be aware of their responsibility for the public safety, health and welfare. They need to demonstrate an understanding of and a commitment to practice according to the fundamental canons of ethics.

Specific Competence 14. This includes appreciating, from historical and contemporary perspectives, the technical, environmental, societal, political, legal, aesthetic, economic and financial implications of civil engineering works, starting at the project stage, and going through the construction and the final functional stages.

Specific Competence 15. A need for abilities in reading, speaking and writing, possibly not only in the graduate's native language. Civil engineers should be able to present and communicate technical information to a range of audience and be versatile with graphics, the worldwide web and other communication tools.

Specific Competence 16. As a natural evolution, civil engineers tend to move to managerial positions with time. As such, they should be aware of the attitudes conducive to such positions and of the desirable behaviors of leaders.

Specific Competence 17. Life-long learning (continuing education and professional practice experience) is crucial for personal and professional development of every individual.

Specific Competence 18. Civil engineers should be able to participate as team members, or to become eventually team leaders. This requires understanding team formation and evolution, collaboration with various personalities, co-operation among diverse disciplines and so on. Basic recognition of such disciplines might also be needed.

In summary, from the 18 specific competences presented previously, we see the need for non-traditionally considered engineering topics in at least 10.

2.5. Taking a look to the U.S.

The list of competences presented in the previous subsection was constructed on the basis of a list of 15 outcomes defined by the Body of Knowledge (BOK) Committee of the American Society of Civil Engineers (ASCE). This second list itself was also an extension to Civil Engineering of a preliminary list of 11 outcomes defined by the Accreditation Board for Engineering and Technology (ABET). ABET is related to professional and technical societies representing the fields of applied science, computing, engineering and technology, and therefore the 4 additional outcomes added by ASCE are specific to Civil Engineers.

At the moment we write this report, the final results of the EUCEET-TUNING Task Force regarding specific competences are not available. Thus, we will focus on the already published results regarding the ASCE - BOK Committee. First, we should concentrate in the similarities and differences of the competences established by EUCEET-TUNING and ASCE. This can be done using a simple Table (see Table 1). In this Table we have cross-identified the 18 specific competences defined by EUCEET-TUNING with the 15 outcomes selected by the BOK Committee of ASCE. The numbering refers to the one given by each Committee.

Table 1: Comparison of the outcomes for the ASCE - BOK Committee and those of EUCEET-TUNING

EUCEET - TUNING	**ASCE – BOK**
1. An ability to apply knowledge of mathematics and other basic subjects	1. An ability to apply knowledge of mathematics science and engineering
2. An ability to use knowledge of mechanics, applied mechanics and of other core subjects	Included in (1)
3. An ability to design a system or a component to meet desired needs	3. An ability to design a system or a component to meet desired needs
4. An ability to identify, formulate and solve common civil engineering problems	5. An ability to identify, formulate and solve civil engineering problems
5. An ability to identify, formulate and solve complex civil engineering problems	Included in (5)

6. An understanding of the interaction technical/ environmental issues and ability to design and construct environmentally friendly CE works	---------------
7. An ability to design and conduct experiments, as well as analyze and interpret data	2. An ability to design and conduct experiments, as well as analyze and interpret data
8. An ability to identify research needs and necessary resources	---------------
9. An ability to use the techniques, skills and modern engineering tools, including IT	11. An ability to use techniques, skills and modern engineering tools necessary for engineer. practice
10. An ability to apply knowledge in a specialized area related to civil engineering	12. An ability to apply knowledge in a specialized area related to civil engineering
11. An understanding of the elements of project and construct. management of common CE Works	13. An understanding of the elements of project management, construction, and asset management
12. An understanding of the elements of project and construct. management of complex CE Works	Identical to (13)
13. An understanding of professional and ethical responsibility of civil engineers	6. An understanding of professional and ethical responsibility of civil engineers
14. An understanding of the impact of solutions for CE works in a global and societal context	8. A broad education necessary to understand the impact of engineering solutions in a global and societal context
15. An ability to communicate effectively	7. An ability to communicate effectively
16. An understanding of the role of the leader and leadership principles and attitudes	15. An understanding of the role of the leader and leadership principles and attitudes
17. A recognition of the need for, and the ability to engage in, life-long learning	9. A recognition of the need for, and the ability to engage in, life-long learning
18. An ability to function in multi-disciplinary teams	4. An ability to function in multi-disciplinary teams
-----------------	10. A knowledge of contemporary issues
-----------------	14. An understanding of business and public policy and administration fundamentals

Several things must be noted from Table 1. First, EUCEET-TUNING extends some of the more technical outcomes of BOK into two different specific competences. Second, two new competences appear in the EUCEET-TUNING methodology, regarding research skills (#8) and an environmental approach to Civil Engineering Works (#6). On the other hand BOK incorporates two non-engineering competences regarding contemporary issues (#10) and administration fundamentals (#14) which are not included in the EUCEET-TUNING list.

The first step performed by SP4 WG was to analyze in detail these competences and to classify them into categories. Seven different categories have been identified:

- Managerial and economics related competences
- Legal studies, including labor issues
- Communication and negotiation skills
- Humanistics, self-awareness (need for life-long learning included here), interpersonal skills and ethics
- Aesthetics and arts (preservation of cultural heritage)
- Foreign languages
- Ecology, sustainability and social responsibility

In the next section we use these categories to analyze the present situation of Civil Engineering study programs in Europe, in order to later proceed towards when competences included in these categories should be acquired by CE professionals, if ever.

3. ANALYSIS OF THE EXISTING SITUATION

3.1 Procedure

A compilation of the different subjects that are taught in universities through Europe and that cannot be considered amongst the traditional topics in engineering has been performed. The actual methodology used was to download all the information for the different higher education partners included in the Thematic Network EUCEET. The subjects were classified into 7 categories, based on the generic and specific competences obtained from the Tuning methodology. The seven groups are as follows:

a) Managerial and economics related subjects

b) Legal studies

c) Communication and negotiation skills

d) Subjects related to humanistic studies (including leadership attitudes and ethics, plus life long learning)

e) Arts

f) Foreign languages

g) Other subjects (ecology issues included here, but extended to include subjects that do not belong to the previous 6 groups)

For each subject we specify whether it is compulsory or optional, and in which year the course is taught. The results have been compiled and are included as an Appendix to this report. Information from at least one institution has been obtained from 25 countries. The total number of institutions compiled is 73. The catalog of institutions with available data, sorted by country, is included in Table 2.

Table 2. Institutions where information regarding teaching of non-traditional engineering subjects has been compiled.

Université Catholique de Louvain	BE	*
Université de Liège	BE	*,x
Universidade do Porto	PT	
Universidade de Coimbra	PT	
Universidade do Minho	PT	
Instituto Superior Tecnico	PT	
Universidade da Beira Interior	PT	
ETSI Caminos, Canales y Puertos de Madrid (UPM)	ES	
ETSECCP Coruña	ES	*
ETSE Camins, Canals i Ports Barcelona (UPC)	ES	*,x
ETSI Caminos, Canales y Puertos CCP Santander	ES	*
ETSI Caminos, Canales y Puertos de Ciudad Real	ES	
ETSI Caminos, Canales y Puertos de Valencia (UPV)	ES	*
Ingeniería Técnica Obras Públicas U Extremadura	ES	
Heriot-Watt University	UK	
The University of Nottingham	UK	
Cardiff School of Engineering (University of Wales)	UK	
Loughborough University	UK	
University of Portsmouth	UK	x
University of Leeds	UK	
Imperial College of Science, Technology & Medicine	UK	
University of Dublin-Trinity Collage	IE	*
Département de Génie Civil (INSA- Toulouse)	FR	
INSA Lyon - Enginyeria Civil i Urbanismo	FR	
Ecole Normale de Cachan	FR	
Inst. Superieur du Batiment et des Travaux Publics	FR	x
École Nationale des Ponts et Chaussées	FR	
Ecole Généraliste d'Ingenieurs de Marseille	FR	
Ecole Nationale des Travaux Publics de l'Etat	FR	x
Univerza v Ljubljana	SI	
Technical University of Civil Engineering Bucharest	RO	

Universitatea "Ovidius" Constanta	RO	*
Universitatea Tehnica Din Cluj-Napoca	RO	
Budapest University of Technology and Economics	HU	*
Universitet po architectura,stroitelstvo i geodesia	BG	
Slovenska Technicka Univerzita v Bratilave	SK	
Ceské Vysoké Uceni Technické V Praze	CZ	*,x
Vysoké Uceni Technické V Brne	CZ	*
Vysoka Skola Banska-Technicka Univerzita Ostrava	CZ	*
Univerzita Pardubice	CZ	x
Technische Universität München	DE	x
Fachhochschule Oldenburg	DE	x
Technische Universität Dresden	DE	
Technische Universität Berlin	DE	
Technische Universität Darmstadt	DE	*
Ingeniorhojskolen Odense Teknikum	DK	
Tallinna Tehnikaúlikool	EE	*
Norges Teknisk-Naturvitenskapelige Universitet	NO	x
Riga technical University	LV	*
Politechnika Wroclawska	PL	x
Politechnika Warszawska	PL	x
Università Tà Malta	MT	
Tampereen Ammattikorkeakoulu	FI	
Teknillinenkorkeakoulu	FI	
Kungl Tekniska Högskolan	SE	
Lunds Universitet	SE	
Chalmers Tekniska Hogskola	SE	
Háskólinn Íslands - University of Iceland	IS	
Technological Education Institute of Serres	GR	x
Technological Institute of Piraeus	GR	x
Aristoteleio Panepistimio Thessalonikis	GR	
National Technical University of Athens	GR	x
Panepistimio Patron - University of Patras	GR	
Technological Educational Inst. of Thessaloniki	GR	
TU Wien (Austria)	AT	
TU Graz (Austria)	AT	
Universita degli Studi di Roma "Tor Vergata"	IT	*
Universitá degli Studi di Genova	IT	*
Politecnico di Torino	IT	
Politecnico di Milano	IT	*,x

Università di Bologna Alma Mater Studiorum	IT	
Università degli studi di Firenze	IT	*,x
Universitá degli studi di Trento	IT	

A symbol x means information has been provided by the institutions. Otherwise, it has been compiled from the information in the web site. A symbol * means that information on more than one curricula is compiled (e.g., there is a separation between Bachelor and Master, or among different Masters). Full information about the actual subjects taught is provided in the Appendix

3.2 What is presently being taught at the Higher Education Institutions?

Here follows a compilation of the different subjects that are taught in higher education institutions in Europe (compiled from the information in the Appendix). Notice that here we have not included the actual name of the course being taught, but just the most relevant topics.

a) Managerial and economics related studies (NOTE: management of CE Works is considered a technical engineering topic)

- Macroeconomics
- Microeconomics
- Stock market
- Business management
- Marketing
- Financial accounting
- Fiscality

b) Legal studies

- Territorial legislation
- Civil law
- Laboral law
- European law
- Industrial law
- Engineering rights

c) Communication and negotiation skills

- Technical reporting
- Public speaking / Oral expression
- Discussion
- Negotiation skills
- Multidisciplinary project
- Decision taking

d) Humanistic Studies and personal development

- History of Science
- History of Civil Engineering
- History of Architecture

- Cultural heritage (from the local to the European level)
- Social sciences/ Social impact
- Psychology
- Philosophy
- Anthropology
- Demography
- Personal development
- Ethics
- Leadership attitudes
- Learning to learn

e) Arts

- History of arts
- Artistic drawing
- Design/creativity
- Aesthetics

f) Foreign languages

- English as a scientific language
- Second language (mostly English, French, Spanish, German, Italian, Russian, but some other languages are also taught depending on geographical considerations)

g) Others (NOTE: environmental impact of civil works is considered a fully technical engineering topic)

- Ecology
- Sustainability
- Pollution
- Elements of architecture (and related issues such as acoustics, fire control, ...)
- Geopolitics
- Sports
- Religious studies
- Cooperation with developing countries
- Ergonomy

3.3 Are all these topics really needed? A critical overview

The most important point so far is that in **all institutions some** of the topics are taught, but also, in **no institution** are **all** these topics taught as an individual subject. It is clear that the different educational institutions feel the need to teach to civil engineering students some concepts about non-traditionally considered engineering topics. Also, the number of teaching credits is finite, and there is a strong need to fill it with engineering topics. Where is the equilibrium?

It is quite clear that a civil engineer in the XXI century is not a Renaissance Person. We are far from the days when a single person could master a large number of topics, including science, literature, politics, and the arts. Therefore there is a need to somewhat classify the topics in order of importance to civil engineers.

All institutions acknowledge that the different outcomes need not be mastered at the same level. Therefore, ABET defined three different levels of competence, ranging from mere **recognition** (reasonable level of familiarity), to **understanding** (mental grasp and comprehension of concepts), and finally, at the highest level, that of **ability** (capability to perform with competence). We use the same terminology (also adopted by ASCE and TUNING) to classify the list of topics listed in the previous subsection. Since ASCE - BOK already used this classification to define the outcomes (notice the words are used in each one of the outcomes that appear in Table 1), we use their results as a point for comparison.

a) Managerial and economics related studies

Wearne (2004) provides very interesting results regarding a survey carried out on professional engineers in the UK. The most striking result of the survey is that more than 50% of engineers classified themselves as employed in managerial positions. It is therefore of outmost importance for professional Civil Engineers to show an understanding of economic and management concepts. The question, which we will address in the next section, is at what stage should CE acquire this understanding.

b) Legal studies

Civil Engineers are faced with legal issues several times along their professional practice life. While this is true for almost all CE, it is especially true for those involved in territorial development. On the other hand, legal issues must be dealt by layers, not by engineers. We believe CE professionals must be able to recognize some of the relevant issues, without deepening further. This is different from the view of ASCE, which state that legal aspects of public policy must reach the understanding level.

c) Communication and negotiation skills

In the same survey already mentioned, Wearne (2004) provides data showing that over 60% of professional engineers in the UK require negotiating skills in their present job. But the most important result in our opinion is that 87% consider making formal presentations a required competence. While the results are applicable only to the UK, we believe these results can be somehow generalized to other countries either now or in the future. As a consequence communication and negotiation skills should reach the level of ability for all professional civil engineers. Further, ASCE promotes multidisciplinary work in their Policy Statement 418.

d) Humanistic Studies

Within this group we have incorporated the need to have an understanding of contemporary issues (outcome #10 in ASCE), but also personal development self-awareness and ethics. We consider this a need for the Civil Engineering profession, as CE Works have a definite impact on society. This is more the case when CE will in the future have a larger international mobility, thus the need for having some ideas at the recognition level of the history of civilizations. Further, we incorporated into this group continuous personal development, that is life-long learning (LLL). The need for LLL in Civil Engineering can be grasped just by reading the ASCE Mission, which is to "provide essential value to ASCE members, their careers, ASCE partners and the public by **developing leadership**, advancing technology, **advocating lifelong learning**, and promoting the profession". Other relevant topic in this group is that of ethics. We must notice that both ASCE - BOK and EUCEET - TUNING propose ethics as a standalone outcome. The importance of ethics in Civil Engineering is continuously being reinforced with time, as some professional bodies have written a Code of Ethics (available on-line for most professional bodies in Europe, Japan and the U.S.). A large amount of articles and reports on the subject of ethics in Civil Engineering can be found at www.icivilengineer.com/General/Engineering_Ethics/

e) Arts

It is perhaps more questionable the amount of knowledge in issues related to arts that a Civil Engineer would use during their professional life. While concepts regarding history of arts and aesthetics are highly recommendable to civil engineers, we do not believe that the majority of civil engineers actually need this knowledge.

f) Foreign languages

All through Europe most of the companies hiring civil engineers require the young professionals to be fluent in English, particularly at the technical level. We foresee this issue to be more and more important in the future. Now the question is the need to learn a second foreign language. While we advocate that the more languages you know, the better, we believe the knowledge of a second foreign languages is not a necessary condition (but a plus) for young civil engineers.

g) Others (including environmental issues)

Concepts of ecology, pollution control, global warming must form part of the knowledge of all civil engineers. We believe this knowledge should be at the recognition level. Again, we point out here that we consider the subject of environmental impact of civil works as a fully technical engineering topic, and therefore the need for an ability on this particular outcome is not the subject of SP4.

The members of SP4 WG believe there is no need to include as a must for all Civil Engineer professionals topics such as politics, sports, or religion, though we encourage the personal freedom of every individual.

4. *WHEN* AND *WHERE* SHOULD CIVIL ENGINEERS ACQUIRE SPECIFIC COMPETENCES?

When analyzing both the generic and the specific competences defined by EUCEET-TUNING or by ASCE-BOK, the immediate question arising is whether all of them should be acquired at the University years. Actually education is a life-long process, and that competences can be acquired either during:

- the High School years
- the University years
- after University

In the following subsections we analyze these three periods

4.1 Learning in high school

High school years would allow future Civil Engineer students to start reaching understanding, knowledge, and in some cases even abilities in specific non-technical outcomes. In most countries students access university at 18. An 18 year old young person can be fluent in one or more foreign language. Traveling (mostly within Europe) would allow that young person to know different realities through Europe, and maybe to start realizing the benefits of cultural diversity.

Schools would more and more teach students the need toward new technologies, thus showing them how rapid knowledge evolves, creating the seed for the need for life-long learning.

We can even say that some of the outcomes in humanities **should** be the goal of high schools. Issues such as philosophy and arts must start at this level. Awareness of environmental issues, such as pollution, can also be addressed at this level.

Finally, the age at which students reach the University allows them to be involved in social problems and politics at the local government level.

4.2 The University years

Most of the outcomes **must** be acquired at this stage. During the university years, a CE student is exposed to formal and non-formal learning. All technical outcomes must be obtained through regular learning (in the next section we will analyze the different types of regular learning we consider).

In the following we will analyze the level at which the members of SP4 consider graduates from CE Universities should have at the end of the University years, that is, at the **starting** of the professional life.

The boundary condition is that the number of formal credits should not vastly exceed the present situation, as the core of the curricula should be devoted to technical engineering aspects. Thus, it is important to look at the present situation regarding the number of credits in non-technical engineering subjects at the European institutions. According to a survey carried out by EUCEET-I, and as an average through Europe, 5-year programs in Civil Engineering have 7% credits in non-traditional engineering subjects. In 4-year programs this figure increases to around 13 %. In both cases 60% of the credits correspond to subjects related to economics and/or business. The remaining 40% are mostly topics related to humanities and foreign languages. Fr this reason we believe that these complementary subjects sould not exceed 10% of the full curricula, independently of the duration (4-5 years). This figure call for a rationalization of the curricula in the sense that we should try to compile way to acquire some of the competences or skills without actually taking them in a formal way.

a) Managerial and economics related studies

In our opinion, most managerial abilities should be acquired after University, either due to personal interest, or encouraged (and financed) by the companies. In any case, concepts of microeconomics and basic financial accounting are most probably needed by most young CE, and therefore we suggest including it in the MSc curriculum. There is no need to have specific knowledge on economics at the bachelor level. Economic competences can only be acquired through regular learning.

b) Legal studies

While we believe that it would be recommendable the all CE should reach the understanding level regarding legal aspects of public policy, we have taken the approach of reducing the competences that we consider least important. Therefore, we will not recommend including legal studies in all CE curricula. In any case, in those countries were it is possible, we believe universities should encourage students to use some of the optional credits to get basic knowledge regarding legal studies.

c) Communication and negotiation skills

In this case we have no doubt that CE graduates must reach full competence (ability level) regarding communication (both oral and written) and negotiation skills. Thus, all universities should provide ways so that their students have full abilities regarding the following issues: public speaking, negotiation skills, decision taking, plus they can show ability to work on multidisciplinary projects.

d) Humanistic Studies

Amongst the many topics that are included in this group, we consider no especial need to insist in issues such as historical topics, as they can be tackled at the high school level. Thus, only the topics of history of science or history of civil engineering should be addressed at the University level.

On the other hand, University years is time for personal maturation. Universities must provide means for students to learn the benefits of life-long learning, self-awareness, multiculturalism and ethics. This can be done by different means, not necessarily linked to formal education (lessons/credits), as we will address in Section 5.

Last, formal education might be needed to submerge students into the impact of Civil Engineering works in society. Therefore, we recommend incorporating into all curricula a (small) number of credits in social impact of CE works or related topics. On the contrary, we see no need of including issues such as psychology, philosophy, demography or anthropology into a general curriculum.

A more debatable question is whether universities should aim at creating future leaders or if this is a personal skill to be acquired after university. Our idea is that students should get to the level of understanding their potential future role as leaders, but that this competence should really be acquired at the professional level.

e) Arts

As already stated in the previous section, we believe that while concepts regarding history of arts, aesthetics and creative design are highly recommendable to civil engineers, we do not believe that the majority of CE actually need this knowledge. Therefore we do not advocate for including artistic aspects into a general CE curriculum.

f) Foreign languages

One of the advantages of foreign languages is that they can be studied at all levels. That means higher education institutions should use all their political influence to encouraging learning foreign languages at the pre-university level. In our opinion CE graduates should be capable at least of reading and writing technical reports in english (the common technical language nowadays). This does not necessarily mean that Universities must include language learning in the curricula, as language competences can better be acquired using non-formal education. What we consider a **must** is that universities provide possibilities of learning technical English, as well as possibly some additional foreign languages to CE students. We will deepen in this topic later.

g) Environmental issues

Here we propose no direct subjects regarding ecology as part of the curricula, but rather an approach based on learning through adapting the full curriculum to making the student sensible to environmental issues far beyond the topic of evaluating environmental impacts. We will develop this concept later.

Using this global approach we believe Civil Engineering curricula could devote around 10% to non-traditional engineering topics. This would call for minor adjustments in present curricula that will be (in most situations) fully compatible with the future adjustments to be made in the curricula to adapt to the EHEA.

4.3 Learning is never over

Learning should never end. Life-long learning should be incorporated into the mentality of all CE students to account for both technical and non-technical topics. In most cases LLL aims at acquiring specific competences in technical topics, including the use of new software. We will focus here on non-technical subjects.

a) Managerial and economics related studies

Possibly one of the two areas where there is a largest gap between what a professional engineer would need a few years after graduating and what can or should be taught at universities. As stated before, in our opinion, most managerial abilities should be acquired after University, either due to personal interest, or encouraged by the companies.

b) Legal studies

Some professional engineers would eventually find the need for deepening their knowledge in legal studies. Otherwise, there is no much need to be trained in legal specifics.

c) Communication and negotiation skills

Graduates should have full abilities regarding communication. Only practice makes perfection, but in general there will be no need to attend additional formal learning. The situation is a little different regarding negotiation, as full abilities can seldom be obtained at the university level. Therefore additional negotiating skills might be obtained though either formal or informal learning after graduation.

d) Humanistic Studies

Several concepts regarding multiculturalism and ethics can be obtained during the university years at some theoretical level. A few years after graduation, civil engineers would develop their own conscience and awareness about the practical implications regarding ethics and the social impact of their profession. We consider this a highly important aspect of LLL in Civil Engineering. As stated before, in our opinion leadership attitudes should be obtained at this professional level.

f) Foreign languages

Again, additional skills regarding communication using foreign languages can be obtained by professional practice. This includes working in foreign countries or traveling, and presenting own projects to different audiences. We advocate foreign language learning through life.

g) Environmental issues

Some professional engineers would eventually find the need for deepening their knowledge in environmentally related issues, either for personal or professional interest. Otherwise, there is no much need to be further trained in specifics.

5. *HOW* SHOULD CIVIL ENGINEERS ACQUIRE THE NON-TECHNICAL COMPETENCES?

In this section we will recover the reflections from section 4.2 and try to analyze how Civil Engineering students can acquire the required competences at the specified level during the University years. At this point it is important to state that we keep the idea of "using" only 10% of the credits for formal education in non-technical subjects.

Thus, we consider three types of learning during the university years:

- formal learning, meaning having to take a non-technical subject to complete a CE curriculum. Here we do not separate whether learning is through lesson attending, or project-based. An example would be taking a course on communication skills

- embedded learning, meaning the students acquire specific non-technical competences while studying a technical subject. An example would be acquiring communication competences by defending a personal work in a course such as structures, geotechnics or road planning.

- informal learning, through activities that are supported (or not) by the university, which could provide credits for the student or not, but that are clearly out of the classroom. As an example, communication skills can also be acquired too by participating in the campus newspaper.

All these methods can be used for non-technical competences, but not always the three of them are equally valid. Specifically, we believe:

a) Managerial and economics related studies

Mostly acquired through formal learning. Only some concepts of financial risk and decision techniques can be hinted in statistics (embedded learning).

b) Legal studies

Again, mostly through formal learning.

c) Communication and negotiation skills

As we have seen in the example communication skills can be acquired both as formal, parallel or non-formal learning. Our opinion is that formal learning **needs not** be used at this stage. Students should be encouraged to present in public their work, particularly during the last years, when technical aspects are the core of the curriculum, and when work is closest to their future professional activity.

The same happens with the ability to work in multidisciplinary teams. This can better be obtained through embedded education, encouraging students to work in groups where each one of them would take the lead in part of the work, while the final objective is to discuss and present a single project.

d) Humanistic Studies

History of science or history of civil engineering should be addressed through formal learning. A project-based approach can better suit this type of education which is clearly different than that of technical subjects.

Regarding multiculturalism, ethics and social studies, we consider embedded and informal education as best suited. Universities should encourage students to progressively acquire such competences, by means of including different aspects in the technical subjects. That is, for example, a Civil Engineering project must be analyzed not only for its technical aspects, but also by its potential social impact. Thus, we encourage professors to find projects and examples that are not "theoretical", but that are based on real "hot social problems". This would allow professors and students to discuss the concept of ethics while at the same time focusing on the technical aspects of the solution. But we also consider the possibility of using embedded learning in this area. We are thinking here about promoting international exchange experience, practical placement, and extracurricular activities (campus newspapers, cultural activities, integration in society by means of social work, and so on).

Leadership issues can also be tackled through embedded and informal education. Such attitudes can be promoted by using group work with a predefined leader in any technical course. Sports, politics, cultural activities, and so on can also help promoting leadership attitudes in extracurricular activities.

f) Foreign languages

This is the area where more possibilities are available. Formal learning would include specifics of technical English for Civil Engineers. On the other hand we could use embedded learning as follows: by promoting students to read technical literature to use in the technical subjects, by asking students to write class technical reports and to present them in public in a given foreign language, or even by carrying some of the formal lessons in this foreign language. Promoting international exchange and cultural activities in a foreign language are other alternatives.

g) Environmental issues

Again some creativity can be used here. The important point to be made here is that students must be aware of the potential impact of their work. One way to do that is by promoting environmentalization of the curricula. Most of the formal technical classes could be used here. Starting from the more scientific subjects such as physics to the very technical ones, examples regarding environmental problems can be used to promote this idea. Then, all technical projects carried out by students should incorporate the issue of environmental impact.

6. SOME FINAL THOUGHTS

We believe works of the type presented here can help providing a forum for discussions about the direction in which curricula should tend in the next future. At this moment several countries are in the process of defining new curricula that should adapt to the EHEA. Even in those countries where curricula have been recently changed, there is still room for changes in the future, once the new curricula are assessed.

We believe all CE students must know and understand the need and the importance of non-technical subjects in their future professional life. This calls for students to acknowledge the need for incorporating some of these topics in their curricula, particularly in those countries where students can choose a number of free elective credits to complete their curricula.

Still, we are facing a unique opportunity to face the challenges of the CE of the new millenium. The creation of the EHEA implied the changes of educational paradigms, to account for the possibility of the future exchange of professionals. Somehow there is a need for harmonizing the curricula at the European level. While this is difficult for technical core curricula, it will be a formidable challenge for non-technical subjects. In this sense we have provided a potential solution by using a combination of learning at different stages in life (before, during and after the University years), and, within the university years, by learning through different approaches (formal, embedded and informal). We believe this is the only way to allow young professional CE to acquire the minimum number of competences and skills that are (or soon will be) required by employers.

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Report of the
Working Group for the
Specific Project 10

Specialised knowledge and abilities of graduates of civil engineering programmes

SPECIALISED KNOWLEDGE AND ABILITIES OF GRADUATES OF CIVIL ENGINEERING DEGREE COURSES

Laurie Boswell*

1. INTRODUCTION

1.1 Objectives

The objective of SP 10 is to identify the knowledge attained and the abilities that have been developed by graduates of Civil Engineering degree programmes and to provide appropriate benchmark statements. A European perspective has been adopted in order to match the objective with the changing demands of the European Construction Sector.

According to the European Monitoring Centre on Change, www.emcc.eurofound.eu.int (2005) construction is one of Europe’s biggest industries, including the building, civil engineering, demolition and maintenance industries. The Sector has an annual turnover in excess of 900 billion euros and more that 12 million employees. It represents a strategically important sector for the European Union, providing building and infrastructure on which all sectors of the economy depend.

The Sector is characterised by many small enterprises and high labour intensity; it is also highly dependant on public regulations and public investments. Thus policy makers frequently use the Sector as a trend indicator - a cyclical stabiliser of macro-economic trends, restricted in periods with economic expansion and stimulated in periods of recession.

Therefore, it is important to review the Civil Engineering subject matter, which is being delivered in European university departments’ and to provide benchmark statements for subjects and groups of subjects. Civil Engineering is a profession directed towards the skilled application of a body of knowledge based upon mathematics, pure and applied science, together with management, business and legal studies. Civil Engineering degree programmes should not be totally prescriptive and there are differences throughout Europe. Thus, what is important is that graduates should be able to demonstrate a knowledge and understanding of the essential facts of the subjects that are being studied. They should develop intellectual abilities to solve problems and design systems and structures. The development of practical skills and transferable skills are also

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essential. Graduates should also be aware of their social and legal responsibilities.

The delivery of Civil Engineering education cannot be achieved successfully without reference to the Construction Sector. The complex nature of the Sector has already been mentioned and it is essential that there is a steady flow of graduates into the industry, who have been prepared for employment. The relevance of systems of higher education to national economies is accepted by governments around the world. Writers such as Reich (1991, 2001) and Reed (2002) have expressed the importance for economic prosperity of creativity, innovation and entrepreneurialism in the workforce. The development of these skills should be embedded in Civil Engineering degree programmes. The concept of learning and employability will be discussed later.

It is recognised that the degree courses in Civil Engineering, which are offered in European universities will differ in content, style and method of delivery. These differences reflect the individual university's approach to education, as well as local specialisation and subject strengths, for example. More recently, the influence of resources has affected the scope of degree courses. It is generally accepted that the core subjects contributing to courses should have a strong science base and that there is an adequate coverage of applicable subjects, which are relevant to the work of a Civil Engineer. In addition to these requirements there is scope and flexibility to introduce other subject matter as a means to complete the formal education process. These are later defined as non-technical subjects and are considered in detail by the Working Group SP.4

Postgraduate or Master's courses are more focussed in subject content than first-degree courses and involve the study of advanced material. Thus, there are accepted and recognised differences between Civil Engineering degree courses throughout the European Community and that the majority of graduates will be employed in the Construction Sector at sometime in their career.

In order to achieve the objectives of the Specific Project 10, a Working Group was formed to address the issues, which are relevant to the topic. In particular, it was necessary to agree common definitions for knowledge and understanding of the subjects that comprise a degree course. It was also be necessary to provide generic statements regarding intellectual abilities, practical skills and transferable skills, for example. This will lead to Benchmark statements for the main areas of Civil Engineering studies. The work of Specific Project 1, " Core Curricula for Civil Engineering," is particularly relevant in establishing the subjects of importance to Specific Project 10.

It was considered that information about Civil Engineering degree courses that are offered within Europe would be of interest together with some facts concerning employment. Also, the concept of learning and employability should form a link between the taught curricula and its application. Reference will be made to the findings of the other working groups in the EUCEET thematic network, where appropriate.

In order to link the educational output with the demands of the Construction Sector, a review has been undertaken of the Sector with respect to technical matters, which are important and kind of works, which are being undertaken. This approach enables university output put to be conveniently compared with construction activities.

1.2 Working Group Membership.

The first meeting of the working group took place on 27th February 2003 at the EUCEET General Assembly hosted by the Technical University of Athens. The following persons formed the group.

Membership of Working Group SP 10

- Laurie Boswell (Chairman) — City University, London,UK
- David Lloyd Smith — Imperial College London,UK
- Ian May — Heriot Watt Edinburgh,Scotland
- Mohammed Raoof — Loughborough University,UK
- Ulvi Arslan — TU-Darmstadt Germany
- Adnan Ibrahimbegovic — ENS-Cachan France
- Doina Verdes — TU Cluj-Napoca, Romania
- Aarne Jutila — TU Helsinki, Finland
- Alberto Corigliano — Politechnic of Milan, Italy
- George Pilot — CNISF, Paris, France
- Joan Casas — UPC, Barcelona, Spain
- Bernard LeTallec — ISBTP, Marseille, France
- Giorgio Novati — University of Trento, Italy
- Theossios Papaliangas — TEI, Thessalonikis, Greece
- Demetrius Papageorgiou — TEI, Piraeus, Greece
- Wojciech Baranski — University of Lodz, Poland
- Jose Luis Aracil — UP Madrid,Spain

1.3 Deliverables.

The Working Group agreed at their first meeting that the following deliverables would be the outcome of the activities of the Group.

1. An agreement for common definitions for knowledge and understanding of the subjects that comprise a Civil Engineering degree course.
2. An agreement for generic statements, which may be applied to intellectual abilities, practical skills and transferable skills, for example.
3. The development of benchmark statements for the main areas of Civil Engineering studies.

4. A review of the degree programmes in European Community universities (EUCEET members) with respect to the three aforementioned deliverables and reference to learning for employability.

5. A comparison of the specialised knowledge and abilities of graduates with the needs and expectations of the Construction Sector in Europe.

1.4 Group meetings and method of working.

In addition to the first meeting in Athens, two further meetings were held in September 2003 (Cuidad Real, Spain, corresponding with the University of La Mancha Civil Engineering Education Conference) and May 2004 (Malta, corresponding with the Second EUCEET General Assembly). Electronic communication was carried out at all other times.

A questionnaire was agreed by the group and sent to group members for consideration.

The questionnaire (Appendix I) was designed to provide direct information to enable the deliverables one to three to be completed. Thus, information was gathered from group members to establish what subjects were being taught and researched in programmes and what criteria was being used for their content. Information was also obtained for benchmark statements. A good deal of the work that would be the basis of the fourth deliverable had already been undertaken in the EUCEET I thematic network and reported by the Working Groups A and D, Manoliu and Bugnariu.(2001) and would be reviewed in the current context. The final deliverable would be undertaken in collaboration with the industrial member of the Working Group. There were strong interactions between many of the working groups in the EUCEET II network and reference has been made to these, where appropriate.

2. CORE CURRICULA SUBJECT MATTER

Part of the activities of Working Group SP.10 are closely linked to Working Group SP.1 “ Core Subjects in Curricula for Civil Engineering.” Thus, it seemed expedient to incorporate the SP.1 subjects into SP.10 and it was agreed that these subjects would form the core material for degree programmes. The work of SP.1 involved all the universities in the EUCEET thematic network and the subjects that have been proposed, therefore, represent a European view of core curricula. Allowance should be made for the specific breakdown of the curricula. However, it should be noted that the coverage is comprehensive. The diversity of the European Civil Engineering education system allows for particular programmes to adopt some flexibility in the final make up of subject matter.

2.1 Core Subjects in Curricula for Civil Engineering.

The list of following subjects has been presented by Working Group SP.1 and will be adopted by SP.10. Agreement for common definitions regarding the knowledge and understanding of these subjects by graduates was the first task of SP.10 and would form the first deliverable.

Core Subjects in Curricula for Civil Engineering

1 Mathematics and Applied Mathematics
2 Applied Chemistry
3 Applied Physics
4 Computer Science and Computational Methods in C.E
5 Drawing and Descriptive Geometry
6 Mechanics
7 Mechanics of Materials
8 Structural Mechanics
9 Fluid Mechanics and Hydraulics
10 Engineering Surveying
11 Building Materials
12 Buildings
13 Basis of Structural Design
14 Engineering Geology
15 Soil Mechanics and Geotechnical Engineering
16 Structural Concrete
17 Steel Structures
18 Timber, Masonry and Composite Structures
19 Transportation Infra Structure
20 Urban and Regional Infra Structure
21 Water Structures and Water Management
22 Construction Technology and Organisation
23 Economics and Management
24 Environmental Engineering
25 Non-technical Subjects

It is normal practice for universities to describe in some detail the educational aims and outputs for the core subjects, which have been mentioned. Embedded in this detail would be the skills, attributes and qualities that would be expected of a graduate Civil Engineer. This information is to be found in course handbooks and other quality assured documentation and provides a transparent explanation of the education, which is being delivered. In order to provide practical information to satisfy the first deliverable, the core subjects will be grouped and the statements made for knowledge and understanding would then be applicable for each group. This approach allows flexibility for the assignment of subjects to a particular group, where subject treatment provides a choice for grouping. This is essentially the treatment, which has been adopted by the Quality Assurance Agency for Higher Education, www.qaa.ac.uk (2000).

3. KNOWLEDGE AND UNDERSTANDING OF CORE CURRICULA SUBJECTS

The individual groups, which form the overall content of Civil Engineering programmes are given as follows. It is acknowledged that an alternative listing might be possible. However, this generic approach allows for the possibility of "tuning" if it is necessary to be more specific. The subject "non-technical" has not been included since the descriptor does not allow assignment to a particular group. However, evaluation of the subject has been the task of Working Group SP.4

Civil Engineering Generic Groups

1 Mathematics
2 Science
3 Information Technology
4 Design
5 Business Context
6 Engineering Practice

3.1 Group Criteria

Mathematics and Science

Mathematics and science are the basic tools, which Civil Engineers use to understand the physical world in which they work. A good understanding of science is necessary and many of the applicable mathematics subjects such as structures, fluid mechanics and soil mechanics may be classified in this category. The various science subjects will be studied in some depth. Civil Engineers should be numerate and have a good grasp of mathematical methodology.

<u>Knowledge and Understanding of</u>

Mathematics; Appropriate mathematical methods in engineering applications in general and in Civil Engineering in particular.

Science; The fundamentals, which are appropriate to the specific subject, ie, fluid mechanics.

Information Technology

Computer science and technology are closely linked to mathematics and involve the effective use of computational techniques and computer usage. Part of design studies may also be relevant to computer applications and simulation.

Knowledge and Understanding of.

The application of computer science and computer methods for quantitative analysis, simulation and solution of Civil Engineering problems, the fundamentals of IT procedures.

Design

The design of Civil Engineering works is central to the activities of professional engineers and provides the opportunity of creativity and originality. The fundamentals of the basic subjects, which have been taught in a degree programme are the tools that the engineer will use. Although there is a formal procedure to many aspects of design, the engineer must understand how to make a practical approach to a problem and, where necessary, to be innovative.

Knowledge and Understanding of.

The general principles of the design of Civil Engineering structures, systems and works in the broadest context; the performance of materials.

Business Context

It has already been stated that Construction is one of Europe's biggest industries by developing, providing and maintaining the infrastructure. These activities cannot be carried out without reference to the environment, health and safety, codes of practice, political, legal and financial issues. Thus, the business and management context of the work of a Civil Engineer is critical. In addition the engineer is required to understand the social responsibility of these issues.

Knowledge and Understanding of.

Management and business practices, to include, law, finance marketing and human resource management; Civil Engineering project management.

Engineering Practice

The procedures associated with construction processes are usually well founded and graduates would be expected to be familiar with the details of these processes. Typical amongst these are, the design of structures and earthworks, transportation planning and the consideration of both onshore and offshore construction activities. The list is clearly very extensive. The proper management of these processes is essential and requires dealing with technical uncertainty, the evaluation of risk and team-working.

Knowledge and Understanding of.

The operation of construction processes; codes of practice, environmental impact and the associated legal framework; health and safety and the effective control of risk.

4. INTELLECTUAL ABILITIES, PRACTICAL AND TRANSFERABLE SKILLS FOR CORE CURRICULA SUBJECTS

The same generic grouping, which has been used in section 4. will be adopted in this section.

4.1 Group Criteria

Mathematics

Intellectual Abilities.

The ability to select the appropriate mathematical methods for the solution of Civil Engineering problems.

Practical Skills

The skill to use mathematical methods and associated computational techniques for Civil Engineering problem solving.

General Transferable skills

Data manipulation and handling, graphical output and data presentation.

Science

Intellectual Abilities.

Application of fundamental concepts to Civil Engineering problems; modelling of problems.

Practical Skills.

Design of experiments and competence in the use of equipment.

Transferable skills.

Understanding the scientific method.

Information Technology

Intellectual Abilities.

Ability to select and understand the appropriate computer techniques for modelling and analysis of Civil Engineering problems

Practical Skills.

Use of programming languages and general computing facilities.

Transferable Skills.

Appreciation and use of general IT facilities.

Design

Intellectual Abilities

Analysis and design of formal Civil Engineering components and systems.

Innovation and creation for project and system development.

Practical Skills

Design of components and structures with associated technical evaluation; research for information.

Transferable Skills.

Use of creativity and innovation in problem solving; use of a general knowledge base.

Business Context

Intellectual Abilities

Risk and fiscal evaluation

Transferable Skills

Understanding of business economics

Engineering Practice

Intellectual Abilities

Ability to solve problems in the context of Civil Engineering; ability to understand the full implications of risk.

Practical Skills

Ability to apply problem solving methods in an industrial and commercial context; project management.

Transferable Skills

A general engineering approach to the solution of problems; leadership and team working; resource management.

5. BENCHMARK STATEMENTS

Benchmark statements for the core curricula in Civil Engineering programmes are statements of expected levels of achievement. The statements, threshold, good and excellent build upon each other. Once more, the terminology from the QAA Guide to Programme Specification www.qa.ac.uk (2000), has been adapted for the purposes of Working Group SP.10.

It is recognised that programme designers and lecturers may interpret the various criteria in a different way. Thus, the proposed criteria are indicative rather than prescriptive and should be used as a guide only. Generally, therefore,

- Threshold performance is associated with the minimum acceptable standard,
- Good performance impinges upon sound understanding, and the effective use of Civil Engineering methodology,
- Excellent performance is associated with profound understanding and application of analysis of all that encompasses the work of a Civil Engineer.

5.1 Group Criteria

Mathematics	Threshold	Good	Excellent
Knowledge and Understanding	Knowledge of maths methods essential to Civil Engineering	Knowledge and understanding of several methods including an appreciation of range and limitation	Comprehensive knowledge and understanding of a wide range of methods applicable to Civil Engineering
Intellectual Abilities	Aware of the function of standard methods in Civil Engineering	Able to select an appropriate method for the solution of a Civil Engineering problem	Able to identify an appropriate method and apply in a practical situation
Practical Skills	Able to apply routine methods	Application of a range of methods, previously known or researched	Able to research and use new methods where appropriate
Transferable Skills	Manipulation and presentation of data in standard forms	More advanced achievements in data presentation to improve understanding	Able to criticise quality of data and differentiate between methods presentation and manipulation. Provide advice on good practice.

Science	Threshold	Good	Excellent
Knowledge and Understanding	Basic knowledge of principles	Appropriate understanding for a specific Civil Engineering problem	Comprehensive knowledge of principles

Intellectual Abilities	Use of principles to solve basic problems, model and analyses of Civil Engineering systems	Use of principles to solve unfamiliar problems and non standard Civil Engineering systems	Innovative use of principles to solve problems and to model and analyse Civil Engineering systems
Practical Skills	Use of equipment for routine testing, data acquisition and report writing	Design of equipment and experimental procedure, data collection and analysis of results for non standard Civil Engineering problems	Demonstrate innovation with respect to the investigation of difficult problems, collection and manipulation of data using the latest methodology.
Transferable Skills	Analysis of available evidence to analyse basic problems	Able to analyse non-routine Civil Engineering problems	Able to support the analysis of complex problems

Information Technology	Threshold	Good	Excellent
Knowledge and Understanding	Basic knowledge of ITC	Both knowledge and understanding of the role of ICT	Comprehensive knowledge and understanding and limitations of ITC
Intellectual Abilities	Recognition of the scope and limitations of computer methods in Civil Engineering	Understands the scope and limitations of computer methods	Application of computer methods to solve Civil Engineering problems with a full knowledge of scope and

			limitations
Practical Skills	Use of computer based engineering tools to acquire data, solution and display	Able to use computer methods to solve unfamiliar problems	Able to make an individual decision regarding the best method for the solution of an unfamiliar problem
Transferable Skills	Basic familiarity of IT skills	Good understanding and application of IT skills	Excellent range of skills and competences

Design	Threshold	Good	Excellent
Knowledge and Understanding	Knowledge of the essential materials, elements and methods of Civil Engineering design	Has a knowledge and understanding of the essential materials, elements and methods in familiar Civil Engineering situations	Has a comprehensive understanding and considerable knowledge of the essential materials, design process and methodologies. Confident in unfamiliar circumstances
Intellectual Abilities	Aware of the relationship of analysis and design, able to undertake the routine design of CivilEengineering elements and systems	Understanding of the need for analysis linking to elements and systems in design Design competence is good	Comprehensive understanding of analysis and design, Able to demonstrate innovation and creativity for elements and components
Practical Skills	Able to design modifications to	Able to undertake the	Production of an innovative

	existing elements or systems to meet a specification, report writing, fact finding	design of a Civil Engineering system to meet a specification, participation in design planning and implementation	design, able to plan and execute a design solution
Transferable Skills	Develop a new solution from an existing solution	Able to make judgement regarding solution and adopt best practice	Able to generate new ideas, make critical judgements using technical criteria

Business Context	Threshold	Good	Excellent
Knowledge and Understanding	Has a basic knowledge of management and business practices	Has a good understanding of management and business practice	Extensive knowledge of management and business practice and the limits of application
Intellectual Activities	Can evaluate commercial risk using analysis tools	Can evaluate risk in difficult circumstances	Able to make evaluations using risk analysis
Transferable Skills	Can make technical and business presentations, can undertake life long learning	Can organise and deliver at business events, can learn new concepts independently	Can integrate various presentation techniques, Can understand new concepts outside areas of special interest.

Engineering Practice	Threshold	Good	Excellent
Knowledge and	A basic	A working	Comprehensive

Understanding	knowledge of construction processes, and Civil Engineering codes of practice	knowledge of construction processes and good experience of code applications, particularly with respect to unfamiliar circumstances.	understanding of construction processes and application of design codes relevant to Civil Engineering works. Applications to a wide range of situations
Intellectual Abilities	Can integrate the core subject groupings for routine problems. Can evaluate technical risk.	Integration of core subjects and technical risk evaluation of unfamiliar problems.	Profound understanding of the integration of core groupings and technical risk evaluation, incorporating creativity and innovation.
Practical Skills	Develop a plan and allocate resources to Civil Engineering projects. Understand technical and commercial constraints	Experience of applying engineering techniques to construction processes and regard for commercial and industrial constraints	Considerable experience of the application of engineering techniques to construction processes. Can manage a changing operating environment with regard to technical risk and fiscal matters.
Transferable Skills	Can solve general problems and develop a personal work plan as well as the ability for team working.	Can solve problems in an unfamiliar environment and identify critical personal activities.	Demonstrate problem solving skills in a multi disciplinary context, able to undertake a leadership role.

6. EUROPEAN UNION UNDERGRADUATE AND POSTGRADUATE CIVIL ENGINEERING EDUCATION

The initial work of SP.10 agreed the core curricula of degree programmes and defined the knowledge and understanding of the curricula subjects. Generic statements were made, which may be applied to intellectual abilities, practical skills and transferable skills, for example. In order to define levels of achievement, benchmark statements were made, for the core curricula groups.

At this stage in the working group's activities it was thought useful to examine in some detail the current state of Civil Engineering education within the European Union. In particular, details from the members of the EUCEET network were considered to be useful. This approach would give some application to the initial three deliverables, whilst concurrently reviewing the degree courses, which provide the specialised knowledge and abilities that the graduates acquire.

The problem of the relevance of Civil Engineering education and its suitability as a preparation for employment has always been recognised. Generally, universities work with industry to ensure that best practice is followed. The expansion of the educational opportunities within Europe now requires a more formal approach to Civil Engineering education than might have been considered previously. A consideration of what might constitute this approach is part of the working groups fourth deliverable.

6.1 Civil Engineering at Undergraduate Level

During the studies of the first EUCEET thematic network Working Group A, Manoliu and Bugnariu, (2001) produced a considerable amount of information concerning civil engineering education at undergraduate level. The working group gathered data to enable the study of:

- the organisation of Civil Engineering education at undergraduate level in Europe,
- the curricula structure for the first Civil Engineering degree.

That part of the study concerned with organisation addresses issues such as, the title and duration of studies, academic calendar, entry and selection requirements, progression, examinations, final assessment, education in foreign languages and student exchanges.

The study of the curricula structure provides very useful supporting data for the current work of SP.10.The topics, which were considered included the number of contact hours, the distribution of subjects between academic years, weighting of subjects in the curricula and national characteristic that had been observed.

The information gathered by Working Group A is useful for the current study because, the education framework, within which the specialised knowledge and abilities are delivered, has been described in some detail for undergraduate courses.

6.2 Civil Engineering at Postgraduate Level

Manoliu and Bugnariu, (2001) also reported the study of Working Group D, which considered postgraduate education for both Master's and Doctoral levels. The study was presented in two parts:

- Master or Master-type programmes.
- Doctoral studies.

The "Master's" part of the study was more relevant to the work of SP.10 than the "Doctoral" part. Thus, the former part included a discussion of academic structure, details of Master students, activities during Master studies, and award of Master degree. It would seem that education at the Master's level is less prescriptive than at undergraduate level. The reason for this could be the transition period that is taking place after the Bologna Agreement and which is affecting some universities. However, the knowledge and abilities of Master's graduates is no less important. Once more the provision of this data is useful supporting information for SP.10.

The "Doctoral" part of the study considers, academic structure, student details and activities, and awarding a doctoral degree. The work of SP.10 has concentrated on taught programmes and doctoral considerations are generally outside its scope. It should be mentioned, however, that the benchmark description at the "excellent " level would be at least the minimum level of achievement for a doctoral candidate.

6.3 Employment Destinations

Working Group D has collected some information regarding the first destination of employment of graduates. However, it would appear that there are no particular trends for either Master's or Doctoral students. Typical destinations include, teaching at school or university level, industrial or university research work, and business employment. No further details were obtained. The broad base and depth of Civil Engineering education provides scope for many transferable skills and prepares graduates for jobs that may not be within the engineering profession.

6.4 Learning and Employability

Different ways of teaching the same content can lead to similar performances on tests of content mastery and to significant differences in other respects. For example, problem based learning (the subject of Working Group SP.5) and conventional presentation of material can be associated with similar levels of content mastery, but the former is also frequently associated with better problem solving, a better grasp of practicalities and greater understanding of client requirements. This difference is sufficient to make the point that different teaching approaches often have different outcomes. These are not necessarily reflected in the general conclusions that can be made from the deliverables, 1 to 4, of Working Group SP.10. Here, it has been assumed that the information presented in these deliverables is good and accepted practice. However, the style of delivery and the links with relevance and employability are only tacitly referred to in theses deliverables. The working group have considered it to be worthwhile to expand on this theme. An excellent reference is provided at www.heacademy.ac.uk/employability (2004), which has been used in this section.

6.4.1 What are employers looking for?

In recruiting to graduate level jobs, employers are looking for graduates who possess high level skills, knowledge and personal attributes, and who can grow into the job. In some employment situations, the application of subject specific expertise is critical, whereas in others it is not.

Many surveys of graduate employment try to assess the extent to which knowledge and skills developed during higher education are being used in employment or the extent to which they are being used in current job situations. This latter consideration leads on to questions of graduate over or under employment, Bowers-Brown and Harvey, (2004).

Research over a quarter of a decade finds a broad consensus about the attributes that employers expect to find in graduate recruits. They should exhibit the following:

- Imagination/creativity
- Adaptability/flexibility
- Willingness to learn
- Independent working/autonomy
- Working in a team
- Ability to manage others
- Ability to work under pressure
- Good oral communication
- Communication in writing for varied purposes/audiences
- Numeracy
- Attention to detail time management
- Assumption for responsibility and for making decisions
- Planning, coordinating and organising ability

Many aspects of employability, which include those given in the above list, are to be found in Yorke and Knight (2004). It is important to note that, in general, these attributes are to be found embedded in sections 4. and 5. in this report. There is a risk, however, that lists of qualities and attributes such as that given will draw attention away from the diversity of the Construction Sector labour market in which there are small, medium and large enterprises, private and public sector organisations. Not all organisations want the same set of attributes.

6.4.2 The Curriculum and Employability

Institutional learning and teaching strategies are expected to deal with the issue of how the institution is addressing employability through its curricula. Many teaching activities that promote good learning in the particular subject also promote employability in general. Employability and subject specific learning are complementary. The studies of many of the working groups in the EUCEET 1 and II thematic networks support this viewpoint.

It is useful to consider how curricula can be "tuned" to enable fine adjustments to be made to accommodate the concept of employability. Key considerations for tuning curricula include:

- Developing an appreciation of what employability might mean for the curriculum in question, and expressing it in terms of student entitlements.
- Considering how the intended learning outcomes were distributed across the curriculum, and how the distribution might be made more effective for the promotion of employability.
- Applying a similar consideration to the provision of teaching and learning opportunities intended to foster those outcomes, and checking that assessment practices also promoted them.
- Determining what adjustments to (a) curriculum structures and (b) pedagogical approaches would be feasible within existing validated programmes of study-hence, in innovative terms, this could be characterised as a "low pain, high gain " approach.

Placing employability activities in Civil Engineering curricula should not be difficult and presents opportunities.

6.4.3 Supporting the Development of Employability

What can the individual lecturer or course team do at a local level to foster the notion of employability? Usually, employability correlates with good learning and that good learning is mostly likely when students are engaged by challenging tasks. It is accepted in Civil Engineering programmes that there will be a variety of learning and teaching approaches that embed the notion of employability.

The development of student personal awareness and a personal development plan, although not part of formal instruction, should be encouraged within programmes and help students' to.

- become more effective, independent and confident self-directed learners,

- understand how they are learning and relate their learning to a wider context,
- improve their general skills for study and career management,
- articulate their personal goals and evaluate progress towards their achievement,
- encourage a positive attitude to learning throughout life.

The subject of the last statement has been considered in detail by Working Group SP.12.

The use of reflection is another approach to encourage students to link their studies to employment. Questions such as:

- What employment relevant skills have you used today?
- Has this activity developed your knowledge and skills?

can be asked at the end of a lecture to prompt reflection.

Perhaps the most effective method of linking academic studies with employment is the use of integrated programmes, whereby students have the opportunity to work in the Construction Sector whilst undertaking higher education. Such schemes are common across Europe and take a variety of forms involving short (two months) or long (one year) secondment in industry. The student has a senior engineer to act as an industrial mentor and is visited by an academic member of staff. The student keeps a personal development plan of the secondment. The results presented by Working Group C in the EUCEET I studies (2001) show that there is considerable activity between universities, research, industry and public authorities in the Construction Sector. Therefore, learning and employability is an accepted notion within European Civil Engineering departments.

7. A COMPARISON OF THE SPECIALISED KNOWLEDGE AND ABILITIES OF GRADUATES WITH NEEDS OF THE CONSTRUCTION SECTOR

The activities within the European Construction sector are very diverse and reflect the different economic needs of the EU countries at the various stages of their infrastructure development. Therefore, it is not practicable to be too specific in trying to balance the outcomes of a graduate Civil Engineering education with the perceived needs of the Construction Sector. It is important, however, to establish some basic relationships to demonstrate that the general needs of the Sector are being met.

An interesting example to illustrate this point is the rise in steel prices in 2004 and likely affect this would have on the sale of structural steel and, hence, it's use as a material of construction within Europe. Figures produced by the 2005 European Statistical Bulletin showed that in the majority of European countries the effects of the price rises had not seemed to affect sales of structural steel www.steelconstruct.com (2005). Whatever had been the outcome of the price rise, the need to consider steel as a construction material and associated courses in steelwork design would have not have changed. Thus, the specialised knowledge and abilities of graduates should satisfy the Construction Sector in a general and stable way.

In order to understand how the knowledge and abilities "fit in" with the Construction Sector, two approaches might be considered:

- Consideration by technical matters: construction materials, construction processes, construction design, behaviour of works, etc.
- Consideration through the kind of works: highways, buildings, bridges, etc.

Since companies are organised according to the latter consideration, this approach will be adopted.

7.1 Classification by kind of work

The following classification of the various works within the European Sector will be adopted. It is recognised that it is not exhaustive and that alternative definitions are possible

- Highway Engineering
- Urban or Utilities Engineering
- Soil and Foundation Engineering
- Bridge Engineering
- Building Engineering
- Environmental; and Sustainable Development
- Risk and Risk Management
- Business and Engineering Practice

The following three examples for, bridges, road infrastructure and soil and foundation engineering are typical and may be modified for other headings in the classification list.

Bridges

Subject	Knowledge & Understanding	Skills
1.Advanced materials *High performance concrete* *New metals*	 Applied mechanics Material technologies Physics Chemistry	 Mechanics of mixtures Advanced material testing Composite material technologies

Composite materials		Constitutive equations of materials
2.Advanced bridge design		
Fixed structures *Innovative structures* *Large bridges*	Construction Mechanics Numerical modelling Informatics Vibration of systems	Constructions processes Design of structures Analysis for effects of wind and vibration Earthquake engineering Familiarity with specialised software
3. Bridge maintenance		
Diagnosis *Monitoring and surveying* *Maintenance technologies*	Mechanics Construction Survey strategies Monitoring of structures	Survey technologies (including sensors and data transmission) Defect analysis Structural mechanics Reinforcement technologies

Infrastructure (Roads)

Subject	**Knowledge & Understanding**.	**Skills**
1.Materials for Roads basic materials *Bitumen, aggregates, cements,* *Aggregates* recycled materials *road material* *industrial by-products* *urban incinerator slags*	Applied mechanics Physics Chemistry	Applied engineering geology Sustainable development Environmental Protection Rheology of materials
2. Mixed Materials *bituminous mixtures* *hydraulic binders mixtures* *concretes*	Applied mechanics Physics Chemistry	Mechanics of mixtures Rheology of mixtures Specialised testing

3. Pavement Mechanics *stress-strain calculations* *pavement design* *deterioration processes* *pavement reinforcement*	Applied mechanics Modelling Informatics	Pavement behaviour (Flexible, rigid, semi-rigid) Use of specific software Mechanisms of deterioration
4. Construction Processes *construction equipment* *constructio technologies* *quality control*	Machinery functioning Applied electronics Information technologies	Road construction equipment Sensor technology Robotics and data base Basic quality control
5. Road use properties *road safety drivers comfort environment protection*	Physics Testing equipment Quality management	Basic road properties (evenness, skid resistance, noise) Testing procedures, in laboratory and in situ Agreement procedures (ISO 9000, ISO 14000)
6. Road asset management *Construction maintenance safety asset preservation*	Economy Strategies Informatics	Pavement condition diagnosis Maintenance sophisticated technologies Software for strategic choices

Soil and Foundation Engineering

Subject	Knowledge & Understanding.	Skills
1. Advanced testing methods	Applied mechanics	Boring technologies

laboratory testing *in-situ testing*	Engineering geology Hydraulics	Soil testing methods Evaluation of soil behaviour
2. Advanced modelling *numerical modelling* *centrifugal modelling*	Mechanics Informatics Numerical modelling Simulation methods	Soil and structure modelling Constitutive equations for soils Centrifugal technology
3. Deep foundations	Related soil properties Deep foundation technologies	Bearing capacity calculation Pile foundation testing
4. Embankments on soft soils	Engineering geology Related soil properties Hydraulics	Soil consolidation calculation Embankment stability calculation Use of related software Monitoring of soft soils
5.Slope stability	Engineering geology Related soil properties Hydraulics	Slope stability concepts Slope stability calculation Use of related software Monitoring of slopes
6. Retaining structures	Construction technologies Related soil properties Soil-structure interaction	Retaining structure technology Concepts on internal and global stability Use of related software
7.Earthworks		Compaction of soils Earthwork methods In-situ-quality control
8. Soil improvement	Related soil properties Earthworks technologies Soil treatment methods	Consolidation calculations In-situ pore pressure

	Advanced soil properties Soil improvement techniques	and shear strength measurement Use of specialised software In situ quality control

7.2. Some comments regarding output and needs.

It is interesting to compare the list of core curricula given in section 2.1, which are related to the knowledge, understanding and skills, to those given in the tables of section 7.1. If a broader view were to be taken, it is reasonable to state, that universities deliver the necessary knowledge and understanding and the skills, which are essential for Construction Sector employment. Importantly, these have been quantified by the European university system within a framework of quality assurance and subsequently given benchmark statements.

8. SUMMARY AND CONCLUSIONS

A review has been undertaken of the specialised knowledge and abilities of graduates of Civil Engineering degree courses within the European Union. Universities with EUCEET membership have been involved in the review.

Section 1.3 of this report has cited five deliverables, which were to be achieved by Working Group SP.10. These deliverables have been achieved. Thus, common definitions for knowledge and understanding for the groups forming the core curricula for civil engineering degree programmes have been agreed. Also, generic statements have been made that may be applied to intellectual abilities, practical skills and transferable skills, for example. Benchmark statements regarding achievement levels for the core curricula groupings have been made.

A review of European civil engineering degree programmes demonstrates their conformity with deliverables one to three and, therefore, the practice of good QAA procedures. An interesting observation concerns the natural embedment of the principles of employability within degree programmes.

Finally, a study of the structure of the “kind of works” being undertaken in the Construction Sector shows, that there is a direct comparison of the specialised knowledge and understanding of the outcomes of graduate education with employment activities.

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Appendix I.

The following questionnaire was sent to the members of Working Group SP.10 for evaluation

EUCEET II

Specific Project 10

<u>Specialised Knowledge and Abilities of Graduates of Civil Engineering Degree Courses</u>

1. What Civil Engineering related subjects are being taught at undergraduate and post graduate levels and what are being researched?

Subject (Taught).	Knowledge and Understanding.	Skills.
Subject (Research).	Knowledge and Understanding.	Skills.

2. What are the criteria for the content of Civil Engineering programmes?

Subject	Knowledge and Understanding	Intellectual Abilities.	Practical Skills.	Transferable Skills.

3. Benchmark Statements for the main areas of Civil Engineering.

Subject.	Threshold.	Good.	Excellent.

4. A review of Civil Engineering taught and research programmes in the EUCEET member countries, with respect to the aforementioned deliverables.

Provide appropriate information.

5. A comparison of the specialised knowledge and abilities of graduates with needs and applications of the European Construction Sector.

Provide appropriate information.

Report of the
Working Group for the
Specific Project 11

Academic and professional recognition and mobility of European civil engineers

ACADEMIC AND PROFESSIONAL RECOGNITION AND MOBILITY OF EUROPEAN CIVIL ENGINEERS

Prof. Dr. C. Ahrens[1]

1. INTRODUCTION

Not only in Europe, but everywhere in the world men can see, live with, be delighted by, be getting full of enthusiasm of and can be thrilled by numerous outstanding buildings and even congestions of such forming an outstanding city. The UNESCO-catalogue gives an extremely impressive picture of the world heritages as having been built by civil engineers all over the world, within different national communities and having experienced different national education systems and conditions – since thousands of years.

In the past as well as today the education and training of civil engineers was and still is different, but always closely connected to national education systems and professional paths to gain experiences within civil engineering companies and professional surroundings [1]. No civil engineer could achieve positions at the beginning of his career to build one of the above mentioned buildings. But every civil engineer gained more and more experience during his employment within a company, society, association, projecting office etc. to come up in a very experienced stage to build normal and extraordinary buildings and other civil engineering works.

So, there could really be no objection not to trust or have confidence in the education of civil engineers and its procedures to gain quality and professional experience in another country, especially in another EU-member state, as the education and living conditions are so closely connected to each other.

But the daily experiences at universities as well as in companies and even in regulating professional associations or chambers show that there are still a number of bureaucratic hurdles, difficulties in understanding, description of competencies etc. The data, the SP 11 work group has collected, show it too.

2. DEFINITION OF A CIVIL ENGINEER

Why do civil engineers envisage difficulties as described above? Are different working fields or different tertiary education systems the reason for? Could the following definition of a civil engineer help ending this problem? –

[1] Chairman of EUCEET II SP. 11 Work Group,
Vice president of European Council of Civil Engineers (ECCE)FH OOW,
Professor, University of Applied Sciences Oldenburg/Ostfriesland/Wilhelmshaven, Oldenburg, DE

The definition is from an ECCE working paper and has been adopted by the SP. 11 work group.

Civil Engineering is a great art, on which wealth and wellbeing of the whole of society depends. Its essential feature is the exercise of imagination to fashion the products, processes and people needed to create a sustainable natural and built environment. It requires a broad understanding of scientific principles, knowledge of materials and the art of analysis and synthesis. I t also requires research, team working, leadership and business skills.

A civil engineer is one who practises all or part of this art.

A civil engineer by this is an academically educated and practice-oriented professional who has and uses scientific, technical and other pertinent knowledge and skills to create, enhance, operate and maintain safe and efficient buildings, processes or devices of practical and economic value, for industry and the community.

3. PROFESSIONAL RECOGNITION UNDER THE EU-DIRECTIVE – TARGETING QUESTIONS OF SP 11 WORK GROUP

Based on the given definition of a civil engineer the following questions have been formulated at the Malta-conference in May 2004 [2] and repeated in the Oldenburg meeting of the SP 11 working group in May 2005 [3]:

- How does the EU-directive COM (2002) 119 (which is now **Directive 2005/36/EU [4]**) influence mutual professional recognition?
- Does it reflect the appropriate higher education of civil engineers?
- Does it support the cross border settlement and delivering of services of civil engineers?
- What are the benefits of a **common European platform** for (civil) engineers?
- Who can work out and/or give advice for building such a platform?
- How many civil engineers will have profits from such a directive?
- How can quality be assured in relation to international registers?

4. TRAINING, RECOGNITION AND MOBILITY AND COMMON EUROPEAN PLATFORM FOR PROFESSIONAL CIVIL ENGINEERS

4.1 General Remarks

The New Directive 2005/36/EU of the European Parliament and the Council on the Recognition of Professional Qualifications dated 7. Sept. 2005 is a General Directive which covers all professions and shall replace the Directives

89/48/EEC and 92/51EEC on the general system and a number of other Council Directives.

The New Directive makes provisions for the recognition of professional qualifications as a combination of **academic qualifications and professional training and experience** to enable movement of workforce between Member States. These provisions apply to the regulated profession and concern free movement of the professionals as well as delivering services.

4.2 Effects of recognition

The effects of recognition are, of course, the basis for mobility and are described in Article 4 of the directive as follows:

1. The recognition of professional qualifications by the host Member State allows the beneficiary to gain access in that Member State to the same profession as that for which he is qualified in the home Member State and to pursue it in the host Member State under the same conditions as its nationals.

2. For the purposes of this Directive, the profession which the applicant wishes to pursue in the host Member State is the same as that for which he is qualified in his home Member State if the activities covered are comparable.

4.3 Regulated Profession

The description/definition of what is meant by a regulated profession is placed in Article 14 of the directive as follows:

Definitions

1.For the purposes of this Directive, the following definitions apply:

(a)"**<u>regulated profession</u>**":

a professional activity or group of professional activities, access to which, the pursuit of which, or one of the modes of pursuit of which is subject, directly or indirectly, by virtue of legislative, regulatory or administrative provisions to the possession of specific professional qualifications; in particular, the use of a professional title limited by legislative, regulatory or administrative provisions to holders of a given professional qualification shall constitute a mode of pursuit. Where the first sentence of this definition does not apply, a profession referred to in paragraph 2 shall be treated as a regulated profession;

(e) **“regulated education and training”**:

any training which is specifically geared to the pursuit of a given profession and which comprises a course or courses complemented, where appropriate, by professional training, or probationary or professional practice. ….

(b), … (i) do not apply

4.4 Academic Qualification or Levels of Qualification

Up to now EU-regulations concerning higher education are discussed within the wording schemes of Bologna Process, European Higher Education Area, EUR-ACE etc. With the directive 2005/36/EU there is an additional player in action. Even though the directive is dealing with regulated professions it introduces the new wording of "**training**" and besides this it describes – outside each Bologna paper – **two levels of higher education** in article 11 as follows:

Article 11 **Levels of qualification**

(d) a diploma certifying successful completion of training at post secondary level of **at least three and not more than four years‘ duration**, or of an equivalent duration on a part time basis, a university or establishment of higher education or another establishment providing the same level of training, as well as the professional training which may be required in addition to that post secondary course;

(e) a diploma certifying that the holder has successfully completed a post secondary course of at **least four years‘ duration,** or of an equivalent duration on a part time basis, at a university or establishment of higher education or another establishment of equivalent level and, where appropriate, that he has successfully completed the professional training required in addition to the post secondary course.

4.5 Common European platform for professional civil engineers

Up to now it is the normal procedure for any individual to personally apply for being accepted whether to a university or to a professional regulating body when going abroad to study or settle down as a professional (civil engineer).

In most cases this individual application is connected with the fulfilment of a number of specific regulations and demands and by this to come up with compensation measures in the host (member) state.

The most convenient possibility by which this can be done in a relative clear, secure and quick way is by waiving of compensation measures and is set out in Title 1 General Provisions, Article 15. This article opens the possibility that "European professional organisations may establish common platforms at European level" providing adequate guarantees as regards the applicants level of competence. Again: By this the respective individually necessary compensation measures as described in Article 14 will be minimised.

Article 15 **Common Platforms**

1. For the purpose of this Article, **"common platforms"** is defined as a **set of criteria of professional qualifications** which are suitable for compensating for substantial differences which have been identified between the training requirements existing in the various Member States for a given profession.

These substantial differences shall be identified by comparison between the duration and contents of the training in **at least two thirds of the Member**

States, **including all Member States which regulate** this profession. The differences in the contents of the training may result from substantial differences in the scope of the professional activities.

2. Common platforms as defined in paragraph 1 may be submitted to the Commission by **Member States** or by **professional associations or organisations which are representative at national and European level.**

If the Commission, after consulting the Member States, is of the opinion that a draft common platform facilitates the mutual recognition of professional qualifications, it may present draft measures with a view to their adoption in accordance with the procedure referred to in Article 58(2).

These common platforms as a set of sufficient criteria of professional qualifications can be established only by European professional organisations for a **specific profession**.

It is ECCE, the European Council of Civil Engineers, and ECEC, the European Chamber of Engineering Chambers, which represent a specific profession, the specific profession of Civil Engineers. ECCE was created in 1985 and has established a formation process for professional civil engineers, which has been accepted by 22 countries including all those countries within the European Union where the profession is regulated (except Austria). ECEC has been created in 2002 and consists of 9 European member chambers.

The respective platform of European associations will be described in chapter 7.

5. MAIN ACTIVITIES OF SP 11 WORKING GROUP

5.1 Meetings

The working group SP 11 was installed in Malta and participated in the following EUCEET-meetings:

- Malta, 6. – 8. May 2004, Action Plan (9 members out of 32 attendants)
- Autumn 2004, Visits to and discussion with different CE associations by members
- Februar 2005, Distribution of Questioning cases to all members
- Oldenburg, 20. – 21. May 2005, Meeting of SP 11 (4 members, 4 apologizes)
- Helsinki, 14. June 2005, Report back by A. Lovas

5.2 Questionnaire/Case Studies

The questionnaire has been developed in a form of possible cases and was addressed to

- Institutions of Higher Education
- National Civil Engineering Associations, Societies, Organisations etc.

- Building/Construction Companies

During the Oldenburg meeting it was decided that no actions should be continued or newly be started concerning any investigation at universities. The “old” education system will find an end very soon and will be replaced by the European Bologna System.

5.2.1 Cases for Civil Engineering societies, organisations, authorities

The questioning cases are given as follows to Civil Engineering societies, organisations, authorities as follows:

Case A1

A young civil engineering has just finished his 4-year education with a Bachelor degree in a Member State of the EU e.g. Ireland. His degree is officially equivalent to a 4-year education in your home country. He speaks sufficiently your language to come up with normal life.

Would you allow him to get a license for employment? Under which conditions?

Do you accredit his degree or title as a civil engineer? Under which conditions?

Do you envisage any problems with home civil engineers or companies?

Case A2

An adult (senior) civil engineer from an EU-member State with 10 years of experience in a company and being a member of his national civil engineering association, chamber or society is asking for a job in one of your home companies. He is very much skilled but speaks not very fluently the language of the host country.

Would you allow him to get a license for employment? Under which conditions?

Do you accredit his degree or title as a civil engineer? Under which conditions?

Do you envisage any problems with home civil engineers or companies?

Case A3

A civil engineer from abroad (not an EU-member State) with a 3-year Bachelor education and some years of professional experience at home is asking for a job in Your company. He has got a work permit in your country, his degree has been valued at his home country as equivalent to the „lowest“ civil engineering degree in your country. His language skills are not too good.

Would you allow him to get a license for employment? Under which conditions?

Do you accredit his degree or title as a civil engineer? Under which conditions?

Do you envisage any problems with home civil engineers or companies?

5.2.2 Building/Construction Companies

The questioning cases are given as follows to Building/Construction Companies as follows:

Case B1

A young civil engineering has just finished his 4-year education with a Bachelor degree in a Member State of the EU e.g. Ireland. His degree is officially equivalent to a 4-year education in your home country. He speaks sufficiently your language to come up with normal life.

Would you employ him? Under which conditions?

If you do, would he be paid the same salary like the home civils?

Do you envisage any problems with your civil engineering societies or government?

Case B2

An adult (senior) civil engineer from an EU-member State with 10 years of experience in a company and being a member of his national civil engineering association, chamber or society is asking for a job in Your company. He is very much skilled but speaks not very fluently the language of the host country.

Would you employ him? Under which conditions?

If You do, would he be paid the same salary like the home civils?

Do You envisage any problems with Your civil engineering societies or government?

Case B3

A civil engineer from abroad (not an EU-member State) with a 3-year Bachelor education and some years of professional experience at home is asking for a job in Your company. He has got a work permit in your country, his degree has been valued at home as equivalent to the „lowest“ civil engineering degree in your home country. His language skills are not too good.

Would you employ him? Under which conditions?

If you do, would he be paid the same salary like the home civils?

Do you envisage any problems with your civil engineering societies or government?

5.3 Answers/Results

5.3.1 Civil Engineering societies, organisations, authorities

Answers have been given by societies, associations, authorities etc. from

- Croatia - Cyprus
- Estonia - Finland
- France - Germany
- Hungary - Latvia
- Slovenia - Spain (3)

Reponses – case A1 „Youngster“ EU-state, Bachelor (4 ys), language sufficient

	yes	no	Remarks
Would you allow him to get a license for employment?	9	1	has to apply, a lot of “buts”
Under which conditions?			specialties, language ability
Do you accredit his degree or title as a civil engineer?	6	4	
Under which conditions?			aptitude test, language test, membership in society after 1 year
Do you envisage any problems with home civil engineers or companies?	1	5	“but”, see above

Reponses – case A2 „Senior“ EU-state, member of society, language poor

	yes	no	Remarks
Would you allow him to get a license for employment?	10	3	has to apply, a lot of “buts”
Under which conditions?			Depending on experience and language ability
Do you accredit his degree or title as a civil engineer?	6	3	
Under which conditions?			aptitude test, language test, membership in society after 1 year
Do you envisage any problems with home civil engineers or companies?		5	“but”, see above

Reponses – case A3 “Foreigner“ Lowest degree, 3 years-Bachelor, language poor

	yes	no	remarks
Would you allow him to get a license for employment?	4	9	has to apply, a lot of “buts”
Under which conditions?			never, language test

Do you accredit his degree or title as a civil engineer?	3	8	
Under which conditions?			aptitude test, language test, membership in society after 1 year
Do you envisage any problems with home civil engineers or companies?	4	5	"but", see above

Summary: Not sufficient language skills are seen to be the biggest problems.
Licensing and accreditation depend very much on experience and specialties.
Application for licenses and membership in association are necessary.
In all countries the civil engineer has to undergo individual tests and judgments of qualification; there is no automatism procedure.

5.3.2 Building/Construction Companies

Answers were given by companies from

Spain	(8)
Hungary	(summary)
Slovakia	(17)
Germany	(5 and summary North-West Germany)
Greece	(19)

Reponses – case B1: „Youngster“ EU-state, Bachelor (4 ys), language sufficient

	yes	no	remarks
Would you employ him?	36	4	
Under which conditions?			same like home civils, but needs knowledge in contracting and language, only as technician
Would he be paid the same salary like the home civils?	36	4	depending on experience, after test and period of work
Any problems with your civil engineering societies or government?	3	30	acknowledgement of degree

Reponses – case B2: „Senior“ EU-state, member of society, language poor

	yes	no	remarks
Would you employ him?	19	9	never
Under which conditions?			language skills are a must, needs knowledge in contracting
Would he be paid the same salary like the home civils?	18	12	depending on experience, never after test and period of work
Any problems with your civil engineering societies or government?	7	24	acknowledgement of degree

Reponses – case B3: „Foreigner“ Lowest degree, Bachelor (3 ys), language poor

	yes	no	remarks
Would you employ him?	12	21	never
Under which conditions?			language skills are a must, needs knowledge in contracting
Would he be paid the same salary like the home civils?	17	13	depending on experience, never, after test and period of work but less
Any problems with your civil engineering societies or government?	8	15	acknowledgement of degree

Summary: Not sufficient language skills and knowledge in contracting procedures are seen to be the biggest problems.
Employments and salaries depend very much on experience and specialties.
In all countries the civil engineer has to undergo individual tests and judgments of qualification; there is no automatism procedure.

Comment: Even if the questionnaire does not give a representative picture of the conditions of employment, licensing and mobility of civil engineers within the European region this picture shows the same diversity as other investigations e.g. the recent one of the European Council of Civil Engineers (ECCE).

6. ECCE - INVESTIGATION OF THE EUROPEAN CIVIL ENGINEERING PROFESSION 2005

The European Council of Civil Engineers (ECCE) has recently undertaken an investigation of the situation and conditions of the European civil engineering profession [5]. As ECCE is a member of EUCEET some parts of the results concerning the topic of Working Group SP 11 are given as follows.

6.1 The Education System of Civil Engineers

The situation as it was and the status quo of the academic education of civil engineers at institutions of higher education are described in Tab. 1 (chapter 1 of ECCE-book). It is obvious that most of the ECCE-member states changed their education system towards the requirements of the Bologna Process.

6.2 Undergraduate and Graduate Training

The new approach of educating a (civil engineering) professional is to speak about academic education at an institution of higher education and training. This training as part of awarding an academic degree belongs to the undergraduate training. Professional recognition more and more needs graduate training, too. The actual situation concerning professional oriented training is described in Tab. 2 (ECCE-chapter 4).

6.3 Recognition and Protection of Title

The situation in Europe concerning this question is best described by showing a picture of great variety in procedures of national recognition and protection of titles. There are countries where the profession of civil engineers is:

- regulated and the title of (civil) engineer is protected;
- not regulated and the title of (civil) engineer is not protected;
- a mixture of both.

In detail this situation is shown in Tab. 3 (ECCE-chapter 3). This overview makes clear that it is still difficult to find a common way or - with respect to the EU-directive on Professional Qualification – platform for mutual recognition.

6.4 Professional Organization and Registration

Very closely connected to the question of recognition and protection of professional title of civil engineers is the question whether professional organizations require membership or – the other way round – whether registration of civil engineers is obligatory in their country. In detail this situation is shown in the Tab. 4 (ECCE - chapter 7), which is also part of the ECCE-publication 2005.

Tabel. 1: THE EDUCATION SYSTEM

Questions: *General Education System*
Environmental Training within the Civil Engineering Education
Bologna Process
Foreign Language Learning

COUNTRY	***Education System***	***Environmental Training***	***Bologna Process***	***Foreign Language***
Croatia	4,5 y. BA (Grad.Civ.Eng.) 2 y. Master, also 3 y. Civ.Eng.(Technical High School)	Yes, compulsory and voluntary	3+2+3 (Bachelor-Master-PhD), also 4+1+3 system, starting 2005/6	Engl.+German obligatory / others optional
Cyprus	3 y. Technician Engineer New courses at new University .	Part of education, even courses Civ.Eng and Environment	Totally in new Uni since 2003	English obligat., others optional
Czech Republic	5 years	Very important specialities, but also embedded	4+1+X since2003/4	English obligat., others optional
Estonia	4 y. Technical Institute 5 y. University	Embedded	(3+2=) 5 years since 2002	English obligat., others optional
Finland	> 5 y. Technical University 4 y. Polytechnics	Obligatory modules, much emphasis	3+2+X from 2005/6	Swedish,English,(German)
France	5 years Ingénieur Diplôme	No specific studies, embedded	3, 5, 8-system in progress	English and others voluntary
Germany	> 5 y. Technical University	No specific studies,	3+2+3 mostly	English mandatory,

	4 y. Fachhochschule	embedded	2005/6	Others: French, Spanish,Chinese
Greece	5 years university education	Embedded	Not implemented yet	English mandatory, Others: German, French
Hungary	5 y Technical University 3 y. Institute of Technology	Embedded	4+1, 5+3 mostly 2005/2006	Voluntary
Ireland	5 y. at University 4 y. at Institute of Techn.	Embedded	(3+2=) 5 years integrated Master	Voluntary
Italy	3 y. Laura 5 y. Laura specialistica	Embedded	3+2 since 2000	Voluntary
Latvia	4,5 Bachelor+1 Master since 2004	Embedded	Implemented since 1996	English (mainly) or German
Lithuania	4 Bachelor+2 Master since 2000	Uni. Of Vilnus special Environment. Faculty	In work	voluntary
Poland	5,5 y. Master	Number of specific curricula	5 y. Engineer and 3+2 (Bach./Master)	Yes, different
Portugal	5 y. University 3 y. Polytechnic	Mandatory modules	3+2 or 4+1 not yet decided	Foreign language from school
Romania	3 y. Inginer colegiu 5 y. Inginer diplomat	Special curricula, others: no mandatory	3-4 + 2-1 from 2005/6	Russian, now Engl. and others

		modules		
Russia	5,5 y. Dipl. Engineer 4+2 Bachelor to Master Academic	Embedded	4+1 or 4+2, for special program 5+2 from 2007/8	English, also German, others voluntary
Slovak Republic	5 years	Embedded, study programme at some faculties of civil engineering	3-4 (Bachelor) + 5 (Master) + 3 (PhD.)	Usually one foreign language is mandatory (English, German or French)
Slovenia	5 years	Embedded	3-4 (Bachelor) + 5 (Master) +	English mandatory, others optional
Spain	5 years (6 years) Escuela de Caminos (university)	No mandatory modules, some optional	4 years + 6 months End of Career Proyect + 1 or 2 yr Master +Doctoral Degree	English mandatory, others optional
Turkey	4+2-tier system 4+2 Bachelor/Master	Embedded	4+2 like before 4+1 (without thesis)	English at school, German by family contacts
United Kingdom	3 y. BEng+Matching 4 y. MEng/BEng (hon.)	Numerous obligatory modules normally embedded	No movements	Some offers, but not mandatory

ECCE's Partner Organisations (just for additional information)

American Society of Civil Engineers (ASCE)
Japan Society of Civil Engineers (JSCE)

COUNTRY	***Education System***	***Environmental Training***	***Bologna Process***	***Foreign Language***
USA	4 years Master	Numerous obligatory modules, normally embedded	Licence after equivalent 5 years Master	Some efforts, but not mandatory. Western part US: Spanish
Japan	4 years Bachelor + 2 years Master	Numerous obligatory modules, normally embedded	Remaining to 4+2+3 system	English mandatory

Tabel 2: TRAINING

Questions: *Is a period of professional training compulsory as part of the undergraduate study? If so, for how long is training required? and/or*
Is a training period required after graduation?

COUNTRY	***Undergraduate Training***	***Postgraduate Taining***
Croatia	4 weeks in summer	3 to 5 years to gain special licences training periods to obtain status
Cyprus	Depends on country of study	1 year (2 years in future)
Czech Republic	No	No
Estonia	Yes (no time given)	No (depends on company)
Finland	Minimum 6 weeks at University, 7 months at Polytechnics	No
France	Time varies from some weeks to 1 year	No
Germany	No, at Technical Universities 1 or 2 semesters at Fachhochschule (FH)	No, for normal work some years for specialists
Greece	No	no
Hungary	No	2 for 5 years' education, 5 for 3 years' education, 10 for specialists
Ireland	No	4 years
Italy	No	Not compulsory, but normally 6 months
Latvia	26 and 32 weeks	3-5 (8) years before to get Certificate
Lithuania	8 weeks in three different topics	No, but companies have their own programme
Poland	Yes, a period of ...(*unspecified*)	From 2 x 1 month to 4 x 1 month
Portugal	No, but indirectly necessary after graduation	6 months under supervision of an older member of OE
Romania	2 x 1 month in summer	No regulation, but up to 2 years sometimes necessary

Russia	Yes, 23 weeks	Not compulsory
Slovak Republic	About 2 months as a part of graduate study	Different, but strictly regulated, depending on the specialisation
Slovenia	About 2 months as a part of graduate study	Different, but strictly regulated, depending on the specialisation
Spain	No	No
Turkey	45 days	No
United Kingdom	No	Regulated training periods of 3-6 years' duration

Tabel 3: RECOGNITION AND PROTECTION OF PROFESSIONAL TITLE

Questions: *Is there any legislation in your country that obliges you to have a certain qualification in order to carry out the profession of civil engineer?*
Is the title of "civil engineer" or "Graduate Engineer" or similar, protected under law?

COUNTRY	***Legislation***	***Protection of title by law***
Croatia	Yes by Building Law (2003) Formal requirements	Yes Civil Engineer, Graduate Civil Engineer
Cyprus	Yes by authorisation of Cyprus Technical Chamber	Yes Civil Engineer
Czech Republic	Yes authorisation by Chamber	Yes Bachelor of Science, Master of Science
Estonia	Since 2003 title of Bachelor and Master of Science	Yes, Civil Engineer, Applied Engineer
Finland	Yes by Building and Land Use Law to "quality requirements"	Yes Engineer
France	No no protection of title of Civil Engineers	Yes "Ingénieur Dimplômé de l'Ecole de ....". No, for all others.
Germany	Yes (Law of Bundesländer) Diplom-Ingenieur (Dipl. Ing.)	Yes (Law of Bundesländer) Diplom-Ingenieur (Dipl. Ing.)
Greece	Yes	Yes
Hungary	Yes	Yes
Ireland	Yes	Yes Chartered Engineer
Italy	Yes Royal Decree, Art. 167 (31 Aug. 1933)	Yes Ingegnere Civile e Ambientale (iunior), Ingegnere Industriale (iunior)
Latvia	Yes. Building Law, Law on higher education	Yes Engineer, Bachelor, Master, Dr.sc.ing.
Lithuania	Yes	Yes Bachelor and Master of Science

Poland	Yes	Yes
Portugal	Yes Authorisation by Ordem dos Engenheiros	Yes Civil Engineer
Romania	No	No
Russia	Yes	Yes, Civil Engineer, Bachelor and Master Academician
Slovak Republic	Yes Authorisation by the Slovak Chamber of Civil Engineers Act No. 138/1992	Yes The title "Authorised Civil Engineer" is protected under law
Slovenia	Yes	Yes
Spain	Yes	Yes
Turkey	No	No
United Kingdom	No but authorisation by ICE	Yes Chartered Engineer, Corporated Engineer, Engineering Technician

Tabel 4: PROFESSIONAL ORGANISATIONS AND REGISTRATIONS

Questions: *Are civil engineers obliged to register (e.g. with a state organisation or Chamber of Engineers) in your country?*
Are there voluntary professional organisations for civil engineers?
Are there professional sectoral societies in particular fields/specialisations?

COUNTRY	***Registration (necessary)***	***Voluntary Membership***	***Sectoral Societies***
Croatia	For special work	Normal	Many
Cyprus	Yes	Choice between two	No, only committees
Czech Republic	Yes	Choice between two	Many
Estonia	Yes		Some
Finland	No	Normal (in similar associations)	Many
France	No, only geodetic surveyors	Normal (in similar associations)	Many divisions
Germany	No	Normal (in similar associations)	Many
Greece	Yes	Yes in others	Many
Hungary	Yes	Also in others	Many
Ireland	Yes		Many divisions
Italy	Yes (at provincial level)		Many divisions
Latvia	No	Also in others, normal	some
Lithuania	No	Normal, also in others	Some
Poland	Yes,for independent	Normal, also in many others	Many

	activity		
Portugal	Yes	Additional also	Many
Romania	No	Yes in some others	Some
Russia	No	Yes	Many
Slovak Republic	Yes for authorised civil engineers	Yes, also in others	Many
Slovenia	Yes	Yes in many others	Many
Spain	Yes	Yes, Asociación de Ingenieros de caminos	Manys of Civil Engineering
Turkey	Yes (civil engineers in designing)	Yes in many others	Many
United Kingdom	No	Normally yes	many

7. THE EUROPEAN PLATFORM FOR PROFESSIONAL CIVIL ENGINEERS (Proposal)

7.1 The Professional Formation Framework of Civil Engineers of ECCE/ECEC

The Professional Formation Framework of Civil Engineers of the European Council of Civil Engineers (ECCE) and the European Chamber of Engineering Chambers (ECEC) has been devised

- to be definite, transparent, directly applicable and objectively reviewed;
- to contain sufficient flexibility to meet the national requirements of the different Member States;
- to take into account the two different education/training levels at institutions of higher education as described in the directive;
- to follow the descriptors and educational demands within the Bologna process in the European Higher Education Area (EHEA);
- to apply criteria of professional education by outcomes [2] and competencies instead of just education time;
- to be based on a combination of elements of education, training and professional experience;
- to define minimum conditions of professional postgraduate experience;
- to acknowledge rules of professional conduct
- and to being equivalent and/or comparable to other national/international (civil) engineering platforms.

ECCE and ECEC, thus, offer two different ways to fulfil the requirements of a common two-levelled platform which includes both the traditional education schemes and the new developments within the European Higher Education Area on the academic side as well as the still existing professional practice.

7.2 Platform for Civil Engineers with a Master Degree (CE-MD)

7.2.1 Description

To be a member of a platform for Civil Engineers with a Master Degree (CEMD) requires at least

1. the achievement of an academic diploma of level e (Article 11 e) which means having achieved a **Master degree** of an approved University Program given by either a University or other recognised body at University level, and which certifies
   1.1 a minimum education time of four years and/or
   1.2 the equivalent achievement of at least **240 ECTS** units;
2. a professionally oriented academic education equivalently described by the outcomes as defined for the **second cycle education** (see chapter 6 and [2]);

3. a minimum of three years of professional experience after having finished the higher education and/or having officially acquired and attested the respective outcomes of a second cycle degree;
4. being a member of the respective national association/society/chamber of civil engineers in the home member state, which regulates or supervises the professional qualification or, if there does not exists such a professional national body, the respective national governmental body;
5. signing the respective code of conduct of the respective national association/ society/ chamber of civil engineers in the home member state, which regulates or supervises the professional qualification or, if it does not exist at home, that of the host member state association.

The description of having achieved a Master Degree has to be transformed to the former certificates/diplomas/degrees in an equivalent way.

7.2.2 Benefits and Recognition

Each civil engineer within a Member State who fulfils the requirements of the common platform as described in 7.2.1 will benefit of it in the way that the host member state recognises his professional status totally and with no restriction to any normal civil engineering work as executed by civil engineers with a second cycle degree.

Normal professional civil engineering work is described by serving society with multi-disciplinary work in a number or in all of the following fields of works and services which have to be understood as examples and not as a complete set:

Works

Infrastructure, Highway Engineering, Soil Mechanics, Transportation Engineering, Foundation Engineering, Steel Structures, Structural Engineering, Building Physics, Structural Mechanics, Water Resource, Water and Wastewater Engineering, Bridge Engineering, Building Materials Technology, ……...(to be completed)

Services

Building supervision, Project Management, Facility Management, Construction Economics and Management, Environmental Protection, Consultation, Design, …….(to be completed)

7.2.3 Specific demands and possible exclusions due to demands by national law

Civil engineers in pursuing their profession have to fulfil the special demands of society with respect to environment, sustainability and safety because their products have a great impact on life and public safety and security.

So, allowances of performing special works and services concerning design, supervision, proof engineering, governmentally installed/accredited consultancy, special duties with high impact on health and safety are restrictedly given by national governmental bodies in a number of Member States. Very often these works and services can be executed or given only after a special examination or test or training periods under supervision of the respective national society/association/chamber or governmental bodies as demanded by national law.

In accordance with the spirit of the directive all requirements of the host country concerning

a) the number of required years of experience as well as

b) the home member state's allowance of serving as civil engineering specialist have to be taken into account and, thus, accepted to achieve also the host Member State's qualifications for special services in the same way like for home civil engineers. Missing years of professional experience and/or qualification

In addition all migrants have to undergo an aptitude test concerning legal aspects of the working conditions of the host Member State.

7.3 Platform for Civil Engineers with a Bachelor Degree (CE-BD)

7.3.1 Description

To be a member of a Platform for Civil Engineers with a Bachelor Degree (CEBD) requires at least

1. the achievement of an academic diploma of level d (Article 11 d) which means having achieved a **Bachelor degree** of an approved University Program given by either a University or other recognised body at University level, and which certifies
   - 1.1 an education time of a minimum of three but not more than four years and/or
   - 1.2 the equivalent achievement of at least **180 ECTS** but not more than **240 ECTS** units;
2. a professional education equivalently described by the outcomes as defined for the **first cycle education** (see chapter 6 and [2]);
3. a minimum of three years of professional experience after having finished the higher education and/or having officially acquired and attested the respective outcomes of a first cycle degree.
4. being a member of the respective national association/society/chamber of civil engineers, which regulates or supervises the professional qualification (if there exists such a national body)

5. signing the respective code of conduct of the respective national association/society/chamber of civil engineers in the home member state, which regulates or supervises the professional qualification or, if there does not exist it, that of the host member state association.

The description of having achieved a Bachelor Degree has to be transformed to the former certificates/diplomas/degrees in an equivalent way.

7.3.2 Benefits and Recognition

Each civil engineer within a Member State who fulfils the requirements of the common platform as described in 7.2.1 will benefit of it in the way that the host member state recognises his professional status totally and with no restriction to any normal civil engineering work as executed by civil engineers with a second cycle degree.

Normal professional civil engineering work is described by serving society with multi-disciplinary work in a number or in all of the following fields of works and services which have to be understood as examples and not as a complete set:

Works

Infrastructure, Highway Engineering, Soil Mechanics, Transportation Engineering, Foundation Engineering, Steel Structures, Structural Engineering, Building Physics, Structural Mechanics, Water Resource, Water and Wastewater Engineering, Bridge Engineering, Building Materials Technology, ……...(to be completed)

Services

Building supervision, Project Management, Facility Management, Construction Economics and Management, Environmental Protection, Consultation, Design, …….(to be completed)

7.3.3 Specific demands and possible exclusions due to demands by national law

Members of the CE-BD-platform are not educated and trained enough to fulfil the special demands as described in chapter 7.2.3.

7.4 Remarks onEducation and Professional Experiences

7.4.1 Tertiary Education

The specific higher education of a civil engineer will be conducted through an approved University Program given by either a University or other recognised body at University level. The approval can be given by the national governments and/or national or otherwise accepted accreditation agencies. As long as there does not exist a European accreditation procedure or board or equivalent procedures or bodies the courses shall been accredited within the Member State as being contained within or deemed equivalent to the standards set within the FEANI INDEX of schools and courses and which must be accepted as having a suitable balance between Basic Sciences, Civil Engineering Sciences and non-engineering subjects. Examples of accredited courses and universities are given by those universities listed in the FEANI INDEX and/or the ECCE-book “Civil Engineering Profession in Europe 2005” [5] and/or the lists of the national Civil Engineering Associations/societies/chambers of ECCE-members and/or ECEC-members.

7.4.2 Professional Experience

Based on the undergraduate academic education and postgraduate or academically equivalent education and training a period of developing professional experience of not less than three years is necessary. This is an essential element in the completion of the minimum Professional Formation of a Civil Engineer and has to be certified by the respective European national association of Article 15 or, if it does not exist there, by the national governmental body. The purpose of this professional experience is to develop and achieve the competencies within the two levels as described afore.

7.5 Operation of the Common Platform

7.5.1 General Remarks

It is essential that any civil engineer wishing to obtain the benefits of meeting the requirements of the common two-levelled platform should have secured a review by a competent body within the Member State of the packages of elements that lie within the Professional Formation set out in this Common Platform. Such a review should confirm the educational base and should be satisfied on the validation of the professional civil engineering experience.

Any applicant from a Member State wishing to move to or work in another Member State and to utilise the freedom of movement and avoidance of compensation measures identified in the General Directive will need to provide appropriate documentation to the Host State. In order to comply with this Common Platform, this documentation should include:

- Evidence of University, School and Course where a Degree has been awarded and that it is included e.g. in the FEANI INDEX or is accredited by the home Member State as set out in paragraph 3 of the Common Platform documentation above;
- Evidence of completion of the Professional Formation Framework as

set out in paragraph 3 of the Common Platform documentation above;

- Evidence of being a member of the respective national association/society/chamber of civil engineers, which regulates or supervises the professional qualification
- Evidence of having signed the respective code of conduct of the respective national association/society/chamber of civil engineers in the home member state, which regulates or supervises the professional qualification or, if there does not exist it, that of the host member state association.

In order to facilitate the benefits of freedom of movement obtained through the use of the Common Platform, procedures should be put in place to ensure ease of operation of the Common Platform in which both National and European Civil Engineering bodies should play a significant role.

7.5.2 Register

For the implementation of a common platform for European civil engineers ECCE and ECEC are building up a Register for European Civil Engineers (RECE), which exactly accepts those European Civil Engineers who fulfil one set of the requirements of the common two-levelled platform as described afore.

The ECCE and ECEC Register of Civil Engineers (RECE) will be supervised and its quality and accreditation standards guaranteed by a steering committee which consists of ECCE-representatives, ECEC-representatives and members of national bodies/societies/associations/chambers.

The register has to be driven and supervised by a set of respective articles and organisational orders. – ECCE has started such considerations on an early stage [7].

The register has to be built up to having two different levels and, thus, the two different sub-registers for European Civil Engineers:

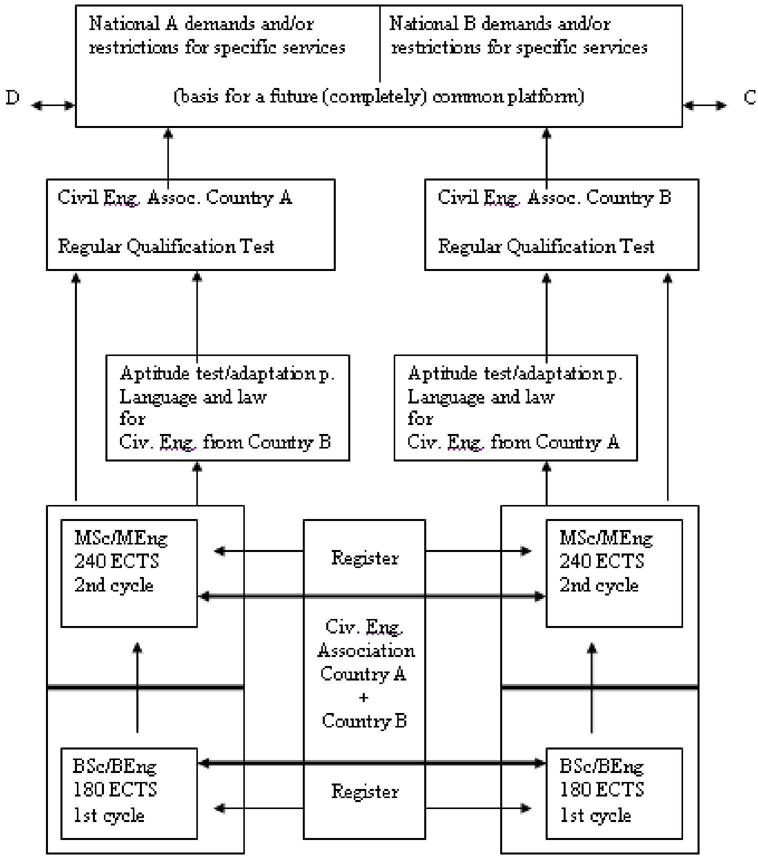
a) Register for European Civil Engineers with a Master Degree (RECE-MD)

b) Register for European Civil Engineers with a Bachelor Degree (RECE-BD)

The register should/will be an electronically maintained register which collects and describes the respective personal and professional data of its members and gives the right distinction to the respective levels. Parts of the personal data sheets could be reserved for additional descriptions of professional experience by the holder himself.

Figure 1 shows the structure of the described two-levelled platforms for civil engineers.

Proposal of a common platform for civil engineers (ECCE and ECEC)



Member State A	Cooperation Member State A + B	Member State B
Regulations and Qualification Procedures	Civil Engineering Associations and Contact Points Definition of Registers	Regulations and Qualification Procedures

Fig. 1: ECCE and ECEC draft of a structure of a common platform of civil engineers

7.5.3 Professional Card

As the Register will be an electronically maintained register the data of a registered civil engineer of these two-levelled registers could be used to produce a professional card of all registered civil engineers and, thus, for the applicants. The data of personal and professional evidence have to be described and settled in an objective and data-protecting way.

7.6. Acceptance of the Common Platform

It is proposed that all professional civil engineers who can be attested as conforming to the provisions of this Common Platform shall be accepted between all States within the European Union. Any civil engineers whose formation does not meet these requirements will still have the benefit of the full provisions of the New Directive, subject to the compensation measures that may be required by a Host State and it is recommended that due regard be paid to the equivalent requirements of this common platform in establishing such measures.

The common platform as described above is still a proposal. It is not common within the ECCE and ECED associations, because a number of member associations only accept a common platform for which the members have to have the highest academic degrees as entry qualification.

In addition the EU-commission is not in favour up to now to follow such an "engineering way" of describing a European platform. Additional work has to be put on this proposal.

The ECCE member states are:

Croatia, Cyprus, Czech Republic, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Poland, Portugal, Romania, Russia, Slovakia, Slovenia, Spain, Turkey, United Kingdom.

The ECEC member states are:

Austria, Croatia, Czech Republic, Germany, Hungary, Montenegro, Italy, Poland, Slovakia, Slovenia

8. FORMER FEANI-PLATFORM

The FEANI-platform as described below is no longer valid, because FEANI withdraw it at the end of year 2005. FEANI realised that it is too difficult to bring together on a common platform so many different sections of engineers including civil engineers. And it was stated that the amount of work is too much compared with the relative small number of benefiting engineers. FEANI is now a strong promoter of the "professional card" [6].

But it is interesting and necessary within this context or discussion to know the ideas and contents of this proposal, as it follows below.

It is essential that any engineer wishing to obtain the benefits of meeting the requirements of the common platform should have secured a review by a competent body within the Member State of the package of elements that lie within the Professional Formation set out in this Common Platform. Such a review should confirm the educational base and should be satisfied on the validation of the professional engineering experience.

The combination of these elements of training and experience should then be evaluated against the competence requirements for a professional engineer.

Where it is necessary such a review should include an interview with experienced senior engineers.

The combination of the criteria described above as being the necessary requirements for a professional engineer to benefit from this common platform can be encapsulated in the formula

B + 3U + 2(U/T/E) +2E

with the following meaning of abbreviations:

	B	**completed secondary education**
	U	**1 year university education**
	T	**(1 year) Training**
	E	**(1 year) professional experience**

Thus, it needs seven years of education/training/experience to meet the requirements of a common European (FEANI) platform.

Member States have different requirements for the combination of these three elements of formation of a professional engineer, but typically all professional engineers have:

- an ability to serve society through a sound understanding of engineering principles based on a study of mathematics, scientific and technological subjects;
- an ability to apply theoretical and practical methods to the analysis and solution of engineering problems;
- a facility for multi-disciplinary working, with managerial and communications skills.

Whilst the particular specialisms are readily identifiable, it is also recognised that professional engineers fall into two main profiles of different but equally important competencies. These can be described as:

- Engineers who are proficient in the more theoretical aspects dealing with original concepts and their creation (more theoretically orientated) and
- Engineers who have a firm understanding of engineering principles and an ability to apply them (more applications oriented).

9. THE (INTERNATIONAL) ENGINEERING MOBILITY FORUM (EMF) AND THE WASHINGTON ACCORD

The academic as well as the cross border professional recognition of civil engineers and the other professionals is not restricted to Europe, but has also to be seen and treated worldwide. In this context the European engineers shall envisage demands of professional groups acting worldwide like the Engineering Mobility Forum (EMF).

The Engineering Mobility Forum (EMF) as well as the member states of the APEC and Sidney Accord members follow the rules and demands of the Washington Accord. The **EMF** established the **International Register of Professional Engineers** which began operation in 2002.

The Entry to the register is open to engineers who:

- are registered in a signatory jurisdiction,
- have an academic qualification equivalent to an accredited degree,
- have seven years post-graduation experience,
- have two years in responsible charge of engineering work, and
- are maintaining continuing professional development.

These criteria are, deliberately, identical to those defining the APEC Engineer. Although not providing, at this time, mutual recognition of professional title the signatories are committed to make it easier the admittance to national registers of incoming engineers who are on international Register.

10. BODY OF KNOWLEDGE (BOK) OF THE AMERICAN SOCIETY OF CIVIL ENGINEERS (ASCE)

As the Accreditation Board for Engineering and Technology (ABET) is member of the Washington Accord mutual recognition across borders very much has to take into account demands of our partners across the Atlantic, which in this context is the rather powerful American Society of Civil Engineers (ASCE). So it is necessary to know under which conditions US-American civil engineers will gain their licence and, thus, recognition.

10.1 ASCE's actions to redress the deficit

ASCE's revised Policy Statement 465, unanimously adopted by the Board of Direction in 2004, states that the Society "… supports the concept of the master's degree or equivalent (MOE) as a prerequisite for licensure and the practice of civil engineering at the professional level". A Task Committee on Academic Prerequisites for Professional Practice (TCAP[3]) formed a Body of Knowledge Committee which was charged with defining the Body of Knowledge (BOK) required to enter the practice of civil engineering at the professional level (licensure) in the 21st century.

Committee recommendations considered

(i) what should be taught and learned,
(ii) how it should be taught and learned and
(iii) who should teach and learn it.

An outcomes approach was developed towards the 'what' dimension of civil engineering education, building on 11 outcomes drawn up by the Accreditation

Board for Engineering and Technology (ABET), adding another four outcomes and prescribing more technical depth and additional breadth.

10.2 BOK (Body of Knowledge)

The 21st century civil engineer must demonstrate [6]:

1. ability to apply knowledge of mathematics, science and engineering
2. ability to design and conduct experiments, as well as analyse and interpret data
3. ability to design a system, component or process to meet desired needs
4. ability to function on multi-disciplinary teams
5. ability to identify, formulate and solve engineering problems
6. understanding of professional and ethical responsibility
7. ability to communicate effectively
8. broad education necessary to understand the impact of engineering solutions in a global and societal context.
9. recognition of the need for, and an ability to engage in life-long learning
10. knowledge of contemporary issues
11. ability to understand the techniques, skills and modern engineering tools necessary for engineering practice
12. ability to apply knowledge in a specialised area related to civil engineering
13. understanding of the elements of project management, construction, and asset management.
14. understanding of business and public policy and administration fundamentals.
15. understanding of the role of the leader and leadership principles and attitudes.

11. MEMBERS OF SP. 11 WORK GROUP

The active members of SP 11 Work Group are (in alphabetical order):

- Carsten Ahrens, FH OOW, Oldenburg, DE
- Josef Dizky, Technical University of Bratislava, Bratislava, SK
- Antal Lovas, Technical University of Budapest, Budapest, HU
- Demetrious Papageorgiou, TEI Piräus, Piräus, GR
- ...., ..., ..., ES

12. CIVIL ENGINEERING SOCIETIES IN EUROPE

ECCE	http://www.eccenet.org/	European Council of Civil Engineers
ICE	http://www.ice.org.uk/	Institution of Civil Engineers
CNI	http://www.tuttoingegnere.it/	Consiglio Nazionali degli Ingegneri
CNISF	http://cnisf.org/	Conseil National des Ingenieurs et Scientifiques de France
VDI	http://www.vdi.de/	Verein Deutscher Ingeniere
BingK	http://www.bingk.de/	Bundesingenieurkammer
ZDI	http://www.zdi.de	Zentralverband Deutscher Ingenieure
CICCP	http://www.ciccp	Colegio de Ing. de Caminos, Canales y Puertos
OE	http://www.ordeng.pt	Ordem dos Engenheiros
IEI	http://www.iei.ie/	The Institution of Engineers of Ireland
ROIS	http://www.mtu.ru	Russian Society of Civil Engineers
CKAIT	http://www.ckait.cz	Chamber of Certified Engineers and Technicians
RIL	http://www.ril.fi	Finnish Association of Civil Engineers
CyCCE	http://www.cceaa.org.cy	Cyprus Council of Civil Engineers
EEL	http://www.ehitusinsener.ee	Estonian Association of Civil Engineers
ACEG	http://www.spme.gr	The Association of Civil Engineers of Greece
HCE	http://www.mmk.hu	Hungarian Chamber of Engineers
HSGI	http://www.hkaig.hr	Croatian Chamber of Arch. and Civ. Engineers
LSIS	http://www.lsid.lt	Lithuanian Association of Civil Engineers
UAICR	http://www.utcb.ro	Romanian Union of Civ. Engineers Associations
IZS	http://www.izs.si	Slovenian Chamber of Civil Engineers
TCCE	http://www.imo.org.tr	The Turkish Chamber of Civil Engineers
LatACE	http://www.lbs.building.lv	Latvia Association of Civil Engineers
SKSI	http://www.sksi.sk	Slovak Chamber of Civil Engineers
PZITB	http://www.zgpzitb.org.pl	Polish Ass. of Civil Engineers and Technicians

and abroad:

ASCE	http://www.asce.org/	American Society of Civil Engineers
JSCE	http://www.jsce-int.org/	Japan Society of Civil Engineers

13. BIBLIOGRAPHY NOTES

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Report of the **EUCEET-Tuning** Task Force on the Cooperation as a Synergy Group of the Thematic Network **EUCEET** (European Civil Engineering Education and Training) with **Tuning**

REPORT
ON THE COOPERATION AS A SYNERGY GROUP OF THE THEMATIC NETWORK EUCEET (EUROPEAN CIVIL ENGINEERING EDUCATION AND TRAINING) WITH TUNING

1. INTRODUCTION

1.1 Basic facts about EUCEET

EUCEET (European Civil Engineering Education and Training) is a Thematic Network initiated by the Technical University of Civil Engineering of Bucharest and coordinated by the Ecole Nationale des Ponts et Chaussées Paris.

EUCEET was granted a 3-year contract (1 September 1998-31 August 2001) within the third round of application for Thematic Network under the SOCRATES programme. On September 2001, the European Commission approved an one-year extension of EUCEET for dissemination purposes (1st October 2001- 30th September 2002).

A new Project, EUCEET II was approved by the EC and developed between 1st October 2002 and 31st December 2005.

The evolution of the number of partners is shown in table 1.

Table 1

SOCRATES CODE	EUCEET I			DISS	EUCEET II		
	1998/ 1999	1999/ 2000	2000/ 2001	2001/ 2002	2002/ 2003	2003/ 2004	2005
EDU.4	43	50	59	66	97	100	101
ASS.1	7	8	13	13	14	14	14
ASS.2	2	2	2	2	1	1	1
ASS.3	1	1	1	1	1	1	1
RES	5	5	5	5	6	6	6
SER					7	9	9
Total	58	66	80	87	126	131	132
	(20)	(24)	(25)	(25)	(29)	(29)	(29)

Codes significance: EDU.4 – Higher education institution; ASS.1 – Non-profit association (national); ASS.2 – Non-profit association (international); ASS.3 – Association of Universities; RES – Research institute; SER – Private company (services). In parenthesis is the number of countries represented.

A full proposal for another Project EUCEET III, to be undertaken between 1st October 2006 and 30th September 2009, was submitted to the EC by 1st March 2006.

From its foundation, EUCEET decided to bring together all existing communities in the civil engineering field.

The main objective of the Thematic Network EUCEET and of the projects developed under its auspices is to enhance the cooperation between universities, faculties and departments of civil engineering in Europe, with the involvement of academic and professional associations, in order to contribute to the development of civil engineering education and to increase its quality and effectiveness.

Activities and cooperation among partners during the first phase of the project, EUCEET I, lead to the preparations of six reports:

- "*Curricula in European civil engineering education at undergraduate level*", with two parts:
  - Study on the organization of civil engineering education at undergraduate level in Europe
  - Study on the curricula structure for the first civil engineering degree in Europe
- "*Postgraduate programmes and continuing professional development in civil engineering education*"
- "*Balance and change in civil engineering education*"
- "*Accreditation and quality assessment in civil engineering education*"
- "*Synergies between universities, research, industry and public authorities in the construction sector of Europe*"
- "*Demands of the economic and professional environments in Europe with respect to civil engineering education*".

The six reports made the substance of two EUCEET volumes. A third EUCEET volume published within the EUCEET I Project was represented by the proceedings of the International Conference organized jointly by EUCEET and ECCE (European Council of Civil Engineers) in Sinaia, Romania, on 13-17 July 2001, with the theme "*Challenges to the civil engineering profession in Europe at the beginning of the new millennium".*

In the EUCEET II Project, six major themes, A … F, were tackled and within each theme one or several Specific Projects were undertaken, leading to a total of 12 reports for 12 Specific Projects, SP.1 … SP.12.

Theme A "*Curricula issues and developments in civil engineering"*

SP.1 *"Studies* and recommendations on core curricula for civil engineering"

SP.2 "*Practical placements as part of the civil engineering curricula"*

SP.3 "*Environmental and sustainable development matters in civil engineering education*"

SP. 4 "*Non-technical subjects in civil engineering education*"

Theme B: "*Development of the teaching environment in civil engineering education*"

SP.5 "*Problem-oriented, project-based education in civil engineering*"

SP.6 "Use of ITC in civil engineering education"

Theme C: "*Promoting the European dimension in civil engineering education"*

SP.7 "*Harmonisation of European construction codes and regulations'*

SP.8 "*Synergies between TN EUCEET and other activities under the Socrates Erasmus programme and European research Networks in civil engineering"*

Theme D: "*Enhancing the attractiveness of civil engineering profession"* (SP.9)

Theme E: "*Recognition of academic and professional civil engineering qualifications*"

SP.10 "*Specialised knowledge and abilities of graduates of civil engineering programmes"*

SP.11 "*Academic and professional recognition and mobility of European civil engineers"*

Theme F: "*Lifelong learning in civil engineering*" (SP. 12)

The 12 reports on the Specific Projects SP.1 … SP.12, form the content of two additional EUCEET Volumes.

Another EUCEET Volume which was published within the EUCEET II Project was entitled "*Civil engineering education in Europe - 2004"* and contains reports on civil engineering education in 26 countries of Europe, together with an overview on the impact of the Bologna Process on this field of education.

All reports elaborated under EUCEET I and EUCEET II, included in six EUCEET volumes, can be found on the EUCEET web page: www.euceet.utcb.ro

1.2 EUCEET involvement in Tuning

In a meeting with Thematic Network Projects Coordinators, held in Brussels on 29th January 2004, the representative of the Directorate General for Education and Culture of the European Commission formulated an explicit request for the involvement of Thematic Network in Tuning. On the same occasion, Julia Gonzalez, joint co-ordinator (with Robert Wagenaar) of the Tuning project, showed that Tuning envisages cooperation with Thematic Networks at three levels:

I. Exchange of information
II. Cooperation as a Synergy Group
III. Cooperation as a Core Area.

Cooperation as a Synergy Group implies the involvement of the Thematic Network only in *one or several* lines of Tuning, while cooperation as a Core Area implies the involvement in *all* Tuning lines.

At the meeting of the EUCEET II Management Committee, which took place in Paris on 16th February 2004, an unanimous decision was taken for the involvement of EUCEET in Tuning as a Synergy Group in the action lines 1 (Generic competences) and 2 (Subject specific competences) of Tuning. It was also decided to propose to the Tuning Steering Committee to nominate Professor Hendrik Ferdinande (Gent University), coordinator of the TNP Physics, as Tuning expert for EUCEET. The proposal was accepted and, hence, Prof. Ferdinande was invited to attend the EUCEET II 2nd General Assembly which took place in Malta on 6-7 May 2004. Prof. Ferdinande made presentations on Tuning both in a plenary meeting and in the first meeting of the EUCEET-Tuning Task Force, which took place on 7th May 2004, after the closure of the General Assembly.

Core members of the EUCEET-Tuning Task Force met in Paris, on 24th September 2004 and prepared a draft of the "*Questionnaire on specific competences in civil engineering*" which was eventually circulated among the whole membership of the Task Force and of the EUCEET II Management Committee.

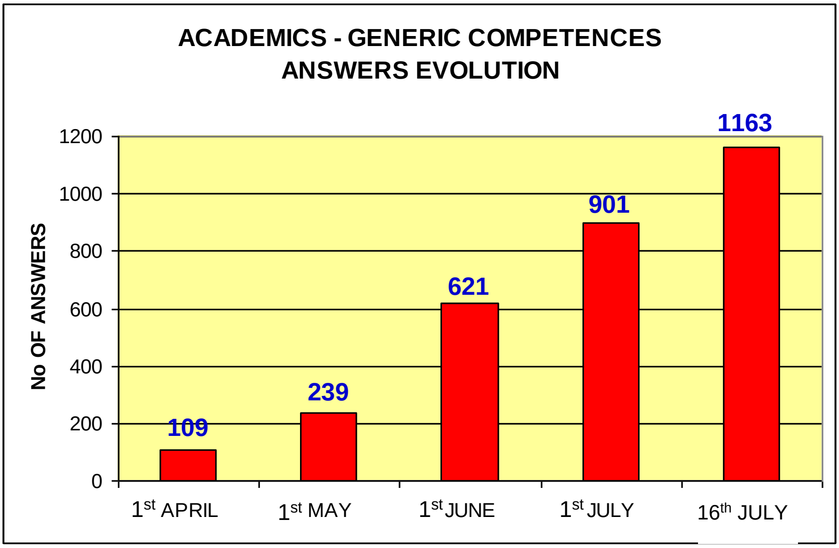
The final form of the *Questionnaire* was approved by the EUCEET II Management Committee in the meeting which took place on 10th December 2004 in Barcelona.

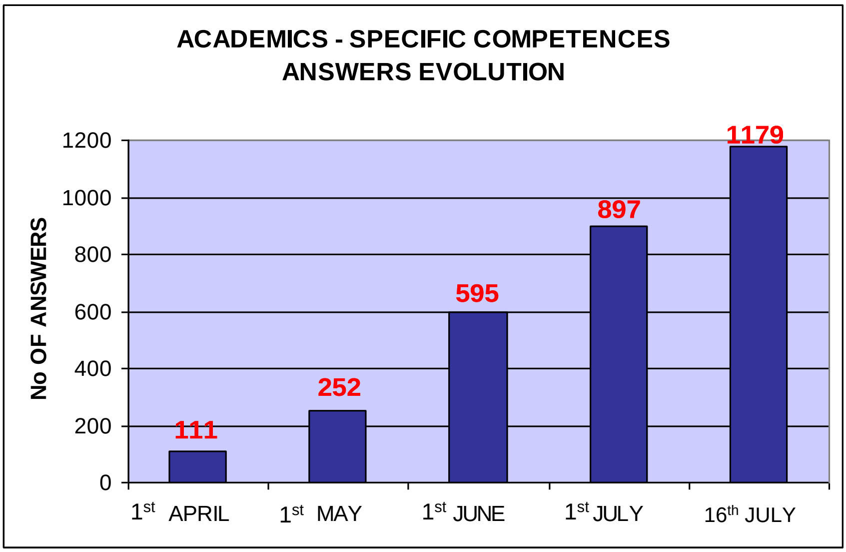
On February 1st 2005, the Chairman of EUCEET-Tuning Task Force met in Brussels with the Tuning Coordinator, Julia Gonzalez (Deusto University Bilbo). Conditions for the cooperation as a Synergy Group between EUCEET TN and Tuning were defined on that occasion, as follows:

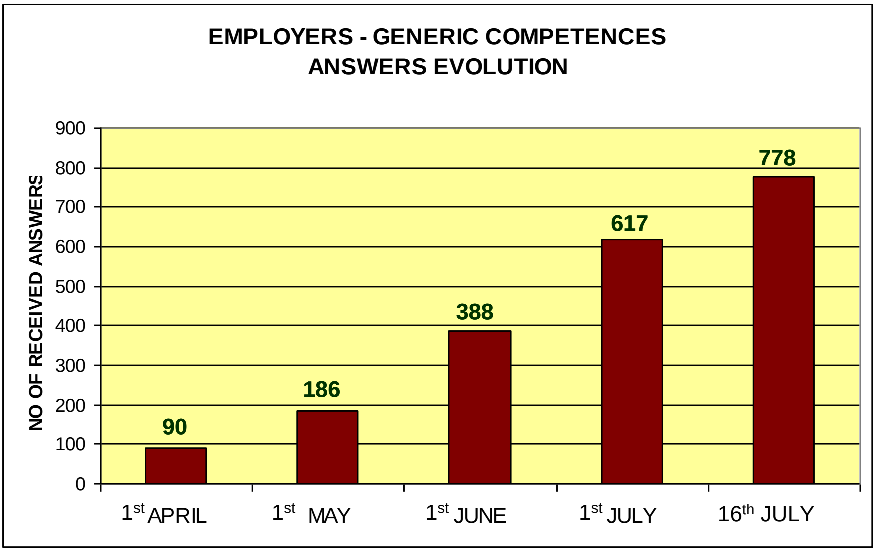
- EUCEET will be involved in the Tuning action lines 1 and 2
- the Tuning questionnaire on Generic competences prepared by Tuning for academics will be also used for employers
- the survey on generic competences will be conducted among employers and academics
- no limitation concerning the number of universities to be involved
- for both surveys on-line consultation will be undertaken, with web address and passwords provided by Deusto University for each University partner in EUCEET II (for answers to the questionnaires addressed to academics) and for each country represented in EUCEET II (for answers to the questionnaire addressed to employers).

The on-line consultation started at the beginning of March 2005 and a number of answers were already received by 23rd April 2005 when the chairman of the EUCEET-Tuning Task Force met Julia Gonzalez during the launching Conference for Tuning Phase III, held in Budapest.

It was decided to let open the consultation on-line until mid-July and to have updated, on a monthly basis, lists of universities and countries from which answers were received. As a result of the close monitoring and of the calls of the EUCEET-Tuning Task Force, the number of answers received on-line increased steadily, as illustrated by the following diagrams.







To the surveys among academics and employers, undertaken by EUCEET-Tuning Task Force with the support of the Deusto University, responded 1179 academics from 61 universities and 778 employers from 24 countries. To better assess these figures related to only one area – civil engineering, it is worth to remind that the surveys under Tuning I for seven areas lead to 998 answers from academics and 994 answers from employers from 16 countries.

An analysis of the results of the on-line consultation, made by Dr. Paul Laka from Deusto University, was included in the preliminary report presented by the chairman of the EUCEET-Tuning Task Force in a plenary session of the 3rd EUCEET II General Assembly on 30th September 2005 in Paris.

An evaluation of the involvement of EUCEET Thematic Network and lines of future cooperation were discussed in a meeting of the chairman of EUCEET-Tuning TF with Tuning coordinator, Julia Gonzalez, on 5th November 2005 in Bilbao.

A EUCEET-Tuning Workshop was organized and hosted by the Riga Technical University on 25th November 2005.

2. INTRODUCTION TO THE SUBJECT AREA CIVIL ENGINEERING

2.1 Civil engineering and its goals

Civil engineering is concerned with the application of science and engineering principles to the provision and maintenance of a built environment for mankind which will sustain modern living standards and, wherever possible, enhance them. It seeks to do this in a sustainable way, based on the following:

- an understanding of the physics, mechanics and behaviour of the materials (including soil) used in all types of construction, and the application of these to safe, efficient and sustainable construction;
- the harnessing of natural resources for the provision of water and power, and the removal of waste;
- the development, management and improvement of the systems which sustain 21st century life, including the supply and distribution of water and energy and the movement of people and goods.

2.2 Areas in which civil engineers are involved

Within the vast field of civil engineering, there are numerous areas and branches, such as:

- structural engineering (concrete structures, steel structures, timber structures, masonry structures a.s.o)
- geotechnical engineering (earthworks engineering, foundation engineering, etc)
- road and railways engineering
- hydraulic engineering (hydraulic structures, river engineering, coastal engineering, ports and waterways etc)
- water management (hydrology, irrigation, water supply, sewerage, waste water treatment etc)
- earthquake engineering
- transportation planning (infrastructure planning, public transport design and operation, traffic management etc)
- building engineering (building structures, building physics, real estate development etc)
- urban engineering.

In all mentioned areas, the involvement of civil engineers in the design, construction and maintenance of various works is mandatory.

3. DEGREE PROFILES AND OCCUPATIONS

3.1 Providers of civil engineering education in Europe

The higher education institutions providing civil engineering programmes in Europe belong to two distinct sectors:

- university sector
- non-university sector

In the university sector are found Universities, Technical Universities and (only in France) Grandes Ecoles.

In the non-university sector, there is a large diversity of providers, such as Fachhochschulen (Austria, Germany, Switzerland), Hogescholen (Netherlands, Belgium-Flanders), Instituts Supérieurs Industriels (Belgium-Wallonie), Engineering Colleges (Denmark), Polytechnics (Finland), Technological Education Institutions-TEI (Greece), Technical Colleges (Hungary, Ireland), Polytechnic Institutes (Portugal), University Colleges (Romania, Sweden, Norway), Polytechnic Schools (Spain) etc.

3.2 Typical degrees offered in civil engineering in Europe

First cycles studies offered in the university sector

Prior to the process triggered by the "*Bologna Declaration on the European Higher Education Area*", signed on June 19th, 1999 by Ministers of Education from 29 countries, only in a few countries (U.K., Ireland and Baltic countries) universities were offering both first and second cycle programmes put in a "*ladder*". In continental Europe (with the exception of Baltic countries) universities were offering integrated programmes of 5 years (or even 6 years) nominal duration.

Various types of first cycle degree courses

As for the content, the first cycle degree courses offered by the higher education institutions in Europe, both in the university sector and in the non-university sector, can be recognized as belonging to one of the following two categories:

- degree courses more application oriented
- degree courses more theoretical oriented.

At the same time, as previously shown, the first cycle degree can serve mainly as "*stepping-stone*" (like in the 3+2 structure adopted by some research universities) or can qualify graduates prepared to enter professional life (like in UK and Ireland universities, in HEI of the non-university sector or in the 4+… programmes adopted by some research universities).

Second cycle studies

HEI belonging to the university sector are the main providers of second cycle studies.

As previously shown, the second cycle studies can be part of integrated programmes, leading directly to a SCD or can represent distinct, autonomous programmes, which can be accessed following completion of FCD studies.

Some integrated programmes, such as the ones provided by the Grandes Ecoles in France or the MEng programmes in UK, tend to be rather high level general education programmes, while other integrated programmes allow a certain amount of specialization in areas such as structures, hydraulic works, transportation etc.

Second cycle degree programmes, following FCD studies, are offered as specialist programmes, in the areas mentioned at 2.2 others.

Recent developments show that, as a result of the Bologna process, providers of the second cycle degree programmes can be found also in the non-university sector (in Germany, Portugal, Norway etc).

Third cycle studies

Third cycle or doctoral studies in civil engineering area organized in institutions belonging to the university sector. As revealed by a survey undertaken in EUCEET I project, in about 60% of the institutions a research doctoral programme is offered, while the others are offering a taught and research programme. In both cases, the doctoral studies are finalized by the submission and public defence of a doctoral thesis which should reflect original research work. The degree awarded has different names in various countries, but the word “doctor” is present in almost all cases.

Typical occupations of the graduates in the subject area

Although statistical data at European scale are not available, it is currently admitted that the vast majority (over75%) of the graduates of civil engineering programmes offered by both university and non-university sector are employed in construction, in a wide range of activities, such as:

- design of various projects/ buildings, roads, railways, water supply and sewerage schemes, water treatment plans, hydro-power plants, dams, bridges, airports, tunnels, offshore platform etc
- execution of all kinds of civil engineering works
- supervision of the execution of works
- maintenance of completed projects
- research activities in the field of civil engineering
- teaching activities in secondary education or a tertion education system
- town and country planning
- consultancy to investors or to public authorities, etc.

A good number of graduates, estimated at 15%...18% are working in other fields than the civil engineering one, but carrying out activities and responsibilities in which the engineering education is put into value, such as:

- building materials industry
- insurance
- banking
- computer sciences (software development)
- information and communication technology
- health security
- national defence, etc.

Around ¾ of the civil engineering graduates are employed in the private sector and ¼ in the public sector.

The title of "civil engineer" is protected by law in most European countries. In U.K. the protected titles are "Chartered Engineer" and "Incorporated Engineer", which are given by the professional institutions (such as "The Institution of Civil Engineers" and "The Institution of Structural Engineers") under license from the Engineering Council. In France the title of Civil Engineer is not protected by law.

Legislation in various European countries concerning the right to carry out the professions is very diverse.

Role of civil engineering in other degree programmes

What we know as civil engineering is sometimes found as an important competent of other discipline, for example architecture, environmental engineering, environmental science, town planning, engineering geology. Key components of civil engineering degrees, such as fluid mechanics, finite element analysis, structural analysis etc. are often also found as

A special mention should be made for the degree courses on geodesy which in several countries are offered by departments/ faculties which offer civil engineering programmes, being thus considered as a civil engineering specialization, while in most countries are offered by separate units/ institutions and considered as belonging to a distinct sector and profession. In both cases, however, civil engineering should be part of the programme.

4. THE USE OF TUNING METHODOLOGY TO DEFINE LEARNING OUTCOMES AND COMPETENCES IN CIVIL ENGINEERING

4.1 Generic competences

As shown under p.1.2 the same Tuning questionnaire on generic competences has been sent to academics and employers. The questionnaire, comprising both description and shorter labels, was the following one.

Competence number	Shorter label	Descriptor
1	*work in an interdisciplinary team*	Ability to work in an interdisciplinary team
2	*diversity and multiculturality*	Appreciation of diversity and multiculturality
3	*knowledge area*	Basic knowledge of the field of study
4	*knowledge profession*	Basic knowledge of the profession
5	*analysis and synthesis*	Capacity for analysis and synthesis
6	*applying knowledge in practice*	Capacity for applying knowledge in practice
7	*generating new ideas*	Capacity for generating new ideas (creativity)
8	*adapt to new situations*	Capacity to adapt to new situations
9	*learn*	Capacity to learn
10	*critical abilities*	Critical and self-critical abilities
11	*decision-making*	Decision-making
12	*computing skills*	Elementary computing skills (word processing, database, other utilities)
13	*ethical commitment*	Ethical commitment
14	*interpersonal skills*	Interpersonal skills
15	*second language*	Knowledge of a second language
16	*oral and written communication*	Oral and written communication in your native language
17	*research skills*	Research skills

The sample distribution, showing the number of answers per country received from the academics and the employers, is given in the table 2.

Table 2

	ACADEMICS	**EMPLOYERS**
Belgium	5	9
Bulgaria	28	16
Czech Republic	31	19
Germany	55	41
Denmark	36	2
Estonia	30	16
Spain	49	68
France	40	20
Greece	82	56
Hungary	88	8
Ireland	5	2
Italy	64	17
Lithuania	19	19
Latvia	20	22
Netherlands	12	--
Norway	20	24
Poland	162	65
Portugal	37	26
Romania	233	117
Slovenia	36	41
Slovakia	28	6
Turkey	42	60
United Kingdom	29	14
Total	**1151**	**728**

The respondents were asked to rank in the order of importance the first 5 from the 17 generic competences.

The ranking of generic competences, as resulted from the answers provided by academics, is given in the figure 1.

The original ranking in 17 positions could be pooled into five groups, so any ranking difference between items in the same group is statistically non significant. The five groups are shown in the figure 2.

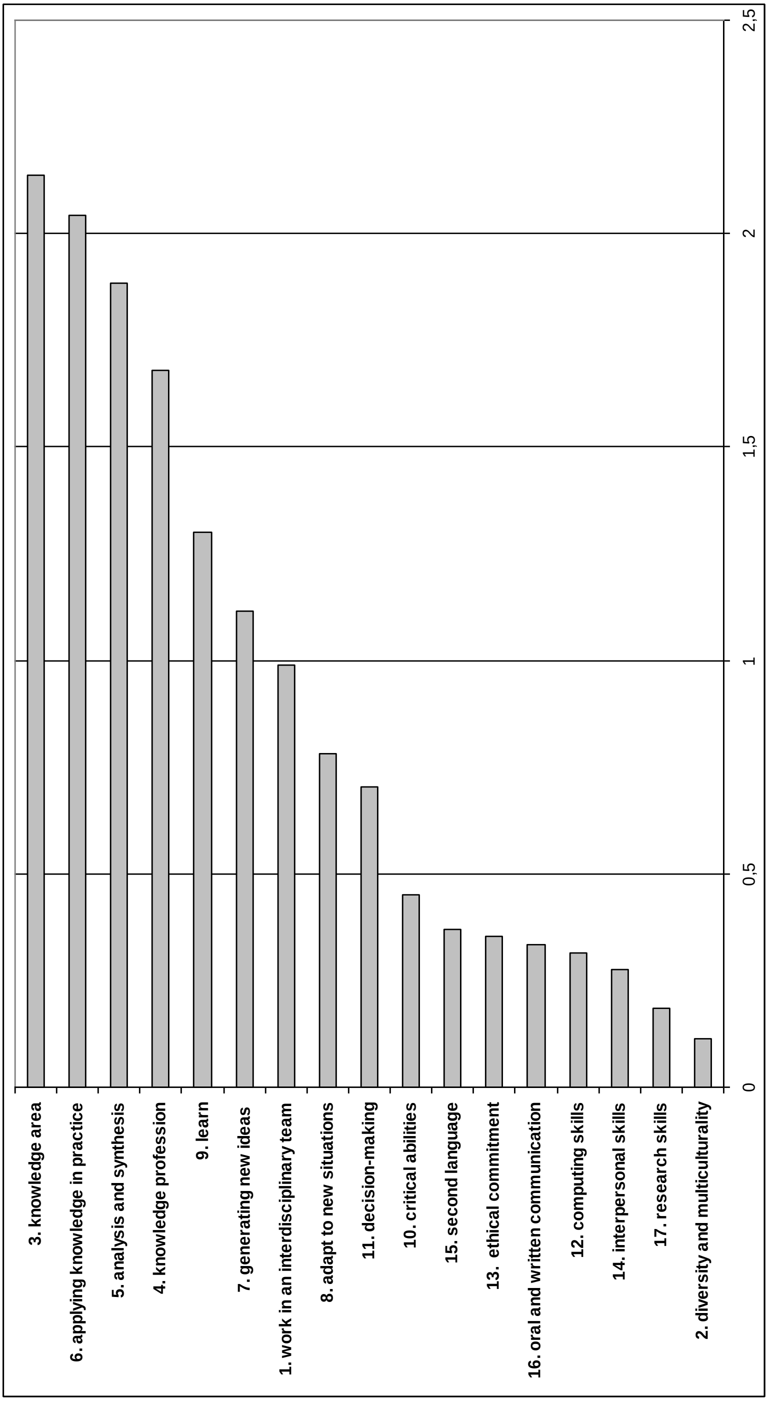

3. knowledge area
6. applying knowledge in practice
5. analysis and synthesis
4. knowledge profession
9. learn
7. generating new ideas
1. work in an interdisciplinary team
8. adapt to new situations
11. decision-making
10. critical abilities
15. second language
13. ethical commitment
16. oral and written communication
12. computing skills
14. interpersonal skills
17. research skills
2. diversity and multiculturality
0
0,5
1
1,5
2
2,5

Figure. 1

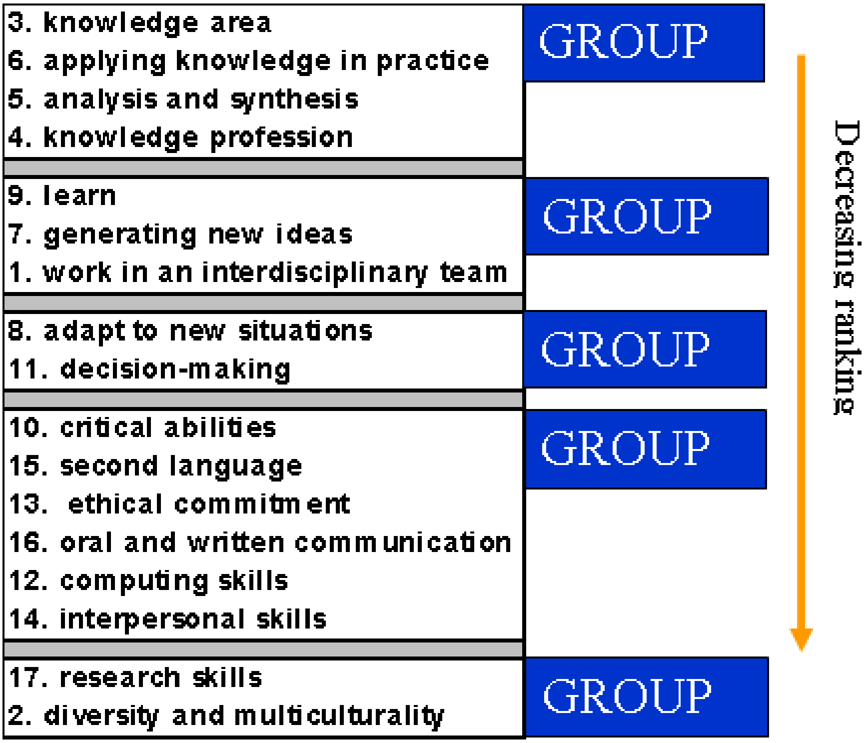


Figure. 2

The ranking of generic competences, as resulted from the answers provided by employers, is given in the figure 3.

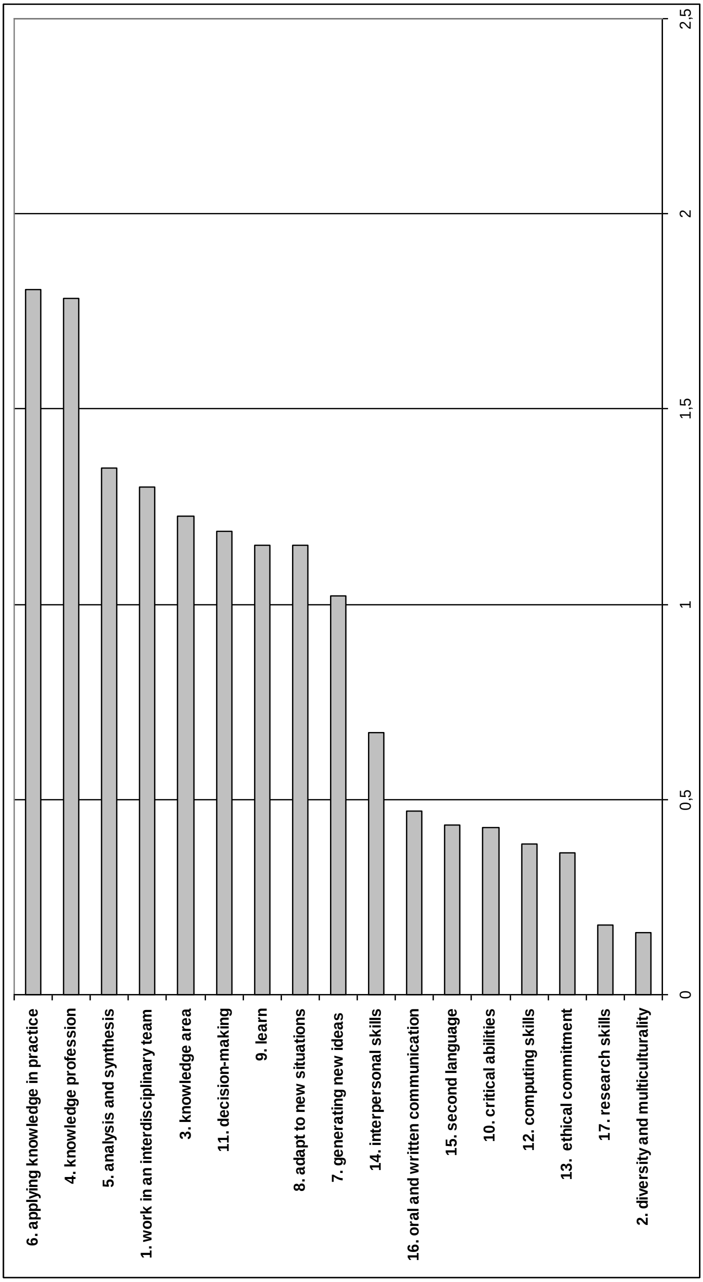


Figure. 3

Here, too, the original ranking in 17 positions could be pooled into five groups, as shown in the figure 4.

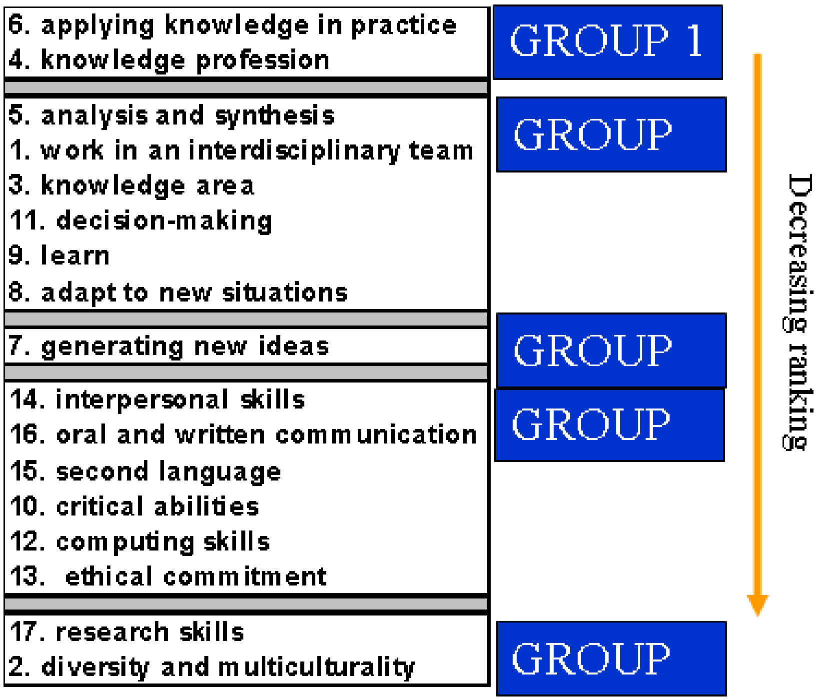


Figure. 4

The two rankings of the generic competences, provided by academics and employers, are compared in the table 2.

Table 2

	Ranking academics	Ranking employers
3. knowledge area	1	5
6. applying knowledge in practice	2	1
5. analysis and synthesis	3	3
4. knowledge profession	4	2
9. learn	5	7
7. generating new ideas	6	9
1. work in an interdisciplinary team	7	4
8. adapt to new situations	8	8
11. decision-making	9	6
10. critical abilities	10	13
15. second language	11	12
13. ethical commitment	12	15
16. oral and written communication	13	11
12. computing skills	14	14
14. interpersonal skills	15	10
17. research skills	16	16
2. diversity and multiculturality	17	17

Greatest ranking differences

In the answers obtained from the academics, there were 5 items where countries showed some significant heterogeneity, meaning that at least one of the countries showed a significant difference from the overall mean, $\alpha < 1\%$.

These were:
1. Working in an interdisciplinary team
3. Knowledge area
4. Knowledge profession
5. Analysis and synthesis
12. Competing skills

In the answers obtained from the employers, none of the items showed a significant heterogeneity among countries.

4.2 Specific competences

The questionnaire on specific competences for civil engineering was prepared by the EUCEET-Tuning Task Force. The questionnaire was preceded by the following introduction:

“Below are presented a series of competences specific to your area. For each of them we would ask you to do two things:

a. Indicate how important you think it is that a student should require the competence in his/her education **for the First Cycle**. Please use the values 1 to 4 according to the following key:

1 = None, 2 = Weak, 3 = Considerable, 4 = Strong. Please, **select the options** in the corresponding box using the mouse of your computer.

b. Indicate how important you think it is that a student should acquire the competence in his/her education **for the second cycle**. Please use the values 1 to 4 according to the following key: 1 = None, 2 = Weak, 3 = Considerable, 4 = Strong. Please select the option in the corresponding box using the mouse of your computer.

Important note. *By preparing the questionnaire, the EUCEET Tuning Task Force considered that the First Cycle is leading to a degree being by itself "**relevant to the European labour market**", as required by the Bologna Declaration.*

*Some of the competences listed below and commentaries are adapted from the **outcomes** defining the "**Body of knowledge**" developed in 2003 by a Committee of the American Society of Civil Engineers.*”

To each of 18 competences a short commentary was added.

The questionnaire put for the on-line consultation was the following one:

Civil Engineering

Questionnaire for academics

SPECIFIC COMPETENCES	Importance for First Cycle None=1 Weak=2 Considerable=3 Strong=4	Importance for Second Cycle None=1 Weak=2 Considerable=3 Strong=4
1. **An ability to apply knowledge of mathematics and other basic subjects** Commentary: Knowledge of Mathematics, Applied Physics, Applied Chemistry, Geology, Ecology forms the basis for the good understanding of the engineering sciences and provides intellectual tools of graduates of civil engineering programme.		
2. **An ability to use knowledge of mechanics, applied mechanics and of other core subjects relevant to civil engineering** Commentary. Mechanics, applied mechanics (strength of materials, structural mechanics, soil mechanics, fluid mechanics & hydraulics) reinforced concrete, steel structures, engineering surveying, building materials, computer science and computational methods, construction technology & organization, buildings construction, transport engineering, water structures and water management, environmental engineering are among the core subjects for civil engineering programmes, as established within EUCEET Thematic Network on the base of a wide inquiry among European civil engineering faculties. The core subjects are subjects common to all degree courses in the civil engineering field, regardless of the specialization		
3. **An ability to design a system or a component to meet desired needs** Commentary: Design is at the heart of civil engineering and is where graduates of civil engineering programmes demonstrate their depth and breadth of knowledge and skills. Design encompasses a wide range of works from, for instance, structural components (beams, columns, slabs etc) and simple systems (concrete footings, cofferdams, concrete or steel frames, embankments, etc) to complex civil engineering works (large dams and bridges, multi-storey buildings, offshore structures etc). Design methodology includes problem definition, analysis, risk assessment, environmental impact statements, safety, constructability, sustainability. Other important design elements are: estimating engineering costs; interaction between planning, design and construction; and life-cycle assessment		

4. **An ability to identify, formulate and solve common civil engineering problems** Commentary: Assessing situations in order to identify problems, formulate alternatives and recommend feasible solutions is an important aspect of the professional responsibilities of the graduate of a civil engineering programme		
5. **An ability to identify, formulate and solve complex civil engineering problems** Commentary: Solving complex civil engineering problems, would require from the graduate, in addition to the ability to identify and formulate the problem, experience in performing numerical analysis and parametric analysis by using adequate computer codes, in assessing critically the results, in assessing risks, selecting constructions methods a.s.o.		
6. **An understanding of the interaction between technical and environmental issues and ability to design and construct environmentally friendly civil engineering works** Commentary: Civil engineers must be aware that the built environment they create always interferes with the natural environment. The changes introduced by their activity cannot damage this environment, should be friendly not only for people but for all living nature, as well. This refers to the aesthetic aspects, too.		
7. **An ability to design and conduct experiments, as well as analyse and interpret data** Commentary: Civil engineers frequently design and conduct field and laboratory studies, gather data, analyze and interpret the results. The graduate of a civil engineering programme should be able to do this in at least one major civil engineering areas, such as geotechnics, transportation, water resources a.s.o.		
8. **An ability to identify research needs and necessary resources** Commentary: Complex civil engineering projects often require undertaking research activities to support the design. The graduate should be able to identify the appropriate area of research.		
9. **An ability to use the techniques, skills and modern engineering tools, including IT, necessary for engineering practice** Commentary: This includes the role and use of appropriate information technology, contemporary analysis and design methods, and applicable design		

codes and standards as practical problem solving tools to complement knowledge of fundamental concepts.		
10. **An ability to apply knowledge in a specialized area related to civil engineering** Commentary: Examples of specialized technical areas related to civil engineering are: structural engineering, water resources engineering, transportation engineering, geotechnical engineering, environmental engineering, construction engineering and management, public works management.		
11. **An understanding of the elements of project and construction management of common civil engineering works** Commentary: Important elements of the constructions activity involve constructions processes, methods, systems; equipment; planning; safety; cost analysis and cost control; labor issues. Projects management essentials include project manager responsibilities, defining and meeting client requirements.		
12. **An understanding of the elements of project and construction management of complex civil engineering works** Commentary. In addition to the elements of the construction activity underlined for the previous specific competence, in the case of complex civil engineering works other elements are of relevance, such as owner-engineer-contractor relationship; project delivery systems; estimating construction costs; bidding by contractors; labor management issues etc. Project management essentials include project manager responsibilities, defining and meeting client requirements, risk assessment and management, contract negotiations, preparation and monitoring etc.		
13. **An understanding of professional and ethical responsibility of civil engineers** Commentary. The graduates of civil engineering programmes should be aware of the responsibility of the civil engineer for the public safety, health and welfare. They need demonstrate an understanding of and a commitment to practice according to the fundamental canons of ethics.		
14. **An understanding of the impact of solutions for civil engineering works in a global and societal context** Commentary. Graduates of civil engineering programmes need to appreciate, from historical and		

contemporary perspectives, the technical, environmental, societal, political, legal, aesthetic, economic and financial implications of civil engineering projects.		
15. **An ability to communicate effectively** Commentary. The graduates of civil engineering programmes should prove abilities in reading, speaking and writing, not only in their native language, but also in at least one foreign language. They should be able to present and communicate technical information to a range of audience and be versatile with graphics, the worldwide web and other communication tools.		
16. **An understanding of the role of the leader and leadership principles and attitudes** Commentary. Graduates of civil engineering programmes, who might well, during their professional career, reach positions of leadership, should be aware of the attitudes conducive to such positions and of the desirable behaviors of leaders.		
17. **A recognition of the need for, and the ability to engage in, life-long learning** Commentary. Life-long learning is crucial for personal and professional development of every individual. This includes continuing education and professional practice experience. Personal and professional development includes: permanent complementing of knowledge and improving professional skills, developing communication skills and broad education in new disciplines connected with civil engineering. This can be achieved by self-education, by post-graduate studies, by active involvement in professional societies a.s.o		
18. **An ability to function in multi-disciplinary teams** Commentary. Graduates of civil engineering programmes should be able to participate as a member of a team or to become eventually the leader of a team, which requires understanding team formation and evolution, collaboration with various personalities, co-operation among diverse disciplines a.s.o.		

The sample distribution, showing the number of answers per country received from academics is given in the table 3.

Table 3

Germany	58
Denmark	29
Estonia	27
Spain	43
France	42
Greece	70
Hungary	86
Ireland	5
Italy	75
Lithuania	17
Latvia	19
Netherlands	10
Norway	18
Poland	167
Portugal	40
Romania	234
Sweden	1
Slovenia	47
Slovakia	33
Turkey	45
United Kingdom	36
TOTAL	***1179***

To facilitate the presentation of the analysis, shorter labels were used for the 18 items, as shown in the table 4.

Table 4

Shorter label	Descriptor
1. apply knowledge of mathematics	An ability to apply knowledge of mathematics and other basic subjects
2. mechanics, applied mechanics	An ability to use knowledge of mechanics, applied mechanics and of other core subjects relevant to civil engineering
3. design a system to meet desired needs	An ability to design a system or a component to meet desired needs
4. solve common civil engineering problems	An ability to identify, formulate and solve common civil engineering problems
5. solve complex civil engineering problems	An ability to identify, formulate and solve complex civil engineering problems
6. interaction between technical and environmental	An understanding of the interaction between technical and environmental issues and ability to design and construct environmentally friendly civil engineering works
7. design and conduct experiments,	An ability to design and conduct experiments, as well as analyse and interpret data
8. identify research needs and necessary resources	An ability to identify research needs and necessary resources
9. use the techniques, skills and modern tools	An ability to use the techniques, skills and modern engineering tools, including IT, necessary for engineering practice
10. apply knowledge in a specialized area	An ability to apply knowledge in a specialized area related to civil engineering
11. management of common works	An understanding of the elements of project and construction management of common civil engineering works
12. management of complex works	An understanding of the elements of project and construction management of complex civil engineering works
13. professional and ethical responsibility	An understanding of professional and ethical responsibility of civil engineers
14. the impact of solutions	An understanding of the impact of solutions for civil engineering works in a global and societal context
15. communicate effectively	An ability to communicate effectively
16. the role of the leader	An understanding of the role of the leader and leadership principles and attitudes
17. need for life-long learning	A recognition of the need for, and the ability to engage in, life-long learning
18. function in multi-disciplinary teams	An ability to function in multi-disciplinary teams

The results of the analysis of the answers on specific competences, received from the 1179 academics from 21 countries, are presented in the figures 5 …. 10.

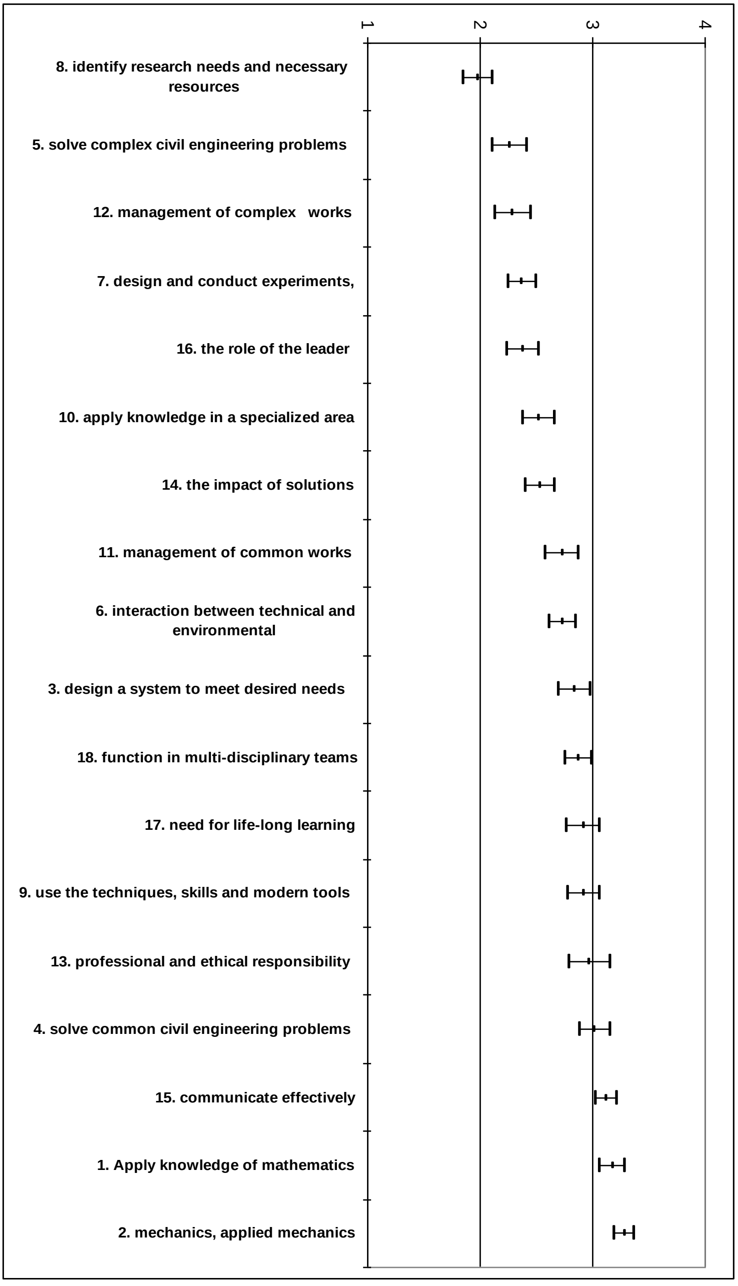
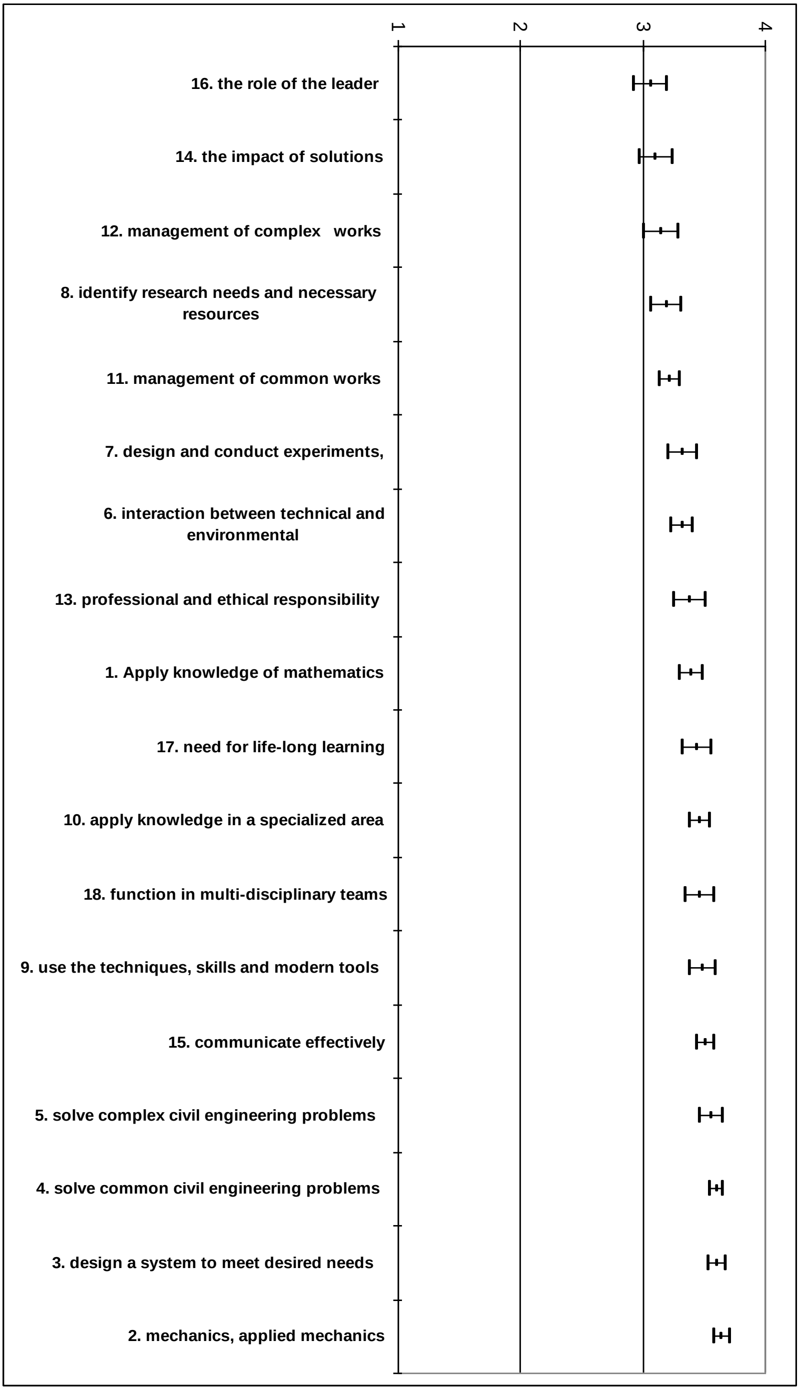


Figure 5


1
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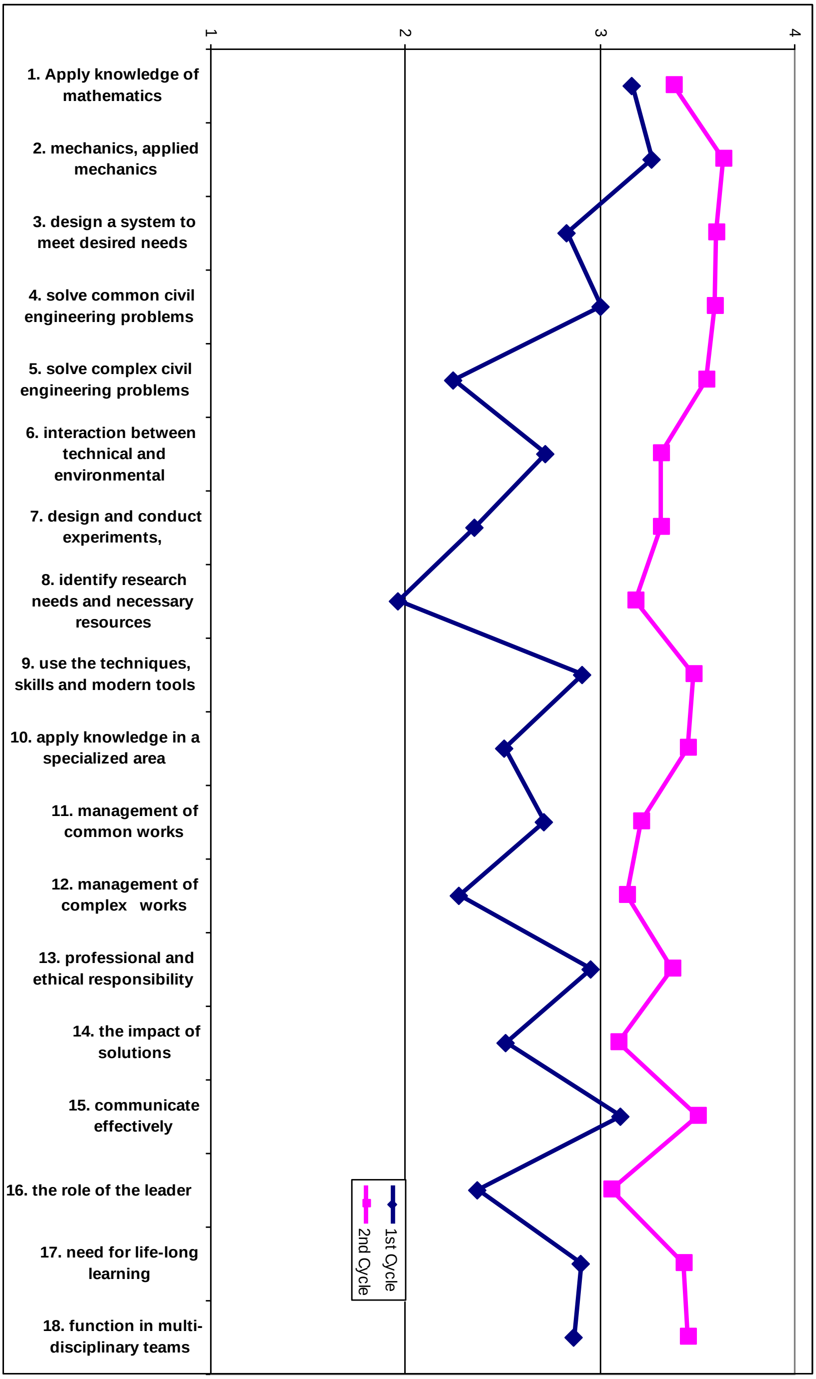
16. the role of the leader
14. the impact of solutions
12. management of complex works
8. identify research needs and necessary resources
11. management of common works
7. design and conduct experiments,
6. interaction between technical and environmental
13. professional and ethical responsibility
1. Apply knowledge of mathematics
17. need for life-long learning
10. apply knowledge in a specialized area
18. function in multi-disciplinary teams
9. use the techniques, skills and modern tools
15. communicate effectively
5. solve complex civil engineering problems
4. solve common civil engineering problems
3. design a system to meet desired needs
2. mechanics, applied mechanics

Figure 6


1
2
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4
1. Apply knowledge of mathematics
2. mechanics, applied mechanics
3. design a system to meet desired needs
4. solve common civil engineering problems
5. solve complex civil engineering problems
6. interaction between technical and environmental
7. design and conduct experiments,
8. identify research needs and necessary resources
9. use the techniques, skills and modern tools
10. apply knowledge in a specialized area
11. management of common works
12. management of complex works
13. professional and ethical responsibility
14. the impact of solutions
15. communicate effectively
16. the role of the leader
17. need for life-long learning
18. function in multi-disciplinary teams
1st Cycle
2nd Cycle

Figure 7

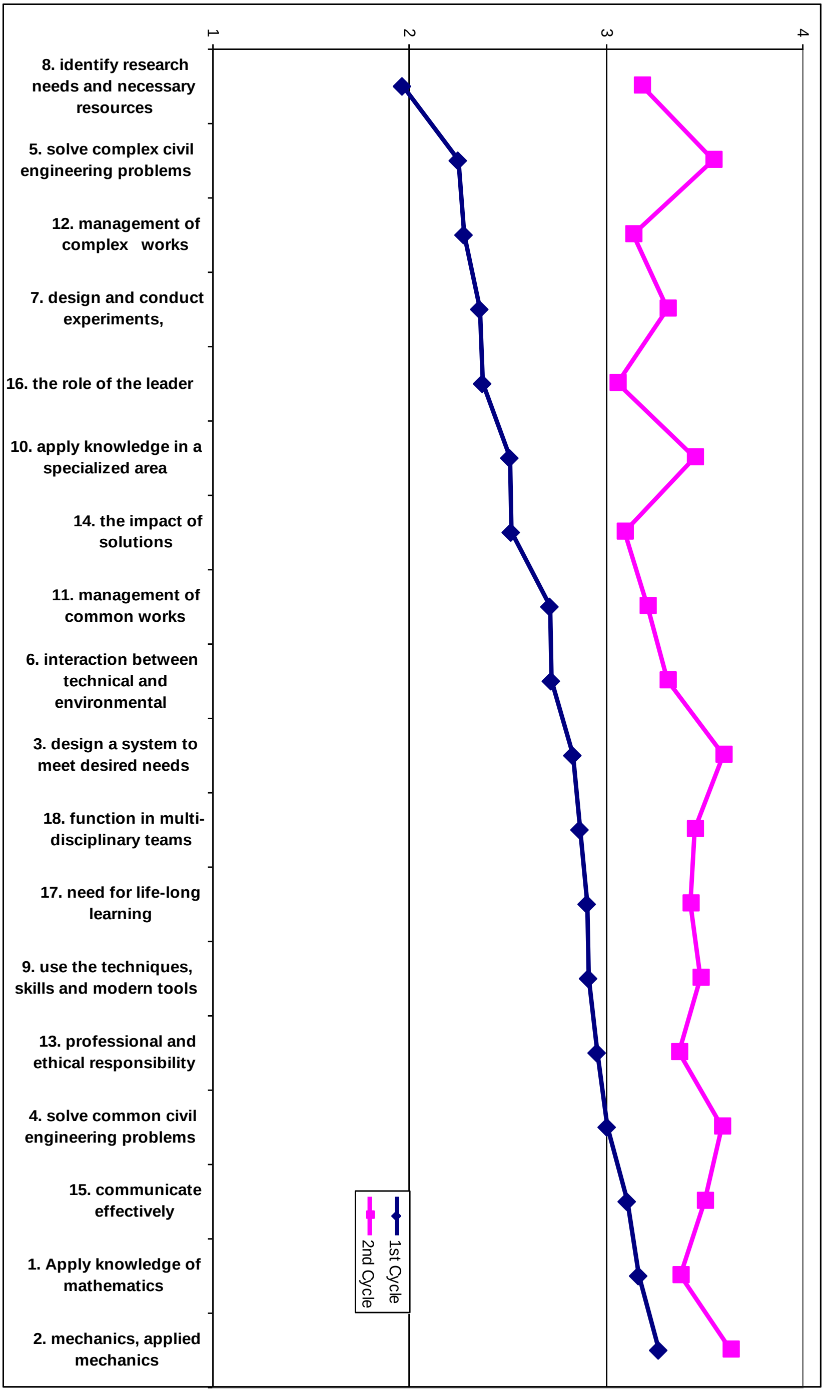
1
2
3
4
8. identify research needs and necessary resources
5. solve complex civil engineering problems
12. management of complex works
7. design and conduct experiments,
16. the role of the leader
10. apply knowledge in a specialized area
14. the impact of solutions
11. management of common works
6. interaction between technical and environmental
3. design a system to meet desired needs
18. function in multi-disciplinary teams
17. need for life-long learning
9. use the techniques, skills and modern tools
13. professional and ethical responsibility
4. solve common civil engineering problems
15. communicate effectively
1. Apply knowledge of mathematics
2. mechanics, applied mechanics
1st Cycle
2nd Cycle

Figure 8

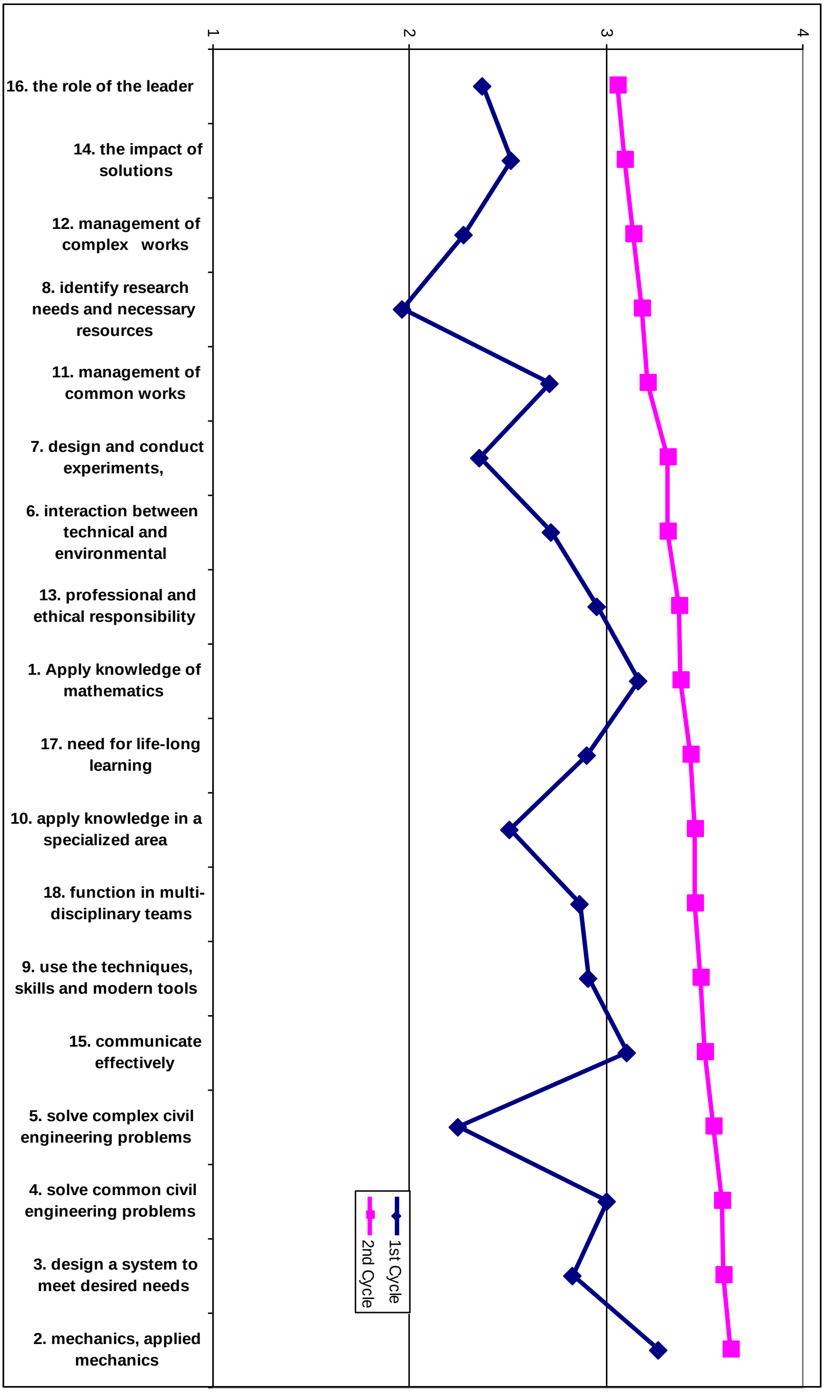
1
2
3
4
16. the role of the leader
14. the impact of solutions
12. management of complex works
8. identify research needs and necessary resources
11. management of common works
7. design and conduct experiments,
6. interaction between technical and environmental
13. professional and ethical responsibility
1. Apply knowledge of mathematics
17. need for life-long learning
10. apply knowledge in a specialized area
18. function in multi-disciplinary teams
9. use the techniques, skills and modern tools
15. communicate effectively
5. solve complex civil engineering problems
4. solve common civil engineering problems
3. design a system to meet desired needs
2. mechanics, applied mechanics
1st Cycle
2nd Cycle

Figure 9

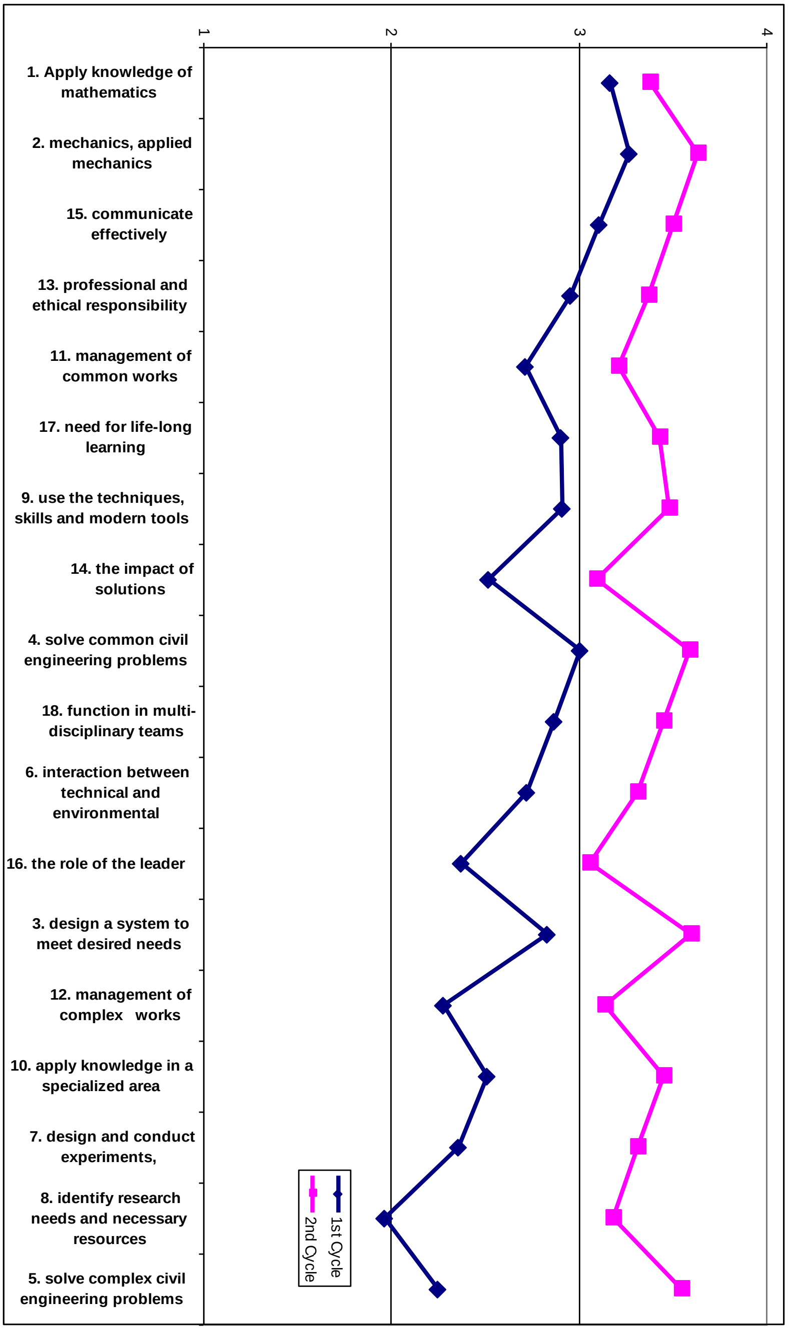
1. Apply knowledge of mathematics
2. mechanics, applied mechanics
15. communicate effectively
13. professional and ethical responsibility
11. management of common works
17. need for life-long learning
9. use the techniques, skills and modern tools
14. the impact of solutions
4. solve common civil engineering problems
18. function in multi-disciplinary teams
6. interaction between technical and environmental
16. the role of the leader
3. design a system to meet desired needs
12. management of complex works
10. apply knowledge in a specialized area
7. design and conduct experiments,
8. identify research needs and necessary resources
5. solve complex civil engineering problems
1
2
3
4
1st Cycle
2nd Cycle

Figure 10

Items where countries showed some significant heterogeneity are given in the table 5.

Table 5

FIRST CYCLE	SECOND CYCLE
1. Apply knowledge of mathematics	5. Solve complex civil engineering problems
3. Design a system to meet desired needs	7. Design and conduct experiments
4. Solve common civil engineering problems	8. Identify research needs and necessary resources
5. Solve complex civil engineering problems	9. Use the techniques, skills and modern tools
8. Identify research needs and necessary resources	12. Management of complex works
9. Use the techniques, skills and modern tools	13. Professional and ethical responsibility
11. Management of common works	14. The impact of solutions
12. Management of complex works	16. The role of the leader
13. Professional and ethical responsibility	17. Need for life-long learning
16. The role of the leader	18. Function in multi-disciplinary teams
17. Need for life-long learning	

5. EUCEET FINDINGS ON THE LEARNING OUTCOMES AND COMPETENCES OF THE GRADUATES OF CIVIL ENGINEERING DEGREE COURSES

By the time the surveys on Generic competences and on Subject Specific competences in civil engineering were conducted by the EUCEET-Tuning Task Force, using the Tuning methodology (March-July 2005), two of the Working Groups in EUCEET II, in charge with the Specific Projects 1 (*Studies and recommendations on core curricula for various degree programmes*) and Specific Projects 10 (*Specialised knowledge and abilities of graduates of civil engineering programmes*) had already completed their undertakings. The reader is advised to consult the reports for SP.1 and SP.10 on the EUCEET web page to realize that, indeed, the major outcomes of the two Specific Projects are closely related to the results obtained by the EUCEET-Tuning Task Force, convincing proof of the synergy established between EUCEET and Tuning.

6. CONTRIBUTIONS TO THE REPORT

The present report was prepared by **Iacint MANOLIU**, **Laurie BOSWELL** and **Colin KERR**, with input from the EUCEET-Tuning Task Force.

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