INQUIRIES INTO EUROPEAN HIGHER EDUCATION IN CIVIL ENGINEERING

LIFELONG LEARNING - ERASMUS
THEMATIC NETWORK PROJECT

**EUROPEAN CIVIL ENGINEERING
EDUCATION AND TRAINING**

NINTH EUCEET VOLUME

Edited by
Iacint Manoliu

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FOREWORD

This is the ninth in a series of volumes entitled "*Inquiries in the European Higher Education in Civil Engineering*", published within the frame of the Thematic Network Project EUCEET III, run on the basis of a grant of the European Commission under the auspices of the Erasmus component of the Lifelong Learning programme.

The story of the volume is short and simple. In the original workplan of the Project EUCEET III, the 3rd (and last) General Assembly was foreseen as a Pan-European Conference on civil engineering education and profession. However, when the Management Committee undertook the preparations for the General Assembly, it became immediately clear that, due to severe time constraints, contributions to the Conference could not be accommodated in the programme of a 2-day event. So, the idea of a "*in-print Conference*" was born, with contributions referring to the 8 themes of the project EUCEET III or to other themes considered as relevant. A call was addressed by the Management Committee to EUCEET III partners and to other representatives of the academic and professional worlds. The answers to this call made possible the publication of this volume.

Although covering a wide range of topics, the papers could rather easily split in three distinct groups, to form the three parts of the volume:

Part I – "*Sharing the experience of study programmes across Europe*" (8 papers)

Part II – "*Focus on disciplines: teaching, learning, assessment*" (9 papers)

Part III – "*Challenges to civil engineering education and profession*" (11 papers).

The diversity of issues tackled in the papers was matched by the diversity of authors' styles and approaches. There is, nevertheless, an unifying element: the interest showed by the authors for the advancement of civil engineering education in Europe.

The editor expresses his gratitude to all contributors to the volume. Thanks are also due to dipl. eng. Mia Trifu and eng. Doina Irodel for the help provided to the editor.

When preparing for publication this volume, the moment seemed appropriate to strike a balance of EUCEET main outcomes.

The EUCEET I Project started on 1st October 1998, the EUCEET III Project ended on 31st March 2010. Except an interruption of 9 months (January - September 2006), between the Projects EUCEET II and EUCEET III, the Thematic Network EUCEET was active for almost 12 years. The main EUCEET outcomes are, obviously, the 9 volumes: six devoted to the Reports of the Working Groups (volume 1 and volume 3 for EUCEET I, volume 5 and volume 6 for EUCEET II, volumes 7 and volume 8 for EUCEET III), one for a EUCEET – ECCE Conference (volume 2) one for a state-of-the art of civil engineering education in Europe in 2004 (volume 4) and one for a EUCEET III "in-print Conference" (volume 9).

The entire "*EUCEET library*", can be found and downloaded from the site www.euceet.eu It represents not only a source of references for those interested in matters of civil engineering education but, also, a solid foundation for the activities of the EUCEET Association founded in 2007 as an expression of the sustainability strategy promoted by the Thematic Network EUCEET.

Professor Iacint MANOLIU

Chairman of EUCEET III Management Committee
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Prof. Iacint MANOLIU is President of the Romanian Geotechnical Society, Vice-President of the Union of Associations of Civil Engineers of Romania and Chairman of the Standing Committee on Education & Training of ECCE (European Council of Civil Engineers).

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PART ONE

SHARING THE EXPERIENCE OF STUDY PROGRAMMES ACROSS EUROPE

CIVIL ENGINEERING IN SPAIN

Benjamín Suárez Arroyo[1]

1. INTRODUCTION

In recent decades, the civil engineering profession has undergone major change that has had far-reaching effects. Perhaps the greatest impact has been on the knowledge required to work in this profession, in line with the new norms of ethics and social responsibility. However, this does not detract from the technical ability that constitutes one of the main social values of civil engineering. These issues have emerged in the professional field as a result of increasingly complex and sophisticated demands from a technical and functional perspective that are also related to the perception and social significance of the activity.

This new dimension to the civil engineering profession has changed the frame of reference. More is required of engineers than in the past, particularly in terms of the personal abilities required to understand and translate to everyday practice the ***social and global nature*** of a professional activity that has a major impact on people's well-being. Many of these issues are ignored, or are only touched on, in the academic curricula that constitute the starting point for the civil engineering profession. Perhaps more worryingly, there is little interest in this matter in the engineering sector, as shown by the situation that has occurred in our country, and perhaps in many other European countries, in recent years. The academic and professional debate sparked by the Bologna Process has focused more on the length of courses and their impact on the professional attributes of civil engineers (general competences of the group) than on the focus and content of the curricula (personal competences of individuals).

2. INITIAL CONSIDERATIONS OF CIVIL ENGINEERING EDUCATION

An in-depth analysis of this topic is not easy, but it is necessary. The courses that we refer to in this document are at university level. Thus, to achieve the appropriate scope and level of excellence, they must have some complex characteristics related to process quality and requirements, and to the relevance and depth of the objectives and course content.

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2.1 Educational objectives

It may be time to give up on the aim that civil engineering education, at least at in the early stages of an engineer's career, should cover the whole gamut of professional activities undertaken by civil engineers and provide all the attributes of the profession. We must accept from the outset that the professional skills of civil engineers—which are clearly essential for the development of society and individuals—are formed gradually throughout life, according to the experience gained in employment and in specialised training. This process occurs through personal development that does not reach its peak in youth. However, effective training in civil engineering should be excellent and should obviously be measured with other parameters and compared with similar courses.

An approach in which course objectives are tied to the set of professional activities undertaken by civil engineers is unbalanced and leads to situations that are fairly irrational from an educational perspective (any list of the professional activities of civil engineers is enough to illustrate this). Consequently, course objectives must be redefined to focus on fostering the personal abilities that students need to build their knowledge independently, in the broadest sense, with civil engineering as a point of reference.

In sectors that are concerned with these issues, it is argued, and consequently proposed, that civil engineering education should be solid and excellent and provide the knowledge and abilities required to tackle civil engineering problems with a broad-minded and socially responsible approach; with scientific rigour, expertise and operational efficiency; with confidence, enthusiasm, determination and a critical spirit; with a desire to work in a team and to manage personal, information and knowledge resources.

A good declaration of intentions is valid even in times of uncertainty. However, it may be difficult to put into practice, both academically and professionally. In any event, occupation should not be confused with profession. These are different expressions of an individual's capacity for employment, which develops with experience in the posts that are held throughout life. Therefore, many leading international forums recommend that the concept of employability be used in the definition of a university course's objectives, as it is broader than the concepts of occupation and profession.

2.2 Course content

It makes little sense to define more or less complex objectives for specific courses if the content of the subjects in the course curriculum are not related to these objectives. In civil engineering, as in many other well-established courses, this sequence is often inverted. In other words, the course objectives are undefined, vague, or in the best of cases, have emerged naturally from a set of subjects that are usually unconnected or only vaguely connected. Most of the subjects have been taught for many years.

Civil engineering courses are often based on in-depth scientific content. An example of this can be seen in the admiration that mathematicians feel or felt until recently for civil engineering, due mainly to the mathematical training that the discipline involves. Some people consider that civil engineering courses offer the broadest and most intensive mathematical education of all types of engineering. This may reflect two very different intentional or unintentional strategies. The first may be considered positive, as it is closely related to unwritten educational objectives. The second is less positive and could even be said to be spurious, as the main aim is to select students. Clearly, there may be intermediate situations in which, as the maxim goes, virtue lies. However, many forums argue that the selective aspect of the basic sciences in engineering courses has ended up discrediting them as educational disciplines.

According to the professionals, practical professional development shows that engineers require only basic mathematical knowledge, but it also shows that what they do need are many of the associated intangible skills (abstraction, formalism, induction-deduction, etc.). This is paradoxical, especially if we take into account the fact that civil engineering school curricula tend to focus more on the first aspect than on the second. In a modern concept of education, particularly higher education, all of these matters are encompassed in the idea of competences, which are defined as the knowledge, skills and abilities that are attained with a specific curriculum. Knowledge boosts abilities and helps skills to develop sequentially and progressively.

Education must promote the habit of studying to facilitate subsequent lifelong learning, in a process that depends on the four pillars described in the Delors report "Learning: The Treasure Within". These pillars are learning to know, learning to do, learning to live together and learning to be. The concept of learning to know definitively eradicates the idea that it is possible to learn everything once and for all and that any educational institution can reproduce all knowledge in the microcosm of its classrooms. Learning to do requires the stimulation of a critical attitude and the acquisition of humanistic, technological and social culture as well as abilities related to the profession, occupation or speciality in question. Learning to live together and learning to be are closely related to the development of personal, interpersonal and social skills.

2.3 Educational processes

In the current times, an ambitious reform of any university system should not just adapt courses to a new structure. Instead, a paradigm shift is required: from teaching-centred training (focus on the teacher) to learning-centred training (focus on the student), so that a culture and a way of tackling knowledge is created that facilitates lifelong learning. Learning has always been one of the objectives of educational processes at all levels and the aim of lecturers in their teaching roles, but it now also a priority of the educational system. The relationship between lecturers and students is established with and on the basis of specific knowledge. Furthermore, learning is based on an understanding of content, and specific competences emerge and develop as a result of this understanding.

Multidisciplinarity deserves a special mention, as the issue appears repeatedly in discussions of European higher education. Clearly, multidisciplinarity is necessarily more than a bit of this and a bit of the other, and courses that aim to implement responsible multidisciplinarity should have clear objectives and a well-defined field of knowledge. This ideal situation is far from the supposed specialisations that often ignore the fact that university education is more than the acquisition of technical, scientific and humanistic skills, which are naturally more closely linked to a professionally focused education, even if this education is wide ranging.

Clearly, the entire educational process depends on the agents who are involved—lecturers and students—and on their abilities and commitment. However, if courses are not designed correctly, if they do not include aspects related to competences from the outset, it is difficult to attain real and deep levels of learning. The key lies in relating knowledge and the content of the various subjects and topics in the curriculum to learning and to the competences that are generated, or vice versa. The culture of learning must include a comprehensive review of assessment systems, which are currently based on the concepts of ‘pass’ and ‘fail’, to boost, stimulate and reflect students’ efforts.

Teaching methods are strongly related to these matters and it is recognised—even by the most conservative academic communities—that traditional methods must evolve and be centred on both personal and cooperative work. All courses should be focused on resolving problems and on encouraging participation, activity, independence, creativity and teamwork among students. The lecturer guides and facilitates learning by designing motivating activities, but it is really the student who learns. Therefore, a balance needs to be found between lectures and the time devoted to more personal activities, such as seminars, workshops and individual or group work.

Information and communication technology (ICT) will doubtless be of great help in the process. However, for its contribution to be truly effective, it must be tied to two related factors: learning and thinking. In other words, ICT in education must be about more than information repositories activated by means of search engines that are more or less intelligent or sophisticated. ICT should help us to meet two of the main methodological challenges of any reform: flexibility of processes and working in networks. Both of these factors are of great importance to higher education and to the knowledge society. Virtual classrooms and laboratories, virtual areas for group work, virtual libraries, online tutoring (which could even be carried out by video conferencing), online discussions and many other options may be the mechanisms used to build the virtual dimension of universities or digital universities.

3. CONSIDERATIONS ON THE SPANISH REFORM OF CIVIL ENGINEERING COURSES

The key aspects of the Spanish reform are described in Royal Decree (RD) 1393/2007, of 29 October, which establishes the regulations for official university courses. However, the interpretation of the official regulations may have many nuances that not only depend on the ministerial orders with which they are subsequently developed, but also on how they are applied at each moment.

The prologue of the RD discusses several general aspects that could drastically alter the Spanish university system, if they are put into practice. These include the flexibility and autonomy of universities, course objectives and competence-based training, results assessment and quality assurance, lifelong learning and employability. To all intents and purposes, the RD defines five branches of knowledge: arts and humanities, sciences, health sciences, social sciences and law, and engineering and architecture.

In the RD, the courses that lead to official qualifications that are valid throughout Spain are divided into three levels: bachelor's, master's and doctoral degree courses. Bachelor's degree courses provide a general education in one or more disciplines and prepare students to undertake professional activities. Master's degree courses provide specialised education in a specific or multidisciplinary field and may have an academic, professional or research focus. Doctoral degree courses involve advanced training in research techniques and include the creation and presentation of the corresponding doctoral thesis.

The RD establishes that bachelor's degree courses must comprise 240 ECTS credits. It specifies a broad spectrum of basic subjects for each branch of knowledge, which makes up part of each course (60 ECTS to be taken in the first two years). These basic subjects must be recognised from and by different educational institutions and universities when a student takes a course in the same branch of knowledge, for example between all engineering and architecture courses. The content of the curriculum must be verified before a bachelor's degree course can be set up. Then, confirmation must be obtained from the Universities Council. The regulations for verification are established by specific ministerial orders that act as general guidelines for courses and define curricular requirements (course names, objectives and planning). For courses that are associated with current regulated professions, these requirements are directly related to the corresponding professional attributes.

Master's degrees are official courses, as testified to by the fact that they must be included in the Register of Universities, Schools and Qualifications (RUCT) under the same conditions as bachelor's degrees. However, the RD is flexible about the length of master's degree courses (from 60 to 120 ECTS) and their focus (professional, research or academic) in each branch of knowledge. Thus, a wide range of options is available. However, master's degree courses must be compatible, transparent and socially significant. In principle, the content does not need to meet any prior requirements, beyond those established by the norms of good practice for courses that aim to provide specialised or multidisciplinary advanced training. However, when master's degree courses lead to professional attributes, the access and admission requirements and the content are regulated by the government.

Doctoral degrees may be the level that generates the most confusion, as the reform leads to a qualification with the same name as in the present system and because doctoral degree courses are highly flexible courses that may comprise two clearly differentiated stages: training and research. The committees that coordinate the doctoral programmes are responsible for defining the kinds of training activities that are required, whether a master's degree is enough or is simply not necessary, and which qualities are required for a student to be admitted to the research period.

4. VERIFICATION REQUIREMENTS FOR CIVIL ENGINEERING COURSES IN SPAIN

Royal Decree 1393/2007 states that the Ministry of Education and Science shall specify the content that will be taken into account in universities' applications for verification of curricula for the official bachelor's and master's degrees that enable graduates to work in regulated professions. The orders that follow on from the RD classify the following as regulated professions: public works engineer, which is linked to a bachelor's degree (CIN/307/2009), and civil engineer, which is linked to a master's degree (CIN/309/2009).

4.1 Degree in Public Works (ITOP)

The course objectives are established by means of a dozen competences that are defined in very general terms from an unspecified point of view, and are more closely related to the professional activities of a public works engineer than to educational requirements and objectives. By way of example, one of the competences—perhaps the most significant—is given below:

> *An understanding of the many technical and legal constraints that are encountered in the construction of a public work, and the ability to use proven methods and approved technologies to attain greater efficacy in the construction, with due respect for the environment and the health and safety of workers and users of the public work.*

It is very difficult, if not impossible, to summarise the objectives that all of these competences define, as they contain a mix of factors related to functions, technical and legal constraints and specific tasks, as well as more operational aspects such as the planning, management, design, administration, maintenance and conservation of public works. However, scant information is provided on the methods, sciences and techniques needed for the courses and for professional activity in this field. After an analysis of the objectives, it is hard to objectively consider that there is space left to develop other professional civil engineering careers.

In the regulations, courses are divided into three areas: a basic training area worth 60 credits, an area that is common to all civil engineering courses, also worth 60 credits, and an area of specialisation worth 48 credits. The three existing areas of specialisation coincide with current ITOP courses. Courses culminate in a 12-credit final thesis and 180 ECTS are regulated out of a total of 240 (i.e. 75% of the total course). The basic training area covers an extensive area of mathematics, practically all graphic techniques, high-level computer science, much of the field of applied physics, the earth sciences from an engineering perspective and corporate aspects of civil engineering.

The second area, which is common to all civil engineering courses, deals with topographic techniques, materials and their properties, construction materials and their applications, the behaviour and analysis of structures, geotechnics and soil mechanics, the technology of concrete and steel structures, hydraulics and hydrology, constructions and safety, energy and its effects, the environmental impact and procedures of construction and machinery. This area contains almost a dozen topics of great importance in the scientific and technical training of civil engineers.

As stated above, there are three areas of specialisation. The first is Civil Constructions. It includes prefabrication, manufacturing processes, building works, maritime works, road networks, railways, construction planning and management, geotechnical works, and sanitation and water supply works. The second is Hydrology. It deals with hydraulic works, systems and resources, ecosystems and the environment, urban services and water supply and sanitation systems. The third is Transport and Urban Services. It looks at urban and rail infrastructure, urban development planning, regional planning and transport planning. In all cases, the topics are of great importance to civil engineering activities. The course is completed with a final thesis whose scope is much greater than it has been in the past.

The regulations clearly show that the aim of the legislators was to reproduce the current ITOP. The subjects that are included in existing curricula have been translated into competences, but that is the extent of the changes. Legislators did not hesitate to keep the same specialisations as specific areas, although the course duration has been increased by one year. The increase in course length is a positive aspect, as long experience of ITOP courses has shown that there is a mismatch between the content and the time in which students are expected to cover it. In any case, there is a great imbalance between the technological areas, especially when they are supposed to represent alternative options, as is the case in current ITOP courses. This strengthens the impression that the reform has not attempted to address even the most basic issues. Therefore, we conclude that the reform increases the duration of ITOP courses by a year and makes them into European bachelor's degrees, but it does not change any of the academic objectives or the educational content, and even contemplates the possibility that there might be three different ITOP qualifications in the future.

4.2 Master's Degree in Civil Engineering (ICCP)

The course objectives are established through eighteen competences that are defined in very general terms from an unspecified point of view. The competences are more closely related to professional civil engineering activities than to requirements or educational objectives. One of these competences is given below as an example. It is the same as that provided above for ITOP courses, although considerable differences can be observed:

> *An understanding of the many constraints of a technical and legal nature and in relation to property that are encountered in the design of a public work, as well as the ability to establish valid alternatives, choose the best method and express it appropriately, taking into account potential construction problems and using the most suitable traditional and innovative methods and technologies, to attain the maximum efficacy and to promote the progress and development of a society that is sustainable and respects the environment.*

It is difficult to summarise the objectives stated in the regulation for similar reasons to those stated above for ITOP courses. However, it can be seen that terms such as proven methods, approved technologies and efficacy in the construction, which are used to describe ITOP competences, are qualified as valid, best and innovative, for example. The most in-depth training in the master's degree is identified with more and better competences, which are described by phrases that include broader concepts, such as recycling of knowledge; greater creativity and innovation in the activity; ability to carry out research, development and innovation; deepening of scientific knowledge, etc. However, the most professionally oriented master's degrees are still limited to a specific area. Hence, in the ICCP course objectives, legislators aimed to make it clear from the outset that such courses include all of the competences of ITOP courses in all areas of activity, as well as additional important and wide-reaching competences.

Perhaps the most relevant aspects of Order CIN/309/2009 are those related to controlling the admission of students to master's degrees in civil engineering that qualify graduates to work in this profession. Firstly, access is granted to all students who have acquired the ITOP competences through courses planned in accordance with the provisions in the regulations for official ITOP courses, i.e. ITOP degree holders are admitted. These degree holders are, of course, qualified to work in the regulated profession of public works engineering. In other words, the master's degree produces a civil engineer who was previously a public works engineer.

Access is also granted to all students who have the required competences and have taken courses planned for ITOP, but have not fully met the requirements for the area of specialisation. In other words, these students will have taken the 48 credits in the third area, but in a combination of areas. Hence, they are not qualified to work as public works engineers, but can access ICCP courses. In this case, the initial ITOP studies act as a bridging course that enables students to undertake what is known in the language of the reform as an integrated master's degree. Students of this academic path can only work professionally in the field on completion of the master's degree course. In other words, the master's degree produces a civil engineer who is not a public works engineer, although he/she could become one with a little additional effort.

Finally, students who hold any bachelor's degree can access the ICCP master's degree course. However, any bridging courses that are considered necessary may be required. In other words, the master's degree produces a civil engineer from a bachelor's degree course that should, in principle, be related to civil engineering, with some specific bridging courses.

In the regulations, master's degree courses are divided into two training areas: one 18-credit area to increase scientific education, and another 42-credit area on a specific technology. The course culminates in a master's degree thesis, which has an unspecified number of credits (60 ECTS are regulated, along with around 30 credits for the thesis, although 60 credits meet the minimum length requirements specified by the law).

The first area increases scientific education by addressing subjects that allow students to tackle advanced mathematical problems in engineering. Topics include the approach, formulation and numerical or analytical solution of problems, continuous media mechanics, fluid mechanics, materials mechanics and structural theory. The second area on specific technology deals with the applications of soil mechanics; advanced calculus for structures and structural integrity; the design, implementation, execution and maintenance of structures and buildings; the design, implementation and construction of hydraulic works; the assessment, planning and regulation of water resources; purification systems and water and waste treatment; oceans, coasts, ports and maritime works; transport planning; infrastructure logistics and funding; regional planning and urban development planning; and the planning, management and use of infrastructure.

All of the above indicates that the aim of legislators was more to preserve the profession of civil engineering than to programme coherent master's degree courses that are in line with international standards and represent the starting point for a technically and socially modern and competitive profession. The current legislation distinguishes between access and admission to specific courses. In both cases, the regulations should be clear so that prospective students have equal opportunities and are treated according to their merits and abilities.

5. THE FUTURE CIVIL ENGINEERING (ICCP) COURSES IN THE FACE OF CURRENT LEGISLATION

5.1 The structure of Civil Engineering (ICCP) courses

Many academic managers and the Professional Association of Civil Engineers consider that, in accordance with the above information, the most logical educational path for ICCP courses is the integrated master's degree. This degree does not have professional attributes and may or may not come under the umbrella of an ITOP curriculum. Therefore, it is classified as open, and can be followed without interruption by a master's degree in ICCP, which qualifies the student for professional practice. In other words, it is an academic degree that could theoretically take six years. It recovers much of the letter and the spirit of the Escuela de Madrid, which is the only school in Spain that has not incorporated the previous university reform (LRU).

However, this approach has serious hidden dangers. It seems logical that some Spanish universities wish to continue to teach existing courses by giving them a new bachelor's degree (almost 20 public works schools) or master's degree format (10 civil engineering schools). Some universities that run ITOP courses will take advantage of the situation and the reform to make their course catalogue more comprehensive and their courses more advanced. These universities will programme new ICCP master's degree courses. Others will see the reform as a good opportunity to programme new bachelor's degree courses in ITOP, particularly taking into account the strong position of the profession in the labour market.

The most traditional universities that have schools with extensive experience in managing and teaching ICCP courses will probably programme their master's degree courses in the following way. They will take ITOP courses as a basis and promote two alternative academic paths (either with two professional aspects or with just one). Some of the universities that currently only teach ITOP courses will programme cyclical master's degree courses. A new path is emerging that will allow some universities to include, for example, construction engineering as a course that leads to the master's degree, either with or without an additional bridging course and depending on each university. However, to some extent, this decision will also depend on the quality assurance agencies that verify the courses.

Some academic managers consider that they can control the system with the admission process, rather than with the obligatory access process. In other words, they believe that they can design admission procedures that value one type of educational background over another. This may be possible. However, they should not underestimate the impact of demand (cyclical paths involving two professions may be more attractive to young people) and equal opportunities. For example, it will be difficult to justify admission results that prioritise an access path or an institution of origin or both of these factors outside of the corporate sector, either socially or academically, in terms of merit and ability.

5.2 Civil Engineering (ICCP) courses

The competences, course objectives and curricula envisaged by legislators for the ITOP bachelor's degree and the ICCP master's degree are more of a defence of professional factors than a course design that facilitates and promotes intellectual aspects and the scientific, technological and technical progress of students. In reality, an appropriate, modern, competitive curricular design for higher education needs a more accurate definition of the objectives, the professional profiles to be attained, which should be interpreted from an academic perspective, and the competences to be acquired during a specific period. If this were the case, it would be easier to socially and professionally justify the fact that not all universities and schools have the human resources, the knowledge and the facilities required to teach courses of this type.

Competent universities, that is, universities with the ability and resources to teach these courses, should design flexible bachelor's degree courses that are compatible with scientific, technical or applied backgrounds. In all cases, bachelor's degree courses should continue to be of a general nature and to include all the characteristics of the most typical fields of work in civil engineering. Courses should have optional modules to make different academic paths possible. These paths should be related to the two major fields of activity in civil engineering: works (the construction company) and design (the consultancy). To attain this objective, the compulsory and optional subjects in the curriculum should have at least three focuses: scientific objectives and content, technological objectives and content, and applied (construction) objectives and content. In each topic, students can choose optional subjects in order to explore more applied aspects in greater depth. This will enable them to attain a professional profile that is closely related to construction. Alternatively, they can choose a profile that is associated with science or engineering sciences, to attain a more abstract, technical or technological profile.

These issues could strengthen the system. However, they could also weaken it if practical applications continue to be linked to fragmented, disjointed knowledge. The new approach to education requires knowledge, but not all knowledge can be taught at this stage. This is of key importance when we determine the length of a course and its curriculum. However, if the duration of courses is already defined and the process cannot be changed, a more practical solution should be found: what general training can be included in a four-year period so that students can, with reasonable effort, attain the minimum objectives?

Three elements are of key importance in the design of bachelor's degree courses: reasonable effort, success and the minimum comprehensive knowledge that is required. Everything appears to indicate that a bachelor's degree course should not be the result of trying to squeeze the current five-year civil engineering course into four years or of expanding the current three-year public works diploma to make it into a four-year course. Instead, a new course should be created, in which the subjects coincide to a great extent. However, the subjects that are used to develop the required knowledge should not be the same as those that are used today. Instead, there should be a radical change in the content and focus of courses and even in their names, to create a more coherent and attractive education.

Special attention should be paid to master's degrees that qualify students to work as civil engineers. Such degrees should not be just another step in the educational process. Instead, they should be singular and selective. Master's degrees should provide advanced training and seek excellence. Not all of the students who have passed the bachelor's degree will have the abilities required for the ICCP master's degree course, even when they have chosen the most professionally and academically suitable academic paths. These reflections are not linked to the concept of professional attributes. They are more closely related to the abilities and personal attitudes on which to construct competences, which may then be transformed into attributes throughout life. Civil engineers should not be satisfied with taking short courses on many topics, even if they are of great professional relevance. In fact, the opposite is the case: they should value their personal, scientific, technical, technological and even cultural worth, or in other words, their intellectual merit.

Consequently, master's degrees should be much more demanding than bachelor's degrees, although this is not often the case in the present system, and they should not only be more demanding for students, which is comparatively easy to achieve, but also for schools and lecturers, and in terms of the content and processes. The idea that this can be achieved through mathematics or similar scientific materials, lecturers who are PhD holders or the use of traditional educational processes in the classroom is outdated. There is an easy solution to this problem. However, to achieve it, we must look to and emulate other countries that are more committed to courses of this type and have been offering attractive and relevant programmes whose prestige is recognised internationally for many years.

6. FINAL CONSIDERATIONS

An increasing number of people in developed countries consider that university education does not by itself enable one to become a professional with all the required professional attributes. In its report "Civil Engineering Body of Knowledge for the 21st Century", the American Society of Civil Engineers (ASCE) stated that knowledge and abilities continue to be necessary, but are not sufficient to enter a profession with full professional competence.

The attitude, or rather the way in which civil engineers approach their work, determines how knowledge and abilities are used effectively. The ASCE defends the need to incorporate alternative educational processes into formal education, including distance learning and teaching provided by other, non-traditional educational suppliers. In addition, we should consider the essential role that work experience and chartership-related processes play in education.

Beyond whether we agree or disagree, everything indicates that we are at the end, or very close to the end, of a road. The vehicle that transports Spanish civil engineers is beginning to find it difficult to move smoothly with the characteristics that the current era requires. In the new social paradigm, the design of university courses must be much more flexible than in the past, in terms of the structure and volume of training, its focus, the professional profiles and the graduate profiles. However, the profession of civil engineering should also develop throughout life, so that it matures and advances with work experience and with additional, more specific training that is carried out through formal processes and less formal or informal methods. These issues lead to new challenges for educational and professional systems. Training and professional progress at all levels, cycles and categories should provide different options for people, according to their personal interests and their intellectual and professional abilities.

CIVIL ENGINEERING AND ARCHITECTURE DOUBLE DEGREE PROGRAM: EXPERIENCE OF INSA LYON AND ENSAL, FRANCE

Fabrice Emeriault & Chantal Berdier[1]

1. INTRODUCTION

The world of building, public works and urban planning, is an extremely complex world by the diversity of designed objects, but also by the multitude of actors involved in projects from conception to completion. In France and probably in many of the European countries, this complexity is further increased by the distance between the engineer and architect worlds, a distance which creates many communication problems. This cleavage is obviously bad for the construction industry, in terms of accountability, competitiveness, and it certainly seems more effective to set up multidisciplinary teams able to complete projects for designing structures in their entirety.

Based on previous successful collaboration, the Civil Engineering Department of INSA Lyon and the Lyon School of Architecture proposed to create a double degree program in 1992. It allows students from one institution, provided that they take specific classes during their last 3 years of studies (equivalent to the master level according to Bologna definition), after graduation to be enrolled for the last 2 years of studies in the second institution and finally get both degrees.

The ambition of this double degree program is to provide construction companies, clients, local authorities and consultants with multidisciplinary and polyvalent partners or employees, having two major assets:

- high level technical competencies (acquired in an engineering school)
- a great architectural sensibility (acquired in a renowned School of Architecture)

These multidisciplinary professionals can be mobilised at any level or phase of a project as designer or coordinator. In a consultant company, they can have a particular view on the design, a good compromise between creativity and rationalism. In the field, they appear as privileged interlocutors for all the construction actors and they guaranty the good timing of the operations, the respect of deadlines and the efficiency of their company.

The aim of this paper is to present the general organization of this double degree program, the first of its kind in France and some of the difficulties that have arisen.

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2. HISTORY

The collaboration between INSA Lyon and the Ecole d'Architecture de Lyon (EAL) started in 1983, with the initiation of joined final year "technical projects". Created in 1980, the concept of technical projects in the final year of the Civil Engineering studies was first limited to technical considerations. It has been a first step to the integration of different disciplines in the analysis of one single problem, for instance the design of a building. Rapidly, it appeared that some architectural consideration was required, thus a few professional architects were included in the team of academics and professionals managing the students groups. There was then a smooth evolution of the objectives of the technical project, moving from the technical design phase to the general design. This evolution was also necessary to avoid redundancy between the 4th and 5th year programs. The collaboration proved to be successful, students of both institutions being satisfied of this experience.

Based on this successful collaboration between INSA Lyon and EAL, on the idea that it could be better to bring together the two worlds from the start, i.e. during the training of both engineers and architects and on the willingness of some of the students to develop knowledge and competences in both majors, the Civil Engineering Department of INSA Lyon and the Lyon School of Architecture proposed to create a double degree program.

This double degree program has been introduced in 1992 in INSA Lyon, allowing engineering students to do part of their studies at the Ecole d'Architecture de Lyon (EAL currently ENSAL-Ecole Nationale Superieure d'Architecture de Lyon). Since 1998, students in ENSAL have conversely the opportunity to follow this double degree program with INSA Lyon.

At the same time, the EAL signed an equivalent agreement with the ENTPE (National School of Engineer for Public Work) and a few years ago with the ECL (Ecole Centrale de Lyon). In recent years, similar types of double degree programs have been created in France.

3. GENERAL ORGANIZATION OF THE DOUBLE DEGREE PROGRAM

3.1 Program for Engineer – Architect (IA)

INSA Lyon delivers engineering degrees after 5 years of an integrated program in which students can choose a major for the last 3 years. One of these majors is civil engineering. The Department of Civil Engineering and Urban

Planning graduates approximately 100 students every year. They are equally distributing in the 3 specializations proposed by the Department: Urban planning, Building and Public works.

Upon admission in the Department of Civil Engineering and Urban Planning (in their 3rd year of INSA), students can apply for the Engineer-Architect double degree program. Each year, more than 20 applications are recorded. Between 8 and 12 students are selected based on the application file and on an interview with a jury consisting of teachers from INSA Lyon and ENSAL and of a professional architect.

During their 3 years of civil engineering studies, these students have to take courses in the ENSAL (approximately 150 hours / year) and they are exempt of some of the courses at INSA. Courses in ENSAL include art classes, history of architecture, architectural analysis, architectural projects, ... At the end of each year, a jury is held by ENSAL and depending on their results, students are allowed or not to continue the double degree program. At the same time, if a student does not pass the exams in civil engineering (his/her major), the jury of the Department of Civil Engineering can decide to withdraw the student from the double degree and enrol the student back in the regular civil engineering cycle.

At the end of the 5th year (3rd year of civil engineering studies as well as 3rd year of the double degree program), students having validated all their modules get two degrees:
- the civil engineering degree (Ingénieur)
- and their DEIA (Diplôme d'Etudes Initiales en Architecture) equivalent to a Licence degree (according to the Bologna definition).

With this latter degree, students can enter ENSAL and get in about 2 years and half their final degree in architecture: the HMONP degree (Habilitation à la maîtrise d'œuvre en Nom Propre - Authorization for project management in own name) that replaced the Architect - DPLG degree (Diplômé Par Le Gouvernement - Graduated by the Government) and that is equivalent to a Master degree (according to the Bologna definition).

Students can also enter any other school of architecture in France. The enrolment is not straight-forward but requires a phase of so-called "validation of experience".

3.2 Program for Architect – Engineer (AI)

Upon enrolment in ENSAL, even though the double degree program only starts in the 3rd year of studies, students who aim to follow the AI program must take additional classes in math and physics. At the end of the second year, they can officially apply for the AI program. The selection is made after an interview with a jury consisting of teachers from ENSAL and INSA Lyon. Selected students have then to follow the so-called "preparatory cycle" in one of three schools of engineering partners of ENSAL (ENTPE, INSA, ECL). They are exempt of some of the courses at ENSAL.

The entire program is 150 hours of face to face per year (with specific courses in mathematics, physics, mechanics, heat transfer and strength of material). At the end of each year of this preparatory cycle, a jury analyses the results obtained by the students. At the end of the third year (at the same time they receive their degree of architecture from ENSAL), they can apply for an enrolment in the Department of Civil Engineering and Urban Planning in 4^{th} year. They can then obtain the degree in civil engineering in two years.

4. DATA AND STATISTICS

At the moment, approximately 36 students are enrolled in the double degree program with INSA Lyon and ENSAL (Table 1).

Table 1: Number of students in double degree program (2009-2010)

	Engineer – Architect (INSA Lyon)	Architect – Engineer (ENSAL)
1st year	12	2
2^{nd} year	10	0
3rd year	10	2

Since 1995, date of the first graduating class, over 60 engineers have received the DEIA. More than 15 have received their DPLG degree (HMONP), 10 are still studying in schools of architecture.

Many engineers who obtained their DPLG degree are currently practicing as professional architects (in architect firm, architect territorial, …). Others have joined technical consulting companies offices (even for civil engineering works) allowing use of their dual training.

Among those who stopped after the DEIA and did not follow further architecture studies, some also make use of their dual training in their professional activity (programmiste for example).Nevertheless, in the past 3 years all the students enter a school of architecture after graduating from INSA Lyon.

The first 4 architects have been enrolled in the Department of Civil Engineering of INSA Lyon in 2001-2002.

An association has been created in 2000: GAIA (Groupement Associatif des Ingenieurs – Architectes) is dedicated to the promotion of the double degree and of the architecture in general for INSA Lyon students and organise a national conference every two years in INSA Lyon.

5. OTHER MULTI-DISCIPLINARY ACTIVITIES

During the final year of civil engineering studies at INSA Lyon, in addition to their final year research project, students have to realise a so-called „Technical project" in one of the three majors proposed by the Civil Engineering Department: Urban development, Building and Public works. Every year more than 30 % of the 100 students choose the Building technical project.

The "technical project" corresponds to 12 ECTS credits and covers the second semester of the final year (from February to June) with approximately 12 hours scheduled per week. It is associated with elective courses (total of 5 representing each 2 ECTS credits) taught in the second part of the first semester.

The Building technical project is a unique experience in the civil engineering studies in France and possibly in Europe for several reasons, the most important being the association with the Lyon School of Architecture (ENSAL) and the fact that the students have to work by groups of 6 (3 students from INSA and 3 from ENSAL) on the architectural and technical design of a building or group of building (Emeriault et al. 2008).

Even if it's an academic project, the students are not asked to just apply the knowledge acquired during the courses of the 3rd and 4th years, but they have to face a situation that more or less resembles what they will face during their professional life as civil engineers in the construction industry.

They have to actively participate as engineers in the design of one or several buildings and public services, taking into consideration architectural, sociological, societal, economical and technical constraints and their interactions.

The association between INSA Lyon and ENSAL gives an opportunity to the future engineers and architects to work together and discover each other. It can be considered as a way to close the existing gap between the two majors and cultures.

The program is different every year and corresponds generally to a public equipment (theatre or conference centre, recreational or sport equipment such as swimming pools, housing programs) located in urban areas with specific problems of integration in the existing urban network. Nevertheless all the groups of students have to work on the same program and site with the same initial constraints.

The technical analysis and design covers the geotechnical, structural and material aspects of the project as well as acoustics and heating and cooling consideration. A one-hour public defence is organized at the end of the semester and a final written report should be provided.

Considering the size of the student groups, the complexity of the interactions between the different technical aspects and the limited time allowed, the technical project is also a way to introduce project management. The final oral defence is therefore an important element of the exercise.

A total of 16 persons are in this way regularly in contact with the students to answer their questions and analyze the progression of their work:

- 3 architects (professionals and academics)
- 6 academics of INSA (specialized in structural, geotechnical engineering, heating/cooling systems, acoustics, sociological issues, …)
- 7 senior professional consultants (covering also all the technical aspects of the construction industry).

In the recent years, programs are focussing on Sustainable Development and High Environmental Quality, French equivalent of Green Building (US) or Comprehensive Assessment System for Building Environmental Efficiency (Japan).

6. CONCLUSIONS

Despite the difficulties inherent to collaboration between two different institutions (for instance in terms of compatibility of schedules or of organization of special groups of students with small number), the double degree program created in 1992 by INSA Lyon and ENSAL is a successful experience.

Nevertheless, it appears that, even though the number of applications is increasing year after year and the feedback from companies is good, it is not possible to increase drastically the number of students enrolled in this double degree program (approximately 10 students from each institution per year). Interestingly, in recent years, similar types of double degree programs have been created in France (with ENTPE or ECL in Lyon for example).

The Building technical project is another way to make the students in civil engineering and architecture more aware of the necessity to have a multidisciplinary approach for the design of a building. Despite the difficulties and difference between the two cultures, the collaboration between students in civil engineering and architecture is always a profitable experience.

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IS IT REALLY POSSIBLE TO IMPLEMENT THE TWO TIER SYSTEM IN LATIN COUNTRIES?

Diego Lo Presti[1]

1. INTRODUCTION

The paper discusses the cultural obstacles for an effective implementation of the two tier system in European Latin Countries like Italy. The discussion is conducted by comparing two well – known textbooks of Geotechnics. More specifically the textbooks by R. Lancellotta (Geotechnics Zanichelli, 3rd Edition) and by J. Atkinson (Geotechnics, Mc Graw-Hill) are compared each other. The comparison concerns essentially the structure of the books (introduction and indexes), the fundamentals of Mechanics and some well known aspects of Soil Mechanics (geostatic stresses, effective stress concept, etc.).

The purpose of the paper is to outline the observed differences and to stress that in the book by J. Atkinson it is privileged the intuitive and inductive approach, whilst in the book by R. Lancellotta the deductive approach is mainly adopted.

This second approach obviously requires that students have already a good knowledge of basic subjects like Mathematics, Physics (Mechanics), Theoretical Mechanics, Solid and Structural Mechanics. Therefore the second approach makes questionable the possibility of educating in three to four years an Engineer because most of the first two years should be spent for basic subjects.

2. COMPARING THE TEXTBOOKS

This section does not intend to establish which of the two compared books is better. On the other hand the paper does not intend to judge single statements reported in the two books. As already stated, the only purpose is to compare the two books stressing the main differences.

2.1 Book structures and indexes

It is interesting to notice that while the general structure (index) of the two books is quite similar, there are some fundamental differences. More

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specifically, the first chapter of the Atkinson's book tries to answer the question "What does Geotechnics serve for?". This chapter simply defines the aims of Geotechnics, introduces constitutive models and peculiar aspects of soil behaviour and main geotechnical structures (specifying types, design criteria and relevant factors). What is very interesting to notice is that the reader is not requested any specific background for the understanding.

As far as the Lancellotta's book is concerned, such a chapter does not exist. On the other hand, the introductory remarks (two pages) explain to the reader how to use the book. A list of chapters reporting the basic concepts and of those treating advanced topics is given. It is worthwhile to comment on what the Author considers advanced topics. This will be discussed later on.

Eventually it is worthwhile to remark that both Authors assume that Soil Mechanics is capable of solving Geotechnical Problems trough a Scientific Approach. Anyway, it is necessary to clarify what a "Scientific Approach" is. With this respect it seems convenient to recall few statements from Burland (2008). The statements concern the born of Soil Mechanics and more specifically the point of view of Terzaghi (1936):

"What he (Karl von Terzaghi) witnessed was a steady decline from 1880 in recorded observations and descriptions of behaviour. This was replaced by myriads of theories postulated and published without adequate supporting evidence. This experience must have been uppermost in his mind when, in his Presidential Address to the First International Conference, he stated the following: "In pure science a very sharp distinction is made between hypothesis, theories and laws. The difference between these three categories resides exclusively in the weight of sustaining evidence. On the other hand, in foundation and earthwork engineering, everything is called a theory after it appears in print and if the theory finds its way into a text book, many readers are inclined to consider it a law".

2.2 Fundamentals of continuum mechanics and constitutive models

First above all it is worthwhile to give some general information about these parts of the two books. In the Lancellotta's book the chapter on fundamentals of continuum mechanics extends for 40 pages with 141 equations. The chapter on constitutive models extends for 26 pages with 61 equations. On the other hand the same chapters in the Atkinson book consist respectively of 11 pages with 13 equations and 18 pages with 27 equations.

More specifically, the chapter on continuum mechanics in Lancellotta's book concerns the tensor calculus, the strain and stress analysis, and the following theorems and principles:

- Gauss theorem on divergence
- Reynolds transport theorem
- Principle of mass conservation
- Momentum principle (Eulerian formulation)

- Angular momentum principle (Eulerian formulation)

All the above topics are introduced using a very formal mathematical language. In addition the Author deals with some advanced topics. More specifically, the Author considers the following as advanced topics:

- Angular momentum principle (Lagrange formulation);
- First and second laws of thermodynamics;
- Constitutive axioms.

On the other hand in the Atkinson's book normal and shear stresses and strains are introduced in a quite intuitive way showing simple sketches. Differences between axysimmetric and plane deformation are highlighted. Stress and strain analysis is restricted to the use of Mohr circles. Few quite intuitive concepts on the mechanics of rigid body are also provided. Constitutive models of interest in soil mechanics are introduced making reference to the outcome of usual geotechnical laboratory tests.

From the above it is quite evident that, as far as the Lancellotta's book is concerned:

- fundamentals of continuum mechanics and constitutive laws are very comprehensive;
- it is difficult to believe that the book has been written for students or for education and training of future practising engineers. It seems that the book has been written for the education of future professors of Civil Engineering. This implicitly assumes that the same basic education is required for any degree (Bachelor, Master Ph. D) and future occupation.

Obviously, the comprehension of the two above considered chapters of the Lancellotta's book requires a very good knowledge of basic subjects.

2.3 Geostatic stresses and effective stress concept

To conclude the comparison between the two considered textbooks, it is interesting to discuss how the concepts of geostatic stress and effective stress are introduced. These concepts represent two very fundamental topics of any soil mechanics class.

In the Lancellotta's book the effective stress concept is first introduced. The Author mentions the Terzaghi's works of 1923 (on consolidation) and of 1936 (first Conference on Soil Mechanics) giving the historical evolution of the Terzaghi's ideas till the definition of effective stress and its practical relevance.

The effective stress is defined in a very general way by means of the following equations:

$$\sigma'_{ij} = \sigma_{ij} - u\delta_{ij} \qquad (1)$$

where: δ_{ij} = Kroneker's delta

or

$$\sigma'_{ij} = \sigma_{ij} - \left(1 - \frac{K_{sk}}{K_s}\right)u\delta_{ij} \qquad (2)$$

where: K_{sk} and K_s are the bulk moduli of the soil skeleton and the grains respectively.

As for the geostatic stresses, the Author first states the conditions of symmetry for a soil element resting at a given depth. These conditions lead to the fact that no shear stress is acting on horizontal and vertical planes and there are only two normal stress components (i.e. principal stress components).

The expression of the vertical stress is derived from the equilibrium equation in the vertical direction:

$$\frac{\partial \sigma_{vo}}{\partial z} - \gamma = 0 \qquad (3)$$

The effective vertical geostatic stress is obtained through the application of the effective stress concept after defining the water pressure.

As for the horizontal geostatic stress, the empirical Ko coefficient is introduced.

In the Atkinson's book, the total geostatic stresses are first introduced in a simple and intuitive way. The vertical total geostatic stress is simply the weight of the soil column overlying the soil element. It is interesting to notice that three different cases of practical interest are defined. More specifically:

- a soil element at a given depth below ground level;
- a soil element below the sea bottom
- a soil element at a given depth below ground level where a uniform and infinitely extending pressure (q) is applied.

The Author defines the water pressure under hydrostatic conditions. The water pressure is defined trough its measure, i.e. its height in a piezometric pipe. The hydrodynamic conditions are anticipated but not discussed in detail. The condition of partial saturation is also discussed. The concepts, again, are introduced in a very intuitive and simple way. At the same time the reader can easily understand that in some circumstances (hydrodynamic conditions, partially saturated soils) the explained concepts cannot be sufficient, so that additional knowledge or research is necessary.

The above comparison leads to the same comments previously stated in section 2.2.

3. CONCLUSIONS

The differences between the examined textbooks, that I have tried to highlight, represent, on my opinion, the most relevant differences between the Anglo-Saxon and Latin education systems. In one case (Anglo-Saxon) the learning process is mainly based on an inductive approach which starts with intuitive concepts and step by step moves towards a generalization. Therefore it is possible to first educate a Bachelor and step by step move towards a Master or a Ph D.

On the other hand (Latin), the learning process is mainly based on a deductive approach which derives the individual applications from more general concepts. The understanding of these general concepts requires a robust knowledge of basic subjects. Obviously, for the Latin education system it is necessary to start with a very strong education in basic subjects (Mathematics and Physics). Therefore it is very difficult to have a Bachelor degree (in three or four years) followed by a Master and a Ph. D.

It is worthwhile to answer the question which type of graduates the two systems can produce. The first level degree in a two-tier system should graduate practising engineers capable of solving simple and repetitive problems. The second level degree should graduate specialised engineers capable of getting innovative solutions. The third level should graduate people for the academic career or research centre.

It seems that the target of the Latin education system is to graduate only "Scientists" or "Future Professors". This is why the two tier system finds so many difficulties to be implemented in Latin Countries.

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BOLOGNA PROCESS AND STUDY PROGRAMMES "TRANSPORTATION ENGINEERING"

Juris Rihards Naudzuns, Ainars Paeglitis, Juris Smirnovs[1]

ABSTRACT

There is only one university in Latvia offering higher education in the field of Transportation Engineering - Riga Technical University (RTU). We provide programmes organized in two levels that allow obtaining the Bachelor's and Master's degrees in transportation engineering. Upon the completion of the first level in RTU, students are conferred the Bachelor's professional degree in Transportation Engineering, which grants them the right either to continue education in Master studies or enter labour market, because having completed the Bachelor studies, students receive the Engineer's qualification. Upon the completion of the Master's studies, a student may pursue the doctoral programme to be awarded the Dr.Sc.Ing. The objectives of the given paper are to: 1) summarize the Latvian experience in organizing the higher transportation engineering education after winning of independency in 1991; 2) show the latest trends in the field of higher transportation engineering education; 3) emphasize the structure of higher transportation engineering education in Riga Technical University.

1. INTRODUCTION

The year 1863 may be regarded as the foundation year of the education of civil engineers in Latvia, when the Faculty of Construction was created in the Riga Polytechnicum. Over the years more that ten thousand specialists have acquired the qualification of civil engineer in the Riga Polytechnicum, later Riga Polytechnic Institute, and now the Riga Technical University. Structures designed and built by our graduates have become important parts in our lives and in some cases have become highly appreciated in the society of civil engineers around the world. Over the years in changing countries where the present Riga Technical University has been located, the structure of education programme has changed, as well. The aim of this paper is to illustrate the changes implemented in the education of civil engineers in recent years in the time period from 1993 to 2009, when the requirements of Bologna Declaration to create a two-level system of higher education were implemented.

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2. HISTORICAL BACKGROUND

When the Construction Faculty in Riga Polytechnicum was created, the study programmes adopted in Karlsruhe University and Eidgenossiche Technische Hochschule, Zürich, were taken as an example. The study programmes provided 5 year studies, and it was one-level higher education system. After successful graduation from these studies the students acquired the qualification of civil engineer. With few changes such system existed until the 90-ties of the 20th century when the decision to organise separate Bachelor’s and Master’s studies was made.

The last years of the USSR were characterized by the pessimistic attitude of young people (especially students) towards higher education, which was caused by the “flat” salary system and hopelessness. This crisis lasted until 1993 when only 89 students (Table 1) were enrolled in the Faculty. The situation was made even worse by the crisis of transition period (1991 - 1997) in building and civil engineering sector itself.

In 1993 the existing study programme for civil engineers was divided into two parts. The first part lasting for three years was organised as the academic study programme for Bachelors and after graduation the students were awarded the degree of B.sc.ing. The second part was created as three years long academic Master’s studies and after graduation the students acquired the degree of M.sc.ing. After acquiring of Bachelor’s degree the students were also able to continue their education in two years long Engineer (Master type) studies. After academic studies for Bachelor’s degree where most of attention was paid to fundamental subjects the students had to present bachelor’s thesis. After that according to the recommendations of Bologna Declaration a bachelor had to be able to start to work independently. The described changes of education programmes are presented in Figure 1.

It is important that these changes in Riga Technical University were implemented in 1993 – namely, several years before the requirements of Bologna Declaration were formulated. When in 2001 the first EUCEET volume „Inquiries into European Higher Education in Civil Engineering” was published, the two-level system of civil engineering education was existing only in some European countries (see Figure 2), including Latvia. Formally we may assume that we had started the implementation of recommendations of Bologna convention some years before they were formulated and officially adopted.

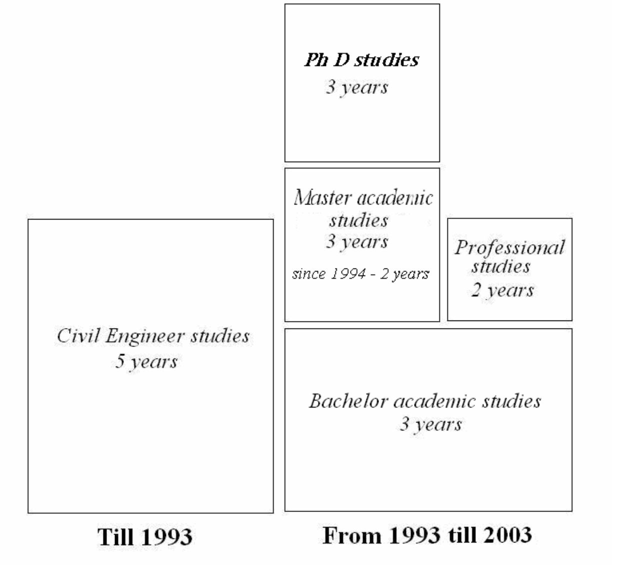

Figure 1. Development of Civil Engineer's curricula.

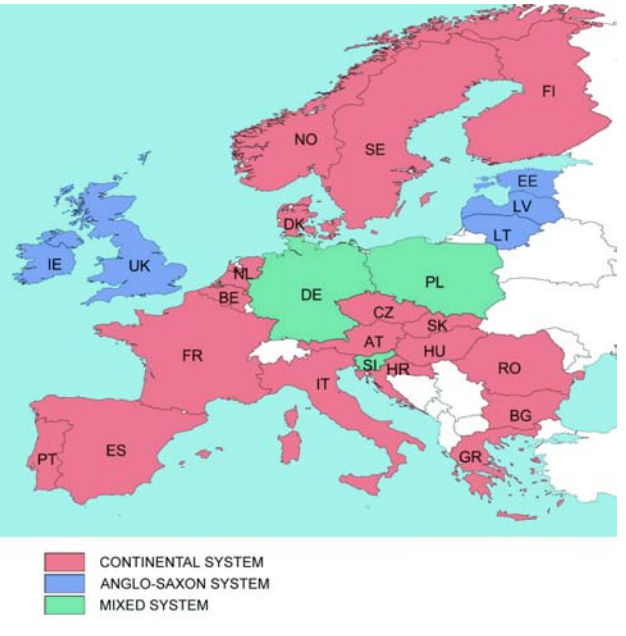

Figure 2. Distribution of Civil Engineering education systems across European countries 1999 -2000 [2]

Curricula of Bachelor's academic studies in civil engineering in Riga Technical University was carried on for more than ten years and the achieved results allowed drawing important conclusions.

After restructuring the higher education system for civil engineers the situation emerged that the specialists with Bachelor's degree had in fact not finished the higher education in accordance with the Latvian legislation of that time. The minimum length of study curricula for higher education was 4 years in Latvia. In addition to that, the amount of courses on topical themes of construction practices was too insufficient for graduates to start independent career in construction industry. It has to be noted that the Bachelor's curricula did not include any practical placement that also created problems to acquaint with the practices of road construction companies. Therefore new specialists found themselves in the situation where they could not start their career independently as they lacked professional knowledge, they had no formally approved higher education and they had no qualification of an engineer.

Also the Latvian Association of Civil Engineers evaluated the Bachelor's curricula and came to conclusion that it had insufficient number of professional courses on construction in order to award the new Bachelors with a certificate for independent work. In the given situation practically all Bachelors instead of starting working independently continued their education mostly in Engineer's programme. This meant that as before 1993 everybody studied for 5 years (3 years of Bachelor's studies and 2 years of Engineer's /(Master type) studies although the aim of introducing separate Bachelor's and Master's studies was to reduce the length of studying so that specialists could start working independently earlier. The mentioned results showed that improvements were needed in the Bachelor's academic curricula.

3. NEW STEP IN CIVIL ENGINEER'S CURRICULA

In 2003 the Riga Technical University started the new Bachelor's programme in civil engineering – Professional Bachelor's programme. After graduation the students acquired the degree of Professional Bachelor in civil engineering (B.Eng.) and the qualification of engineer.

Mandatory prerequisite for the creation of professional study programme was the standard of profession that defined knowledge and skills to be acquired during the studies. Standards of professions in Latvia are elaborated by professional associations but not by universities. This means that with the acquisition of knowledge and skills defined in the standard of profession the students will meet the requirements set by the professionals of construction industry and will be able to start their working careers.

During the preparation of this programme the recommendations of EUCEET were observed that were published in the fifth EUCEET volume, namely that during the initial 4 semesters all students of civil engineering faculty were involved in core courses only. Because of this, at least 2 study years in addition to the first two years are needed for special courses. Thus the total length of studies is 4 years. The programme proposed by EUCEET has no defined length of practical placement and therefore our programme has become longer for one semester as the practical placement is a uniform part of the study programme.

The new Bachelor's programme was entitled as the professional Bachelor's study programme „Transportation Engineering". It is 9 semesters long and it contains both courses important for professional career and practical placement. Practical placement is a mandatory part of the studying process and lasts for 26 weeks, i.e. for almost 2 semesters. Studying semester at the Riga Technical University lasts for 16 weeks.

For the purpose of comparison the programme had to be informally split into groups. Within this context the following grouping is offered: GE – general education subjects, FRT – engineering field related theoretical courses and information technology courses, FRP – field related professional specialisation courses, AEM – art, economics and management related courses, LA – languages other than Latvian.

Organisation of professional Bachelor's programme "Transportation Engineering" is as given in Table 1.

Table 1

Core courses:	**117* credits**		
• general education subjects (GE)		14 credits	7.8%
• engineering field related theoretical courses and information technology courses (FRT)		44 credits	24.4%
• field related professional specialisation courses (FRP)		59 credits	32.8%
Optional core courses:	**15 credits**		
• field related professional specialisation courses (FRP)		9 credits	5.0%
• art, economics and management related courses (AEM)		2 credits	1.1%
• languages (LA)		4 credits	2.2%
Optional courses	**6 credits**		3.3%
Practical placement	**26 credits**		14.4%
Bachelor's thesis (including engineer's project)	**16 credits**		9.0%
Total:	**180 credits**		100%

*1 Latvian credit point = 1.5 ECTS credit points

As it may be seen a considerable proportion of the programme is formed by civil engineering specific subjects (32.8+5=37.8%). This fact allows to account for students’ professional preparedness and it is also in line with the knowledge level defined by Bologna Declaration for academic category “undergraduate”.

In accordance with the standards passed by the Cabinet of Ministers the second level professional studies have to consist of at least 20% of general education subjects. AEM, LA and GE falls within this group, therefore the standard requirement is fulfilled.

Field related theoretical and information technology courses should not be less than 36 credit points. Organisation of the current programme meets this requirement as FRT courses account for 44 credits.

Field related professional specialisation courses (FRP) are expected to amount up for not less than 60 credit points. In this case it is 59+9 = 68 credits and the requirement is met.

Knowledge level in professional Bachelor’s programme is assessed in the system of 10 points. Methods of knowledge assessment are tests, tutorials, practical placement and exams in accordance with the approved study schedules. Final examination deals with Bachelor’s thesis (including project) and its oral presentation.

Bachelor’s thesis is aimed to demonstrate the student’s ability to solve real problems in relation to civil engineering structures based on literature review and practical skills. Before the final presentation, the thesis is reviewed by a specialist. The reviewing person is nominated on behalf of Department based on the written order of Department Director. Publicly accessible presentation is assessed by the testing commission appointed by the rector of Riga Technical University. The commission consists of delegates from professional associations, business and other institutions.

Structure of the new curricula is shown in Figure 3.

Figure 3. Scheme of Civil Engineer’s curricula after 2003

Bachelor's thesis is aimed to demonstrate the student's ability to solve real problems in relation to civil engineering structures based on literature review and practical skills. Before the final presentation, the thesis is reviewed by a specialist. The reviewing person is nominated on behalf of Department based on the written order of Department Director. Publicly accessible presentation is assessed by the testing commission appointed by the rector of Riga Technical University. The commission consists of delegates from professional associations, business and other institutions.

After graduation from the professional Bachelor's programme the students acquire the professional Bachelor's degree in civil engineering and the qualification of civil engineer. Thus the new specialists are ready for the labour market as engineers. The professional Bachelor's study programme fully complies with the requirements of Latvian Association of Civil Engineers and the graduates acquire professional LACA certificates.

If we analyse the number of students of the first year in the Faculty of Civil Engineering (see Figure 4) in recent years, we may come to conclusion that with the start of the professional Bachelor's programme the number of students has considerably increased with maximum peak in 2007. However, at the same time it has to be noted that in 2004 – 2007 the amounts of construction works in Latvia increased at an enormous rate and the lack of civil engineers in labour market was observed. Therefore the increase of the number of students was mostly determined by the fast development of economy. As we may see, in 2009 when Latvia experienced fast economical recession which led to fast reduction of the amounts of construction works, the number of students matriculated for the first year came back to the usual level of 150 – 200 students.

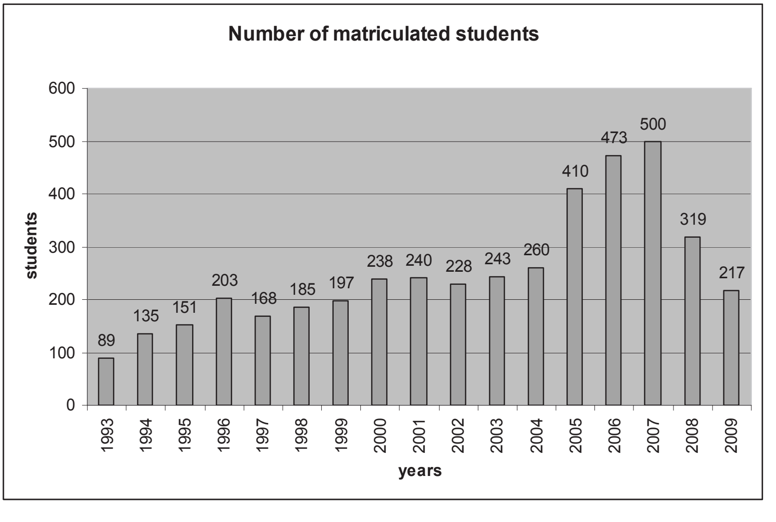

Figure 4. Number of matriculated students in the Faculty of Civil Engineering

CONCLUSIONS

1. The two-level higher education in civil engineering was introduced already in 1993. Over the years it became clear that 6 semesters long academic Bachelor's study programme provided insufficient professional knowledge for graduates to start their careers.
2. In the beginning of the XXIst century a decision was made to create a new Bachelor's study programme oriented towards matching the needs of Latvian construction industry.
3. In 2003 the Faculty of Civil Engineering of the Riga Technical University started the professional Bachelor's study programme that lasted for 9 semesters, included practical placement and met the requirements of civil engineering professionals.
4. With the implementation of the Bologna process at the Faculty of Civil Engineering of the Riga Technical University, it was possible to change the length of civil engineers' studies from 10 to 9 semesters.
5. With the experience of more than 10 years in carrying out the 6 semester long academic Bachelor's study programme we have come to conclusion that 3 years of studies in civil engineering are too short time period to educate civil engineers.

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T.U. DELFT ASSESSMENT FRAMEWORK FOR JOINT EDUCATION

Ellen Touw[1]

1. INTRODUCTION

Setting up a Joint Education programme can be very time and energy consuming, both within the university and at the partner institution. When the TU Delft Executive Board noted that the number of initiatives for developing joint Master's degree programmes with other institutions increased steadily, they considered an assessment framework necessary, in order to find out at an early stage whether a Joint Education Programme can feasibly fit in with the criteria and wishes of the Executive Board of TU Delft. The first version of this Assessment Framework was approved by the Board on 3 October 2006.

2. T.U. DELFT ASSESSMENT PROCEDURE

Proposals for joint Masters are assessed by an internal assessment committee, installed by the Executive Board on the basis of the principles, criteria and guidelines for implementation as described in the Assessment Framework. The Executive Board decision is based on the advice of this assessment committee.

Faculties are advised to request the assessment committee for preliminary advice at an early stage to avoid investing time and money in a joint education degree programme that ultimately comes to nothing. If the preliminary advice is positive, the faculty can continue drawing up plans for joint education.

Applications for a joint or double degree are to be submitted by the dean to the Executive Board. The faculty will compile a complete information file consisting of:

- substantive reasons for choosing partner
- international benchmark
- labour market study
- market research among potential students or analysis of related Master's degree programmes (specialisations)
- information on the relationship with the research
- information on admission requirements
- proposal for the concrete implementation of the degree
- financial analysis
- quality assurance plan

[1] Drs. (in collaboration with the T.U. Delft Joint Education Assessment Committee)

- detailed account of the manner in which the thesis subject will be *jointly* assessed
- implementation plan

After formal approval the arrangements between the partners regarding the implementation of the joint education degree and the organisation around it must be laid down in a *Memorandum of Understanding* with an underlying *business plan*, to be signed by the Executive Board. The programmes are also included in the Registered Degree Programmes.

3. ASSESSMENT CRITERIA FOR JOINT EDUCATION DEGREE PROGRAMMES

The Executive Board decides on a faculty request for a joint education degree programme on the basis of the following assessment criteria. The criteria are derived from the assessment criteria in the existing TU Delft Protocol for New Degree Programmes as approved in the spring of 2003 by the Executive Board.

A. Strategic importance for TU Delft:

- The *partner institution is of good and evident quality* and standing and adheres to a specified quality standard. The status of the partner institution is assessed through: (inter)national rankings, national accreditations, concrete partnership experiences, the internal quality assurance at the partner institution.

- The degree programme helps to strengthen *TU Delft's international appeal and image*, will result in an (inter)nationally recognised diploma and puts TU Delft more emphatically on the international map. This effect is assessed through: international benchmarking.

- The new degree programme *fits in with the education and research portfolio* of TU Delft and is aimed at achieving stronger focus and mass. The relevance is assessed through: the relationship with accredited education and research programmes.

B. Economic added value and viability:

- The degree programme *attracts new target groups* of (inter)national students who would otherwise not opt for a Master's degree programme of TU Delft. Or, the degree programme covers a unique domain that has not yet been offered as a degree programme or Master's specialisation by TU

Delft. The growth scenario for a Master's degree programme is aimed at an annual intake of at least 20 students per Master's degree programme and, in the case of several Master's specialisations, at an annual intake of on average of 20 students per specialisation. The productivity is assessed through: market analysis among potential students, international benchmark.

- The degree programme is c*ost efficient in the sense that it* concerns a knowledge domain of TU Delft that is revitalised by the cooperation with a partner thanks to the fact that the limited capacity is supplemented with the partner's capacity (combination of strengths). To be assessed through: available capacity for education and research.

- The (projected) degree programme is *viable* in terms of necessary preliminary investments, cost-benefit ratio and practical feasibility. The ability to attract sufficient students is the key issue to viability. Viability is assessed through market analysis among potential students and occupational fields, cost-benefit analysis.

4. GUIDELINE FOR THE IMPLEMENTATION

The quality requirements for education as applied by TU Delft are paramount in designing the education programme for a joint education degree. The implementation must therefore take the following into account:

- *With a new degree programme*: The achievement levels of the joint education degree are internationally benchmarked, i.e.: they have been compared with the qualification profiles of reputable institutions[2], tested against the potential international labour market, and related to existing Master's degree programmes of both institutions.

- *With an existing degree programme*: The achievement levels of the existing degree programme of TU Delft are the starting point and frame of reference for the programme and design of the degree.

- *With an Erasmus Mundus programme*: the degree is offered by a maximum of 5 partners, while the actual study programme is delivered by a maximum of 2 partners.

[2] Such qualification profiles have been formulated in the IDEA League context for various TU Delft disciplines. See www.idealeague.org

- *In all cases* the following standards shall apply:

  - The graduation projects are carried out under the (co-)responsibility of teachers of the relevant degree programme of TU Delft.
  - At least 40% (45 ECTS) of the credits are provided by the relevant faculty or degree programme of TU Delft, where the graduation projects – in cases where the responsibility is indeed shared – are allowed to count for 50% (15 ECTS).
  - The total programme is coherent and a joint responsibility of the partners.

- Joint responsibility will exist for assuring the quality of the education, the accreditation procedure and the macro efficiency procedure as well as the rights and obligations relating to these subjects. The partners must make clear arrangements in this respect, particularly about the quality assurance for the joint education degree.

- Definite decision-making takes place by means of a signed statement in which the Executive Boards of the partners involved accept joint responsibility for the joint education degree.

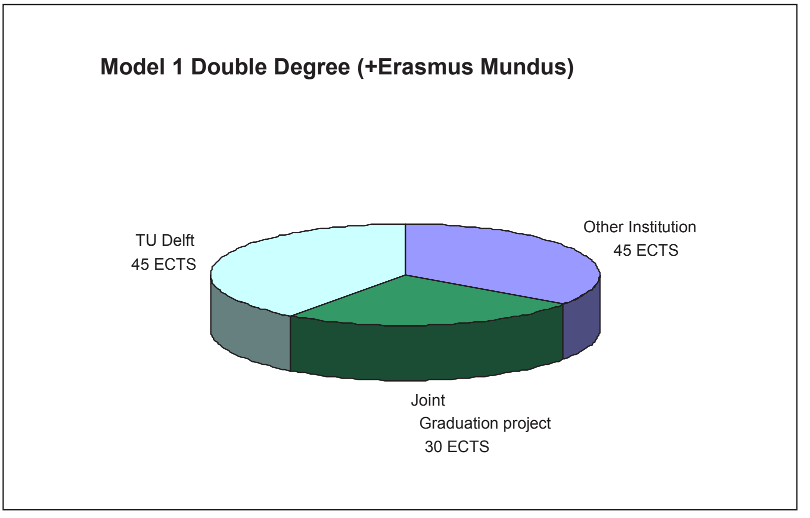
The possible specialisations for a Joint Education Degree are shown diagrammatically in the models shown in Figure 1.

The models shown in Figure 1 are based on a two-year Master's degree programme of 120 ECTS in total.

5. EXISTING OR NEW DEGREE PROGRAMME

A joint education degree can be set up as an *international specialisation* under an existing CROHO-registered degree programme of TU Delft. In this case the name of the degree programme stated on the degree certificate is the name of the existing degree programme plus the additional remark that this concerns a specialisation and joint Master's of the partners involved. The diploma supplement will then state the specifications of the joint degree in detail.

A joint education degree can also be set up as a *new degree programme* where the student receives a degree certificate bearing the name of the new degree programme. In order to be recognised as such, the new degree programme must pass the New Degree Programme Test of the NVAO (Dutch Flemish Accreditation Organisation) and the efficiency test of the Ministry of Education, Culture & Science. This accreditation process takes at least one year.



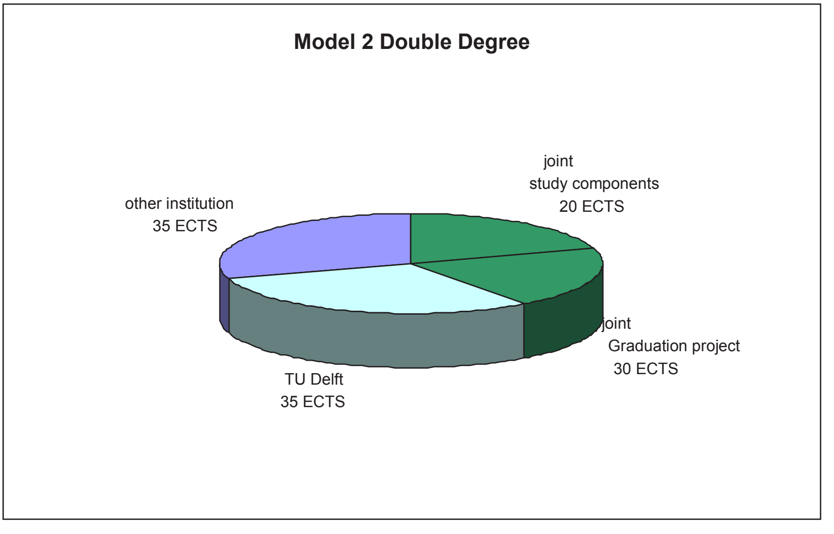


Figure 1

Which of these two options is the most suitable will depend on the objectives of the degree programme, the size, the name and the expected advantages of having the status of independent degree programme (in terms of e.g. marketing, but also admission procedures for non-EU students).

Appendix 1 to Joint Education Assessment Framework

DEFINITIONS

In an international context the term Joint Education refers to the collection of education programmes or degree programmes that are provided by several institutions working together. TU Delft also uses this term. In practice TU Delft makes a distinction between two types of joint education: joint degree and double degree. These terms are defined below. With both types the responsibility for the degree programme rests with both institutions.

Joint degree:

A joint degree is a (new) degree programme provided by 2 or more Higher Education Institutions, with 1 set of achievement levels, 1 joint board of examiners and board of studies, 1 set of teaching and examination regulations, 1 joint quality assurance system and 1 degree certificate featuring the logos of the institutions involved. NB: Dutch law does not yet permit joint degrees. It is expected that this option will be offered by the new WHOO law from 2010. Until then there will effectively be a double degree or bi-certification arising from existing Master's degree programmes.

Double degree:

With a double degree the student is offered an opportunity to graduate at two institutions with at most a limited addition to the study load: largely equal achievement levels, 2 sets of teaching and examination regulations, 2 degree certificates but a largely joint programme. Via exemptions the board of examiners recognises the equality of study components of the other degree programme.

This assessment framework also includes the Erasmus Mundus programmes which, however, are also subject to additional substantive and procedura.

PRACTICAL IMPLEMENTATION OF BOLOGNA PROCESSES AT THE CIVIL ENGINEERING FACULTIES IN POLAND

Andrzej Lapko[1]

1. INTRODUCTION

Poland was a signatory of the Bologna Declaration. The important step for implementation of Bologna process in Poland was the new Higher Education Law of 27 July 2005 [1] and the relevant ministerial implementing Regulations. On this basis on 3rd October 2006 was established in Poland an active Bologna Process Council. Key developments since 2007 include: working out the proposal for National qualifications framework, including outcomes based cycle descriptors. It has been prepared and discussed with the stakeholders and presented to the ministry, but it has not yet been implemented.

Based on the current analysis the author has drawn conclusions about the progress that has been made towards achieving the goals of Bologna Process application at the Civil Engineering area in Polish Higher Education institutions. The survey has been done from the own experience of the author acting as an expert of Polish Accreditation Commission after accreditation visits on Civil Engineering faculties in Poland. The assessment has shown that some Bologna recommendations in Civil Engineering educational area are not correctly fulfilled, as it has been stressed in Stocktaking Report 2009 [2], published for the Meeting of Ministers of Higher Education, to be held in Leuven in the end of April 2009.

The problems with Bologna process implementation in the area of Polish Civil Engineering education concerns the lacked links between learning outcomes and other elements such as qualifications frameworks, quality assurance, recognition and lifelong learning [3], [4]. Author has formulated recommendations for the future of CE faculties arising from the findings of the 2009 Stocktaking Report.

2. BRIEF DESCRIPTION OF RECENT SYSTEM OF HIGHER EDUCATION IN POLAND

The basis for operation of Higher Education system in Poland is included in the Act of 27th July 2005 – Law on Higher Education. The provisions are concerning both public and non-public higher education institutions, it means

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that the standards of studies are offered on the same basis and upon completion of the same requirements.

In line with the aims of the Bologna Process, all HEIs in Poland are required to introduce two-cycle programmes (first-cycle Bachelor's degree programmes followed by second-cycle Master's degree programmes) and replace any long-cycle programmes still in place in most of 118 existing in Poland fields of study.

Programmes in 11 fields, (e.g. art conservation and restoration, canon law, dentistry, law, medical analysis, medicine and others) will be provided only as long-cycle programmes. Programmes in the fields of theology and directing will be provided either as two-cycle programmes or as long-cycle degree programmes. These arrangements are applicable to programmes commencing in the academic year 2007/08.

Higher education institutions are divided, irrespective of their status, into academic and vocational ones. An academic higher education institution is a school in which at least one of its organizational units is entitled to award the academic degree of ***doktor.*** A vocational higher education institution is a school offering first or second cycle study programmes or one-tier (long-cycle) study programmes, and which is not entitled to award the academic degree of ***doktor.***

Study programmes are offered as first cycle, second cycle and one-tier (long-cycle) programmes and doctoral (third cycle) programmes. First cycle programmes leading to a ***licencjat*** degree last from 6 to 8 semesters, and those leading to an *inżynier* degree last seven or eight semesters. Second cycle degree programmes last three or four semesters and one-tier (long-cycle) programmes leading to a ***magister*** degree last from 9 to 12 semesters.

Doctoral study programmes last no longer than 4 years and upon completion graduates are awarded a certificate. Under a separate procedure graduates are conferred the academic degree of ***doktor***. Higher education programmes and doctoral programmes may be offered as full-time or part time programmes.

The new requirements for degree programmes (for first and second-cycle and, where applicable, long-cycle programmes) include: a general description of a field of study, a description of skills and competences of a graduate, general curricular contents, a general description of practical placements, the duration of a degree programme, the minimum course load and the number of ECTS credits.

The requirements for first-cycle programmes are designed to enable students to enrol on a second-cycle programme in the same or (in some cases) different field of study. The new requirements provide a good basis for the development of modern curricula, and will facilitate the introduction of flexible and individualised learning pathways for all students, increase mobility within related fields of study, bring the profile of graduates closer to labour market demands, and thus also serve as a tool for improving the quality of higher education. The Regulation entered into force on 1 October 2007; HEIs are required to respect the new requirements as from the first year of a degree programme.

The number of the ECTS credits provided by the plan of studies for one semester is 60 ECTS credits for an academic year. It is necessary to gather 180 – 240 ECTS credits to complete a first cycle programme, 90 – 120 ECTS credits to complete a second cycle programme.

Academic degrees are conferred by organizational units of higher education institutions, Polish Academy of Sciences and research and development institutions in compliance with the powers granted under a separate procedure.

The academic title is the degree of professor of a specific area of science, while the equivalent degree in arts is the degree of professor of a specific area of arts. The degree of professor is conferred by the President of the Republic of Poland.

A legal body working for the quality in education in Poland is the State Accreditation Committee acting as an independent institution created for the needs of external assessment the higher education institution in Poland for the improvement of the quality in Higher Education.

3. GENERAL ASSESMENT OF THE IMPLEMENTATION OF BOLOGNA PROCESS IN THE EUROPE AND POLAND

3.1 General conclusions for all countries participating in Bologna Processes

In April 2009 it was prepared the Stocktaking Report on the Bologna Process [2] and it has been presented firstly on the Leuven/Louvain la Neuve Ministerial Meeting. This Report has presented conclusions about the progress of implementation of Bologna Declaration of all 48 of countries, which participated in the Bologna Processes. The Report presented in an integrated way the links between learning outcomes and other elements such as qualifications frameworks, quality assurance, recognition and lifelong learning. The working group has formulated recommendations for the future arising from the findings of the 2009 Stocktaking.

Below are presented general conclusions formulated in the Stocktaking Report 2009 [2] showing the current stage and the future of Bologna Process implementation.

Bologna Degree System

1. The implementation the first and second cycle degree system across Europe is generally on the good level; however in some countries the proportion of students studying in the Bologna three-cycle system is still relatively low, mainly because they have just recently started admitting students to bachelor

and master programmes. Also, in some countries certain regulated professions and some specific disciplines are not yet included in the two - cycle system. It is concerned also Poland where some disciplines are outside the two cycle system.

2. Generally the implementation of student access to the next cycle across the Europe is at the good level. It is also concerned Poland. However, in a number of countries graduates have to meet additional requirements such as examinations, additional courses or work experience to actually gain admission to the next cycle, even in the same field of studies. There are also some countries where different types of qualifications in one cycle do not offer the same access to the next cycle.

3. Overall, the implementation of the third (doctoral) cycle is progressing: the third cycle is being included in the national qualifications frameworks and ECTS is widely used in the third cycle. However, in some countries the need to provide doctoral students with transferable skills for employment has not been fully understood.

Qualifications frameworks and lifelong learning

4. Six countries only have already completed the self-certification process of national framework qualification. Therefore the deadline for completion this qualification framework by 2010 in all the European countries is not real. There are still a large number of countries, like Poland, that are just at the beginning of this process or in some countries have not yet started the implementation, therefore full implementation of national qualifications frameworks needs some time.

5. In most countries there is little or no recognition of learning undertaken outside the formal education system. It is concerned also Poland. Only small number of countries have put in place an advanced systems for recognition of prior learning.

6. There is still not enough integration at national level between the qualifications framework, learning outcomes and ECTS. Many countries appear to have implemented these action lines separately. The Stocktaking Report [2] clearly indicates that the introduction of a lifelong learning based on full implementation of a learning outcomes approach – still needs a lot of efforts. The similar situation is generally seen in Poland.

Quality assurance

7. All EHEA countries have introduced external quality assurance (QA) systems including self-assessment and external review; nearly all publish assessment results and carry out follow-up measures. However, only 15 countries have organized assessment of their QA agency. Some countries with small higher education systems do not have a national QA agency but they organize external QA and international participation in other ways.

8. In most countries, like Poland, there are implemented internal QA procedures and the systems for approval of programmes and qualifications are well developed.

9. Overall, student participation in QA is implemented; however students often participate in reviews only as observers, they are not always involved in preparing self-assessment reports.

10. There has been some progress towards achieving a greater level of international involvement in the participation in external review teams and membership of EN QA or other international QA networks, but there are still quite a large number of countries whose quality assurance agencies are not yet full members of EN QA.

Recognition

11. The Diploma Supplement is generally implemented in Poland and in other countries, however not widely as would have been expected. In 2009, over half of the countries have managed to implement the requirement that Diploma Supplement should be given automatically, free of charge and in a widely spoken European language to all graduates.

12. A relatively small number of countries have well-established systems for recognition of prior learning, the situation in many other countries, like Poland, show that there is little or no recognition of learning undertaken outside the formal education system.

13. The interpretation of the Lisbon Recognition Convention's principles as well as the recognition procedures and terminology differ across countries. In some countries, like Poland, the procedures of recognition take into account quality assurance status, learning outcomes and level as the main criteria; in some other countries the base of recognition are formal issues, content of the curriculum and the duration of studies.

14.ECTS is part of the Bologna Process since 1999 and credits are commonly used as transfer and accumulation credits, however in some countries ECTS is still not fully implemented. There are two main challenges that are encountered in fully implementing ECTS: measuring credits in terms of student workload and linking them with learning outcomes.

Joint degrees

15.Three-quarters of the countries have amended their legislation to allow joint degrees. Joint degrees are established in almost all fields of study, however half of the countries estimate that the joint degree cooperation is only between 1% and 25%. A number of actions are stimulating joint degrees, including legal measures; additional funding to support joint programmes; quality assurance/accreditation of joint programmes; codes of good practice and handbooks for establishing joint degrees.

Global dimension

16.The Bologna Process has enhanced cooperation between countries, organizations and higher education institutions inside and outside Europe. While many countries report that they promote their own higher education systems internationally, very few of them seem to focus on promoting the EHEA.

3.2 General assessment of Bologna process implementation in Poland

The general assessment for Poland has been presented in the table 1 on the basis of Stocktaking Report 2009 [2] and the own experience of the author [3] as an expert of the Polish State Accreditation Committee for assessment of Civil Engineering field of the study.

Table 1. General assessment of Bologna processes implementation in Poland

The indicator of original goals of Bologna processes implementation	General assessment of Bologna Process implementation in Poland according to Stocktaking Report 2009 [2]
	IMPLEMENTATION OF DEGREE SYSTEM
1. Stage of implementation of first and second cycle	The Bologna degree system is almost fully implemented in Poland. The percentage of all students in 2009 who are enrolled in a two-cycle degree system (in accordance with the Bologna principles) ranges in Poland between 70 and 89 %.

2. Access to the next cycle	This goal is fully reached in Poland. All first cycle qualifications give access to several second cycle programmes and all second cycle qualifications give access to at least one third cycle programme. However there are fields of studies which are outside this system.
3. Implementation of national qualification frameworks	The implementation of national qualification framework (NQF) in Poland is still at the early stage of development. Actually the proposal for a NQF compatible with the overarching framework of qualifications of the EHEA has been in preparation including: • generic cycle descriptors based on learning outcomes • ECTS credit ranges in the first and second cycles and a timetable for consulting relevant stakeholders has been drawn up but the consultation process has not yet been completed.
	QUALITY ASSURANCE
4. Stage of development of external quality assurance system	Poland fully implemented functioning external quality assurance system operated at national level. Evaluation of programmes and institutions includes four elements: self-assessment report, external review, publication of results and follow-up procedures and a date has been set for peer review of the national QA agency according to the Standards and Guidelines for QA.
5. Level of student participation in quality assurance	In all quality assurance reviews in Poland, students are participating: - in the governance of national bodies for QA - in external review of HE units and programmes: either in expert teams, as observers in expert teams or at the decision making stage, - in consultation during external reviews - in internal QA processes - in preparation of self-assessment reports
6. Level of international participation in quality assurance	In Poland the international participation in QA activities takes place in evaluation of programmes and institutions
	RECOGNITION
7. Stage of implementation of Diploma Supplement	Every graduate in Poland receives automatically and free of charge a Diploma Supplement in the European Diploma Supplement format and in a widely spoken European language
8. National implementation of the principles of the Lisbon Recognition Convention	The Lisbon Recognition Convention has been ratified in Poland and appropriate legislation complies with the legal framework of the Convention. The later Supplementary Documents have been adopted in appropriate legislation and applied in practice, so that main principles are fulfilled: - applicants have a right to fair assessment,

	- in cases of negative decisions the competent recognition authority demonstrates the existence of substantial differences, - the country ensures that information is provided on its institutions and their programmes.
9. Stage of implementation of ECTS System	ECTS credits in Poland are allocated to all components of all HE programmes, enabling credit transfer and accumulation AND ECTS credits are demonstrably linked with learning outcomes
10. Recognition of prior learning	There are no specific procedures/national guidelines in Poland for assessment of prior learning, but procedures for recognition of prior learning are demonstrably in operation at some higher education institutions or study programmes.

4. IMPLEMENTATION OF BOLOGNA PROCESS IN THE FIELD OF CIVIL ENGINEERING IN POLAND

4.1 The range of Civil Engineering education in Poland

The higher education in the area of Civil Engineering in Poland is conducted in 41 public and also non-public Higher Education institutions, mainly on:

- Technical and other profile Universities (in Białystok, Częstochowa, Gliwice, Gdańsk, Kielce, Koszalin, Kraków (2), Lublin, Łódź, Opole, Płock, Poznań, Rzeszów, Szczecin, Warszawa (2), Wrocław, Zielona Góra),
- Agriculture Universities (in Bydgoszcz, Olsztyn, Warszawa, Wrocław),
- Nonpublic of different profile Universities (in Ełk, Kalisz, Katowice, Kielce, Łomża, Siedlce, Warszawa, Włoclawek, Wrocław, Zamość),
- State Vocational High Schools (in Chełm, Elbląg, Jarosław, Konin, Krosno, Piła, Suwałki).

Technical and Agriculture Universities offer Civil Engineering education in the frame of two and (in some Universities) also three cycles (including doctoral studies), whereas State Vocational High Schools and non-public High Schools could offer the education only at the first cycle leading to the engineering diploma of Civil Engineering.
Since last three years the Civil Engineering field of studies in Poland is probably one of the most popular field, therefore the number of candidates for the first year of studies is the largest on the Technical Universities.

4.2 Description of two cycle standard programmes in Civil Engineering formulated on the basis of Bologna recommendations

Two cycle studies

First cycle of studies in Civil Engineering should last not shorter than 7 semesters. The number of contact hours should be not lower than 2500. The number of ECTS credits should be not less than 210.

Second cycle of CE studies should last not shorter than 3 semesters and the number of ECTS should be not less than 90.

Abilities of CE graduates

The first cycle CE students should posses a knowledge in the area of construction of housing, municipal and industrial building, road engineering, the abilities of design of main structural systems, the managing of building construction teams and building firm, the production, selection and application of building materials and applications of modern building technologies and computer systems in building practice. The CE graduates are prepared for: management of construction of all types of building objects, co-operation in design of building structures, the supervision of building construction and also to long learning self education and their professional perfection. The CE graduates should posses the knowledge of international language on the level B2. The CE graduates should be prepared for access to the studies of second cycle.

The second cycle CE students should posses an advanced knowledge in the area of design and construction of complex systems of municipal and industrial buildings and also of road engineering, the abilities of structural design of complex structural systems, the managing of building construction teams and building firms, the production, selection and application of building materials and applications of modern building technologies and computer systems in building practice. The CE graduates are prepared for solving of complex structural, constructional and technological problems. They should be ready for formulation and realization of research projects including projects on the international level. The graduates should be prepared for lifelong learning and self education and their professional perfection. The CE graduates should be prepared for access to the doctoral studies of third cycle.

Standard programmes for Civil Engineering in Poland

Since the year 2007 the structures of University programmes in the field of Civil Engineering in Poland should be compulsory based on standard framed programmes elaborated at the Ministerial level for two cycles of education. The framed programmes are composed on the requirements for basics subjects and main field (professional) subjects. For any CE field subject the standard programmes give the list of problems and outcomes but it does not define the minimum number of contact hours and minimum ECTS credits. The descriptions of such standard programmes for the field Civil Engineering education in Poland on the two cycles of studies are shown below in the tables 2, 3 and 4. Such structure of ministerial standard programmes in Poland gives an opportunity for creation of flexible university learning paths in detailed Civil Engineering curricula.

Standard programmes in CE education in Poland should be adopted with the requirement to provide for student a flexible learning paths, offering some elective subjects. The minimal number of elective hours in the curricula is also defined in the Ministry regulations and for the first cycle of studies should be not less than 360 hours.

Table 2. Groups of basic CE subjects, minimal number of contact hours and minimal number of ECTS credits

First cycle CE studies			**Second cycle CE studies**		
Types of subjects	Minimum contact hours	Minimum ECTS credits	Types of subjects	Minimum hours	Minimum ECTS credits
Group of basics subjects	315	31	Group of basics subjects	30	3
Group of field subject	660	64	Group of field subject	150	15
Total	975	95	Total	180	18

Table 3. Groups of basic core subjects, minimal number of contact hours and minimal number of ECTS credits

First cycle C E studies			**Second cycle C E studies**		
Group of basics subjects	Minimum contact hours	Minimum ECTS credits	Group of basics subjects	Minimum contact hours	Minimum ECTS credits
Mathematics	120		Advanced mathematics	30	3
Physics	45				
Chemistry	45				
Geology	30				
Theoretical Mechanics	45				
Numerical methods	30				
Total	315	31	Total	30	3

Table 4. Group of field subjects, minimal number of contact hours and minimal number of ECTS credits

First cycle of C E studies			**Second cycle of C E studies**		
Group of field subjects	Minimum contact hours	Minimum ECTS credits	Group of field subjects	Minimum contact hours	Minimum ECTS credits
Descriptive geometry and technical drawing			Theory of elasticity and plasticity		
Surveying			Computer methods		
Building materials			Complex concrete structures		
Strength of materials			Complex metal structures		
Building Mechanics			Management of building enterprises		
Basis of construction					
Geotechnics					
Soil engineering					
Concrete structures					
Metal structures					
Building installations					
Road engineering					
Building physics					
Hydraulics and Hydrology					
Organization of construction works					
Technologies of construction works					
Management of investment processes					
Building economics					
Total	660	64	Total	150	15

4.3. Quality assessment of Civil Engineering studies in Poland

A legal body working for the quality in education in Poland is the State Accreditation Committee. The Polish Law on Higher Education, adopted in 2005 defined the objectives of the State Accreditation Committee. The State Accreditation Committee is an independent institution working within the higher education system in Poland for the **improvement in the quality in education**. The primary objective of the Committee is to support Polish public and non-public higher education institutions in the development of educational standards matching the best models adopted according to Bologna recommendations. The State Accreditation Committee is conducting an obligatory assessments of the quality of education at all the fields of studies and giving opinions on applications for the authorization to provide degree programmes submitted by higher education institutions.

The assessment of quality in all the field areas in Polish Higher Education is carried out by the Committee team consisting of the chairman and two national experts (specialists in the given area of studies) as well as one international expert. In the assessment team of SAC is also included a student and a representative of Polish Higher Education Ministry. The quality assessment of education is expressed by the State Accreditation Committee in the following ratings: **outstanding**, **positive conditional** or **negative.** The negative rating for any field of studies leads to the ministerial decision of closing the education in the given field.

In the field of Civil Engineering in Poland the accreditation activities are carried out any five years and the last cycle of assessment have started in 2009 and will be finished in 2010. Till now the ratings for Civil Engineering faculties are mainly positive and only in a very few cases are conditional with the condition of repeated assessment in the close future.

The own experience of the author of this paper acting as an expert in Polish Accreditation Commission has shown that some Bologna recommendations in Civil Engineering education in Poland are not always correctly fulfilled. In some Higher Education institutions offering the education in Civil Engineering area, the problems concern the lack of flexible learning paths (the curricula are mostly rigid). The other problems result from lacked links between learning outcomes and other elements such as qualifications framework, lack of internal quality assurance, recognition of prior learning and the implementation of a system of lifelong learning.

4.4 Problems with implementation of National Qualification Framework in Poland

Till now in Poland does not exists an implemented model of Polish National Qualification Framework (PNQF). The model should be developed in a close future giving the base for new legislation. The developed National Qualification Framework should be consistent with the European one. This problem is especially valid for Civil Engineering sector in Poland, because of practically lack of vocational education at the ground and secondary professional levels. Therefore, it is a need of urgent activities to create the system of Polish Qualification Framework being in compliance with Bologna Recommendations.

There exist the following problems concerning formulation and implementation to the practice of Polish National Qualification Framework [4]:

- **Legislation problems.** The implementation of the draft National Qualification framework will require some amendments to separate provisions in the Act on the School Education System and a large number of secondary regulations. Similar changes will be needed in acts concerning other spheres of education as well as regarding employment and other fields.
- **Levels of learning outcomes**. A priority task is to define the number of levels in the PQF, with special regard to the relation between post-secondary education and higher education ("level 5"), and the status of basic vocational schools as well as non-degree postgraduate programmes in higher education.
- **Descriptors of learning outcomes**. Work should be continued to harmonise descriptors for the three key sectors: general, vocational and higher education. The final shape of the PQF depends on the mutual relationships between them.
- **Core curricula** for general education to descriptors for levels of learning outcomes. The work should urgently be undertaken to adjust the core curriculum for general education to these descriptors. They should also become a reference system for core curricula for vocational education.
- **An inventory of qualifications**. It is necessary to make an all-inclusive inventory of qualifications (general and vocational) and a related inventory of certificates, diplomas and other credentials awarded as national documents. A full-scale survey of qualifications and competences available in Poland and ways of confirming/validating them (at individual and institutional levels, and in legal, market -, consumption-related and other terms) should be planned in the coming years; the estimated timescale for the survey will probably range between 1 to 2 years, depending on the financial and research resources to be allocated.
- **A register of qualifications.** A register of qualifications in Poland should be created and kept in a central-level institution. Thus, in order to ensure the proper functioning of the qualifications system, it is necessary to create a National Qualifications Register. The Register should be initially kept by an institution responsible for the qualifications system in Poland.
- **Validation.** It is necessary to describe the system for validation of learning outcomes currently existing in Poland and design its target model (principles, procedures, institutions, quality assurance mechanisms, legal requirements) accompanying the framework. It should cover validation of learning outcomes acquired outside the formal education system.
- **Reference procedure**. Considering the fast progress in the work on Qualifications Frameworks in the Europe, it is necessary to start drafting a report relating the PNQF to the European Qualification Framework (EQF). It is necessary to present first proposals concerning the structure of the report not later than in 2010.
- **Dissemination of information about the EQF and PNQF**. It is necessary to design professionally measures for promoting the idea of the EQF and, subsequently, the PQF model among Polish stakeholders. This action has started with the establishment of a website for the project.

5. FINAL CONCLUSIONS

1. Most of Bologna recommendations are adopted in the Polish Higher Education system at the national level. However, at the University levels some of Bologna recommendations are not correctly adopted. It concerns also Civil Engineering field of study and rely on more or less rigid curricula (practically lack of flexible learning paths), as well as it concern missing links between learning outcomes and other elements such as internal quality assurance, recognition of prior learning.

2. Till now in Poland does not exists the implemented model of Polish National Qualification Framework (PNQF). Such model should be developed in a close future and it should be harmonized with existed European Qualification Framework. The lack of such PNQF impede the Civil Engineering sector in Poland, which is currently deprived of vocational education at the ground and secondary professional levels.

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SOME EXPERIENCES ON AN IMPLEMENTATION OF THE TWO-TIER STUDY PROGRAMS AT STU BRATISLAVA

Jozef Dický[1]

1. INTRODUCTION

The history and development of education in the fields of constructional engineering in Slovakia are closely connected with the origin of technical education in our country. Our Faculty of Civil Engineering is the first and the oldest faculty of the Slovak University of Technology, which started its functioning in 1938. On December 5th, 1938, the University moved from Košice to Martin, later to Bratislava, and its instruction was provided by three sections: the Section of Building Construction and Transportation Engineering, the Section of Water and Cultural Engineering, and the Section of Land Surveying Engineering. The launching of its first sections laid the foundations not only for the present faculty, but also for modern education as a whole in Slovakia. At the very beginning it is necessary to state that all the organizational changes the faculty has undergone from the past to the present day has not affected the fact that this faculty endeavours to produce qualified professionals in civil, transportation and hydraulic engineering, architecture, geodesy and cartography.

Currently, the Faculty of Civil Engineering of STU endeavours to produce highly - qualified professionals in a wide range of planning, design, implementation, management and reconstruction activities of civil engineering projects as well as projects in the fields of geodesy and cartography. In the 1992/93 academic year a credit-based modular-unit system for evaluating studies was introduced; this system enables evaluating the study results of students on the basis of differentiation more effectively. Students are also offered the opportunity to take part in creating their own study plan. Since 1997 the Faculty has offered the study as a three-degree accredited study program.

The structure of the obligatory, optional and recommended subjects enables students to choose from a wide range of subjects according to their specializations and personal interests. The compatibility of the faculty with other foreign faculties also enables the students to study abroad for a period of time. The faculty has also prepared a full-time study program called "Civil Engineering" in English.

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The Faculty also offers a wide range of postgraduate courses in order to enhance the qualifications and re-qualifications of university graduates. With regard to study fields or programs, faculty also offers courses of further education, the aim of which is to gradually build up an integrated system of life-long education. In recent years it provided yearly the professional public with a total of 70 courses, which were attended by 1,200 participants. The quality of the individual courses can be evaluated as excellent since they were of great interest to the participants, who especially appreciated the flawless preparation and organization of the courses as well as the quality of the study materials provided.

A step forward for changes in our higher education system was made by the Bologna Declaration. Accepting the main aims, based on the objectives contained in this declaration, faculty proceeded vigorously to reform the educational process. In first stage a new system of study has recently been further updated to a credit system.

1. IMPLEMENTATION OF THE TWO-TIER CIVIL AND TRANSPORTATION ENGINEERING PROGRAM

The Civil and Transportation Engineering Program (CTEP), taught at the faculty from the very beginning of its establishing in 1938, is one of most important programs because of preparing experts in statics and dynamics of buildings and engineering structures. Graduates of this program are qualified not only to perform structural design but also organise and manage civil engineering works such as the construction of bridges, high-rise buildings, industrial structures, foundations and underground structures, as well as special building constructions made of concrete, masonry, steel, timber, soil, rock and newly-developed composites. They are further qualified for the planning, management, implementation, maintenance and reconstruction of transportation-related structures (roads, motorways, railways, airports) and work in the related fields of urban network planning, transportation infrastructures and traffic engineering. To be able to work successful in areas mentioned above student must pass more than 50 different subjects, some theoretical and some practical. This program like other at the faculty taught before the Bologna process, structured as one stage program, was strongly influenced by both Russian and German systems. During the history it changed many times its content as well as the schedule.

First year	Second year	Third year	Fourth year	Fifth year	
Common subjects, 27+27 contact hours, 30+30 credits, 5+5 exams	Common subjects, 27+27 contact hours, 30+30 credits, 5+5 exams	Common/special subjects 21/4+17/8 contact hours, 30+30 credits, 5+5 exams	Common/special subjects 21/4+17/8 contact hours, 30+30 credits, 5+5 exams	Common subjects, 18+0 contact hours, 23+0 credits, 4 exams, diploma project, 3 state exams	**Concrete Structures** **Steel&Timber Structures** **Geotechnics** **Roads& Airports** **Urban Traffic** **Railways**

As it is clear from the upper scheme, the CTEP program was organized in one stream from first to fourth year. The small diversity started only in fourth year of study by one or two optional subjects. The fifth year was organized in six streams, each with about 60% of common subjects and about 40% of different subjects. Typical courses for one-tier civil and transportation engineering program (common 8 semesters) are presented in Table 1.

After finishing eight semesters student could choose from six different modules of specialization. Typical courses for all specializations in last two semesters are presented in Table 2.

A new system of study implemented due to Bologna process has recently been further updated to a credit-based system. Its first part, a three-year course (180 credits), leads to a bachelor's degree. It gives the student the theoretical background necessary for further specialization together with the basics of civil engineering. To broaden the students' educational perspectives, courses in the arts and social sciences, including philosophy, sociology, law, psychology and aesthetics, have been added to the curricula.

The second part of the system, which is aimed at developing special skills in the chosen specialization, is completed by a thesis. Its successful completion results in the award of the Diploma in Civil Engineering - Dipl. Ing., a M. Sc. equivalent degree. This part lasts two years (120 credits) and permits students to implement their individual goals for their vocational education and specialization. Thereafter, a four-year Ph.D. study program in all the major theoretical civil engineering subjects is offered to students with M. Sc. degree. The education and training of experts dealing with structural analysis and design of structures now takes place in two phases as follows.

In the first phase, bachelor study, applicants may study not only in Structural and Transportation Engineering bachelor degree program, which is oriented mainly on civil engineering structures, but they may choose the

Building Structures and Architecture program, which is oriented on complex design of buildings, as well. The curriculum for bachelor Civil and Transportation Engineering Program is presented in Table 3.

Table 1. Typical courses for one-tier Civil and Transportation Engineering Program (common 8 semesters)

Semester																
Subject	**L/S**	**C**	**L/S**	**C**	**L/S**	**C**	**L/S**	**C**	**L/S**	**C**	**L/S**	**C**	**L/S**	**C**	**L/S**	**C**
History of Civil Engineering	1/1c	2														
Buildings Materials	2/2 e	5														
Geology	2/2 e	5														
Basics of Environmental	2/2 e	5														
Deskriptive Geometry	2/3 e	5														
Mathematics	4/4 e	8	4/5 e	9												
Politology			1/1 c	2												
Statics			3/3 e	7												
Building Constructions			3/2 e	6												
Physics			3/2 e	6	2/2 e	5										
Macroeconomics					2/1 c	3										
Technical Equipt. of Buildings					1/1 c	2										
Building Constructions Project					0/3 c	3										
Hydromechanics					2/2 e	4										
Water Supply Buildings					2/2 e	4										
Theory of Elasticity					3/3 e	7			3/2 e	5						
Surveying in Civil Engineering							2/3 e	5								
Building Management							2/2 c	4								
Structural Mechanics							3/3 e	6								
Soil Mechanics							3/2 e	5								
Concrete and Masonry Structs.							2/2 e	4								
Hydrotechnical Buildings							2/2 e	4								
Roads and Highways									4/2 e	6						
Steel and Timber Structures									4/2 e	6						
Foundation of Buildings									3/2 e	5						
Prestressed Concrete									3/2 e	5						
Basics of Law											2/1 c	3				
Sociology											1/1 c	2				
Construction of Roads											4/2 e	6				
Steel Structures											3/2 e	5				
Eng. Geology and Rock Mechs.											3/2 e	5				
Concrete Structures											2/2 e	5				
Field works											2 w					
Surveying Camp									1 w	1						
Foreign Language					0/2 c	2	0/2 c	2	0/2 c	2	0/2 e	2				
Bachelor Thesis											0/2 c	2				
Concrete Structures													2/1 e	3		
Timber Structures													2/1 e	3		
Structural Mechanics													2/2 e	5		
Mathematics													2/2 e	5		
Roads in Urban Areas													3/1 e	4		
Underground Buildings													2/1 e	3		
CAD Project													0/4 c	4	0/3 c	4
Concrete Bridges															4/1 e	5
Steel Bridges															3/1 e	4
Structural Dynamics															3/2 e	5
Railroads															3/1 e	4
Foreign Language													0/2 c	3	0/2 c	3
Field Works															1 w	
Optional Subject (one from list)															2/2 c	5
Optional subjects:																
Airports															2/2 c	5
Comp. Steel-Concrete Structs.															2/2 c	5
Massive Soil Structures															2/2 c	5
Total contact hours per week **Total credits per semester**	**27**	**30**	**27**	**30**	**27**	**30**	**27**	**30**	**27**	**30**	**27**	**30**	**25**	**30**	**25**	**30**

Table 2. Courses for one-tier Civil and Transportation Engineering Program in last two semesters

Specialization Module - Concrete Structures

Semester	9		10	
Subject	**Lect/ Sem**	**Cr**	**Lect/ Sem**	**Cr**
Construction & Commercial Law	2/1 e	4		
Economics of Building Industry	2/1 e	4		
Concrete Bridges	2/2 e	5		
Rheological Effects in Concrete Structures	2/2 e	5		
Special Concrete Structures	2/2 e	5		
Optional Subject	2/2 c	4		
Construction Design	0/3 c	3	0/5 c	4
Lifespan and Repair of Concrete Structures			3/2 c	4
High-Rise Concrete Structures			3/2 c	4
Realisation of Concr. Structures			3/2 c	4
Selected Topics in Concrete Structures and Bridges			3/2 c	4
Master Thesis			5 w	10
Total contact hours per week	**25**		**25**	
Credit Points per semester		**30**		**30**
List of the optional subjects				
Selected Topics in Steel Structures			2/2 c	5
Selected Topics in Soil Mechanics			2/2 c	5
Selected Topics in Statics and Dynamics of Structs.			2/2 c	5

Specialization Module - Steel and Timber Structures

Semester	9		10	
Subject	**Lect/ Sem**	**Cr**	**Lect/ Sem**	**Cr**
Construction & Commercial Law	2/1 e	4		
Economics of Building Industry	2/1 e	4		
Steel Bridges	2/2 e	5		
High-Rise and Long-Span Steel Structures	2/2 e	5		
Stability and Plasticity of Steel Structures	2/2 e	5		
Optional Subject	2/2 c	4		
Specialised Seminar	0/3 c	3	0/5 c	4
Timber Structures			3/2 c	4
Diagnosis&Reconstruction of Steel & Timber Structs.			3/2 c	4
Thin-Walled Steel Structures			3/2 c	4
Selected Topics in Steel and Timber Structures			3/2 c	4
Master Thesis			5 w	10
Total contact hours per week	**25**		**25**	
Credit Points per semester		**30**		**30**
List of the optional subjects				
Selected Topics in Steel Structures			2/2 c	5
Selected Topics in Soil Mechanics			2/2 c	5
Selected Topics in Statics and Dynamics of Structs.			2/2 c	5

Semester	9		10	
Subject	**Lect/ Sem**	**Cr**	**Lect/ Sem**	**Cr**
Construction and Commercial Law	2/1 e	4		
Economics of Building Industry	2/1 e	4		
Advanced Engineering and Hydrogeology	2/2 e	5		
Soil Properties	2/2 e	5		
Geomechanics	2/2 e	5		
Optional Subject	2/2 c	4		
Special Seminar	0/3 c	3	0/5 c	4
Underground Structures			3/2 c	4
Building Foundations under Difficult Conditions			3/2 c	4
Dumps and Sludge Beds			3/2 c	4
Management&Reconstruction of Geotechnic Structs.			3/2 c	4
Master Thesis			5 w	10
Total contact hours per week	**25**		**25**	
Credit Points per semester		**30**		**30**
List of the optional subjects				
Selected Topics in Concrete Structures and Bridges			2/2 c	5
Selected Topics in Steel Structures			2/2 c	5
Selected Topics in Statics and Dynamics of Structs.			2/2 c	5

Specialization Module - Geotechnics

Semester	9		10	
Subject	**Lect/ Sem**	**Cr**	**Lect/ Sem**	**Cr**
Construction and Commercial Law	2/1 e	4		
Economics of Building Industry	2/1 e	4		
Pavement Diagnoses	2/2 e	5		
Road Intersections	2/2 e	5		
Pavement Mechanics	2/2 e	5		
Selected Topics on Airports	2/2 c	4		
Special Seminar	0/3 c	3	0/5 c	4
Selected Topics on Roads and Highways			3/2 c	4
Reconstruction and Innovations of Roads			3/2 c	4
Quality Control and Experiments			3/2 c	4
Selected Topics in Transport Construction			3/2 c	4
Master Thesis			5 w	10
Total contact hours per week	**25**		**25**	
Credit Points per semester		**30**		**30**

Specialization Module - Roads and Airports

Specialization Module - Urban Traffic Engineering

Semester	9		10	
Subject	**Lect/ Sem**	**Cr**	**Lect/ Sem**	**Cr**
Construction and Commercial Law	2/1 e	4		
Economics of Building Industry	2/1 e	4		
Traffic Flow Theory	2/2 e	5		
Traffic Planning and Prediction	2/2 e	5		
Traffic Management	2/2 e	5		
Urban Planning	2/2 c	4		
Special Seminar	0/3 c	3	0/5 c	4
Selected Topics in CAMDI			3/2 c	4
Traffic Management and Organisation			3/2 c	4
Public Transport Structures			3/2 c	4
Selected Topics in Transport Construction			3/2 c	4
Master Thesis			5 w	10
Total contact hours per week	**25**		**25**	
Credit Points per semester		**30**		**30**

Specialization Module - Railways

Semester	9		10	
Subject	**Lect/ Sem**	**Cr**	**Lect/ Sem**	**Cr**
Construction and Commercial Law	2/1 e	4		
Economics of Building Industry	2/1 e	4		
Railways Stations and Junctions	2/2 e	5		
Train-Running Dynamics	2/2 e	5		
Computer Design	2/2 e	5		
Elements of Structures	2/2 c	4		
Special Seminar	0/3 c	3	0/5 c	4
Special Railway Topics			3/2 c	4
Railway Laboratory			3/2 c	4
Track Modernisation and HST			3/2 c	4
Selected Topics in Transport Construction			3/2 c	4
Master Thesis			5 w	10
Total contact hours per week	**25**		**25**	
Credit Points per semester		**30**		**30**

Table 3. Typical courses for bachelor Civil and Transportation Engineering program

Subject	1. year				2. year				3. year			
	1.sem.		2. sem.		3. sem.		4. sem.		5. sem.		6. sem.	
	L/S	Cr	L/S	Cr	L/S	Cr	L/S	Cr	L/S	Cr	L/S	Cr
History of Architecture and Civil Engineering	2/0 k	2										
Mathematics	2/3 s	6	3/3 s	7								
Deskriptive Geometry	2/2 s	5										
Engineering Geology	2/2 s	5										
Building materials	2/2 s	5										
Transport systems in the area	2/2 s	5										
Environmental Engineering	2/0 k	2										
Surveying in Civil Engineering			2/2 s	5								
Building constructions			2/2 s	5								
Physics			2/2 s	5								
Statics			3/2 s	7								
Mathematics					2/1 k	4						
Hydromechanics					2/2 s	5						
Engineering geology and Rock mechanics					2/2 s	5						
Strength of materials					2/2 s	5						
Building constructions					2/2 s	5						
Physics of buildings					2/2 s	5						
Computer aided design							0/2 k	2				
Steel structures							2/2 s	6				
Concrete and masonry structures							2/2 s	6				
Structural mechanics							2/2 s	5				
Soil mechanics							2/2 s	5				
Optional subject (from the upper list) *							2/1 s	3				
Basics of law							1/1 k	2				
Professional praxis							3 týž.,z	0				
Steel load-bearing systems									2/2 s	5		
Reinforced and pre-stressed structural members									2/2 s	5		
Theory of elasticity and plasticity									2/2 s	5		
Building foundation									2/2 s	5		
Roads and highways									2/2 s	5		
Design project									0/3 k	4		
Bachelor thesis											0/9 k	10
Road construction											2/2 s	5
Concrete bearing systems											2/2 s	5
Timber members and structures											2/2 s	5
Civil engineering management											2/2 k	5
Excursion											1 t., z	0
Foreign language			0/2 k	1	0/2 k	1	0/2 k	1	0/2 s	1		
Completely	**25**	**30**	**25**	**30**	**25**	**30**	**25**	**30**	**25**	**30**	**25**	**30**
List of optional subjects:												
*Buliding technology							2/1 s	3				
*Physics II							2/1 s	3				

In the second phase student can also choose between two engineering and educational programs. Those who want to be experts in civil engineering structures, choose Civil and Transportation Engineering master degree program, others choose Structures of Buildings program. The curriculum for master Civil and Transportation Engineering Program is presented in Table 4.

2. ACCREDITATION AND EVALUATION PROCESS IN NEW CIVIL AND TRANSPORTATION ENGINEERING PROGRAM

Another important part of this process is also the system of accreditation and evaluation of universities in Slovakia. Author comments this process from his point of view and describes briefly the assessment system at his faculty.

The process of accreditation was implemented into Slovak higher education by Act No. 172/1990. The purpose of accreditation was to oversee, evaluate and independently assess the quality of educational, research, artistic and other creative activity of higher education institutions and to help its improving. The ability for providing education followed by issuing of graduate diplomas, as well as the ability for habilitation and inauguration processes for granting the academic degrees „associated professor“ and „professor“ was assessed. During the developing of new Act on Higher Education, the idea of institutional separation of accreditation and evaluation was refused. Evaluation became the main factor of assessing the quality of fulfillment of the university mission and it was included into complex process of accreditation, which is carried out by the Accreditation Commission.

Table 4. Typical courses for master Civil and Transportation Engineering Program

Subject	**1. year**				**2. year**				**3. year**			
	1.sem.		2. sem.		3. sem.		4. sem.		5. sem.		6. sem.	
	L/S	Cr	L/S	Cr	L/S	Cr	L/S	Cr	L/S	Cr	L/S	Cr
History of Architecture and Civil Engineering	2/0 k	2										
Mathematics	2/3 s	6	3/3 s	7								
Deskriptive Geometry	2/2 s	5										
Engineering Geology	2/2 s	5										
Building materials	2/2 s	5										
Transport systems in the area	2/2 s	5										
Environmental Engineering	2/0 k	2										
Surveying in Civil Engineering			2/2 s	5								
Building constructions			2/2 s	5								
Physics			2/2 s	5								
Statics			3/2 s	7								
Mathematics					2/1 k	4						
Hydromechanics					2/2 s	5						
Engineering geology and Rock mechanics					2/2 s	5						
Strength of materials					2/2 s	5						
Building constructions					2/2 s	5						
Physics of buildings					2/2 s	5						
Computer aided design							0/2 k	2				
Steel structures							2/2 s	6				
Concrete and masonry structures							2/2 s	6				
Structural mechanics							2/2 s	5				
Soil mechanics							2/2 s	5				
Optional subject (from the upper list) *							2/1 s	3				
Basics of law							1/1 k	2				
Professional praxis							3 týž.,z	0				
Steel load-bearing systems									2/2 s	5		
Reinforced and pre-stressed structural members									2/2 s	5		
Theory of elasticity and plasticity									2/2 s	5		
Building foundation									2/2 s	5		
Roads and highways									2/2 s	5		
Design project									0/3 k	4		
Bachelor thesis											0/9 k	10
Road construction											2/2 s	5
Concrete bearing systems											2/2 s	5
Timber members and structures											2/2 s	5
Civil engineering management											2/2 k	5
Excursion											1 t., z	0
Foreign language			0/2 k	1	0/2 k	1	0/2 k	1	0/2 s	1		
Completely	**25**	**30**	**25**	**30**	**25**	**30**	**25**	**30**	**25**	**30**	**25**	**30**
List of optional subjects:												
*Buliding technology							2/1 s	3				
*Physics II							2/1 s	3				

Being inspired by Berlin communiqué, in December 2005 the Slovak Rectors’ Conference initiated signing an agreement with Ministry of Education of the SR and European University Association on international institutional evaluation of the Slovak higher education institutions. First universities started their self-evaluation activities in September 2005. Within the framework of the project the higher education institutions prepared a self-evaluation report (in cooperation with students), the international evaluation teams of EUA carried out visits to higher education institutions, while the EUA prepared the self-evaluation report for each participating higher education institution. In the end of the project, in December 2007, the EUA presented a summary report on external evaluation of Slovak higher education institutions.

Our university met the requirements of Bologna Process in the field of quality assurance. The goal of EU education system is to provide education for everyone in the EU so that people can make better use of their potentials and their capabilities to the benefit of the whole society.

Quality management of education at our faculty plays a significant role in the ever increasing requirements of quality and professionalism of our graduates. The planning process starts with the courses proposals given by supervisors approved by scientific council. These programs must successfully pass the accreditation. Faculty produces information and promotional materials with the main goal to get the most and the best students, on the other hand to ensure comprehensive and quality information to students, staff and the general public. Civil Engineering has established an Academic Information System (AIS), accessible via the web interface, which provides information on all study subjects, the sponsors and speakers. The responsibility on quality of education is one of duties of dean, vice-dean for education and the guarantors of study programs. The responsibilities and powers set of functional staff are given in Figure 1.

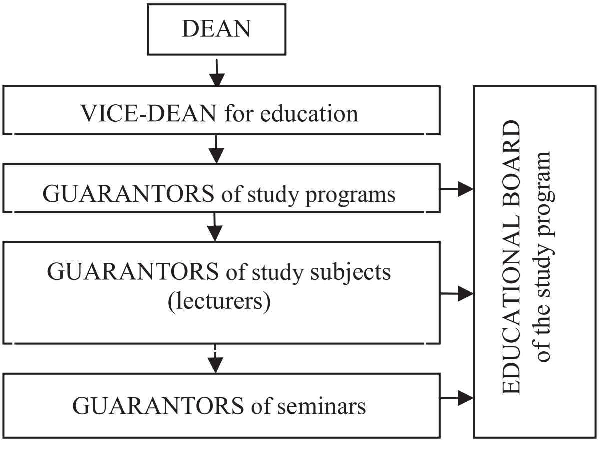

Figure 1

Educational Board plays an important role in managing and improving the quality of teaching process. It is open to students and practitioners who can provide feedback on quality improvement of teaching process. Communication with students is carried out through meetings of the guarantor of the study program with students and faculty at academic meetings. Students are also members of the Faculty Academic Senate. When approving courses student representatives are invited to the meeting of the Scientific Council.

Faculty pays close attention to the educational process, educators and students. Assessment of teachers by students is carried out through anonymous questionnaires. Vice-dean for teaching activities with the guarantor of study program provides evaluation results and informs the teacher of the outcome evaluation. Evaluation results serve as a feedback for teacher and, in case of negative evaluations, give impetus to the search for measures to improve the educational activity.

Monitoring the quality of the educational process at the faculty includes mainly the following activities:

a) the input quality control:
   - syllabi of courses, award, methodical manuals and literature provided by teachers of the faculty, teaching techniques used
   - teachers´ training ,
b) ongoing quality control :
   - regular controls of teaching process by faculty management, guarantors of study programs and guarantors of subjects,
   - using the didactic technique in teaching process,
   - regular evaluation of teaching process in educational boards,
c) output quality control:
   - compliance with the requirements of students' knowledge (credits, exams)
   - successful completion of university studies at all levels,
   - duration of study (average length, number of students in above standard length),
   - the practical application in various fields (using questionnaires to graduates after a specified period of service)
   - assessing the quality of graduates in practice (in the form of questionnaires to employers of our graduates).

3. EMPHASIZING THE EUROPEAN DIMENSION IN HIGHER EDUCATION

The analysis of the degree of higher education in Slovak Republic showed that the mobility of teachers and students plays the key role in the frame of internationalization processes. The possibilities of common academic programs with foreign partners, i.e. dual and joint diplomas, are sometimes limited by legislative rules. Slovak higher education institutions are more successful in outward student mobility. Still, activities in inward student mobility and reciprocal exchanges are less successful, but the development trends seem to be improving from year to year. Amounts of teachers' mobility are increasing, too, while being supplemented by active participation of teachers in the educational process of the host institution. Foreign partners are getting more and more involved into the study programs of Slovak higher education institutions. International study programs (study branches), and study of foreign languages are becoming more and more popular with students.

An internationalization of study, including technical, thus becomes thanks to an expansion the border and competencies of the European Union more and more one of crucial phenomena in Europe. University of small countries, Slovakia included, are beginning to realize necessity to adapt to these new conditions some new programs, particularly technical, not only to the internationalization of technical standards and practices, but also increase students' knowledge and ability to work in new conditions in the wider context of EU. Very often it is not sufficient to ensure competitiveness in the regional language study and students begin to look for opportunities to study in one of the world's major languages, especially English.

Based on positive experience in an introduction of two-stage model as well as good examples from abroad, our faculty some years ago started with one Civil Engineering Program in bachelor degree taught in English. Last year we finished the first cycle and this year we started with new accredited program. Beside some tens students from abroad graduated in last three years in this program there are also some Slovak students which study this program in English. The curriculum for bachelor Civil Engineering Program taught in English is presented in Table 5.

Table 5. Curriculum for bachelor Civil Engineering Program taught in English

Subject	**1. year**				**2. year**				**3. year**			
	1.sem		2. sem		3. sem		4. sem		5. sem		6. sem	
	L/S	Cr	L/S	Cr	L/S	Cr	L/S	Cr	L/S	Cr	L/S	Cr
History of Architecture	2/0 k	2										
Building Materials	2/2 s	5										
Mathematics I, II, III	2/3 s	6	3/3s	7	2/2 s	5						
Constructions in Architecture I,II, III			2/2 s	5			2/2 s	5	2/2 s	5		
Constructive Geometry	2/2 s	5										
Geology	2/2 s	5										
Advanced English I	0/2 k	2	0/2 k	2								
Physics			2/2 s	5								
Statics			2/2 s	5								
Environmental Engineering	2/2 s	5										
Surveying in CE			2/2 s	5								
Information Technology I, II			0/1 k	1			0/2 k	2				
Building Physics					2/2 s	5						
Theory of Elasticity					3/2 s	5						
Hydromechanics					2/2 s	5						
Building Economy					2/2 s	5						
Structural Mechanics							2/2 s	5				
Soil Mechanics and Foundation							3/3 s	7				
Design of Concrete Structures							3/2 s	6				
Building Services I							2/2 s	5				
Road Construction									2/2 s	5		
Structural Metal Design									2/2 s	5		
Concrete Technology									2/2 s	5		
Hydrology and Water Resources Management					2/2 s	5						
Design Studio									0/3 k	3		
CAD									0/2 k	2		
Bc. Thesis											0/9 k	10
Water Treatment and Water Supply									2/2 s	5		
Real Estate Market											2/2 s	5
Building Services II											2/2 s	5
Building Technology											2/2 s	5
Sewarage and Waste Water Treatment											2/2 s	5
Slovak Language	0/2	0	0/2	0								
Completely	**25**	**30**	**25**	**30**	**25**	**30**	**25**	**30**	**25**	**30**	**25**	**30**

4. CONCLUSIONS

An important role in further development of CE education in EU also plays the process of the gradual harmonisation of the civil engineering programs at particular universities in Europe. The EUCEET program, thanks to a big amount of knowledge and experiences in this area proposed to hundreds professors all over Europe, including author, the common platform for the mapping of civil engineering programmes and acquired all good experiences obtained from their partners. The enormous potential of knowledge, experience and data on educational systems in CE should also be used in EU official framework. It could also serve for the preparation and implementation of a common degree program in CE offered at universities in the EU in one of the major world languages, which would certainly contribute to a wider enhancing cooperation between universities in Europe.

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CIVIL ENGINEERING PROGRAMMES IN FOREIGN LANGUAGES – A MUST OR A LUXURY?

Iacint Manoliu[1], Nicoleta Radulescu[2]

ABSTRACT

The paper presents the foundation in 1990 and the evolution of the Faculty of Engineering in Foreign Languages of the Technical University of Civil Engineering Bucharest, providing degree courses in English (for Civil Engineering) and in French (for Civil Engineering and Building Services).

1. SHORT HYSTORICAL OUTLINE

It was in mid-June 1990, less than six months since the events in December 1989 which lead to the collapse of the totalitarian regime in Romania, when the senior author of this paper, then Vice-Rector for academic and international affairs, was sent to represent his university at a meeting called by the Rector of the University "Politehnica" Bucharest, the late Professor Virgil Constantinescu, who had taken the initiative to found a new academic unit with all courses taught in English. The University "Politehnica" was supposed to build and run programmes in mechanical, electrical and chemical engineering, while the Technical University of Civil Engineering was in charge with the civil engineering division.

Rector Constantinescu informed the small task force gathered in his office that the Ministry of Education gave an agreement in principle and, as a consequence, curricula of all programmes had to be prepared in just two days, to get the official approval of the Ministry, necessary in order to organize in July 1990 the first examination admission for the new unit.

It was quite a challenge which the senior author, responsible for the civil engineering branch, could meet by taking advantage of the experience and knowledge acquired 20 years before, when he had the opportunity to spend one year, as a Fulbright scholar, at the University of Texas at Austin, associated with the Department of Civil Engineering of that university, one of the strongest department in this field in U.S.A., and being also able to visit during his stay in the State other civil engineering departments of highest reputation, at the University of California in Berkeley, at the University of Illinois in Champaign-Urbana, at Massachusetts Institute of Technology in Cambridge, to name only a few.

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[1] Professor, President of the Council for Cooperation and Relations, Technical University of Civil Engineering Bucharest

[2] Professor, Dean of the Faculty for Engineering in Foreign Languages, Technical University of Civil Engineering Bucharest

Programmes in English, to be developed both at University "Politechnica" and at the Technical University of Civil Engineering, were integrated 5-year-programmes. Knowing that at our university there were three faculties offering such programmes for the civil engineering field, *Faculty of Civil, Industrial and Agricultural Buildings*, *Faculty of Hydrotechnics* and *Faculty of Railroads, Roads and Bridges*, the new programme in English was conceived as having a strong common part, followed by options in directions such as structures, hydraulic works, sanitary engineering, transportation.

One could question: was it, indeed, a priority for the two universities to care in that very moment, to set-up degree courses offered in English? Yes, it was very important.

After more than four decades of almost complete isolation, Romanian universities felt an acute need to open towards the external world and no tool seemed more helpful for accomplishing that goal than having programmes taught in languages of international circulation. The commencement was done in the academic year 1990-1991 with programmes in English, to be followed in 1991-1992 by programmes in French.

For three years, the civil engineering division, with the two branches, in English and in French, was part of the Department created in 1990 at the University "Politehnica". Beginning with the academic year 1993-1994, a similar Department was established at the Technical University of Civil Engineering, transformed in 2007 in the Faculty of Engineering in Foreign Languages.

In the academic year 1994-1995, besides the programmes of Civil Engineering in English and French, a programme in Building Services started to be offered in French.

2. ABOUT RESOURCES

The matter deals, of course, with the human resources, admitting that for material resources the programmes in foreign languages at TUCEB could rely entirely on the university infrastructure and finances.

It goes without saying that, before taking the decision to join the initiative of the University "Politehnica", the Rector of TUCEB, the late professor Mircea Soare, made a quick but comprehensive inquiry on the linguistic abilities of the members of the teaching staff of his university and reached to the conclusion that there were teachers able to cover in English or French all subjects in the curricula. The background of such abilities was put, obviously, in the high-school, knowing that in Romania the study of the two foreign languages was always compulsory in the high school. Some academics had the opportunity to undertake research stages abroad in the 4-5 years of relative openness which marked the beginning of Ceausescu's era (1965-1970). In any case, after 1991, the situation steadily improved as young teachers could become beneficiaries of grants for stages abroad under Tempus or other European programmes. Holders of PhD degrees got after 1990 in various European universities number among the teachers at the Faculty for Engineering in Foreign Languages.

As for the students, as expected there was no problem in having candidates for the Civil engineering English section, where the number of the places offered at the admission rose from 25 in 1990-1991 to 75 in 2009-2010. Surprisingly enough for a francophone country "par excellence", it proved more difficult to recruit students for the Civil engineering French section, hence the offer remained constant at one group (25 students) per year. But the real problem was faced by the Building services French section at which even the 25 students in the 1st year could not be secured, declining to 11 in 2008-2009 and obliging to discontinue the programme in 2009-2010.

3. SOME STATISTICS

As shown, the start was made in 1990-1991, with a 28 students (25 Romanian + 3 foreigners) enrolled in the first year of the civil engineering English section. In June 1995, 23 out of the total number of students who begun studies in October 1990 were able to graduate the 5-year programme.

In the fig. 1 is represented the evolution in time, starting with 1990-1991, for the Civil engineering English section, of the number of students and of the number of graduates.

In the fig. 2 is represented the evolution for the same time interval of the total number of students in the first year, in parallel with the number of Romanian students and the number of foreign students.

Similar representations are presented in f**o***i*g. 3 and fig. 4 for the **c***C*ivil engineering French section, for the time interval 1991-1992 – 2009-2010.

Is important to underline the fact that, starting from 2008-2009, the number of foreign students admitted in the 1st year at Civil engineering French section was bigger than the number of domestic students.

The evolution of the number of the students in the 1st year, of the total number of students and of the total number of graduates for the Building services French section is shown in the fig. 5.

In the academic year 2009-2010, the total number of students of the Faculty of Engineering in Foreign Languages is 579, from which 405 at the Civil engineering English section, 125 at the Civil engineering French section and 49 at the Building services French section.

By the end of the academic year 2008-2009, the total number of graduates of the Faculty of Engineering in Foreign Languages at TUCEB reached 785, from which 446 at the Civil engineering English section, 189 at the Civil engineering French section and 150 at the Building services French section.

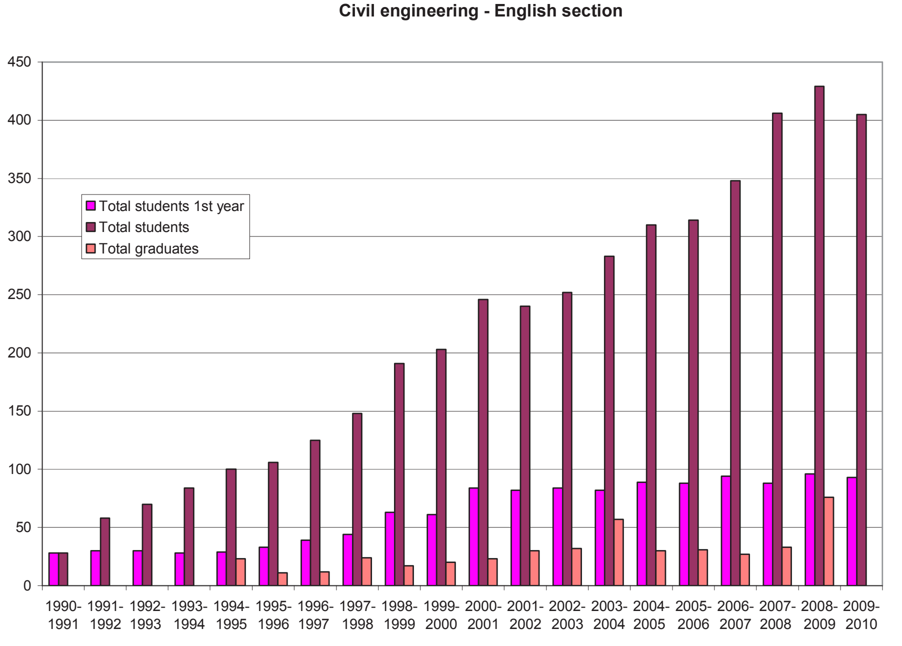

Figure 1

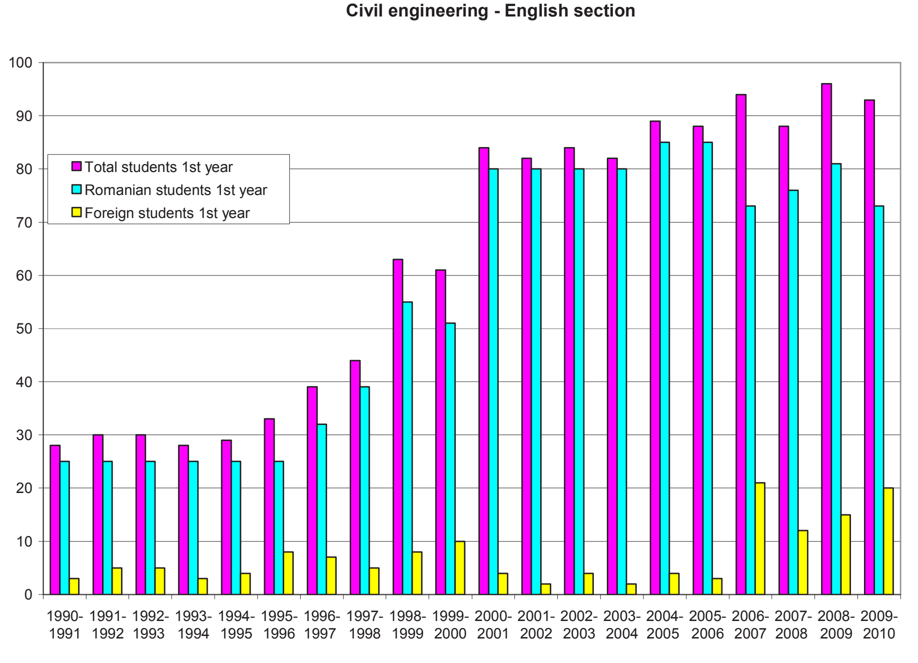

Figure 2

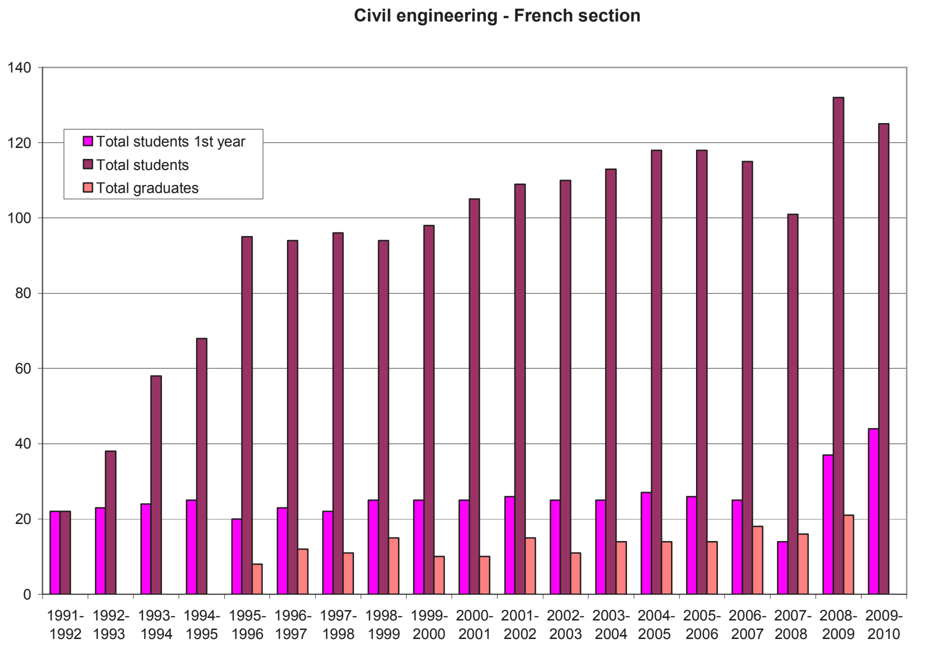

Figure 3

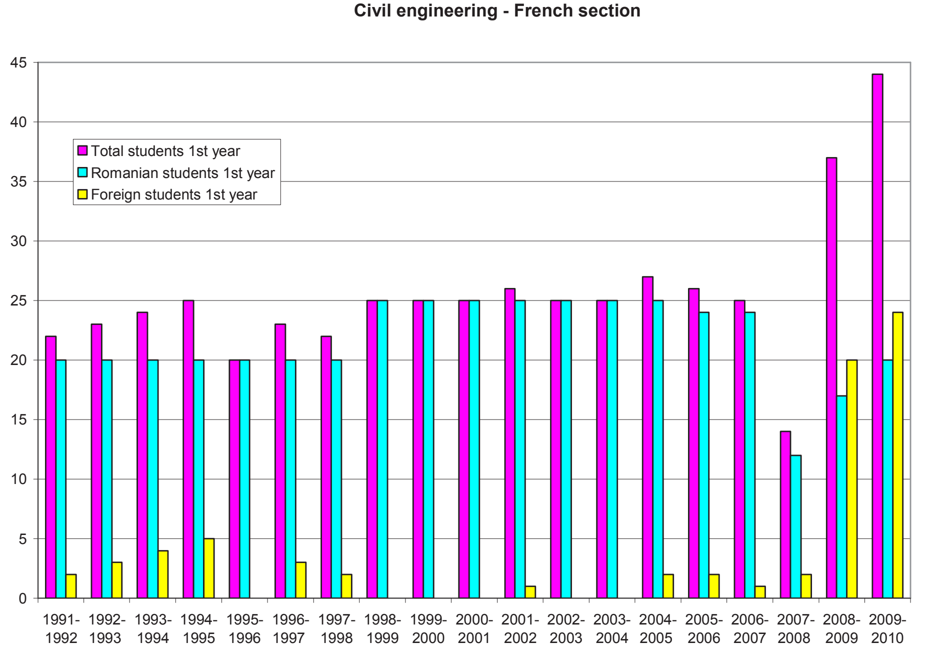

Figure 4

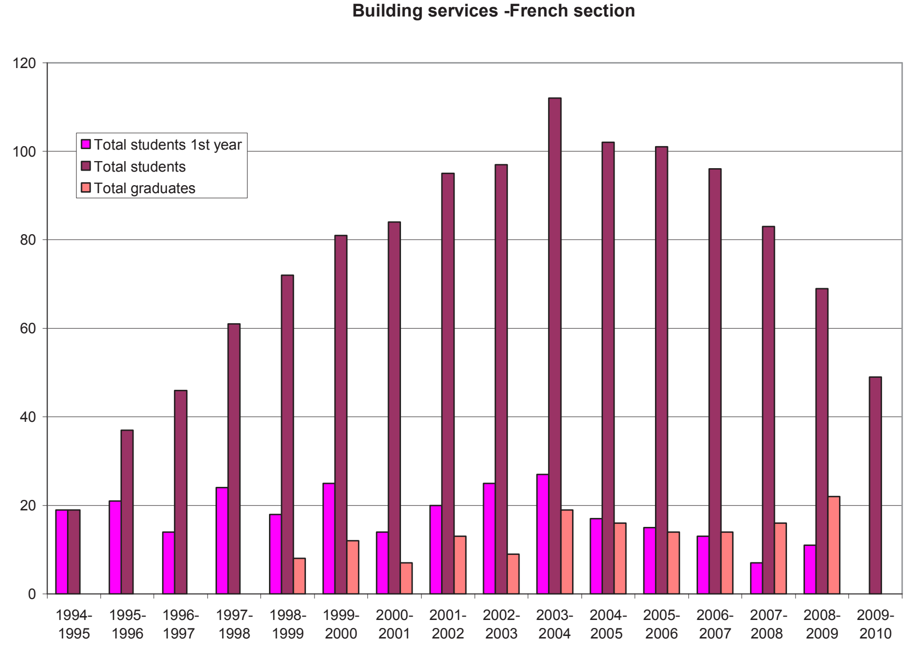

Figure 5

4. THE DOUBLE-DIPLOMA AGREEMENT ENPC-TUCEB

The existence of integrated 5-year degree course in French at the Technical University of Civil Engineering Bucharest, as well as the good cooperation developed since 1992 under the auspices of the European programmes Tempus and Socrates, were at the origin of the conclusion in March 2001 of a double-diploma agreement between TUCEB and Ecole Nationale des Ponts et Chaussées Paris. According to the provisions of the agreement, TUCEB can send at ENPC up to 5 students/year. Until the academic year 2008-2009, the agreement functioned in conditions of compatibility between the programmes of the two institutions to be completed in 5 years by the graduates: 2 years at “Preparatory school” + 3 year at the Grande Ecole for ENPC and 5 years at TUCEB. Under such conditions, students from TUCEB were admitted in the second year at ENPC (corresponding to the 4^{th} year at TUCEB). They finished the second and third year at ENPC, including the final project which was presented and defended first at ENPC and then at TUCEB. As one can understand, by this agreement ENPC fully recognized the first 3 study years at TUCEB, while TUCEB fully recognized the last 2 years at ENPC.

The first 4 students from TUCEB were admitted at ENPC in the academic year 2001-2002 and obtained the double-diploma in 2004. In total, under the conditions stipulated above, 29 students from TUCEB got the double-diploma until 2009.

It is appropriate to give here some information on the results obtained by TUCEB students at ENPC. Thus, more than one-third of them completed the studies at ENPC with an average mark above 15/20, considered to be a very good mark at ENPC. The uncontested leader is *Isabela Manelici* from the 2009 class, with the average mark 16.40/20. From the 34 marks obtained during the 2-year study period at ENPC, she had the very rare record of 13 marks between 17 and 20. At the same time, she graduated TUCEB with the average mark 9.65/10, which is also an exceptional one. No wonder, then, that in April 2010 Isabela wrote to the junior author of the paper, as Dean of her Faculty, to let her know that she was hired for a 2-year job at the World Bank in Washington D.C., as Junior Professional Associate at the Water, Transport and Energy Department.

After almost one century of interruption, the tradition of having Romanian engineers graduating the Ecole Nationale des Ponts et Chaussées has been renewed. *Isabela Manelici* and other 28 young engineers are proud to have their names on the list of graduates of the oldest and most prestigious civil engineering school of Europe.

As a result of the Bologna process, TUCEB shifted from the integrated 5-year programme to the two-tier system, with a first cycle course of 4 years, leading to the degree of Engineer, followed by a second cycle course of 1.5 year leading to the degree of Master. The double diploma agreement ENPC-TUCEB had to be adapted to the new circumstances. The revised form of the agreement was concluded in March 2009 and started to be implemented in the academic year 2009-2010. According to the new agreement, students from TUCEB are admitted in the 2nd year of ENPC after graduating the 4-year first cycle degree course and after being admitted at the Master degree course at TUCEB. They finish two years of study at ENPC, including the final project and return to TUCEB for the last semester of the Master course for presenting and defending the Master thesis, after which requirements for the double-diploma are fulfilled.

5. PERSPECTIVES

The Faculty of Engineering in Foreign Languages is the youngest and the smallest faculty of TUCEB. 20 years ago its foundation expressed the willingness for bridges toward the world. Nowadays, the existence of the Faculty enables the University to attract foreign students seeking civil engineering degrees and to offer periods of study of 1-2 semesters to an ever increasing number of Erasmus exchange students. The internationalisation strategy of the university would be hard to implement without the Faculty of Engineering in Foreign Languages.

Short-term objectives are preparation and opening of several Master programmes in civil engineering in English, aimed to attract, in first place, foreign students graduates of first degree courses of 4-year (240 ECTS).

A very good news is the decision of the University to start the construction of a building to be shared by the Faculty of Engineering in Foreign Languages and the faculty of Geodesy. The bid for the design attracted many strong design offices. The jury decided in favour of the famous Carpați Proiect design office. In fig. 6 is shown a model of the future building, as seen by the architects of Carpați Proiect. If everything will go according to the plan, the new building might be inaugurated in the academic year 2012-2013.

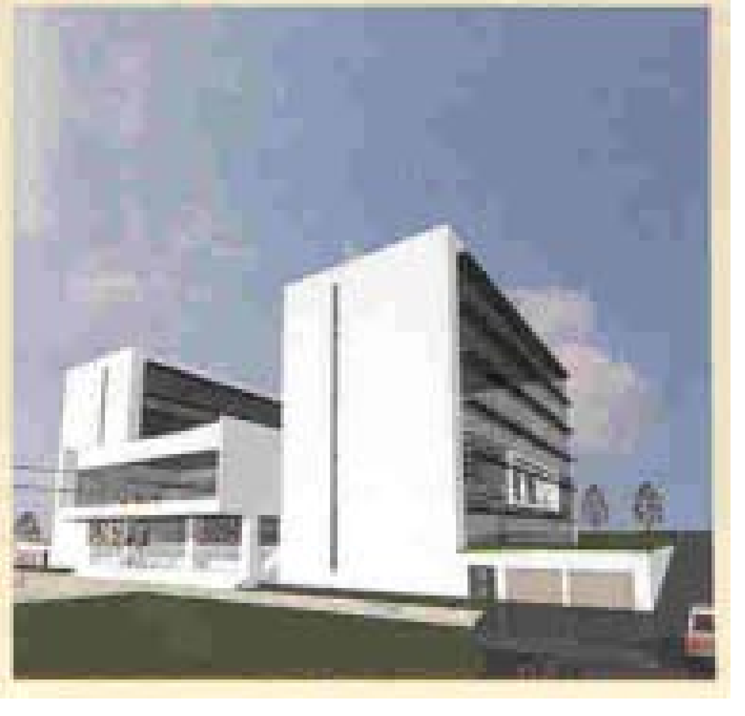

Figure 6

6. CONCLUSION

The answer to the rhetorical question in the title of the paper is: ***at TUCEB, Civil engineering programmes in foreign languages are a must, not a luxury.***

PART TWO

FOCUS ON DISCIPLINES: TEACHING, LEARNING, ASSESSMENT

LEARNER CENTRED APPROACH IN TEACHING ENGLISH TO PRE-SERVICE CIVIL ENGINEERS

Yveta Linhartova[1]

ABSTRACT

The contribution maps the situation in EFL (English as a Foreign Language) taught to pre-service future professionals in civil engineering. The project was carried out at the Faculty of Transport, University of Pardubice, Czech Republic. Its main goal was to make an inquiry into the level of the acquired language skills and sub-skills, as well as into the interest in the study of foreign languages at a technically oriented tertiary institution. Based on this inquiry, a course in English (EFL) was designed, reflecting the needs and interests of the learners. The course in ESP (English for Specific Purposes) largely focuses on specialized vocabulary taught through authentic materials prepared in cooperation with the students, and also on the development of communication ability in different professionally oriented situations. A questionnaire was used for the purpose of the course design, prepared and distributed well in advance before the beginning of teaching period to allow for a thorough preparation of teaching materials. The results of the inquiry largely facilitated the work of lecturers in English in designing a learner-centred course of ESP.

Key words: *English for Specific Purposes (ESP), authentic materials, language, skills, sub-skills, CEFR (Common European Framework of Reference)*

English for Specific Purposes has recently been earmarked as an independent branch of applied linguistics. The reason why this has happened is not to cover a widest possible terminology of a certain field of interest, but to reflect the needs of communication skills in different professional situations. The main purpose of the current ESP developments is to get the students acquired with a set of standard, purposeful, professionally integrated and focused language sub-skills that students might need in their future profession.

The contribution deals with the situation in teaching English as the first foreign language at the Faculty of Transport of the University of Pardubice, Czech Republic. The main objective of this short research is to find out the attitudes of the first year students to the language instruction, their expectations

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[1] Language Centre, University of Pardubice, Czech Republic

and language background. The students major in technical subjects, such as civil engineering, technology of transport means and logistics.

The foreign languages offered at the University are English, German, Russian, Spanish and French, whereas English is a compulsory option. In regard to the European integration, English is a most useful language enabling the students to complete a certain part of their study at a foreign university. Also the field-related materials published by the EU institutions are mostly written in the English language, which has a great influence on the students´ preferences.

It is important to stress that on the enrollment in language courses, a certain level of language skills from the secondary school is expected; the number of beginners is largely limited to two or three groups. The work in ESP seminars is based in the students´ ability to communicate at least on A2 level to be able to use transport-related authentic materials.

The study regulations require that an examination in a foreign language must be completed by the end of the fourth semester that is, by the second year of study.

Materials used in language sessions were mostly general English textbooks (Headway, Face2Face) together with English grammar books that made up with insufficient level of the acquired language skills. Since most language sessions are carried out in the first year, no specific terminology knowledge may be expected in the in-service students. In the case that students attend language seminars in their later years of study (in the form of optional conversation classes), their field-related terminology is largely extended and they are able to cooperate with the lecturer in the selection of suitable study materials.

The language instruction is carried out in the form of seminary work in the scope of two 45-minute sessions a week. There is a strong trend that the number of students in a group does not exceed 20. Otherwise the instruction loses its effectiveness since not all the participants are given an opportunity to develop all the required language skills.

Assessment of the acquired language skills level is carried out in the end of the fourth semester in the form of an oral examination. The exam is based on the work with a specialized text. Students must prove their ability of discourse analysis and the knowledge of relevant vocabulary.

The Language Centre is a professional workplace providing foreign language instruction to 5 faculties of the University. Technical equipment for the language instruction gives an opportunity to work in a modern multi-media classroom with the access to the Internet, to foreign periodicals, specialized textbooks and dictionaries. The Language Centre employs several lecturers of

English – native speakers which represents a great opportunity to develop their productive communicative skills.

Target group of the research

The survey was carried out among the students of the current 2nd year full time students of the Transport Faculty. The number of questioned students was 50. There are about 200 students in one year (that is 10 study groups of 20 students each). The language seminar is a compulsory option that is 80% participation in classes is a prerequisite for a successful pass. English is allocated 2 credit points in the credit system used at the University.

Research tool:

A questionnaire has been used as a research tool distributed to the students prior to the beginning of their second year of study.

The 6 items combine questions designed to inquire the students preparedness for language sessions (items 1-3, 6) and questions directed on the students attitudes to ESP (items 4 and 5)

Item 1: How long have you been studying English?

The assumption underlying this question is the following: on the condition that a student studies a foreign language for at least 4 years (e.g. at a standard high school), the level of his/her knowledge and skills should be at least B1 (intermediate). They will have the required grammar background and sufficiently developed language skills, therefore the lecturer at the university may count on the work with specialized field-relating literature and to link to the language sub-skills already acquired.

The given item must take in consideration the fact that some students might have studied the language with certain interruptions, such as the first year of study at the Faculty of Transport. There exist certain branches that only have English in their second year. If such an interruption lasts over one year and the student fails to compensate for a regular usage of the given language, his/her language skills go rapidly down and he/she loses the automated speech patterns.

Item 1 in the questionnaire underlines a continuous, uninterrupted study with a regular contact with the foreign language environment.

Item 2: How do you assess your knowledge and skills?

This question addresses the frequent problem of a "chronic beginner". In my opinion, some high schools, especially technically oriented, neglect foreign language instruction at the expense of technical subjects. The result is the above indicated problem. Students have the feeling that they are unable to cope with the requirements of language lessons and therefore they tend to rank themselves as beginners and to start on the lowest level repeatedly.

The Language Centre has developed an effective tool to eliminate the problem of a "chronic beginner". It is an on-line placement test used for the assessment of a student´s foreign language level prior to starting a course in English. The test evaluates the level of language skills and based on the percentage, the student´s obligation is to subscribe to a corresponding group. A great advantage to the system is the homogeneity of the language classes enabling the lecturers to use appropriate textbooks, materials and teaching methods.

Item 3: Have you been using ESP in the course of your study so far? If yes, indicate the field and the form of ESP

Item 3 is designed to inquire the percentage of the respondents who already have a certain understanding of specialized terminology in the given field of interest. The Czech Republic has two high schools that specialize in transport, and also several vocational schools offer similar study branches. We can assume that some students have already got acquainted with the specialized terminology. These will be slightly ahead of the students which must be taken in consideration in the preparation of suitable study materials.

Item 4: What is the composition of the classes you prefer?

This item inquires the proportion of students´ interest in ESP. It is assumed that the difference between the indicated terms is known to them, or will be described at the questionnaire distribution. The respondents must be aware of the fact that the down total is 100 %.

The percentage of students preferences will facilitate the making of the course syllabus and preparation of study materials in a balanced way reflecting professional needs, which has been in the centre of the author´s attention.

Item 5: Choose the most likely purpose you will need English for. Select maximum 3 options and number them 1 -3 according to their importance

This item will mostly influence the criteria for the selection of study materials. Based on the evaluation of the results, we find out the substantial part of the used study materials – whether it be specialized periodicals, newspapers, authentic materials – the most demanding portion of a lecturer´s preparation.

Authentic materials are most beneficial in terms of their effectiveness since they give the students an opportunity to meet a real foreign language environment. On the other hand, they are extremely demanding in terms of the time for their preparation. An authentic material can rarely be used as such, without any adaptation to suit the level and the needs of the students. Such adaptation requires a lot of time, can be costly and what is more, it accentuates the teacher´s professional attitude both in terms of the field of interest and the underlying methodology.

Taking in consideration the fact that most language teachers have linguistic education, then the preparation and use of adapted authentic materials presents a great challenge.

The aforementioned results in the conclusion that the students needs analysis should be carried out long in advance to avoid the situation when a teacher is forced to work with hastily written materials downloaded from the Internet and full of hard to understand terminology..

Item 6: Have you ever been in an English speaking country for over 3 months, including a course in English?

Item 6 will find out the percentage of students who are expected to have a high level of language competence. We can assume that a study stay of over 3 months at a parallel study in an intensive English course will enable a student to complete the English examination requirement in a relatively short time. The outcome of this item also helps to estimate the size of most advanced group.

The way of data collection:

The questionnaire is distributed to the students of 2 year through the study department at their registration for study. The students are asked to deliver the completed questionnaire to the Language Centre either personally or by means of internal mailing service. The questionnaire is anonymous. There is a month period between the registration and the beginning of the semester, which enables a lecturer a thorough evaluation and preparation of suitable materials. The students have an opportunity to consult their choice with a language teacher.

The use of collected data:

Each item of the questionnaire is evaluated independently, because the questionnaire contains different types of questions serving different purposes. Such data are used for the needs analysis.

Based on the findings, the selection of materials, especially authentic ones, is made by all the involved language teachers. The monthly period makes a solid space for the syllabus preparation and materials adaptation.

THE QUESTIONNARE

Dear student,

The purpose of the following questionnaire is to inquire about your assumptions and preferences in the subject English as a foreign language. Your opinion and experience will be taken in consideration in the preparation of the syllabus and study materials for the next academic year. We believe that the time for its filling up will contribute to the increase of the quality of language instruction.

1. How long have you been studying English?

Under 4 years	4 - 6 years	7 - 10 years	Over 10 years

2. How do you assess your knowledge and skills? Indicate the type of course-book you have recently used, e.g.: Headway
Matters
Cambridge English Course
Blueprint
Streetwise
Other – state the title

Headway Pre-intermediate	Headway - Intermediate	Headway – Upper-intermediate, Advanced

3. Have you been using ESP in the course of your study so far? If yes, indicate the field and the form of ESP

Field of interest		Used materials	
Transport		Specialized publications	
Medicine		Specialized periodicals	
Economics		Authentic materials	
Machinery		Other	
Chemistry			
Civil engineering			
Electrical engineering			
Other			

4. What is the composition of the classes you prefer?

General English	0%	25%	50%	75%	100%
ESP	0%	25%	50%	75%	100%

5. Choose the most likely purpose you will need English for. Select maximum 3 options and number them 1 -3 according to their importance

	A – social talk
	B – commercial correspondence
	C – business talk
	D – work with specialized materials (periodicals, publications, research, etc.)
	E – presentation at international conferences
	F – study / working stays abroad)

6. Have you ever been in an English speaking country for over 3 months, including a course in English?

Year of study	Country of study	Length of stay	Language course Yes - no

Evaluation

The questionnaire was submitted to 83 students altogether, who registered for English in their second year of study. Number of returned questionnaires is 75.

1) How long have you been studying English?

Under 4 years 12

4 – 6 years 48
7 – 10 years 12
Over10 years 3

Most students did English for the whole period of their high school and they started to learn English at the junior high school. We can count on the fact that basic language skills will have been acquired and we will be able to gradually start with ESP.

2) How do you assess your knowledge and skills? Indicate the type of course-book you have recently used:

Headway	24
Matters	18
Cambridge English Course	2
Blueprint	10
Streetwise	-
Other (English for Language Schools)	41

9 students evaluate their level as lower intermediate, 41 as intermediate and 25 as upper intermediate.

The answers to this question make us assume that students are ready to work with a language textbook lacking comparative approach (Czech-English) since at the high school they worked with British textbooks using the Czech ones as an auxiliary material. The same attitude will be used in the university. Most of the students will be on intermediate level, as it was assumed from the facts found by the first question.

3) Have you been using ESP in the course of your study so far? If yes, indicate the field and the form of ESP:

Transport	2
Economics	8
Machinery	3
Civil engineering	10

3 students indicate the work with specialized periodicals, 56 have met specialized journals and 12 worked with authentic materials in a certain field of interest.

The results show that a great attention will have to be paid to the work with authentic materials and they will have to be thoroughly selected and adapted to the students´ level, since only 12 state a certain experience of such work.

4) What is the composition of the classes you prefer?

48 students state	75% general English / 25% ESP
2 students	100% general
25 students	50% general English / 50% ESP

The preferential proportion of general English to ESP is unambiguously on the side of general English. This result reflects the fact that the so far used system of language instruction does not provide for a sufficient time and scope of language lessons. Students feel a certain lack of opportunity to communicate and also insufficient preparedness for their future professional lives. Therefore they think that a major attention should be paid to the basics in general English. Such insufficiencies should be overcome during the first two to three semesters enabling both the teacher and the students to extend the specialized terminology and vocabulary with the aim to develop their skills towards their professional profile.

5) What is the composition of the classes you prefer?

The fifth question clearly demonstrated the priority of the work with specialized texts (46). The second place goes to study stays (32) and the third is business talk (28)

6) Choose the most likely purpose you will need English for. Select maximum 3 options and number them 1 -3 according to their importance?

In the 6th question, only three students indicated work abroad in a real language environment (all of the stays were relating to au-pair work). No students attended a language course abroad.

CONCLUSION

The results of the questionnaire were used in the preparation of syllabus for the winter and summer term. The course syllabus was based especially on the acquired level of language skills (intermediate), appropriate course-book were selected (Business textbook Profile, Working in English in the more advanced groups and a Czech published grammar guide Modern Textbook of English). The author prepared a complex set of authentic study materials adapted to the language level and professional profile. The set of materials was equipped with language exercises and Czech-English glossary of relevant terminology.

The questionnaire has completed the purpose it was deigned for. A course could be created, reflecting the achieved level of language skills and sub-skills, enabling the students to progress towards their professional needs.

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EDUCATION OF GEOTHERMAL SCIENCES IN GERMANY AS PART OF AN APPLICATION ORIENTATED RESEARCH

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Keywords: Education, research, geothermal sciences, training, university, numerical calculations, german geothermal projects

1. INTRODUCTION

In times of global warming renewable, green energies are getting more and more important. The development of application of geothermal energy as a part of renewable energies in Germany is a multidimensional process of fast growing improvements.

Geothermal energy is the energy, which is stored below earth's surface. The word geothermal derives from the Greek words geo (earth) and thermos (heat), so geothermal is a synonym to earth heat.

Geothermal energy is one of the youngest but certainly auspicious renewable energies. While other renewable energies arise less or more from the sun, geothermal energy sources its heat from the earth's interior, which is caused mostly by radioactive decay of persistent isotopes. In average the temperature increases 3°C every 100 m of depth, which is termed as geothermal gradient. Therefore 99 percent of our planet is hotter than 1.000°C, while 99 percent of that last percent is even hotter than 100°C. Already in a depth of about 1 kilometer temperatures of 35 – 40°C can be achieved. This vast geothermal energy reservoir can be exploited with the aid of suitable methods. Therefore the assignment of geothermal engineers is to explore those areas and to develop them for a use of the gathered energy to cool or heat buildings as well as for a generation of electricity. In areas of geological anomalies, like the Oberrheintalgraben or the Red Sea geothermal gradients of about 6°C / 100 m can be found, which allows economic use of deep geothermal systems. Almost every geothermal powerplant worldwide is located in such high-enthalpie hot reservoirs, so called hot spots, see Arslan (2008).

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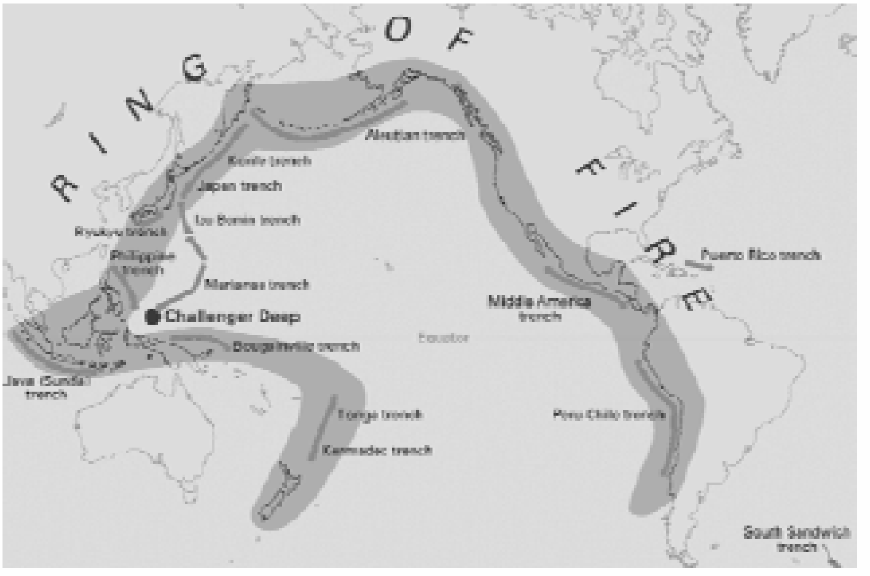

Figure 1. Ring of fire

These high-enthalpie hot spots do mainly correspond with the Ring of Fire, a zone of frequent earthquakes and volcanic eruptions that encircles the basin of the Pacific Ocean. In Germany no such high-enthalpie reservoirs are given. Nevertheless 15 geothermal projects were raised in Germany till the end of 2008, see Arslan (2009). To use the given low-enthalpie potential for a generation of geothermal power inventions and improvements needed to be performed by German scientists. An important part of these improvements is supported by universities and institutes of sciences. German education in geothermics sciences is pointed out in the following to demonstrate the fast growing demand of geothermal sciences.

National and international geothermal projects supported by German Universities and state aided organizations are described. Examples of supervised shallow and deep geothermal systems are given.

2. EDUCATION IN GEOTHERMICS

Geotechnical and geological engineering is a traditional part of the education for civil engineers at German Universities. Due to the process of environmental, green thinking in all societies the education and training of geothermal sciences is also becoming an important task at German Universities. In this paper an overview is given on study programs in geothermal engineering. German Universities teaching education in geothermics are listed up; outstanding geothermal research programs of German Universities and state aided organizations are pointed out.

3. INSTITUTES OF RESEARCH

3.1 Research and Education in geothermal basics

The education in geothermics at German Universities is primarily based on Technical Universities (TU), Universities and the Universities of applied sciences (FH). The education in geothermal sciences at all of these universities mainly bases on the common academics geology and / or geotechnical engineering. Besides these academics thermodynamics are taught in mechanical engineering, mechanics or electrical engineering for example.

Main interest of education in geothermal basics is thermodynamic main theorems and thermal transport mechanisms such as transient change of heat content via conduction, convection and radiation. Basic equations and formulas are summarized in the following:

Heat transfer always occurs from a higher-temperature object to a cooler temperature one as described by the second law of thermodynamics. The heat transfer formula can be written as

$$\rho c \frac{\delta T}{\delta t} = \mathrm{div}(\lambda \cdot \mathrm{grad}T) - (\rho c)_{Fl} \cdot \mathrm{div}(\nu T) + \mathrm{div}(D_{\lambda} \cdot \mathrm{grad}T) + Q_i$$

with its terms of conduction, convection, radiation and thermal sources.

The heat transfer bases in principle on the Fourier´s law that can be written as

$$\vec{q} = -\lambda \frac{dh}{dx}$$

The differential form of Fourier's Law of thermal conduction shows that the local heat flux, q, is proportional to the thermal conductivity λ, times the local temperature gradient.

The heat flux is the amount of energy that flows through a particular surface per unit area per unit time. Heat always conducts from warmer objects to cooler objects, which is demonstrated by the negative λ. The transport of groundwater bases on the analogous formula titled as the Darcy´s law:

$$\vec{q} = -k \frac{dh}{dx}$$

where q is the flux, which means the discharge per unit area, with units of length per time. The variable k stands for the permeability of the object (here ground).

While these basics of thermodynamics are taught in different academics, the application for geothermal purposes are only taught in a few universities in geothermal lectures. An overview of German Universities and Universities of applied sciences teaching thermodynamical basics for geothermal purpose is presented in Table 1.

Following the necessity of an environmental green thinking more and more Universities and Universities of applied sciences are teaching basics of thermodynamics for geothermal purposes.

Besides this development at German Universities geothermal research programs are also supported by state aided organizations and institutes of research. These organizations are described in the following.

3.2 State aided organizations

Main state institute of geothermal research is the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) as well as The Federal Ministry of Economics and Technology (BMWI). These institutions coordinate all state aided research institutes and supports geothermal research institute financially. The BMU and BMWI decide on the financing of renewable energy projects. Therefore it channels the different aspects of research and coordinates the institutes to avoid an overlapping of their research programs.
A brief summary of actual research and development projects on renewable energies supported by the German government by the BMU / BMWI is given in the table 2.

Aim of the BMU / BMWI is to develop the use of geothermics broadly to increase the energy yield and to arrange the development environmental and nature compatible. Above all joint research projects are promoted, which compile common solutions for industry and research, since the research results will transfer as briskly as possible into the practice.

A detailed overview on research projects including brief description of projects is available on the website of Projektträger Jülich (PTJ). The german government's provides information about all support programs The online data base of the german government enables users to get information about concluded as well as current specific projects.

The principles as well as the main research aspects of the former mentioned state aided organizations (GFZ, BGR, LIAG) are described in the following.

Table 1. German Universities teaching geothermics

University	Institute	Education program and main aim
Technical University (TU/TH)		
TU Darmstadt	Institute of geothermics	Lecture and exercise; geothermal basics, heat transfer formula as well as laboratory tests
	TU energy center	summer school geothermics, application of numerical programs (FeFlow)
TU Hamburg-Harburg	Institute of geotechnics and construction operation	Pilot plant for shallow geothermics “HafenCity Hamburg”
	Institute of electricity techniques	Optimisation of the electricity generation from geothermal district heating plants in Germany
TU Braunschweig	Civil engineering	Lecture geothermics; geothermal field and lab exercises
TU Karlsruhe	Institute of applied geosciences	Geothermics as main research
TU Munich	M.Sc. geology and hydrogeology	Lecture introduction to geothermics
RWTH Aachen	Super C Geotherm	Research group for geothermics
Universities		
University Stuttgart	Institute of geotechnics	Geothermics as main research, congress for geothermics in Stuttgart, partnership with VDI
University Duisburg-Essen	Institute of geotechnics	Geothermics as main research
University Siegen	Institute of geotechnics	Geothermics as main research
	Center for renewable energies and optimization	Continuing education drillings for geothermal purpose and installation of closed loop systems
	Research center geothermics	Geothermics as an example for renewable energies
Leibniz University Hannover	Institute of electric power systems	Lecture geothermics, since 2005
Johannes-Gutenberg University Mainz	(planned)	Topics not known yet
University of applied sciences (FH)		
FH Deggendorf	Mechanical engineering	Main research geothermal energy systems
FH Bochum	The geothermal center	Geothermal energy systems (planned)
FH Aachen	Summer school renewable energy	Renewable energies in general

Table 2. German state aided research projects

Institute	**Year**	**Research field**
State aided institutes		
GeoForschungsZentrum, Germany (GFZ) (*Geological Research Center, Germany*)	2008 - 2010	Production and injection of thermal water Groß Schönebeck
	2008 - 2011	Monitoring of long term corrosion
	2007 - 2010	Predicition While Drilling
Bundesanstalt für Geowissenschaften und Rohstoffe (BGR)	2008 - 2009	Workshop GeoHyBe
	2005 . 2009	GeneSys Horstberg II
Leibniz-Institut für Angewandte Geophysik (LIAG)	2008 - 2011	GeneSys GT1
	2005 - 2009	GeoTis
	2005 - 2009	GeneSys
	2006 - 2009	3D seismic investigation
	2008 - 2011	Characterization of aquifers in Munich
Universities		
TU Darmstadt	2009 - 2011	Experimental investigation for the verification of a Finite-Element multiphase model
RWTH Aachen	2006 - 2009	Rock properties of Germany
University Karlsruhe	2006 . 2010	Reduction of drilling risks
University Dresden	2007 - 2009	Electrical impulse drilling
University Berlin	2008 - 2011	Hydrogeological model of Munich
University Munich	2008 - 2009	MonKü - cooling water
Companies		
Geothermie Unterhaching	2008 - 2010	Monitoring Unterhaching
Herrenknecht AG	2008 - 2010	Pipe Express
Geothermie Neubrandenburg GmbH	2009	Modulare monitoring

GFZ

The GeoForschungsZentrum Potzdamm (GFZ) describes their main aim as follows:

The GFZ German Research Centre for Geosciences is working on urgent social, scientific and economic questions.

Besides detailed researches in geothermics the GFZ works in the areas of "Earth and Environment" as well as “Energy" in general. The overarching research aim of the GeoResearchCentre is to develop strategies and to demonstrate practical options, e.g. to preserve natural resources and to exploit them in an environmentally friendly way.

The research programme of the GFZ concerning renewable energies concentrates continual and long-term research, interdisciplinary collaboration between a large number of scientists, and large-scale investment in experimental equipment.

The Renewable Energy Programme is engaged in fundamental questions belonging to materials and process research as well as in the problems involved in putting renewable energies into industrial practice.

The main aim can therefore be summarized to design systems for producing low-price and environmental friendly energy. Therefore the research is focused on exploring suitable geological structures in low-enthalpie regions for the use of geothermal techniques worldwide, by increasing the fluid productivity of geological formations, by developing process technologies for the installation of geothermal power plants and by monitoring all aspects of systems in operation.

BGR

The Federal Institute for Geosciences and Natural Resources (BGR) is the geoscientific center of excellence within the federal government and part of its scientific and technical infrastructure.

The BGR concentrates on geoscientific and natural resource issues, such as stimulating economic development, longterm protection and improvement of the quality of life and enhancing technical and scientific expertise.

LIAG

The Leibniz Institute for Applied Geophysics (LIAG) concentrates its research in the field of physical geosciences. Therefore the uppermost part of the earth`s crust is investigated to find areas of an accessible and economic use for geothermal belongings as well as essential resources. An important issue for the institute is the development of research methods for geological measuring and interpretation techniques such as seismics, magnetics, gravimetry, geoelectrics, well logging, geologic age dating, and basics of geothermics.

Presently, the institute conducts research in the topical research field of:

- ground water systems - structure, quality, processes
- geothermal energy - research and development for economic use

Most of these issues are handled in cooperation with multiple partners such as federal state geological surveys, universities, institutes of sciences, private companies and industry.

As shown before, basic research programs in geothermal education and application are performed by universities and stated aided organizations. All of these programs are leading to outstanding geothermal pilot projects. Some of these shallow and deep geothermal pilot projects are demonstrated in the following:

4. DEEP GEOTHERMAL PILOT PROJECTS

No high-enthalpie hot spots are given in Germany (see figure 1). To produce geothermal green energy the efficiency of deep geothermal low-enthalpie projects needs to be raised. Therefore costs of drilling and the risk of failure needs to be minimized. The degrees of efficiency need to be raised till an economical use of a deep geothermal source can be guaranteed. By raising the total degree of efficiency even low temperatures of about 100°C can be used economically for a production of geothermal power. To achieve the aim of an efficient use of low-enthalpie geothermal power production different research projects are actually supported. These projects of deep geothermal systems supported by german institutes of sciences are pointed out in the following.

4.1 Numerical analyses

Especially in deep geothermics numerical analyses are essential for a correct dimensioning of the geothermal system, see Huber (2006).

Therefore German Universities and state aided organizations are developing numerical programs for a detailed use of application on geothermal systems. Actually the Institut für Werkstoffe und Mechanik im Bauwesen at the Technical University Darmstadt are developing a Finite-Elementmultiphase model, verification by experimental investigation and laboratory tests. This research is supported by the BMWI, a stated aided organization as shown in table 2.

In this modell the subsoil is analyzed as a three-phasesmodel in actual sciences projects with a separated consideration of conduction, convection and advection and their subsequent interface.

Most common numerical programs for geothermal purpose are based on the finite-element-method and the finite-differences method. For further information see Huber (2007).

4.2 Geothermal powerplants

Neustadt-Glewe

Since 2003 the first german geothermal powerplant produces geothermal electricity in Neustadt-Glewe. The research project was supported by the BMU.

Neustadt-Glewe is neither located in a high-enthalpie region, nor in a geological hot spot. At site water of a temperature of only 98°C are raised by the production well of a depth of 2,200 m. Therefore it is a geothermal pilot project for the production of geothermal electricity by low temperatures.

The geological conditions at site of Neustadt-Glewe are shown in the following figure.

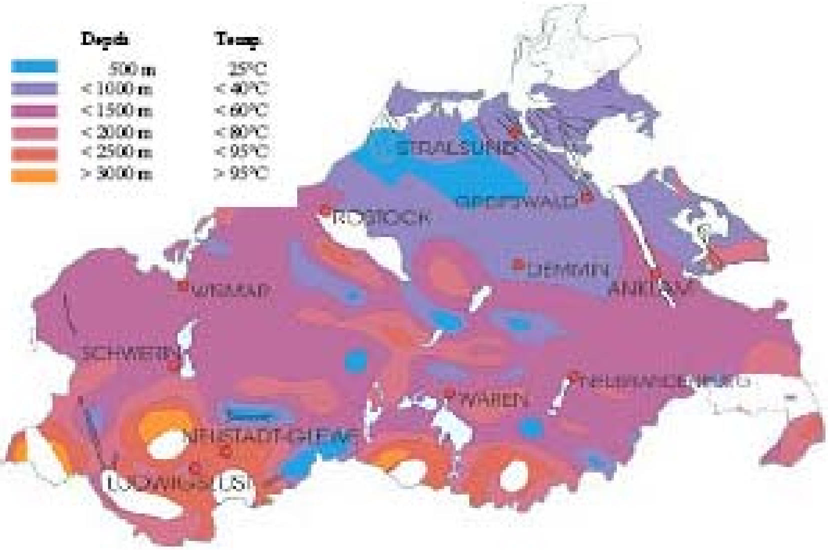

Figure 2. Geological conditions Neustadt-Glewe

Landau

Supported by national universities and state aided organizations (BMU) the ORC powerplant nearby Landau was developed. With its high low enthalpie temperature of 160°C 3 MWel are produced.

Figure 3. Geothermal powerplant Landau

Landau is located in the geological anomaly zone called Oberrheintalgraben. Because of that anomaly a geothermal gradient of about 4.7°C/100m could be reached. That meant a bottom whole temperature of 160°C at a depth of about 3,300 m. The geothermal powerplant Landau was the first economical powered geothermal powerplant in Germany.

Groß-Schönebeck

Groß-Schönebeck is located in the north-eastern region of Berlin. Initialized by the GFZ a geo-research-research center for geothermal purpose was raised upon a former petroleum gas drilling.

The aborted drilling was re-activated in the year 2000 and deepened to its final depth of 4,309 m. The geological conditions and the given geothermal gradient are shown in the figure 4.

The geological conditions of Groß-Schönebeck correspond to most European low-enthalpie regions. Therefore Groß-Schönebeck was predestinated for a research program to develop stimulation methods for low-enthalpie regions to a suitable geothermal power generation.

At site of Groß-Schönebeck a research program for hot-dryrock (HDR) geothermal powerplants was started. Besides stimulation methods the sustainability and the long-term values of a geothermal reservoir were developed.

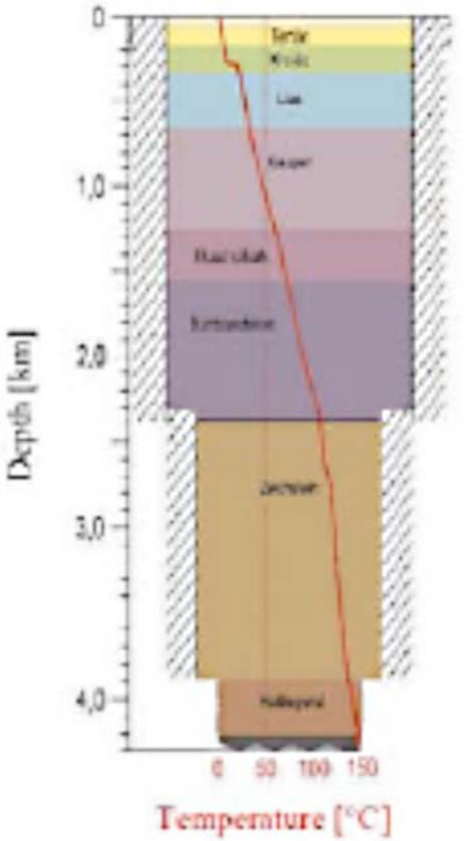

Figure 4. Temperature profile Groß-Schönebeck

Unterhaching

Supported by national universities and state aided organizations the Kalina-cycle powerplant nearby Unterhaching was developed. Gathering 120°C of hot water of an aquifer in 3,500 m about 4 MWel and 30 MWth are produced. An overview of the most important information gathered during the process of the development is shown up.

Unterhaching is located next to Munich. The geological, hydrogeological and geothermal conditions of Munich are quiet different to the before mentioned projects next to Berlin (Groß-Schönebeck), northern Germany (Neustadt-Glewe) and the Oberrheingraben (Landau). With that fourth geothermal powerplant located in Unterhaching the main geological homogeneous regions suitable for geothermics are investigated and researched by pilot projects.

5. SHALLOW GEOTHERMAL PILOT PROJECTS

Besides these deep geothermal pilot projects shallow geothermal research is also promoted in german institutes of sciences. Actual projects of shallow geothermal systems supported by german institutes of sciences are pointed out.

5.1 Geothermal investigation

While for smaller geothermal systems up to 30 kW of heating / cooling power the conductivity can be estimated it is necessary for larger systems to define the conductivity in detail. This investigation is performed by geothermal investigation methods.

The most common geothermal investigation method in situ is the thermal response test (TRT).

To define the effective conductivity in situ a constant heat power is set to the fluid of a borehole heat exchanger (BHE). Before, during and after this heating period the temperature of this fluid is measured. Therefore it is possible to figure out the conducted heat energy of the surrounding ground. As a conclusion the effective conductivity in situ can be defined.

Disadvantage of this well probed geothermal investigation method is that the effective conductivity can only be defined for the whole BHE. The varying of the conductivity according to the change of geological and hydrogeological conditions is neglected and cannot be defined.

To increase the efficiency of geothermal investigation methods different aspects of geothermal parameters are analyzed in Germany. Therefore an enhanced geothermal response test (EGRT) was invented. Within this EGRT the conductivity of a given ground can be analyzed by depth for every single layer. Shallow geothermal methods can be adapted to the actual conductivity of each layer.

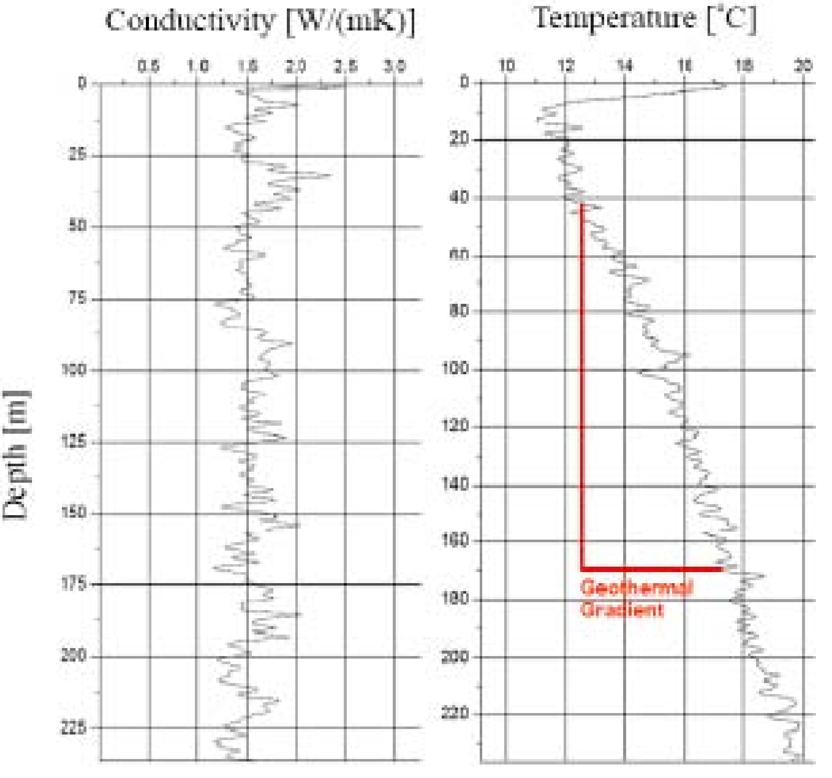

Figure 5. Example for an EGRT result

Besides these improvements in geothermal investigation methods in situ the standards for geothermal pre-studies were also improved immensely. Therefore the online-portal Geotis was developed. Geotis is a research project supported by the BMU and LIAG as well as the University of Berlin.

The Geothermal Information System (GeotIS) offers a voluminous database for shallow and deep aquifers in Germany suitable for geothermal usage. Geoscientific base data as well as current knowledge are provided and continuously complemented. The aim of the project is the minimization of risks in finding proper locations for geothermal installations, such as powerplants.

Therefore data of more than 30,000 drillings in Germany are combined to a geothermal 3D underground model.

Geological structures as well as underground parameters like temperatures, geothermal gradients, porosities and permeabilites can be illustrated in horizontal or vertical sections.

5.2 Shallow geothermal exploration

In Germany different methods of withdrawing shallow geothermal energy are well probed. Famous examples of shallow geothermal projects are the house of parliament, Berlin (seasonal heat storage), the municipality Frankfurt (field of borehole heat exchangers) and different high-rise buildings for example Skyper, Frankfurt (energy piles) or WestendDuo, Frankfurt (groundwater usage).

Besides these well probed shallow geothermal systems a combination of common borehole heat exchangers and horizontal loop systems was invented in Germany. This combination of the advantages of the two most famous geothermal shallow systems is called geothermal radial drilling (GRD).

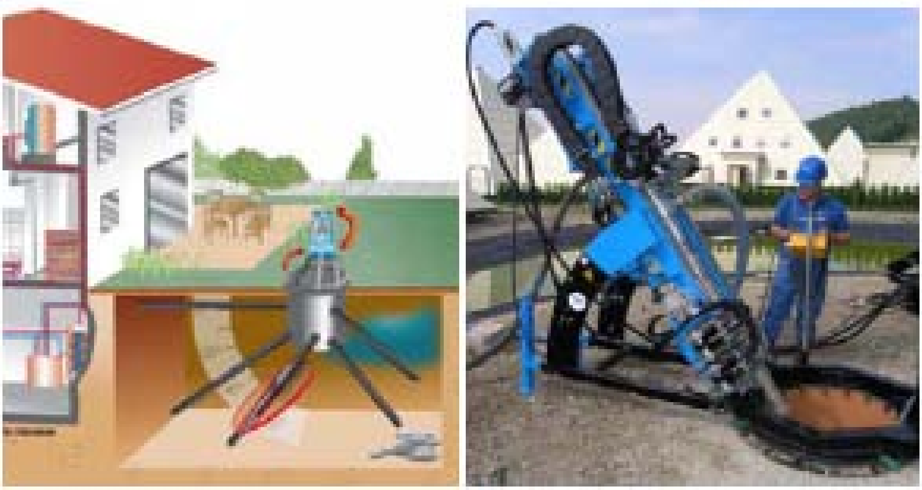

Figure 6. Geothermal radial drilling

With GRD different borehole heat exchangers can be installed to ground operating from one point of drilling. The borehole heat exchangers can be installed with angles from 15° – 60°. With that adaptability GRD utilises the building property's set-up in all aspects. Deep underlying drinking water levels remain untouched. In addition, the GRD technology is based on the need for minimal technical equipment and clearly reduces the overall expenditure for installing borehole heat exchangers.

6. CONCLUSIONS

Having no high-enthalpie regions Germany is forced to perform researches and improvements to produce geothermal power. Therefore geothermal basics have to be taught at German universities to guarantee science orientated improvements of geothermal application.

The progress of implementation of geothermal education at German universities is still going forward – geothermal basics are already taught at many German universities, as shown in table 2.

The improvements shown in this paper are national pilot research projects. The lessons learnt from these projects could be adapted for international purposes. In that way an environmental friendly green geothermal energy production could be performed all over the world, not even in highenthalpie regions. With that possible high number of decentralized geothermal power plants the world energy demand could be satisfied to a considerable extent by geothermal energy.

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EDUCATE!: AN INTERNATIONAL E-LEARNING POSTGRADUATE COURSE IN WATER RESOURCES AND ENVIRONMENTAL MANAGEMENT

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1. INTRODUCTION

The last 30 years have seen a rapid development of Environmental Education in Europe and internationally. This development has been most significant in the countries which had sufficient resources and appropriate long term Higher Education policies. These trends have largely bypassed the countries in South East Europe to the effect that Environmental Education in these countries leaves much to be desired and urgent action is needed. Furthermore, the environment of SE Europe and Western Balkans has been subjected to unprecedented pressures over the years, requiring enormous effort to remedy the situation. The capacity of the region to undertake this work is limited by the lack of trained professionals with the knowledge and transnational perspective required. In view of the ambition for unified regional development and associated environmental protection policy (e.g. the Water Framework Directive), this imbalance needs to be urgently addressed. This paper presents the experience from a new MSc course in Water Resources and Environmental Management "EDUCATE", a multi-institution, e-learning programme. The course is supported by five Engineering Schools from four leading national academic institutions, (1) the School of Civil Engineering, National Technical University of Athens; (2) the School of Chemical Engineering, National Technical University of Athens; (3) the Faculty of Civil Engineering, University of Belgrade; (4) the Faculty of Civil and Geodetic Engineering, UL FGG University of Ljubljana; and (5) the Faculty of Hydrotechnics, Technical University of Civil Engineering, Bucharest. The EDUCATE! course has currently completed its first cycle of operation (2007-2009) and two more cycles are in progress, 2008-2010 and 2009-2011. The first cycle was funded by the INTERREG III CADSES EU Programme. Accreditation of the course is an on-going process, the aim being to develop it into a European joint masters course. A main innovative element of the

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postgraduate course relates to its e-learning component. The course is delivered to the students through a Moodle web-based platform.

2. COURSE DEVELOPMENT

2.1 Course structure

The Educate! Course, (http://www.water-msc.org/), is a flexible, distance learning programme based on e-learning. Lectures and tutorials are given in English. Students can follow the entire postgraduate course (12 modules, 2 years) or alternatively they can select specific course elements, such as Thematic Areas and/or Modules according to their needs. The programme is addressed to professionals working for the Water Industry or Regional and National Environmental Authorities. It is particularly suitable for professionals who cannot afford a major disruption in their work, and who can attend in parallel with their working commitments without leaving their area of residence. The course also targets recent graduates in engineering and environmental science seeking specialization in water resources and environmental management.

The full programme is organized as a pedagogic continuum and includes:

- An introduction and building common scientific background for the participants, organized under **Thematic Area 1.**
- The acquisition and use of concepts in urban water management in an integrative approach within a sustainable make-space-for-water management context, organized under **Thematic Area 2.**
- A thematic specialisation in the issues of catchment and environmental management by utilising hydro-informatics tools, including distributed hydrologic models, advanced optimisation and geostatistics under **Thematic Area 3.**
- Issues of policy, legislation, decision-making and environmental assessment with an emphasis on the Water Framework Directive (WFD), as well as other advanced topics, are provided under **Thematic Area 4.**
- **A research Thesis.**

Host University: Students are registered at the University of Belgrade, Faculty of Civil Engineering.

Assessment: Written examinations are held at the end of the thematic areas, requiring the physical presence of all participating students in their Regional Centre of choice.

Physical presence: Students following the entire postgraduate course are brought together in the University of Belgrade, Faculty of Civil Engineering for a few days at the beginning and at the end of the course. During the first event, students are introduced to the aims and contents of the course and become familiar with the e-learning platform. The final gathering is devoted to the presentation of the thesis and course evaluation. For students following specific elements, no physical presence other than during examinations is required.

Admission criteria: Successful candidates must have a good first degree from a recognized university of at least 4 years of full-time study (B.Eng. + MSc, M.Eng. or equivalent), in Engineering or Natural and Applied Sciences, such as Environmental Sciences, Geology, Chemistry, Biology, Mathematics and Physics. Candidates with other first degrees will also be considered if they can demonstrate commitment to water resources and environmental management issues, usually through work or research experience.

Language requirements: All candidates should demonstrate a good command of the English language.

Degrees awarded: Successful completion of the entire postgraduate course (2 years) leads to the award of the Certificate of Academic Specialization in the field of Civil Engineering, study programme: Water Resources and Environmental Management from the Faculty of Civil Engineering, University of Belgrade. In case that only specific modules are selected, students receive a certificate that includes the corresponding ECTS credits obtained upon successful completion of the selected modules.

2.2 Roles and Structure of the Educate E-learning Platform

E-learning has been attracting, over the past decades, a lot of interest from different stakeholders within the education and training sectors and many generations of e-learning have been announced. Impressive predictions have been made on the future of e-learning, ranging from the most optimistic to the most skeptical views (including statements such as "the biggest growth in the Internet, and the area that will prove to be one of the biggest agents of change, will be e-learning" [1]). Arguably, the growing relevance of the use of Information Communication Technologies (ICT) in education and the increasing acceptance of the potential of new technologies to affect learning systems have brought attention to the contrasting nature of the two components of the "e-learning mix": ICT, as one of the fastest changing components of society, and education, a slower adopter of change [2]. Several examples of e-learning courses and practices in Engineering are presented in the literature [3, 4, 5].

Various concerns have been raised, in particular targeted towards internet connection reliability, and for specific individuals, an affinity to more natural communication. From the point of view of the lecturer, however, a most important remark is made by Makropoulos et al. [6] who suggest that, apart from the issue of communicating the content of the lecture to the students, a face-to-face, classroom teacher can rely on a number of visual cues from their audience: the lecturer can see who is taking notes, trying to understand a difficult concept, or preparing to make a comment. The (attentive and interested) teacher receives and analyzes these visual cues and adjusts the delivery to meet the needs of the class during the lesson. The distant teacher has no visual cues. Part of the role of this feedback is necessarily passed on to other e-learning-specific features.

The Educate! portal was developed by the School of Chemical Engineering, NTUA, and is hosted in the web server of NTUA, at the following address: http://www.water-msc.org/e-learning/. The construction of the portal was based on the Moodle software package. Moodle is an open source course management system (CMS), designed to help create an effective online learning community. Moodle was chosen for this particular application as it presented several advantages, i.e. previous hands-on experience, easy maintenance, the ability to distinguish between different user roles, and its programming design capabilities (object oriented, modular and highly configurable).

In the course of the programme, many modifications and additions of new functionalities on the original Moodle package were necessary in order to satisfy the specific needs of modules and partner countries.

The design and development of the portal was guided by a particular philosophy of learning, which is supported by Moodle, and is referred to as "social constructionist pedagogy". This approach gives emphasis to the fact that learners (and not just teachers) can contribute to the educational experience in many ways. Moodle's features reflect this in various design aspects, such as making it possible for students to comment on entries in a database (or even to contribute entries themselves), or to work collaboratively in a discussion forum or wiki. Moreover, this approach is in line with the international character of the postgraduate course. It allows the cross-cultural exchange of views and ideas both between academics and students and directly supports the broader objectives of promoting cooperation within the Balkans region.

The Educate! portal provides useful information to the general public and to people interested in the postgraduate programme. Students and instructors are able to login into the system and to access the e-learning content. Each registered student has his/her own, fully personalized page, which provides up-to-date information about the educational activities and links to the collaboration and modules areas. Examples of a module home page are given later on in this paper. The home page provides access to the teaching material and it is accessible to all students enrolled to the specific module.

The overall course structure can be seen in Figure 1, while the further breakdown into modules and lessons can be seen in Figure 2 and Figure 3, respectively. A typical lesson component includes:

a. **Topics** in the form of hypertext (lecture notes, case studies) or animated presentations (video, animations, graphics).
b. **Quiz** (Knowledge stabilization units/Formative Assessment) (not to be graded), solved problems, questions and answers, multiple choice questions.
c. **Exercises** (to be graded/Summative Assessment), reports, software applications (GIS, models, commercial software).
d. **Bibliographical material**: digital library (papers, studies, books, manuals), theses catalogue, links to URLs, dictionary of terms.

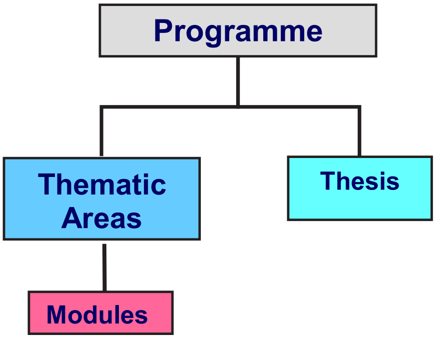

Figure 1.The Educate! course structure

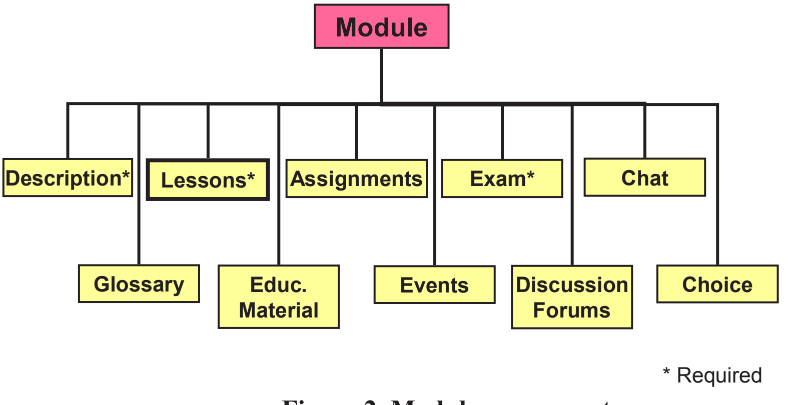

Figure 2. Module components

2.3 Course implementation

The basis for collaboration was formally set-up in a preliminary meeting that took place in Belgrade in May 2006. During this meeting a management board was set up and task allocation among project partners was discussed and agreed. Project's target groups were identified and promotional and communication events were planned out for the following years. The Educate! project was presented to a wide audience from the academic community and industry in the kick-off event that took place in Athens in October 2006.

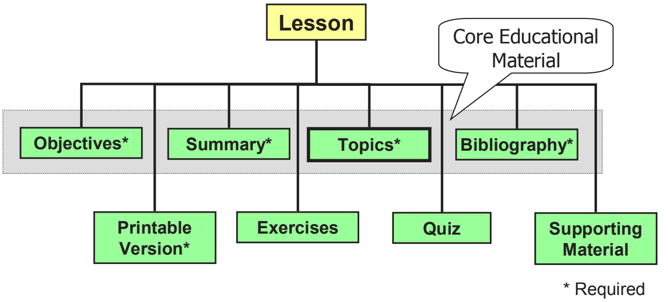

Figure 3. Lesson components

The preparation of educational and training material started early on in 2007. Several issues were discussed during regular management board meetings, i.e. course content and structure, format of educational and training material to ensure compatibility with the e-learning platform, e-learning platform customization, course promotion/marketing, organization and planning. In mid 2007 a training workshop for Educate! tutors and assistants was organised to improve educational material design and use of the e-learning platform. Useful user feedback was received during this workshop that led to further improvement of the platform. The final educational and training material was uploaded on the customised e-learning platform just before the course start, in December 2007. A complete list and description of programme structure, modules, learning outcomes, academic requirements, student selection criteria, assessment rules, application procedures and academic calendar is presented in the course Study Guide (http://www.water-msc.org/en/docs.htm).

The average work load for the maintenance of the platform is estimated at 1 day-person per week. One more day-person is required for the operation of the platform, i.e. opening up lectures, posting announcements, alerting teachers if urgent action is needed from their part, getting in touch with students. Operation load increases considerably during student selection and admission periods.

One of the most important issues raised during management board meetings was course accreditation. To date, accreditation is the single most difficult process in the development of this MSc course. Several alternatives were investigated including the prospect of a joint degree. However, different educational systems in the partner countries made this prospect almost impossible. This is further complicated by the Bologna process and its requirements, as well as the significant variability in the policy of European academic institutions towards it. There are also significant differences in the policies of partner institutions towards tuition fees and, finally, policies on Education and degrees in the partner Member States.

For the time being, the degree offered to successful graduates of the Educate course is a Certificate of Academic Specialization issued by the University of Belgrade. It is hoped that once the first candidates have successfully obtained degree recognition in their countries, national accreditation of the course will also be achieved in Greece and Romania.

3. ASSESSING COURSE MATERIAL

A preliminary reflective assessment of the Educate! course material is first undertaken, using as a framework the key areas of UK's HE Academy Professional Standards Framework [7]. This is a flexible framework which uses a descriptor-based approach to professional standards for education, developed by the Academy on behalf of Universities UK, the Higher Education Guild and the four UK Higher Education funding councils after extensive consultation with the higher education sector. The assessment is broken down into the areas of activities specified by the framework, namely:

i. Design and planning of learning activities and/or programmes of study
ii. Teaching and/or supporting student learning
iii. Assessment and giving feedback to learners
iv. Developing effective environments and student support and guidance
v. Integration of scholarship, research and professional activities with teaching and supporting learning
vi. Evaluation of practice and continuing professional development.

3.1 Design and planning of learning activities and/or programmes of study

The design of a new postgraduate course, such as the Educate! Programme, is both challenging and an intriguing opportunity. The challenge is obvious and lies in the fact that everything needs to be specified from scratch: from identified thematic areas, to the modules contained within each thematic area, to choices between compulsory and electives, streams and core. The opportunity can be understood by comparing this tabula rasa process to "usual practice" in curricula development. The usual approach in development of curricula in courses that have been operating for years is one of incremental changes, usually triggered by non-pedagogical issues.

At the module level, new academic staff “inherit” module descriptions from retiring staff, which are then forced to change to fit the competences of the new instructors rather than what is required by the students. At the level of a programme, additional modules are added, more often than not, to account for the presence of new academic staff, rather than academic staff being added to the faculty to address new teaching needs. In the case of Educate, the curriculum was defined a priori, within the general area of expertise of the participating Universities (which was extensive) and without any significant consideration on who would develop and teach the modules in question. The teaching material itself is an early product of transnational collaboration between academic staff. It has to be stated, however, that the process of multi-institutional collaboration for material development was difficult and based, to a large extent, on good interpersonal relationships between academic staff working together.

3.2 Teaching and/or supporting student learning

The Educate Programme targets both teaching per se and supporting student learning. The boundaries between the two, in view of the specific e-learning delivery mode and course design and organization, are difficult to distinguish. The “lecture” is given in the form of either a basic text (“script”) in suitable html format (Figure 4) or power point presentation with voice over, but at the same time the students are expected to undertake a much more proactive approach to learning, by utilising additional bibliographic material and references, self–assessment exercises, assessment tests and assignments also provided in each lecture (Figure 5). In that second sense, much more of the programme is focusing on supporting student learning than supporting teaching.

It should be noted, however, that this change from “teaching” to “supporting learning” is an important shift in the lecturer’s priorities, which is allowed by the e-learning framework. Freed from their own problem-in-context (to fill-in one or more hours of teaching!), the lecturer is able (in principle) to concentrate on the real objective: assisting the students to learn. Past student assignments or projects can organically be added to the resources available to the student, supporting to some extent the social constructionist claim advocated by Moodle.

3.3 Assessment and giving feedback to learners

Assessment and feedback is a crucial point in terms of both formative and summative assessment – as well as in terms of “experiencing” the results of the learning process. The formative assessment aspect is dealt with through a series of self-assessment quizzes, mostly, but not restricted to the multiple choice variety. The strategy adopted is that of a pool of questions, from which the system picks a specified number randomly, thus allowing for a dynamically changing challenge every time the student re-enters the system to attend the same lecture. The Moodle system allows for a series of assessment methods (actual points given, allowing multiple attempts to complete a quiz with penalties, not-for-grade quizzes with helpful comments and indications of additional reading etc).

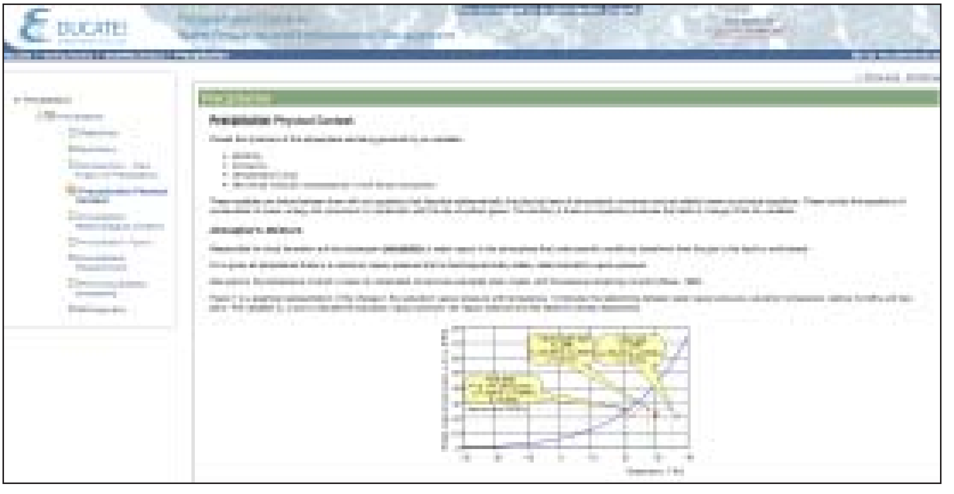

Figure 4. An example of a lecture (item: theory from Figure 5)

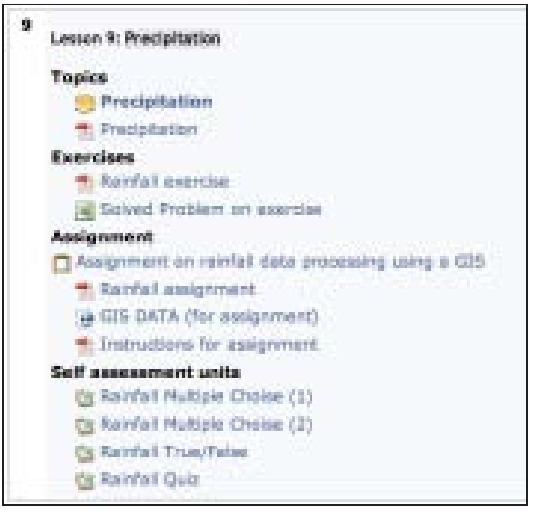

Figure 5. Examples of material available to the student for a given lecture

A suggestion that is currently investigated is whether the quizzes at the end of each lecture could allow for a more interactive, customized specification of the module material: i.e. using the quizzes not only as a formative "assessment" tool but rather as a diagnostic tool modifying the studying/formative assessment process itself. An indication, by the results of the quiz, that specific students have gaps in their understanding of statistics within a module on hydrology, could lead to an alternative route through the module to be suggested to the student, revealing more support material on statistics for each new lecture for the specific students.

The summative assessment process adopted is a combination of by-project assessment, in which students have to complete an assignment for which they get a mark and actual, face-to-face exams in Regional Exam Centres. The decision for the exams was not motivated by a pedagogical imperative, but rather by an accreditation consideration. This is partly due to the inexperience of project partners in e-learning and the need to guarantee quality of learning the "old fashioned way".

On the point of students "experiencing" the results of the learning process, adaptive media[7] such as the online simulation models used in the Educate! teaching material portfolio have the ability to provide feedback to the students in view of a direct (intrinsic) experience of the development of understanding. Intrinsic feedback is defined as "feedback internal to the action that cannot be helped once the action occurs". Extrinsic feedback is external to the action and may occur as a commentary. In the Educate! Project, this latter type is more associated with automated feedback to quizzes, as discussed above.

Intrinsic feedback is much harder to achieve in a class, but the adopted focus on hydroinformatics [8] enables the use of simulation tools, tutorial simulations and virtual environments which facilitate "direct" experiences. For example, a simulation model of a water distribution network, allows the student to "play" with different system configurations and observe whether the impact of pressure to water demand is what the theory in the lecture suggested. Although clearly this is a proxy for a real system, the engineer is able to see the results of changing pressures in the system in real time – an experience at least as real as that of the actual network operator, who changes the pressures within the confines of a control room in a Water Company – with the possible exception of telephone calls with customer complaints that are bound to follow!

3.4 Developing effective environments and student support and guidance

It would be tempting to say that this e-learning programme is all about developing effective environments for student support and guidance. In fact this

[7] Computer media capable of altering their state in response to user actions [9]

element -taken here to mean mostly a way of communicating with the student beyond the lecture delivery- is a crucial and a difficult one for distance-learning programmes of the e-learning variety. This is due to the absence of personal physical contact between teacher and student, due to time and geographic displacement. Communicative media [9] including chat rooms, discussion forums and web-conferencing are available for synchronous and asynchronous collaboration. The extent to which these are going to be used in practice will have to be monitored. Early experience suggests that they are indeed used by students – sometimes more frequently and with less forethought than one would have expected. There is also, still, significant uncertainty as to the exact time demands teaching of these modules will require of instructors. Early experience however suggests that although time investment is significant, the flexibility of when this time needs to be “spent” fits better into the emerging culture of flexible timetables, high mobility and always-online modes of working, favoured by younger academics [10].

3.5 Integration of scholarship, research and professional activities with teaching and supporting learning

The link between teaching and research has long been advocated as paramount but its actual implementation is subject to a series of non-pedagogical issues, such as, inter alia, proximity of the subjects the instructor teaches to his/her own research, flexibility of teaching curriculum to adapt to changes in understanding due to recent research, as well as receptivity of the student. It could be argued that, at least theoretically, all of the above are better served by a flexible, knowledge-driven, proactive approach to learning, supported by e-learning courses. In the case of Educate!, professional activities are at the core of the stated aims of the programme – in view of its vision of influencing professional and indeed economic development in a very specific geographic area. Research is stated as a key element of the studies in the programme collaboration agreement, both through MSc theses, and indeed through course material. Most of the case studies and tools available as educational material in the modules were developed by the researchers/instructors and have been published in peer-reviewed Journals. The pro-active approach to knowledge discovery favoured by the Educate programme, prompts the instructors to include more research findings, rather than fewer, which would have been the case should the aim had been “deliver yet another lecture”.

3.6 Evaluation of practice and continuing professional development

Further than what was suggested above, in terms of the link between practice and the educational process, the programme attempts an even more explicit link between higher education and continuous professional development (CPD). A series of 3-5 day short courses on additional specialised topics, based on the same delivery mode and core material, will be available in each country to professionals from Government and Industry. This is an attempt to ensure two things: (a) that professionals who are not able to attend a full course benefit from the link with current research and thinking and (b) that issues that are identified as crucial within the professional environment – based on feedback from the short courses – will be informing the core education programme, making the graduates more aware of issues relevant to industry and practice.

The short courses were designed through a series of initial workshops with the industry (i.e. the beneficiaries), to reflect their needs better. Clearly this is not the only link to practice since the academic staff, participating in the course, has their own track record of involvement with practice. This is more so, in the context of Eastern Europe as the lack of large highly specialised consultancies creates a niche for academics as "special problem-solvers". The uptake of this role by the academics in Eastern (and Southern Europe) is further necessitated by the insufficiency of research funding by national or international bodies.

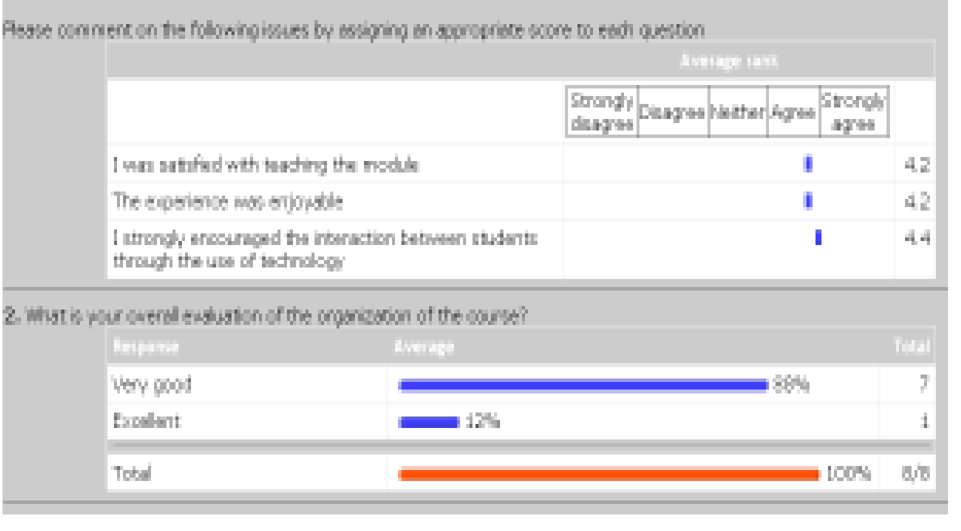

Figure 6. Typical teacher/student assessment questionnaire (figures at right express average scores)

4. OVERALL COURSE ASSESSMENT

There is clearly a need to monitor, evaluate, assess and reflect on the material, course development and delivery and student feedback and assessment. The very aspects of e-learning suggested as positive characteristics here (including the link to research, the organic, flexible development possibilities and the customised navigation of the student through course material) could potentially be problematic. To address these concerns, both internal and external Quality Assurance teams have been set up to undertake evaluations at regular intervals. One result of such an assessment is shown in Figures 6-8. In general, the course assessment by the students found that:

- Students were in principle satisfied with the course and the educational content of the modules
- Despite the heavy workload, deadlines did contribute in keeping the students up to date with the module material before the examinations.
- Quizzes were useful in understanding educational content
- The course face to face examinations were quite reasonable

12. What was the most satisfying part of the course?

#	Response
1	Ability to use some other means of presenting the teaching material. The Moodle system itself.
1	Being able to develop the lecture anytime anywhere, and allow it to grow gradually Being able to respond to students questions anytime anywhere which is compatible to my research work schedule.
1	Final presentation of Mini theses
1	The direct communication with the students
1	The introductory week in Belgrade
1	water treatment technoogies.

Figure 7. Typical teacher assessment questionnaire

A key issue that was identified as a source of stress for the students was the potential non-interactivity by tutors (and vice versa), which was hard to manage given the remote location aspects of the course. In other words, due to the inability to physically meet the tutor (or student) the course was often unable to "enforce" the required interactivity, in the cases when the required self-motivation failed. It is hence concluded that e-learning does come with a prerequisite of self-motivation by both tutors and students albeit this self-motivation can (and should) be supported by a rigorous quality assurance through formal procedures of the academic board, better and more interesting material and topics as well as innovative and imaginative teaching and exercises. In that, it is not that different from face to face courses.

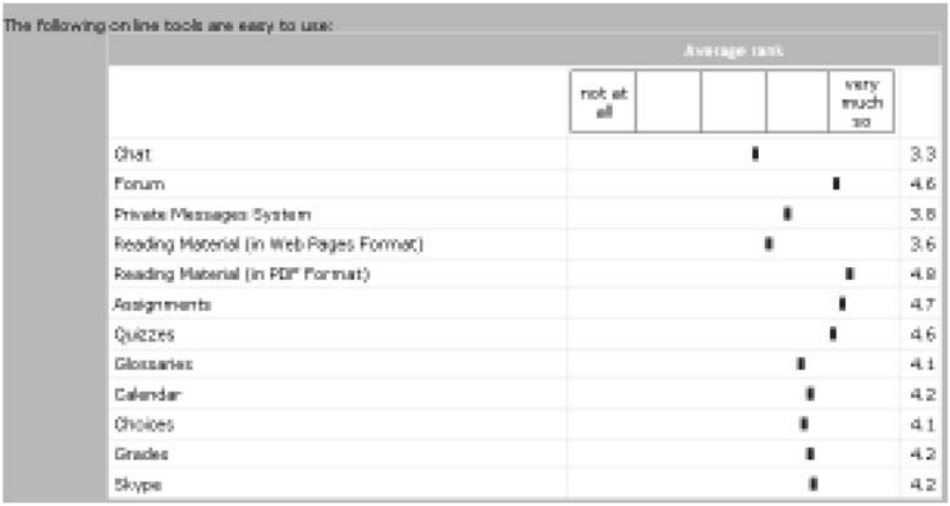

Figure 8. Assessment of platform tools
(figures at right express average scores)

5. NEXT STEPS: WEB 2.0

As technologies evolve, frontline applications such as e-learning should be expected to change with them. Web 2.0 is conceptual term that is often used to describe "*an expected second generation of Web that allows people to create, publish, exchange, share, and cooperate on information in a new way of communication and collaboration*" [11]. A main aspect of Web 2.0 that is of interest in e-learning applications specifically is the issue of connectivity. The Educate! Programme is currently considering evolving its e-infrastructure towards more interconnected modes, including integration with social networking platforms (such as elgg: http://elgg.org/) wikis and groups, outside the strict boundaries of the course. The rationale is that there is a growing community of research, education and practice, developing new knowledge through formal and informal functions that the Educate students should be able to tap into.

Already, students are able to use social bookmarking (through the use of delicious tags: http://delicious.com/) from within the Educate platform to highlight content of interest (e.g. for an assignment) to their fellow students and their tutors. Figure 9 presents an example of using the tagging approach to visually improve important messages and enhance interpretation potential. In this case we simply used as tags the words of this paper (using software from http://tagcrowd.com), but a student "tag cloud" would associate the tags with shared web content. As connectivity (with people and content) improves, there is a greater potential for intelligent learning – far beyond what was possible through traditional media and teaching techniques.

Figure 9. An example of a tag cloud

6. CONCLUSIONS

The authors of this paper are academics within the engineering discipline and not experts in education per se. This dichotomy between the de facto role of educator and the lack of formal education on education, as identified in [6], which is particularly evident in all academic disciplines of the physical and engineering domains, naturally results in a more "experiential" approach to the question of e-learning and its handling within our work. Although formal theoretical treatment (from an Education Theory perspective) of much of the discussion in this paper is perhaps wanting, it is hoped that the hands-on experiences (of the learning-by-doing type) that it brings on the table, are still wanted [6].

It is important to note that although e-learning, multi-institutional MScs, Bologna and ECTS credits are all attempting to increase the transferability, modularity and ultimately flexibility of Education in Europe, this is still very much a period of transition and thus far from ideal. Thinking and practice are moving in a rapid pace, technology is (as always) moving with lightning speed, but the inertia embedded in the process of a meaningful transformation of the educational process itself should not be underestimated.

7. ACKNOWLEDGEMENT

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8. DISCLAIMER

Parts of this chapter have been included in an earlier paper by the same authors [6]. That earlier publication was addressed to a different audience and did not include any discussion on course assessment nor did it include our current thinking towards Web 2.0 concepts and practices.

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THE SCHOLARSHIP OF TEACHING: A CASE IN ENVIRONMENTAL GEOTECHNICS

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ABSTRACT

After a short introduction on the framework of the scholarship of teaching and on the thematic field of Environmental Geotechnics, this article presents elements of an environmental geotechnics course developed within this framework. The article highlights in particular educational material informed by research on learning, such as questions developed to probe student understanding of key concepts and interventions designed to address identified misconceptions. The article also discusses how is modeling incorporated in instruction, an innovation made possible by prior research on the task of modeling and by the existence of an educational software that facilitates comparison of alternate modeling decisions. In addition, the article describes demonstrations that complement instruction and assignments that test student ability to apply material from the course in a wider context. Claiming that the scholarship of teaching must become a collective undertaking, in order to bring about improvements in education that take into account results of research on teaching and learning, the article concludes with recommendations that enable contributions from the wider academic community.

1. INTRODUCTION

Neither the wider academic community, nor the education research community has succeeded in developing transferable educational "technologies" as successful as the textbook, despite the availability of numerous computer-based and web-based applications. While very few faculty members undertake writing their own textbook, all are on the lookout for a good textbook and exchange with colleagues relevant comments and experiences. If we make the popularity and the transferability of textbooks measures of success of educational materials produced, then we must also create avenues for publicity.

This article seeks to encourage public sharing of experiences engineering instructors may have with successful introduction of educational materials in their courses (see Sections 2.4 and 2.5 for examples). The article is written with two audiences in mind. First, instructors of courses on environmental geotechnics and related subjects, who may find some of the material presented herein useful for their own class (this audience may be more interested in

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Sections 2.1, 2.3.2, 2.4 and 3). Second, engineering instructors who may draw analogies with their own course and who may, as a result, get motivated to share their own tactics in enriching their classes (Sections 2.2, 2.5 and 4 may be of more relevance to this audience). It is hoped that both audiences may eventually contribute publicly to identifying needs in teaching specific engineering topics and to showcasing interventions developed by them or others.

The aforementioned contributions are not customarily thought of as an integral part of faculty public duties. For a change of this mindset, two breaks from tradition appear necessary. The first is taking university teaching beyond the confines of a group affair, the group including the instructor and the enrolled students, and into a public sphere, similar to how research is conducted. The second needed change is providing the "stage" necessary for the public aspects of teaching to become visible. This latter requirement will be discussed at the summary section of this article. The former requirement has been advocated through the framework of the "Scholarship of Teaching", which is the topic of the next section.

1.1 Scholarship of teaching

The scholarship of teaching has been discussed and supported for the last 20 years in the writings of key figures in tertiary education, such as Ernest Boyer (1990) and Lee Shulman (e.g. Hutchings and Shulman 1999), to be elaborated most recently specifically for engineering education (Shulman 2005; Borrego et al. 2008). Collectively, these authors present their ideas in a continuum that covers teaching, scholarly teaching, the scholarship of teaching and research in engineering education. The following clarifications are adopted from Borrego et al. (2008). *Scholarly teaching*, except from good content and teaching methods, involves classroom assessment and evidence gathering informed by best practice. It also encourages collaboration and review. The *scholarship of teaching* is public, open to critique and evaluation, and results in products that others can use and build on. Moreover, it involves inquiry and investigation, focusing particularly on student learning. Finally, *research on engineering education* shares the characteristics of scientific inquiry: it poses research questions, interprets the results in light of theory and pays attention to the design of the study and the methods used. It is encouraging to note here that, with time, research on engineering education is increasingly carried out by discipline-based education researchers (including engineering faculty), who are not or at least have not started as cognitive scientists or education specialists, following a trend already observed in physics education (Redish 2000).

It must be made clear that the arguments in favor of university professors becoming more open with their teaching are not confined any more to publications and institutions that deal solely with education, such as education journals and education foundations. Among the most authoritative voices joining in the support for a scholarly attitude to teaching is that of Derek Bok

(2006), past president of Harvard University for over 20 years, who encourages professors to deal with issues of quality university education with the same care they confront propositions in their own scholarly work. Most relevant to the present article, Bok (2006) notes the neglect on the part of faculty members to take into account research on teaching and learning in preparing their classes. Increased use of computers and the Internet can be considered to be improvements of the delivery medium, which do not though lead automatically to improvements in learning (Dutton et al. 2001; Steif and Dollár 2009).

Within this framework as a background, the instruction of an environmental geotechnics course is discussed by highlighting application of best practices and describing activities and interventions developed specifically for this course. The next section gives a short introduction on the thematic field of Environmental Geotechnics, for the benefit of a reader unfamiliar with it, before the article focuses on the particular course.

1.2 Environmental geotechnics

The thematic field of Environmental Geotechnics, or Geoenvironmental Engineering, combines principles from contaminant hydrogeology and geotechnical engineering to address problems related to the protection and restoration of the geoenvironment. Typical applied problems include subsurface characterization, soil and groundwater remediation, as well as waste containment. Courses on Environmental Geotechnics are commonly offered either as elective courses in undergraduate civil engineering curricula, or as graduate courses. An environmental geotechnics course may focus more or less on the geotechnical aspects of waste containment, depending on the background of the instructor and on the academic unit (geotechnical or environmental) offering the course. Hence, course contents are expected to place different weight to the various topics of Environmental Geotechnics. However, as it will be discussed below, contents only partially mirror a course in the absence of detailed learning outcomes.

2. AN ENVIRONMENTAL GEOTECHNICS COURSE AT NTUA

The author of this article is an instructor of an environmental geotechnics course, which she has strived to develop, deliver and disseminate within the framework of the Scholarship of Teaching. She has been teaching comparable versions of the same course, as a graduate or advanced undergraduate course in two institutions in the US and Greece, for 14 years. The current version of the course is taught at the final year of the five-year undergraduate civil engineering curriculum of the National Technical University of Athens (NTUA), Greece. At the School of Civil Engineering at NTUA, the first six semesters are common for all students. During the remaining semesters, students enroll in increasingly fewer common courses, concentrating more and more on courses from one of four specializations: structural, transportation, hydraulic and geotechnical engineering. During the last semester, students work on their thesis, typically in the area of their specialization. Upon graduation, students are awarded a common degree in Civil Engineering, regardless of their elected emphasis.

For the 9^{th} semester of the geotechnical specialization, students must choose four courses from six core electives: environmental geotechnics is one of these six electives. For the students of the other three specializations, environmental geotechnics is an elective belonging in a wide pool from which students choose 1 to 3 courses. The combined result of curricula constraints and course scheduling is that the majority of the enrolled students belongs in the geotechnical specialization, with a small representation of students from the hydraulics specialization. Hence, enrollment varies with the temporal popularity of the geotechnical specialization and ranges between 30 and 50 students.

In summary, the environmental geotechnics course described herein is an advanced undergraduate course, taught to 5^{th} year civil engineering students, most of whom have completed a sizeable number of geotechnical courses. While all civil engineering students have courses on engineering geology (two courses), soil mechanics (two courses) and foundations, students following the geotechnical specialization also have completed a course on experimental soil mechanics, and, most of them, on soil improvement and soil-structure interaction as well. Because the students have the maturity expected in master-level programs, the instructor can design a suitably challenging course, without diverting time to bringing all students to the same level, since they have all followed the same basic curriculum.

2.1 Learning outcomes

The course has been designed from an applied perspective. Given that environmental geotechnics is an applied topic, the course includes the basics needed so that a civil engineer with the background of the course can contribute to the characterization and remediation of a contaminated site or to the design of a landfill liner.

The aim of the course is described in terms of learning outcomes that guide all assessment activities, both for diagnostic purposes, in quizzes and in-class activities, and for final grading. The detailed statement of learning outcomes also enables other instructors to judge whether material developed may be of use to their courses, an evaluation that cannot be made on the basis of course contents alone. This is an important point that will be revisited at the closing of this section.

The overarching goal of the course is to develop environmental thinking related to (i) assessing the severity of a contaminant release in the subsurface, (ii) recognizing the physical-chemical-biological mechanisms that affect the fate and transport of the released contaminant and, (iii) selecting appropriate remedial measures and/or technologies. The goal of the course is mapped to the learning outcomes listed in Table 1. Course contents are listed in Table 2.

Table 1. Learning outcomes of environmental geotechnics course.

The goal is achieved if at the end of the course the students:	
(1)	can locate reliable data on the effects of contaminants on human health;
(2)	are confident in applying principles of groundwater flow, mass transfer and solute transport to problems of contamination and restoration of the subsurface;
(3)	are able to address the geoenvironmental aspects of landfill and clay barrier design;
(4)	are familiar with a wide range of remediation technologies;
(5)	are able to take initiatives related to modeling, i.e. related to the formulation of a simplified problem that admits solution;
(6)	are aware of some social or public policy dimensions of the problems of subsurface contamination and restoration.

Table 2. Contents of environmental geotechnics course taught in respective semester weeks

	Topic	**Week**
1	Cases of contaminated & remediated sites	1
2	Legislation	2
3	Sources and characteristics of contaminants	2
4	Risk assessment	3
5	Groundwater flow, unsaturated flow, multiphase fluid flow	4-6
6	Soil-contaminant interaction	7
7	Mechanisms affecting the fate of contaminants	8
8	Solute transport applications (includes practice in the use of educational software in the School's computer lab)	9-10
9	Landfill liner design and materials	11
10	Remediation technologies for contaminated sites	12-13

It is apparent that there can be no one to one correspondence between a set of learning outcomes and a set of course contents. For instance, the particular learning outcomes listed in Table 1 specify different levels of student performance for each sub-goal (are aware… familiar… able… confident). In addition, some key sub-goals can be further prescribed in terms of level of performance (e.g. see discussion of modeling performance in Section 2.5). Hence, both sets are needed to fully describe a course and allow instructors to judge similarity of courses with the same name or with a comparable list of contents.

2.2 Probing students' understanding

During the planning stage of a course, it is recommended that the instructor come up with techniques to identify the pre-formed concepts that students bring to instruction. At this point, it is necessary to differentiate between contents of prerequisite courses, nominally the same for every student progressing through comparable curricula, and concepts formed by each student as a result of prior instruction, even before college, and often in combination with everyday life experiences.

The distinction between contents of prerequisite courses and pre-formed concepts is important for all domains and particularly so for many branches of engineering. Civil engineering is part of everyday life: we all have many personal experiences with soil and with moving water, while most have seen landslides, cracks in buildings, etc. This is a feature civil engineering shares with physics, for which education research has shown that students of all ages enter courses with mental constructs of some explanatory power as to how things are or work (Redish 2000). To these constructs, new constructs are continuously added throughout formal education, with better or worse fit or, even, in unidentified conflict. Instruction must start with identifying loose-fitting or conflicting concepts, if it aims at bringing about solidly founded change. Unfortunately, assessment in engineering courses is based primarily on problem solving and analysis. Rarely does assessment investigate the nature of concepts formed by students or how do students synthesize related mental constructs and concepts. Tellingly, Montfort et al. (2009) found no significant improvements in conceptual understanding of key mechanics concepts among students in early and late years of an undergraduate civil and environmental engineering curriculum, as well as at the graduate level, despite improvements in their computational skills.

At some point in their careers, instructors invariantly experience bafflement at some of the errors made by students. Most experienced teachers, with time, develop strategies to minimize the frequency of these errors. Few instructors, however, can enunciate a systematic methodology for determining the misconceptions underlying the errors and, ideally, making suitable instruction modifications. Bowden and Marton (1998) discuss a number of studies that have developed qualitative questions to diagnose "pre-conceptions" (what students bring to instruction) and misconceptions, monitor understanding and assess impact of instruction. In fact, Bowden and Marton (1998) consider formulating suitable qualitative questions as the key undertaking in finding out what is learned by students. More importantly, these questions often serve as mirrors that reveal to the students themselves how they have organized knowledge. The remaining of this section gives examples of questions and corresponding misconceptions, while interventions designed to address identified misconceptions are discussed next (Section 2.3).

The questions developed to probe students' understanding deal with topics such as groundwater flow, soil structure, as well as key components of mass transfer and contaminant transport. The answers of the students can feed discussions in subsequent courses, where students are invited to comment on them. Sometimes, class discussion takes turns that suggest further topics and questions suitable for exploration. The author's experience has shown that while some misconceptions can be anticipated, others come as a complete surprise, as will be discussed below.

2.2.1 Groundwater flow

Students come to the environmental geotechnics class with a course in hydraulics and the groundwater flow component of a soil mechanics class. To gauge the degree to which students have integrated elements from prior instruction, a basic question is asked in two alternative ways:

"What makes (ground) water move? Under what circumstances does water remain immobile?"

This question is asked at the very beginning of the course. The answers compiled through the years are being "played back" to the students for comments when concluding instruction on groundwater flow.

The answers to this simple question reveal several half truths and misconceptions. The non-technical phrasing of the question frees many students to revert to what they really believe as true, despite what they have learned and even remember as being correct. Many students simply answer "gravity" or "pressure", although the same students can give the correct form of Bernoulli equation, with all three components of gravity, pressure and velocity. This is evidence of superficial integration of concepts.

Even students who invoke hydraulic head fail to grasp the generality of the concept, as evidenced by answers that read as follows. "Groundwater moves due to differences in hydraulic head between two points. In addition, water also moves as a result of capillary phenomena." Or, [groundwater moves due to] "difference of energy levels between two points, plus capillary phenomena". The students fail to appreciate that hydraulic head encompasses capillary phenomena through corresponding changes in water pressure. One student even forgot the hydrostatic distribution, and answered to the second question "when the permeability of the soil is very small".

2.2.2 Contaminant sorption to the solid phase

The questions that never fail to reveal students' beliefs are those asking for preferences or judging whether something is "good" or "bad", without alluding to potential criteria used for judgement. For example, we may ask for a parameter X, related to a phenomenon or a property Y, “do you prefer X to have a high or a low value?”, in order to probe students’ understanding of Y and its implications. Such a question was asked about the partition coefficient, or distribution coefficient, which relates the concentration of a dissolved contaminant in groundwater to the concentration of the contaminant sorbed to the solid phase, provided that equilibrium is assumed between the aqueous and solid phases. The answer of a student reads as follows. “Because we cannot decontaminate the solid phase, we prefer to have a larger proportion of the contaminant mass dissolved in groundwater rather than sorbed to the solid phase” [and hence we prefer a small partition coefficient]. In a theoretical world, where equilibria are instantly achieved, the student’s answer would be “wrong”. In reality, the student has grasped an important point for remediation. However, the student did not consider a contaminant release scenario, where a lower partition coefficient corresponds to lower retardation factor and, hence, faster spreading of the contaminant.

2.2.3 Nature of dissolved contaminants

This final example did not originate from a probing question phrased by the instructor, but instead came about serendipitously in class. In a discussion about contaminated water moving in the unsaturated zone, the following analogy to watering a flowerpot was used. “We know that if we give just a little water to the plant, all water is held in the soil pores. As we give more water, it finally drains through the bottom of the pot. Like in a flowerpot, if a large volume of contaminated water escapes, it will finally reach the water table”. At this point, a student remarked that the analogy was not a good one, because at a contaminated site the movement of [contaminated] water would reduce the permeability of the soil. This remark baffled the author of this article, as it could not be accounted for by the “half truths” revealed by her students in earlier years. Upon further questioning, it became evident that the student’s mental construct for contaminated water was akin to water carrying the dissolved contaminants like solid particles in suspension (when unraveling the confusion reached this point, then the instructor identified similarities with misconceptions of other students). This mental construct makes the remark understandable: as this imagined contaminated water flows through soil, the particle-like molecules of the contaminant get stuck in soil pores, gradually clogging them and, hence, reducing permeability.

The examples in Sections 2.2.1 to 2.2.3 show that when students are asked to answer open-ended, simply-phrased qualitative questions and are given chances to contribute to free-form discussions, it becomes more probable that they will share their true beliefs about phenomena. This is supported both by the teaching experience of the author and the literature. In fact, some students understand the two different tracks they have been moving and ask “do you want me to tell what I really believe or to give the correct answer”? (Mazur

1997). If the students trust that the instructor does not mean to trick them, they will give candid answers, to the benefit of all.

2.3 Addressing student misconceptions

Some misconceptions are mere misunderstandings, which can be dispelled with some clarifications and carefully chosen terminology. Others are deeply rooted and require targeted interventions. Hence, in addition to the need for phrasing qualitative probing questions, the educational community of each domain must also come up with suitable interventions and then assess their effectiveness. Most probably, help from education researchers will be necessary for a systematic assessment. This section gives two example problems and offers suggestions for addressing them, while stressing the lack of any systematic assessment.

2.3.1 Piezometric surface: a potentially misleading term?

Piezometers are used to measure pressure at the point they are installed. The surface created by the points corresponding to the water surface in each piezometer is sometimes called “piezometric surface” and is depicted on maps with lines of equal elevation. Some textbooks even introduce the term “piezometric head” for the sum of pressure head plus elevation head (e.g. Munson et al. 2002, page 134). At the water surface in a piezometer, the water pressure is zero (atmospheric). Hence, the height of the column in the piezometer is the total hydraulic head at any point within the piezometer, including the point within the aquifer it was installed. In other words, piezometers give us all the information we need to tell where is water flowing within the aquifer. Now, a casual reference to the above may also leave a student with the impression that, since we use the piezometric surface/head to study the movement of water, pressure is the quantity that determines how water moves or, in simple terms, “makes water move”. At this point, this is a hypothesis, which becomes though an even more probable scenario for Greek students, to whom the Greek-origin terms “piezometer” (πιεζόμετρο = pressure meter), “piezometric surface” and “piezometric head” are more easily understandable in their literal sense. In view of the number of students who consistently answer “pressure” to the question “what makes water move”, the author recommends that the terms “piezometric head” and “piezometric surface” be not used. To replace the latter, the term “surface of equipotential lines” is preferred or, if something shorter is absolutely necessary, “potentiometric surface”.

2.3.2 Soil structure

Student understanding of the concept of soil structure has already been discussed elsewhere (Pantazidou 2009). Only a brief summary will be provided herein, in order to demonstrate the guidance provided by the analysis of the students' answers for implementing suitable interventions. The relevant probing question used reads as follows:

"In your opinion, in which soil type may we encounter higher porosity, in a sand or a clay? How do you justify your opinion?"

Students are further advised to support their answer mainly with personal observations (e.g. from everyday-life experiences with soil/dirt, such as playing with beach sand, or from an activity in the soil mechanics laboratory) rather than by what they can recall from instruction. The students' answers were an overwhelming "vote" for sand (28 answers for sand versus 11 answers for clay). It is instructive to identify the categories of the arguments used by the students. Most students give explanations based on observations related either to the large size of sand pores, or to a few physical characteristics of soils (e.g. sands flow), including a measure of the easiness of water flowing through soils (i.e. permeability).

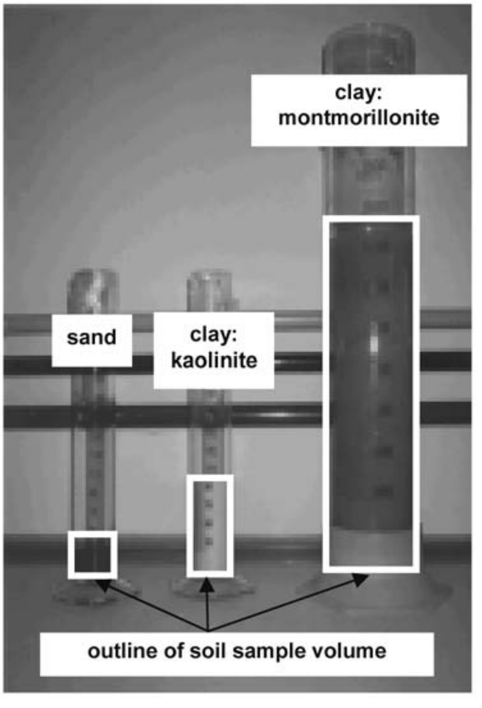

Figure 1. Soil samples produced through settlement of 40 grams of: sand, kaolinite and montmorillonite, with porosity values equal to 0.44, 0.85 and 0.99, respectively (Pantazidou 2009)

The identification of a misconception together with the identification of the justification for the misconception allow the instructor to design suitable interventions. For this particular misconception, the author built experimental models made of sand and clays. Specifically, three soil samples were created in volumetric tubes through settlement of the same weight of dry solids of sand, kaolinite and montmorillonite, which reached a final porosity of 0.44, 0.85 and 0.99, respectively (see Figure 1). Hence the students have a concrete example of two clays with much higher porosity than sand.

In addition, two pore models are introduced in class. One model compares two cubic arrangements that (i) are made of same-size spheres of two different diameters and (ii) have the same porosity: this model is an attempt to address the misconception that soils with larger pores also have larger porosity. In the other intervention, two soil columns are modeled as a bunch of cylindrical tubes. The columns have equal porosity but unequal permeability: this model is an attempt to address the misconception that soils with larger porosity always have larger permeability. For further details on the models, the reader is referred to Pantazidou (2009). As far as using the interventions in class, what has been most successful is incorporating the models in course components (lectures, assignments) throughout the semester. Then, at the conclusion of instruction on clay structure, the instructor can ask students to critique arguments given by students in previous years on the clay-sand question (Pantazidou 2009). These are mere suggestions at this point, however, since the success of the interventions has not been systematically assessed.

2.4 Materials developed/used in class

Up to this point, the discussion focused on probing student understanding of specific concepts and seeking solutions to address related misconceptions. This section discusses three in-class "experiments", developed mainly to enliven instruction (2.4.1 to 2.4.3), an analogy between rubber duck races and mechanical dispersion (2.4.4) and one existing visualization tool (2.4.5), the likes of which are very much needed in instruction.

2.4.1 Solute transport phenomena discussed with the aid of instant coffee

This demonstration is related to a set of probing questions asked at the very beginning of the course (together with the groundwater question of 2.2.1). The questions read as follows:

"(A1) Describe what happens (or what we observe) when we add a few granules of instant coffee in a glass full of water, without disturbing the glass in any way. (A2) If you happen to know, write the name of the physical mechanism accounting for what we observe."

"(B) If we stirred with a teaspoon the glass of the previous question, how would your answers to (A1) and (A2) change?"

Depending on the flow of class discussion, the demonstration with instant coffee is made at the beginning of the class, when some students reply "diffusion" to (A2) – while no one has ever answered advection to (B), or/and at the beginning of instruction on solute transport, when the connection of the spoon stirring with advection has more chances to stick. This simple experiment is easy for any student to repeat at home. Here it must be added that the instructor has repeated a few times the experiment in her kitchen, but never managed to get a completely homogeneous distribution of coffee in the unstirred glass by diffusion alone: a more intense brown color still remains close to the glass bottom by the time when a lot of the dilute coffee has evaporated and the glass must be washed to avoid risking permanent stains.

2.4.2 Mass transfer in shot glasses

Instruction on mass transfer and equilibria between phases is one of the most rewarding parts of environmental geotechnics, because it affords the possibility to unify in a single framework various phenomena students are very familiar with from prior instruction and everyday life experiences, such as evaporation and dissolution. Students have no conceptual difficulty starting from evaporating fluids and equilibrium between (a) a gas and a pure liquid, and then move to equilibria between pairs of (b) a gas and a mixture of liquid organic contaminants, (c) a gas and contaminated water, and (d) water and nonaqueous phase liquid (NAPL) or water and NAPL mixtures. Some students, however, initially at least, have difficulty in including in the same framework equilibria between liquids/gases and a solid phase. A demonstration with various liquids in shot glasses (Figure 2) can help with the transitions from familiar to unfamiliar interactions between phases.

Figure 2 shows the shot glass collection used in class. From left to right, we have (a) corn oil, (b) a mixture of corn oil and olive oil, (c) an aqueous solution of corn oil and (d) the immiscible pair of water and corn oil. Each shot is discussed separately to make the connection with the corresponding parameter, namely, vapor pressure [for pure liquid in (a) and liquid mixtures in (b)], Henry's Law constant [for (c)] and solubility [for (d)]. The affinity of each phase for its neighbor is associated with high values of the corresponding parameter. Then the instructor can ask:

“We explored how each phase interacts with its neighboring fluid. How about the neighboring glass? Any interaction with the glass walls?”

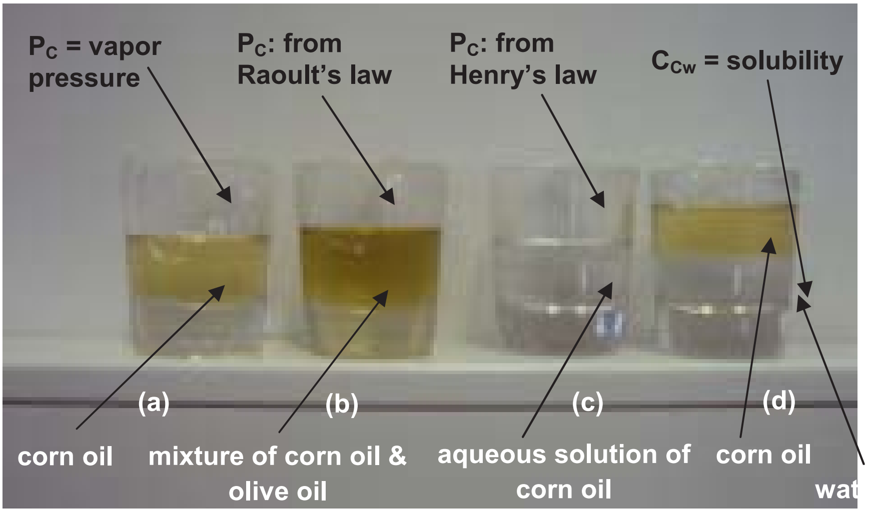

Figure 2. Shot glasses demonstrating possibilities of phase interactions and making the connection with respective physicochemical parameters (P_C = pressure of corn vapors in the gas phase, C_{Cw} = concentration of corn oil in the aqueous phase).

If these questions fail to draw any response, then the instructor may point to the students what happens when we try to wash (by hand, not in the dish washer!) tupperware used for storing greasy/oily food (lots of detergent and several passes with the washing sponge), before asking:

“What about the interaction between the greasy juices of the food and the plastic walls of the tupperware?”

At this point several students start nodding, realizing the inconvenient affinity of oil and grease for plastic food containers.

There is no denying that these demonstrations and questions could appear, at first, a little trivial for an advanced engineering course addressed to high-achieving 22- and 23-year olds. That’s why they are perhaps best presented with a dose of amusement, as if saying “come on, indulge me with something really too simple for you”. The students catch on and, whether they learn better or not, the resulting atmosphere in the class is very pleasant.

2.4.3 In-class "transport experiment": "sorption" affects mobility of chocolates

This demonstration requires some planning, as the instructor must purchase in advance a good number of individually wrapped bite-size chocolates. It is easier to follow the description of the experiment having in mind a typical longish NTUA classroom, as the one shown in Figure 3: a classroom with several rows of tables, each row having three tables with aisles on all sides. Chocolates move through tables with specific rules towards the back of the classroom. Their progress is tracked in time steps.

Variation No 1 of the experiment goes as follows. At time zero, the tables at the front row receive the same number of chocolates, say 12. During the first time step, one front table gives to the table behind ¾ of its chocolates (9), keeping 3 [the ratio (chocolates retained)/(chocolates passed on) is 1:3 and, for the experiment's purposes, corresponds to a partition coefficient $K_p/3$]. The middle front table gives to the table behind ⅔ of its chocolates (8), keeping 4 [the ratio (chocolates retained)/ (chocolates passed on) is 1:2 and corresponds to a partition coefficient $K_p/2$]. Finally, the third front table gives ½ of its chocolates (6), keeping 6 [the ratio (chocolates retained)/(chocolates passed on) is 1:1 and corresponds to a partition coefficient K_p]. This is repeated at subsequent time steps, with each row receiving (with the exception of the front) and giving, rounding up chocolates passed on to the next integer. Students are asked to keep track of the number of chocolates at their desk, which is used to complete a table on the board, showing the progress of the experiment (see Table 3). After a few time steps, it is clear that chocolates have moved faster through the tables with the lowest partition coefficient. Using proper solute transport terminology, these chocolates are more "mobile".

Table 3. Variation No 1 of in-class transport experiment. The number of chocolates corresponds to contaminant concentration. At the front table (tbl) of each row, which corresponds to a contaminant source, 12 chocolates appear at time T=0. The experiment proceeds in 4 time steps, showing the effect of partition coefficient on contaminant spreading in space with time.

Chocolates on tables																	
Side column of tables						Middle column of tables						Side column of tables					
Partition coefficient ⅓K_p						Partition coefficient ½K_p						Partition coefficient K_p					
	T=0	T=1	T=2	T=3	T=4		T=0	T=1	T=2	T=3	T=4		T=0	T=1	T=2	T=3	T=4
tbl.1	**12**	**3**	**1**	**0**	**0**	tbl.1	**12**	**4**	**1**	**0**	**0**	tbl.1	**12**	**6**	**3**	**1**	**0**
tbl.2		**9**	**5**	**2**	**0**	tbl.2		**8**	**5**	**2**	**0**	tbl.2		**6**	**6**	**5**	**3**
tbl.3			**6**	**5**	**3**	tbl.3			**6**	**6**	**4**	tbl.3			**3**	**4**	**5**
tbl.4				**5**	**5**	tbl.4				**4**	**5**	tbl.4				**2**	**3**
tbl.5					**4**	tbl.5					**3**	tbl.5					**1**

Instructors preferring to avoid the time needed for calculating fractions may favor an alternative experiment. In variation No 2, tables in each row keep (for ever) a fixed number of chocolates and give the rest to the table behind. This variation requires more chocolates. Say that we start with 24 chocolates in each front table. One column of tables keeps 2 chocolates (partition coefficient K_p), the middle column keeps 4 chocolates (partition coefficient $2K_p$), while the third column keeps 6 chocolates (partition coefficient $3K_p$). Figure 3 shows variation No 2 at the 2^{nd} time step, when the tables at the "contaminant-chocolate front" of the third row have 18 (K_p), 12 ($2K_p$) and 6 ($3K_p$) chocolates. Granted, variation No 2 is an even less faithful representation of solute transport, compared to variation No 1. However, students have no difficulty seeing the analogy with contaminants retarded due to sorption. In fact, upon returning the few unconsumed chocolates after the last time step, students have commented that the experiment not only models sorption but solute decay as well!

Figure 3. Variation No 2 of in-class solute transport experiment: chocolates move faster through tables with lower partition coefficient K_p

2.4.4 A …literary explanation for mechanical dispersion

Writer David Lodge (2002) provides in his book "Thinks…" a very good analogy for mechanical dispersion. British academic life provides the backdrop to this comedy of manners. At some point in the novel, a raffle is organized in a way made possible by …mechanical dispersion! Raffle participants buy numbered tickets. The day of the raffle, numbered rubber ducks are dropped from a low bridge over the stream flowing through the campus of the novel. All rubber ducks start at the same time, but surely enough some go faster, some are left behind, just as dispersing contaminant molecules. When the first duck arrives at a set downstream point, the holder of the ticket with the same number has won the raffle. Now, of course, one could tie all the rubber ducks together to demonstrate advection (and ruin the raffle). It should be added that the analogy's literary pedigree may be questionable since, according to Wikipedia (2010), rubber duck races are internationally popular for charity purposes. In any case, duck races provide a very suitable introduction to key solute transport phenomena. It would be ideal if the verbal description of the duck race was accompanied in class by pictures of the race at various times, showing the distance between the first and the last duck continuously increasing, similar to what happens with time to the tails of the contaminant distribution. A search on the Internet for "rubber duck race pictures" gives many delightful pictures but not really suitable for educational purposes, since they do not focus on tracking duck dispersion with time.

2.4.5 Visualizing the relative contribution of transport phenomena

This class activity consists of using three videos, which are supporting material of the article by Zinn et al. (2004) "Experimental visualization of solute transport…", published in the scientific journal "Environmental Science and Technology". The videos show water displacing dye in a thin transparent chamber modeling heterogeneous porous media with areas of contrasting properties. Different contrasts are used in order to highlight the relative importance of transport mechanisms and their effect on tailing (or "total remediation" time). The chambers consist of a matrix of glass beads with conductivity K_m, containing circular emplacements of smaller glass beads with lower conductivity, K_e. Three conductivity contrasts are used: (i) $K_m = 6 \times K_e$, (ii) $K_m = 300 \times K_e$, (iii) $K_m = 1800 \times K_e$.

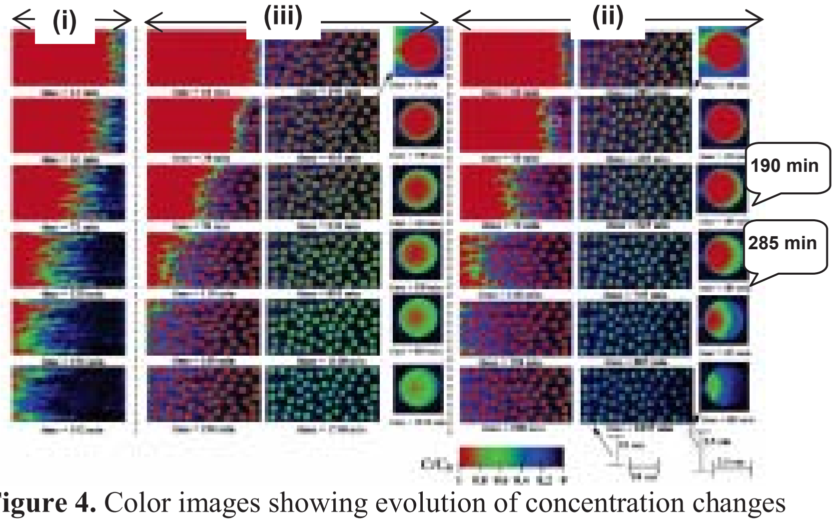

Figure 4. Color images showing evolution of concentration changes as a function of time in three chambers with circular emplacements of lower permeability: (i) 6 times lower, (ii) 300 times lower, (iii) 1800 times lower (Zinn et al. 2004, reprinted with permission by ACS)

Figure 4 shows a still picture of the video from the three chambers and zooms in selected emplacements. Flow takes place from right to left. Notice that after about three hours, chamber (i) is almost entirely clean (darkest shade prevails). At the same time, in chambers (ii) and (iii) the high permeability matrix is clean, while the low permeability circular inclusions still have high dye concentrations. As time passes, the effect of the different contrasts becomes more apparent. In chamber (ii), slow advection through the emplacements cleans the dye, as evidenced, for example, by the crescent-shape of the clean portions of the inclusions at t = 190 and 285 min. In contrast, in chamber (iii) the dye moves slowly out of the emplacements due to diffusion, as evidenced by the progressively bigger, mostly symmetrical cleaner outer ring of the inclusions. Each video lasts a few minutes. After the videos are over, the relative contribution of transport phenomena is further discussed with the aid of a PowerPoint presentation with additional results from Zinn et al. (2004). The effect of the contrast of conductivities in the three chambers is reflected in the breakthrough times of essentially clean water. Chamber (i) is practically clean after flushing 2 pore volumes. In contrast, significant tailing is observed in the breakthrough curves of the other two chambers: chamber (ii) requires flushing of 8-10 pore volumes, while chamber (iii) needs more than 12.

Many students look transfixed while watching the videos. A few times they have asked to watch the videos for a second time. This receptiveness of the students underscores the importance of supporting the development of research-quality visualization tools for education.

2.5 Modeling instruction

Although modeling of physical systems is a key engineering task, the educational literature provides little guidance on how to systematically include modeling exercises in instruction. The key role of modeling in geotechnical engineering in particular has been identified by leading researchers and revered teachers in the field (Burland 1987; 2006; Lundell-Sällfors and Sällfors 2000). In order to systematize modeling instruction, an existing modeling framework is used in the environmental geotechnics course. The methodology followed to develop the framework has been described in detail elsewhere (Pantazidou and Steif 2003; Steif and Pantazidou 2004), as well as its use in the environmental geotechnics course discussed herein (Pantazidou and Steif 2008). This article includes only the final outcome of framework development, which can be summarized with the aid of Figure 5, and some more recent experiences with modeling instruction.

Pantazidou and Steif (2003) proposed that modeling can be described (and, presumably, taught) with the aid of the following ten components. Starting from 1) *problem statement*, modeling then requires from us to determine relevant 2) *phenomena*, 3) *parameters* and 4) *variables*. It also entails decisions on elements of solution approach, which include 5) *analysis type*, 6) identification of the *region of interest*, 7) *qualitative form of solution*, and 8) *solution method*. In all of the above, which do not necessarily take place in the linear order in which they are presented, 9) *simplifications* play a very important role. Finally, the modeling task is complete, if it includes some 10) *reflections on decisions*. In the environmental geotechnics course, students are given as a handout Figure 5, which is supplemented with detailed explanatory annotations for each of the ten modeling components.

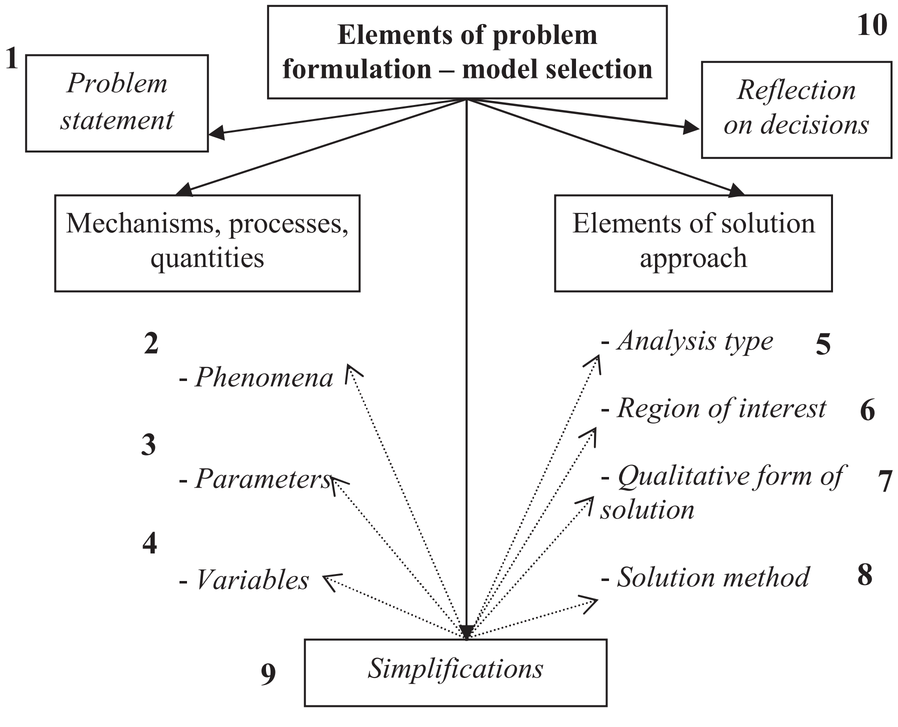

Figure 5. Constituent components of engineering modeling (Pantazidou and Steif 2008)

Perhaps the easiest entry point into modeling for students is approximations. Hence, the first introduction of students to modeling is indirect: a flow problem through a permeable barrier is discussed in class, where an assumption must be made regarding the hydraulic head at the barrier's upstream and downstream faces. In fact, a few different assumptions can be made and students identify most of them during class discussion. Solutions are carried out for each assumption. A few students are appalled by the existence of more than one possible approximations. A few others are delighted with the discussion of alternatives. In the next lecture, modeling is introduced formally, first with the aid of Figure 6 (by Lundell-Sällfors and Sällfors 2000), which shows side by side a real-life partly submerged slope and its geotechnical idealization. (Recall that most of the students enrolling in the class have selected a geotechnical specialization.) Students are then given the modeling handout and are asked to go down the ten modeling components in Figure 5 and identify those relevant to the slope problem in Figure 6. From this point onward, students are given more and more responsibility for shaping the problem they will be solving, rather than focusing mainly on analysis of fully-defined problems.

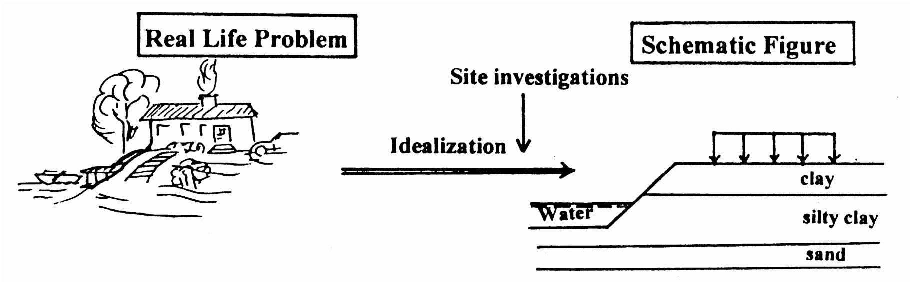

Figure 6. Modeling a real life problem (Lundell-Sällfors and Sällfors 2000).

Problems in environmental geotechnics naturally share similar difficulties with geotechnical problems, e.g. same issues with approximations of geometry and properties, reductions of dimensionality and idealizations of boundary conditions. Moreover, geoenvironmental problems offer a larger menu of phenomena (to take into account or ignore) and of corresponding parameters. In addition, they are characterized by a wider variety of initial conditions, e.g. types of contaminant releases at the source. Hence, as in many applied engineering courses, it becomes a challenging task for the instructor to bring rich "solvable" problems in class. This, in fact, is one of the two main requirements for successful modeling instruction: creating a variety of realistic problems that admit more than one solutions; the other is equipping the students with many alternative solution tools. The latter requirement is best achieved with the use of educational software. The former requirement can be partly met with restating well-defined problems as partly open-ended, paying attention to eliminate as much as possible references to variables and parameters that invariably point to a unique "right" solution.

As an example, Figure 7 shows a fully defined problem and the corresponding open-ended problem statement. The in-class discussion of problems includes first a stage of problem formulation, where students see how many modeling decisions does it take to transform a real-life question, such as (Figure 7a):

- following a contaminant spill in a pond, there is concern whether a downgradient canal may be impacted if no measures are taken to a corresponding fully-defined assignment-type problem (Figure 7b):

- what is the contaminant travel time between the pond and the canal?

- when will 1% of the concentration of the contaminant in the pond reach the canal?

Contaminant transport is an ideal topic to introduce aspects of modeling, as there are many closed-form solutions to the advection-dispersion equation for one, two or three dimensions, for specific conditions at the contaminant source and accounting (or not) for various phenomena (e.g. sorption, decay). The use of partially-defined problems enables selective attention to specific aspects of modeling, which is consistent with learning outcome 5 defined in Section 2.1 (see also next paragraph). For example, some problems are good for deciding which phenomena can be ignored under certain circumstances. Others offer opportunities for considering reductions of the dimensionality of a problem.

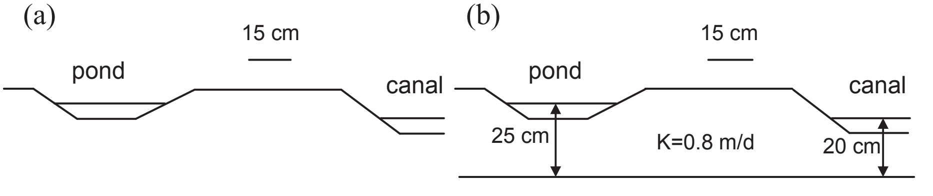

Figure 7. Comparison of (a) a partially-defined to (b) a well-defined problem (Sitar 1985).

As will be discussed below (Section 2.6.1), students also practice anticipating the effects of simplifications, with the aid of numerical modeling and comparisons of numerical solutions at different degrees of idealization with simplified analytical solutions. For this purpose, an interactive web-based (https://netfiles.uiuc.edu/valocchi/gw_applets/) educational software for groundwater flow and solute transport is introduced during instruction in the Computer Lab and used in assignments and for a term project (Section 2.6.1).

The importance of the availability of instructor-friendly and student-friendly software cannot be overstated, both for instruction in general and for modeling instruction in particular. The simulation models used in the course (Valocchi and Werth 2004) provide a prime example of a software developed by instructors who know the needs of teaching and learning. The software consists of a collection of applets that give graphical solutions to a variety of contaminant transport equations and include tutorials with the theoretical background for each equation and its solution. The software is highly interactive. The user can change transport parameters and see immediately their effect on the solution. Figure 8 shows a screen from the applet for the solution of the one-dimensional, advection-dispersion equation for a source of finite duration: the three concentration profiles correspond to different times (t) and different values of retardation factor (R). Most importantly, the developers of the software, believing in the value of their product and the value of disseminating educational material, took the time to publish an article on the software (Valocchi and Werth 2004), which is how this instructor found out about it.

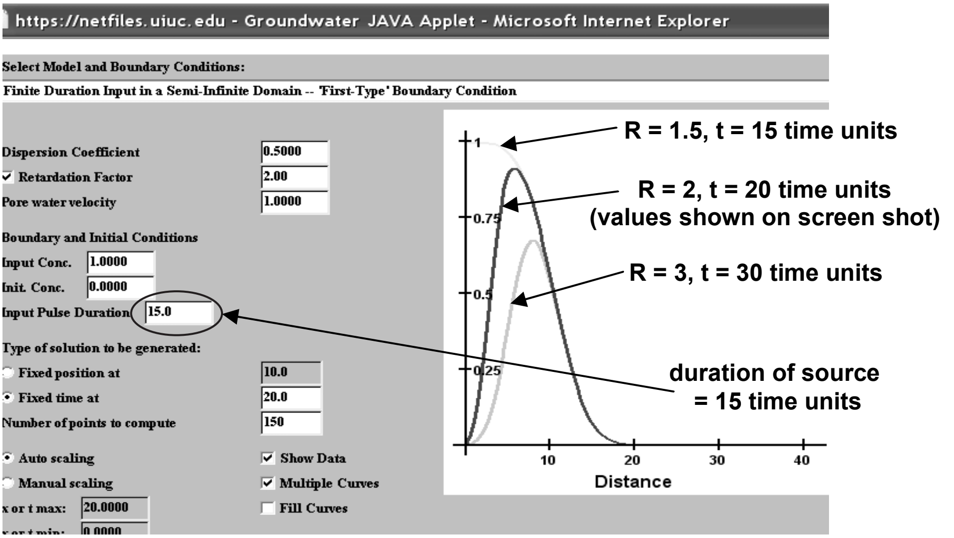

Figure 8. Sample results of interactive web simulation models: concentration profiles for 1-D transport and source of finite duration (https://netfiles.uiuc.edu/valocchi/gw_applets/)

In closing this section on modeling instruction, the learning outcome related to modeling must be further elaborated. Possible learning outcomes related to modeling may correspond to levels of student performance ranging from (i) attending to a few or most aspects of modeling of an open-ended problem, to (ii) producing a fully-defined problem statement accompanied with the information necessary for its solution, the solution itself and reflections on decisions. Based on the fundamental role of simplifications in modeling, and given the supporting role of modeling in the course under discussion, a decision was made to focus performance expectations primarily on familiarity with the simplifications aspect of modeling.

2.6 Environmental geotechnics beyond the classroom

As the course approaches the end of the semester, students must demonstrate that they are able to apply the tools and the concepts of environmental geotechnics to real or realistic problems. To this end, they are asked to work on a term project that requires significant initiative (2.6.1) and an assignment in which they are expected to demonstrate critical skills beyond those of a lay person (2.6.2).

2.6.1 Work on a term project

The term project is designed to primarily test learning outcomes 1, 2 and 5 (see Section 2.1) and also to serve as a rehearsal for consulting work. It counts for 25% of the final grade. Students are asked to perform four main tasks: (1) do some research on a specific industrial activity, (2) select the 1-2 contaminants of most concern for soil/groundwater contamination potentially resulting from that activity, (3) make up a plausible scenario of contaminant release and (4) investigate the fate of the contaminant with the aid of the educational software already introduced in class and discussed in Section 2.5 (Valocchi and Werth 2004). Students work mainly in groups of two, and each group works on a different type of industrial activity.

The list of industrial activities includes mainly installations with significant potential for air, water and land pollution, for which European legislation requires strict measures being taken for pollution prevention (Directive 2008/1/EC). It should be mentioned here that Greece lacks legislation for identifying, characterizing and remediating contaminated sites. The list is supplemented with smaller-scale activities known for creating groundwater problems, such as dry cleaners and car repair shops. Student groups select activities on a first come/first served basis. The aforementioned four tasks require significant research and analysis. To avoid devoting too much time on Task No 1, students are advised to base their project on a case study of a contaminated site resulting from a specific installation, anywhere in the world, if they are unable to locate good-quality data about potential groundwater contaminants of their selected category of industrial activity. One way or the other, groups end up with a list of several contaminants, from which they have to reason about selecting one or two for further analysis. Task No 2 is graded on the quality of their reasoning: students are given some guidance on jointly evaluating undesirable contaminant characteristics, although no uniformity is sought in this ranking process. Task No 3 is the students' opportunity of creating their own assignment and solving it as well. Significant effort is required at this stage to determine flow and transport parameters, including locating representative parameters on the fate of the contaminants, such as partition coefficients and half lives. Finally, Task No 4 consists of predicting the fate of the contaminant using different assumptions and simplifications, the effects of which are explored through some sensitivity analysis.

2.6.2 Reactions to a movie

At the very end of the course, students are given a final assignment that asks them to answer some questions after watching the film "Civil Action" (1998). This assignment specifically aims at testing learning outcome 6, but also at revealing how much students internalized material from the class, as evidenced by their thoughts about a dramatized real case.

"Civil Action" is about the highly publicized lawsuit of the citizens of Woburn, Massachusetts, against industries that were implicated in contaminating Woburn's water supply with trichloroethylene (TCE). Notable dramatic elements of the case are several deaths of children due to leukemia and the bankruptcy of the lawyer of the plaintiffs, by the end of the movie. Most importantly, the case was followed over several years by a skilled writer and the resulting book is rich with technical details (Harr 1996). While the movie is based on the book, understandably it cannot include all details. Nevertheless, it has preserved the essence of the case, which raises several difficult questions that go beyond the human-drama level.

The handout with the questions is almost two-page long and some questions do not make sense without having seen the movie. Only some questions and a few answers are included in Table 4 to give a sense of the potential of such questions to trigger thinking and reveal fundamental beliefs of students.

Table 4. Questions and related comments students give after watching the movie "Civil Action" (1998)

On monetary valuation of human life
• Necessary technical-mathematical approach (in the macroscale of society, the practical management of resources becomes necessary)
• I expected that the life of a child would be at the top of the list, not at the bottom!
What can statistics say about the high frequency of leukemia in Woburn? What do you think of the movie's analogy with coin tossing: "when you toss coins, some crowns or heads are bound to cluster together, that doesn't mean a thing".
• Wrong analogy, coin tossing is random, cancer is not.
• OK, 12 deaths (8 children) from leukemia in 15 years […] but no reference to data prior to these 15 years [implication: we have selectively and, therefore, perhaps erroneously framed the problem]
Did you change opinion about something (e.g. relevant to environmental legislation or to deciding environmental cases in court) by watching the movie?
• The presence and the role of jurors in the court made me think whether this system is "fair" or not. These thoughts made me question my own beliefs of fairness and justice. […]
• It struck me that courts do not like uncertainty […]. Something that infuriates you while watching the movie is that they did not pay attention to the opinions of experts and perhaps this happens because the experts do not inspire trust when they cannot give a single number as an answer.

The answers in Table 4 give ample evidence that students can place problems of subsurface contamination in a broader context. The answers also reveal beliefs that go beyond environmental geotechnics. For example, the question on statistics reveals some deeply held beliefs about the nature of randomness, which are worth exploring with further research.

3. AVAILABILITY OF COURSE MATERIALS

Some of the materials described herein are available in publications (Pantazidou and Steif 2008; Pantazidou 2009). All materials developed for this course are posted at the website of the environmental geotechnics class: http://users.ntua.gr/mpanta/EG.htm. The links are removed at the beginning of each fall semester, during which the course is taught, and are added gradually as the semester proceeds. This decision is made so that students check the website regularly for updates and new material (they do). The website is in Greek, as is all class material. During the summer of 2010, the material will be translated in English and be available at http://users.ntua.gr/mpanta/EnvGeot.htm.

The videos described in Section 2.4.5 are available at the website of the journal Environmental Science & Technology (ES&T) as supporting material. Permission can be granted for materials from the article itself through ES&T's website, which directs requests to the Rightslink Service of the Copyright Clearance Center (http://www.copyright.com/) for instant permission. Permission is granted at no fee, when few figures are requested in order to be printed, posted on the Internet, or reused in classroom.

The educational software described in Section 2.5, which is a key ingredient of the course, is accessible for free at
https://netfiles.uiuc.edu/valocchi/gw_applets/.
Once accessed, the software runs locally, but cannot be downloaded.

4. CONCLUSIONS

This article promotes a new paradigm, whereby engineering faculty contribute publicly to the improvement of engineering instruction. Such a paradigm has been made conceivable by the broadened definition of scholarship offered by Boyer (1990), which includes the scholarship of teaching, and the subsequent elaboration of his ideas specifically for engineering education (Shulman 2005; Borrego et al. 2008). Other disciplines are already making the shift, with physics leading the way (McDermott and Redish 1999; Redish 2000). However, physics is a widely-studied foundational topic, which is more probable to secure funding for education research compared to engineering subfields and, therefore, more probable to attract the attention of cognitive scientists and education researchers. Hence, faculty contributions to the scholarship of teaching are more necessary in less widely-studied fields, such as engineering. There are many ways in which engineering faculty can contribute to the enrichment of engineering education: (i) by identifying needs, (ii) by producing themselves educational materials or (iii) by showcasing materials developed by others and used by them successfully in class.

In terms of needs, this article identified the following, giving examples in each category. Building (1) *a question bank* in order to probe students' perceptions related to key concepts and identify misconceptions. It is recommended that these questions be qualitative, phrased without technical terms and involve justifications. As shown in this article, justifications are valuable because they can give clues for developing (2) *interventions* to remedy misconceptions. In addition, the article highlighted the need for (3) *simple yet rich realistic problems* suitable for modeling instruction, as well as (4) *student- and instructor-friendly educational software* and (5) *research-quality visualization tools*.

The materials used in the environmental geotechnics course described herein fall in two basic categories. Category 1 includes materials developed or adopted with the aim of enriching instruction (Section 2.4) and helping the instructor achieve stated objectives (educational software described in Section 2.5, Section 2.6). Category 2 consists of materials designed to explore student learning and developed with guidance from results of research on teaching and learning (Sections 2.2, 2.3, modeling framework discussed in Section 2.5). Educational materials in category 1, such as demonstrations, videos, pictures, etc., are being developed by quite a few faculty, while the Internet has made them more readily available. For example, for the subject field of geotechnical engineering, which includes environmental geotechnics, see the website of United States University Council on Geotechnical Education and Research (http://www.usucger.org/). On the contrary, educational materials in category 2, such as techniques for probing student understanding, identifying misconceptions and addressing misconceptions, do not exist on the Internet, while they are rarely found in the literature. Nor are they bound to be developed spontaneously, because the production of such materials requires prior needs analysis, targeted contributions, critique and reviews.

For the aforementioned collective contributions to materialize, it is important that educators have the means to inform others and stay themselves informed on educational efforts in their subject matter. This public aspect of the scholarship of teaching necessitates the creation of a (theater) stage, or rather many stages. To this end, it is proposed that, in addition to conference proceedings and journals dedicated to engineering education, research journals establish an "education corner" dedicated to the scholarship of teaching. It is also proposed that engineering funding agencies give "bonus points" to research proposals that include an educational component that addresses learning needs identified by the wider engineering teaching community and, in particular, to proposals for research visualization projects that include production of materials suitable for engineering instruction.

ACKNOWLEDGEMENTS

The author is grateful to the NTUA students enrolling to the environmental geotechnics course, who year after year demonstrate a knack for seeking a strong foundation for their knowledge and the ability of gradually building it. A lot of the course improvements described in this article would have been inconceivable without the students' active participation. The thoughtful review of Nick Sitar helped in clarifying the article's scope.

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T.U. DELFT OPENCOURSEWARE: FROM REPOSITORY TO COMMUNITY

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ABSTRACT

In October 2007 Delft University of Technology (TU Delft) started with its Open Courseware project. In the first year a pilot phase was started. Six different MSc programs participated in the pilot phase. The pilot phase has been very positively evaluated. As a result of the pilot phase the technical infrastructure and the organizational structure (including hands-on support) are in place. The results of the external evaluation and specifically in the case study 'water management' show that the OpenCourseWare initiative is strongly acknowledged by external users. Spin-off from the project is that it leads to a higher quality of the material (external visibility). The central board of the University asked the project team to write a proposal for the next phase. The next phase of the OpenCourseWare project (1/1/2009 – 31/12/2010) was approved in December 2008. This paper will discuss the pilot phase including the evaluation and the set-up of the second phase. Specific attention will be paid to 'Water Management'.

Keywords: open educational resources; Open Courseware TU Delft, water management, evaluation; strategy; community

In October 2009 TU Delft organized an international seminar on Open Courseware with a keynote from the director of the worldwide Open Courseware consortium. All presentations were recorded and published at http://ocw.tudelft.nl/ocw-seminar/.

1. INTRODUCTION

In October 2007, TU Delft (the Netherlands) launched its OpenCourseWare (OCW) website www.ocw.tudelft.nl and became a member of the world-wide OpenCourseWare consortium (http://www.ocwconsortium.org/). From this date, educational resources used for the MSc programs (and even some BSc courses) in *Water management, Micro-electronics* and *Offshore Engineering* have been

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made available to the public, in most cases supported by streaming video (lecturers, demonstrations). In May 2008, the first courses in the field of *Sustainable Development, Nanotechnology* and *Bio-Mechatronics* were published. The pilot phase has laid a solid base for the future. The evaluation of the pilot phase shows that the different external users strongly acknowledge the initiative.

The central board of TU Delft has therefore decided to expand the activities and to approve the second phase (1/1/2009 – 31/12/2010) of the OpenCourseWare project. During the second phase, the TU Delft will publish around 30 additional and highly recognized master courses in the field of, for example, Urban water management, Transport, Quantum mechanics, Media and Knowledge Engineering, Computer Engineering, Wind energy and Design methodology. In addition bridging courses for new master students will be published to support their preparation for continued education in Delft.

A new target group for the second phase is secondary schools. OpenCourseWare materials (science subjects) that are useful for secondary schools (and in most cases jointly developed with these schools) will be published as well as introductory bachelor courses to show potential new students what the study is all about. The aim in this respect is not more students but ‘the right student at the right place’ (motivated study choice by showing what the study is all about). Also a new website will be developed allowing for more interactivity with the users (for example: communities, feedback, links to other resources and experts).

2. PILOT PHASE IN GENERAL

2.1 Context

2.1.1 A few words about TU Delft

The mission of TU Delft is ‘to contribute significantly to the development of responsible solutions to urgent societal problems in the Netherlands and the rest of the world by developing new, ground-breaking insights that will pave the way for the urgently needed technological breakthroughs’. Education and research are interwoven. TU Delft offers 17 Bachelors and 36 Masters Programs (taught in English). The total number of students is around 14,500.

In 2005, TU Delft signed the ‘Berlin Declaration on Open Access’ to knowledge in the science and humanities. By signing, TU Delft has joined parties who are actively working for worldwide and interactive distribution of knowledge and science in society. Within this framework, TU Delft has created a number of repositories (http://repository.tudelft.nl):

- All dissertations (full text) produced at Delft during the past one hundred year are electronically accessible;

- Students' graduation theses;
- Multi-media. Recently, a project has started for the development of a multi-media portal for the disclosure of all streaming video (lecturers), digital cartographic material and historical collections;
- Open Access publishing in journals (http://www.library.tudelft.nl/ws/services/openaccess/index.htm). Research results are published (after an external review) in online journals and made available to the general public worldwide and free of change.
- OpenCourseWare.

2.1.2 OCW initiative at TU Delft – objectives

In July 2006 the central board of the university initiated discussions on OpenCourseWare at TU Delft for the following reasons (quote rector Fokkema): *'The university's core tasks include delivering know-how and building knowledge networks in an international context. Who we are and what we do should be visible for anyone. What we are doing nowadays in separate institutions worldwide, should be done in collaboration with the rest of the world. Branding and visibility are extremely important: we should be recognized as a source of knowledge, as a creative pool'. Open Educational Resources (OER) contribute to that thought, by connecting TU Delft to the rest of the world. Investing in these kinds of projects is also a way to find out how we have to deal with all new technologies and trends influencing the university of tomorrow.'*

The pilot phase of the project (2007/2008) was approved by the board in April 2007. As indicated above, the central board considers OCW as part of mission of the university (dissemination of knowledge). It was also considered as very important in terms of 'exposure & visibility'. For the pilots the objectives to participate differed:

- 'Part of our reputation';
- Further contribution to already existing networks;
- Material is part of a joint degree; other students have easy access to the material;
- Attracting new students and researchers;
- Itch for learning;
- Expansion of knowledge networks;
- Exposure and visibility;
- Opening up for valuable contributions and connections worldwide;
- Investing in future learning and education methods and environments;
- Content for free but you have to pay for additional services.'

The pilot phase was further meant to lay a solid base (technical, workflow, organization, internal commitment, financial) for the future.

Three existing types of OCW can be identified: a content-centred, a learner-centred and a creation-centred model. For the pilot phase the TU Delft focussed on the content centred model à la MIT as starting point for further development. The user knows where the material comes from and the context in which it is being used. The material is closely linked to courses provided by the TU Delft and specific learning outcomes. A characteristic of this model is also that the information flow is one-directional, as there is no direct feedback of users built into the system. In the next phase the approach will still be 'content –centred' but with more room for interactivity with users following the results of the external evaluation.

2.2 Pilot phase Open Courseware: Set-up and actual results

The characteristics and results of the pilot phase are as follows:

- Budget: The budget allocated was K€ 600 of which K€ 420 in the form of an external subsidy;
- License: All course materials published by TU Delft are licensed under Creative Commons (version 3.0/ attribution, non-commercial, share alike). All faculty members sign individually for the publication of their material under this license;
- Quality Assurance: Faculty take final responsibility for their materials on the basis of an internal peer review process within the department involved;
- Workflow: The following workflow (figure 1) has been defined for the publication process:

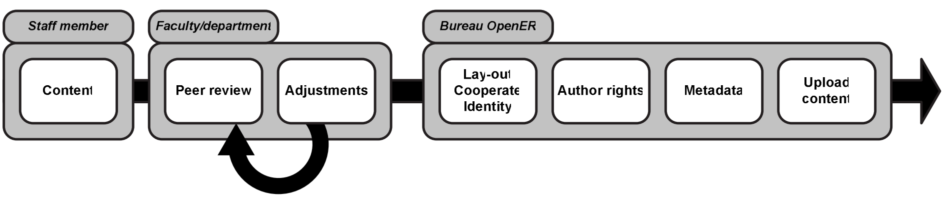

Figure 1. Workflow

- Organization; In May 2008 a small 'bureau' (Bureau opener; 0.8 FTE) was set up to manage the publication process and to give hands-on assistance. The bureau is part of the (central) Directorate of Education and Student Affairs but has very close links with the TU Delft Library and the ICT-department.
- Communication: At the start, the Delft OpenCourseWare was given a soft launch (limited publicity). Communication will get a clear more during the second 2009;

- Technical infrastructure: The choices made for the technical infrastructure are described in figure 2.

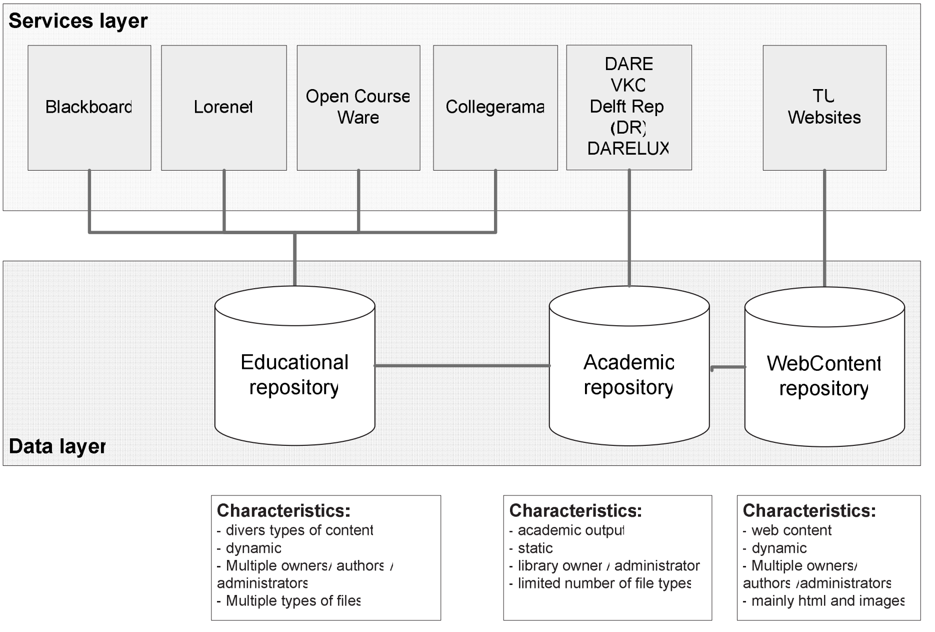

Figure 2. Technical infrastructure of the Delft OpenCourseWare pilot.

- Publication of courses:
  In October 2007, the website went 'live' with ten courses for three master programmes: Water Management, Micro-electronics (Electrical Engineering) and Offshore Engineering.
  Since May 2008 additional courses were published in the following fields: Sustainable Development, Bio-Mechatronics (Bio-medical engineering) and Nanotechnology.
  At this moment (November 2009), 37 courses have been published. The published materials include textbooks, presentations, references, streaming videos ('collegerama'), assessments, software and any other tools. Of course, this varies from course to course. Because of author rights, in some cases not all material could (yet) be published. Almost all material is at Master's level and in English. (all courses at Master's level at TU Delft are being taught in English). This is in line with the target group of the project: students in paid employment and prospective masters-students (what is the study all about, preparatory courses) of whom many come from abroad.

2.3 Results of the evaluation

2.3.1 Internal results

The pilot phase has been completed in October 2008. The internal results of the projects show that:

- More courses (including the course in the 'pipeline') have been published than anticipated; however the finalization of the material by faculty took in most cases more time than expected because of the high workload (updates of material, quality control);
- A clear workflow has been defined;
- The educational repository is more and more also used for other initiatives;
- Not all material could be published because of author rights problems. More awareness is required among faculty when it comes to copyright. To this end a 'central point of expertise' within the library will be developed;
- Student-assistants can do most of the hands-on work;
- A side effect of the project is that the quality of the educational material has been improved before publication (internal review);
- A financial incentive for publication should be built in the internal financial allocation system (same as for research);
- Uploading the course documents is not yet possible by the faculty; this is however a requirement for the future (updates);
- The scope of the project should be broadened, both in terms of target groups and in terms of functionalities of the OpenCourseWare website. Internal and prospective Bachelor students are also important target groups. This will be addressed in more detail in chapter 4.

From a general point of view, the project has received strong and consistent support by the board and the steering committee during the pilot phase.

2.3.2 Visitors during the pilot phase

Access to the Delft OpenCourseWare website was tracked using Google Analytics. Log data was acquired on the characteristics of visits and visitors. The number of visitors shows a slow but steady increase from around 100 visitors per day to more than 200. The material is partly also published at other websites of the faculties involved addressing specific target groups (analysis of visitors unfortunately not available). However, the actual number of visitors is thus significantly higher

Of the visitors that entered the Delft Open Courseware website 73 % came via references from another site, mostly via http://www.tudelft.nl or http://www.ocwconsortium.org and 11% came from search engines: nearly all via Google; this percentage appears to be increasing. Search terms that were most frequently used, were: Open Course Ware and Open Courseware.

Who are the visitors to the Delft OpenCourseWare website? The Netherlands was responsible for 40% of the traffic, which is not surprising. However, as figure 3 depicts, visitors came from 184 countries and resided in 6,483 cities. The exposure of educational material geographically is thus significant. Upcoming countries, such as India and China, are in the top 5 of visiting countries.

Figure 3. Visitors worldwide www.ocw.tudelft.nl

2.3.3 Users/interviews with focus groups

As part of the evaluation interviews were held with (potential) users in the Netherlands (students, companies and teachers) of the six pilot projects [4, 5]. Naturally, the findings were different per domain. However, from a general point of view the outcomes are very consistent:

- Strong acknowledgement of the initiative;
- Very positive about the quality of the content;
- Most interviewees found the structure of the website and its course material obvious and understandable. It all looked well laid out; it was formatted in PDF documents, with clear descriptions of the different resources;
- At the same time, there is need for more interactivity, communication, context and 'search & link' functionality.

Most students and teachers would like to see a higher level of interactivity on the site. For example, a desire for more information about using the site was mentioned, specifically mentioning the added value and use for specific user groups. It would also be very useful if there would be a direct link to resources in the same domain. Showing projects and more contexts would enlarge the perspective and understanding of users. Students mentioned the added value of being able to communicate online with other students doing their course. The website should provide information for its users about the entrance level required to understand the resources and preferably provide revision courses. It was also suggested to add short flash movies about the content and the professional world of the specific OCW-domain.

There was also a clear demand for a 'depository' where users can upload and publish their own material or otherwise.

One of the interviewed companies noted that the course material from TU Delft is disciplinary in nature and that they would like to complement this 'for free' with multi-disciplinary material.

At various external websites about OpenCourseWare or of specific disciplines, reference is made to the material published by TU Delft for example at:

- http://degreedirectory.org/articles/University_Rankings_for_Technology_OpenCourseWare.html
- http://educhoices.org/articles/10_Universities_Offering_Free_Online_Technology_Courses.html
- The homepage of CORE (China Open Resources for Education; http://www.core.org.cn/).

3. CASE 'WATER MANAGEMENT'

In this paragraph one of the master programmes taking part in the Delft OpenCourseWare (OCW) pilot project is highlighted as an example how to convert existing face to face (F2F) courses to OCW courses taking into account different target groups. The selected courses belong to *MSc Civil Engineering* and specialisation of *Water Management, chair Drinking Water Engineering*.

3.1 The Dutch drinking water secret

The Dutch drinking water is famous for its high quality. Drinking water is produced without the use of chlorine for primary disinfection. As a result many international students come to Delft to study drinking water engineering. The following quote from the text book Drinking Water: principles and practices [1] explain why students should come to Delft to become drinking water engineers:

'All our foreign students are putting the same question on the table: How do we benefit from studying the Dutch water supply?' We are used to giving them the following answer: 'The Netherlands has developed the most highly respected drinking water infrastructure in the world, so you not only learn the

most sophisticated and modern techniques, but also you learn from 150 years of experiences, from the successes and, especially, from the failures on the road to that high ranking.”

In the courses on water treatment in the MSc track water management the students learn all aspects of the Dutch drinking water system.

Figure 4. Screenshot of website making references to the Delft University OpenCourseWare initiative

3.2 Water management and its educational program

The chair of Drinking Water Engineering provides education and research on drinking water related topics. The chair is part of the Water Management Department of the Faculty of Civil Engineering and Geosciences of Delft University of Technology. The chair is responsible for 2 BSc courses and 5 MSc courses (table 1). Generally spoken, all courses make use of Face to Face (F2F) education by lectures. In addition, the students do laboratory experiments, design exercises or assignments. The courses are given in an intensive delivery mode, meaning that the lectures of a course are all scheduled on one day in a week (four to six hours of lectures per day). This intensive delivery mode makes the courses attractive for students in paid employment. It is easier for them to be away from their company for only one whole day a week instead of three days for only two hours. All course material is offered to the students by the Blackboard system of TU Delft, only accessible for students of TU Delft.

Table 1. Courses involved in the OpenCourseWare pilot of Water Management

Level	Course code	Course Name
BSc	CT3011	Water management
BSc	CT3420	Sanitary Engineering
MSc	CT4471	Drinking Water Treatment 1 - Technology
MSc	CT5420	Public Hygiene and Epidemiology
MSc	CT5520	Drinking Water Treatment 2 - Design
MSc	CT5550	Pumping Stations and Transport Pipelines
MSc	CT5560	Civil Engineering in Developing Countries

The objectives of the chair of Drinking Water Engineering to participate in the OpenCourseWare pilot were:

- to attract more (international) students and students in paid employment;
- to experiment with modern forms of education.

Attract more (international) students and students in paid employment

Every year about 25 MSc students follow courses in drinking water engineering. About six students out of these 25 students decide to do their MSc thesis on a drinking water engineering topic. The drinking water market (water companies, consultant engineers and research institutes) asks for many more students. Furthermore, these MSc students are also a major source for PhD students. Therefore it has become necessary to attract more students to follow courses in Drinking Water Engineering and to do their final masters thesis in Drinking Water Engineering. To attract more students the chair of drinking water engineering not only focuses on students with a bachelor degree in Civil Engineering but also on attracting international students, BSc students from other faculties of TU Delft and from other Dutch universities, student in paid employment and high school student (see figure 5).

Experiment with modern forms of education

On the internet much information is found on all kind of topics. A lot of information can also be found on drinking water engineering. To communicate their latest research the Drinking Water Engineering group already makes use of the homepage www.drinkwater.tudelft.nl to brand their name and to publish up to date research results. All theses (MSc and PhD) published in the last two decades can be found on the drinking water webpage. Also all publications of the individual researchers are listed and some researchers even have an own research portfolio on the internet making use of video files to present their research. To strengthen the link between research and education it is also necessary to publish all educational material on drinking water on the internet.

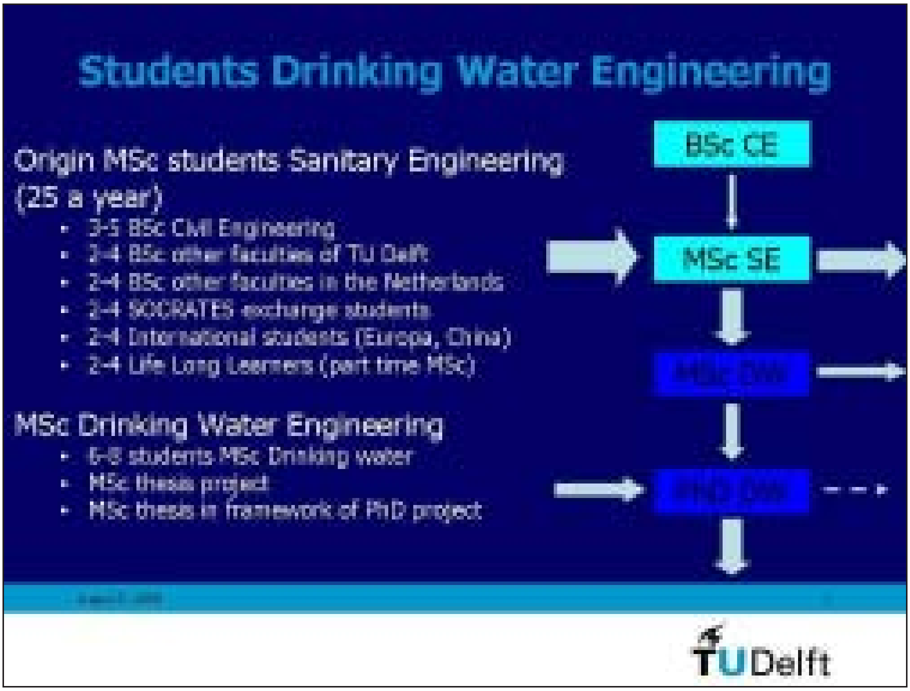

Figure 5. Students numbers in Sanitary Engineering

3.3 Pilot drinking water

3.3.1 Original CT4471 course (before September 2007)

All courses as mentioned in table 1 have been included in the OCW pilot of Drinking Water Engineering. Only the course CT4471 Drinking Water Treatment 1 is explained in more detail in this article. The other Drinking Water courses have a similar set-up. The CT4471 course is a typical F2F course. In about 30 contact hours the theory of different water treatment processes is explained. The following unit operations are explained: aeration and gas stripping, granular filtration, softening, coagulation and flocculation, sedimentation, flotation, adsorption, disinfection, micro- & ultra filtration and nanofiltration & reverse osmosis. The lectures are supported by PowerPoint presentations, lecture notes and advanced literature. This advanced literature comprises of pre selected literature on certain topics. This literature should give the student more up to date background information on the topic. Furthermore, the students have to do several laboratory experiments. Weekly a treatment plant is visited by making excursions. All the material of the course can be found on the CT4471 Blackboard page (figure 6). This Blackboard page is only accessible for students of TU Delft.

3.3.2 CT4471 OCW course (after September 2007)

The OCW project started in September 2007 when the lectures of the course CT4471 Drinking Water Treatment 1 began. The content of the Blackboard pages were transferred to the OCW pages. So the OCW pages also contain pdfs of the presentations and lecture notes, advanced literature, information on excursions and laboratory experiments. The main difference between the Blackboard and the OCW pages is that the OCW pages are now open for everyone in the world by publishing the page on the internet. To promote a fast acceptance of OCW by students and lecturers the layout of the OCW pages have been kept similar as the already widely used Blackboard pages. The navigation structure has been exactly duplicated. However, several new options have been added to the OCW page. One of the options is that all lectures have been recorded with Collegerama (figure 7). Collegerama is a new tool developed by the Multi Media Studio of TU Delft. It combines streaming video recordings of the lectures with Powerpoint presentations. The file format of Collegerama is 'wmv' and recordings are available online within 24 hours after the lectures. In this way the lectures are available for all students in case they have missed the lecture or when they want to hear (parts of) the lecture again. Especially for foreign students (due to language problems) and student in paid employment (because of travel times) the recording of the lectures with Collegerama is a very interesting option. Another new option is that special on-line assignments have been developed to test the students understanding of the lecturing material. Students are encouraged to do the assignment before following the next lecture. Additionally several old examinations have been placed on the website.

3.4 Evaluation of CT4471 OCW course

The course has been evaluated by different target groups:

- Lecturers;
- MSc students;
- Other educational organizations providing BSc courses;
- Students in paid employment.

Figure 6. Screen shot of starting page of the course CT4471

Figure 7. Screen shot of Collegerama of the course CT4471

3.4.1 Evaluation lecturers

The lecture material of all courses was formerly presented to the students by the TU Delft Blackboard (Bb) system. This is a closed system, only accessible for students and employees of TU Delft. Drawback of this closed system is that lecturers sometimes place material on the site that is not perfect of quality. For example, small mistakes in slides of presentations are present, errors in calculations are not corrected or no old examinations are available for students. In the OCW project the Bb sites are accessible for everyone in the world. This open access to the lecturing material has resulted in an increase in visits of the lecturing material. To be certain that visitors come back to the OCW site or that they direct their colleagues to the site all offered material should be of perfect quality. So no errors and typing mistakes are allowed anymore. This has resulted in improved quality awareness among the different lecturers.

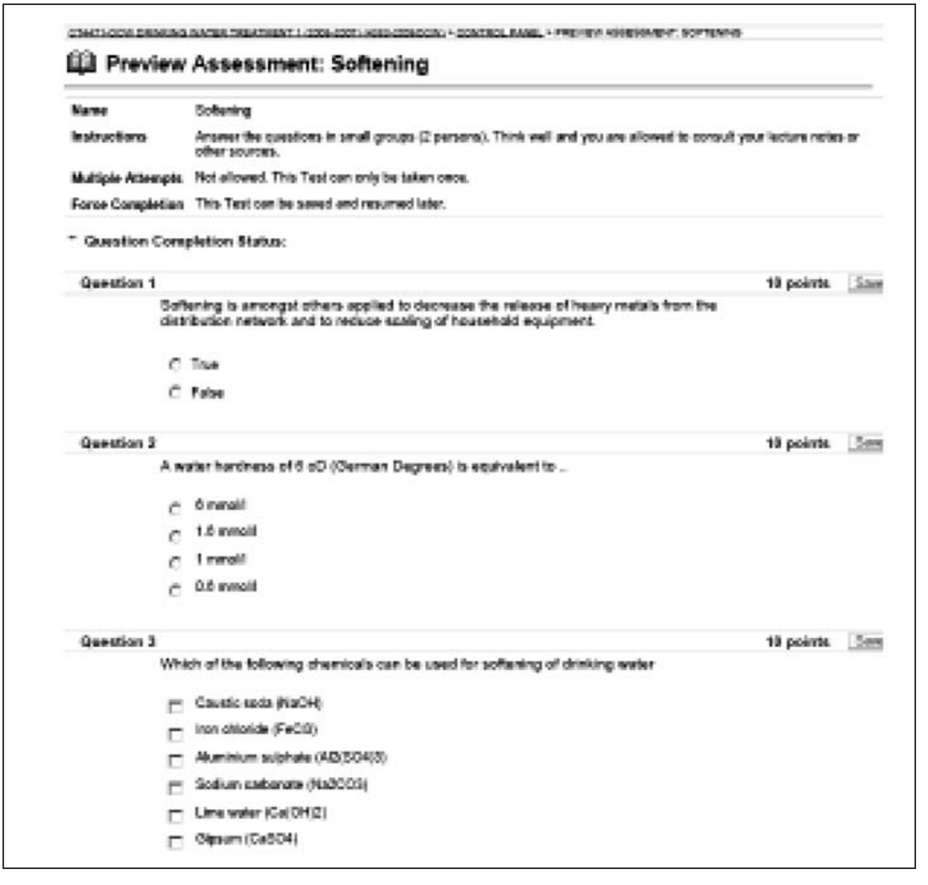

Figure 8. Screen shot of assignments of the course CT4471

3.4.2 Evaluation MSc students

The OCW initiative has been valued very positively by the students. Especially the 'Collegerama' option was valued as very attractive as students don't have to be present at all lectures anymore. Furthermore, the foreign students (especially the ones coming from China) have an option to listen to the lectures again (and again), as they often have problems understanding the lectures due to language problems. The on-line assignments of the different treatment topics were also valued as very useful. A useful contribution to the OCW initiative according to the students is creating communities to discuss results of experiments or theoretical aspects of the different treatment processes.

3.4.3 Evaluation other educational organizations providing BSc courses

One of the objectives for the chair of Drinking Water Engineering to participate in the OCW project was to attract more BSc students from other educational organisations. To attract these students contact has been made with several technical institutes offering BSc degrees. Their lecturers on water engineering have been asked to visit the OCW website to see if they want to make use of material for lectures for their students. The response of the lecturers was positive. Some now even make use of the material present on the OCW site. Students that have the ambition to continue their study on MSc level will be encouraged to visit the OCW website. Furthermore, the OCW site will be used as advanced lecturing material for students doing their BSc thesis.

3.4.4 Students in paid employment

Several interviews have been made with directors and employees of Dutch water companies. In general the reactions were very positive. Dutch water companies are public utilities and therefore the university and the water companies have a combined interest that lecturing material is freely available. The Collegerama option was found very interesting as students in paid employment don't have to follow all courses anymore in Delft and can save in travel time. An essential aspect for the water companies is that quality assurance and keeping the lecturing material up to date is of vital importance for the future success of OCW. The water companies have further indicated that they would like to be actively involved in expert groups to discuss the future direction of the OCW project. The external focus of the OCW initiative and vulnerable exposure of TU Delft by opening their lecturing material for everyone in the world have been assessed as very valuable.

3.5 Future developments case 'Water management'

In the pilot phase of the OpenCourseWare project much experience has been obtained. For the courses on Water management the major conclusions are:

- OpenCourseWare results in a quality improvement of the lecturing material. As the material is freely available for everyone in the world an external judgement system is created. All material should be of high quality.
- Collegerama offers great possibilities for different groups of students that have problems following the courses on the scheduled day. As the presentation is now always available on-line the student can decide him/herself when to follow the lectures.
- Based on the direct success of the OpenCourseWare project the researchers at the chair of drinking water engineering have also started an Open Access journal, called Drinking Water Engineering and Science (www.drinking-water-engineering-and-science.net).

In the coming year (2009-2010) the chair of Drinking Water Engineering will continue with the development of new tools within the OpenCourseWare framework. Special attention will be paid to developing courses in a blended delivery mode by using Open Courseware materials. The more fundamental parts of a course will be offered by recorded presentations. The students have to study these recordings on-line as prerequisite for the more applied part of the course. Essential will be to limit the recorded presentations to a maximum duration of 10 minutes. The recorded presentations will be recorded in a studio (making use of Collegerama) to be sure that all setting are perfect (no sound disturbance, no influence of varying day light). Another option is to use Adobe Presenter. Although no video recordings are displayed, this software offers possibilities to record part of the presentation again when lecturer is not happy with the result. At the F2F lectures in the class room the lecturers will mainly explain the application of theory. Besides the F2F contacts in lectures, the lecturer will be available on pre defined hours to answer questions from students that are abroad. This can for example be done by Skype or other VOIP programs. Furthermore, VODcasts will be developed for students on certain parts of the lecture notes, so the students always have access to the elementary parts of the courses. Also when there are no internet facilities present (for example for students on remote locations). In the coming year also more use will be made of animations and movies to combine theory with field applications.

Another essential development will be to translate the collegerama recording from the Dutch BSc courses into other languages. At the moment the MSc courses are only offered in the English language while the BSc courses are still taught in Dutch. However, these BSc courses are prerequisite for foreign students doing the MSc in water management in Delft. So it is necessary that these courses are available in the English language. As it is not preferred to give the same course in two different languages, speak recognition and translation tools are currently being used to automatically translate the course in another language.

4. THE NEXT PHASE (BROADENING THE PROJECT): WHERE DO WE GO FROM HERE?

As a result of the pilot phase the technical infrastructure and the organizational structure (including hands-on support) are in place and courses from six disciplines have been published. The results of the evaluation and the case study 'water management' show that the initiative is strongly acknowledged by external users. Spin-off from the project is that it leads to a higher quality of the material (external visibility).
The central board of the University asked the project team to write a proposal for the second phase. To this end also all Directors of Education were interviewed. The main conclusions are summarized below (box 1).

Box 1: Conclusions from interviews with Directors of Education TU Delft about the 2nd phase TU Delft OCW

- Publish material jointly developed with secondary schools;
- Publish remedial/preparatory courses for new students;
- Make use of OCW within the framework of joint education;
- Make use of OCW for our own students!;
- Every course: Streaming video. Make also use of new media (VodCast);
- Better integration of OCW with other activities (information for new students, network with secondary schools, Open Access policy, regular education, alumni, etc);
- Consider OCW as a way to improve the quality of your material.

The second phase of the OCW project (1/1/2009 – 31/12/2010) was approved in December 2009, the total budget is around K€ 400 of which about one-third is funded by external sources.

During the second phase the TU Delft will broaden the project in terms of:

A. Courses/target groups:

- Around 30 additional and highly recognized master courses (for example in the field of urban water management, transport and design methodology);
- Bridging courses for prospective master students;
- OpenCourseWare materials (science subjects) that are useful for secondary schools [2];
- Introductory bachelor courses for new students (study choice)

B. Website (functionalities): from content centered to more interactivity

A new website (figure 9) will be developed which allows for more interactivity with the users (for example: communities, feedback, links to other resources and experts). This implies new functionalities like:

- Reward on pay-off for internal and external users (who else used these resources, others who used these resources also used the following documents, number of views, rating, discussion area);
- Additional services (not for free) like customized support/courses, student projects, printing on demand, etc.;
- Community of practice (CoP) for people who have common goals.

The new functionalities will gradually become available for the users.

C. Research around OER.

A proposal for external funding (PhD-research) around Open Educational Resources jointly with African partners has been formulated [3].

Challenges

The above implies quite challenges: the project will be broadened in scope, embedded in the internal organization, serve multiple objectives and target groups and the website will offer more functionalities for the users. The project will both be meant to support new students at TU Delft (study choice, preparation in advance), joint programs as companies, alumni and students in paid employment. This requires a strong integration with the regular educational and communication activities of TU Delft.
The publication process is also being reviewed so faculties are in control when it comes to updates, etc.

The rewards for the university are also clear: expansion of networks, external recognition, better prepared students and one of the means to support an adequate study choice for potential Bachelor students.

Open Courseware is also very instrumental in offering courses in a blended mode. For the water management MSc track discussions with the Anton de Kom University of Surinam (AdeKUS), Institut Teknologi Bandung (ITB) in Indonesia and International Centre of Excellence in Water Resource Management (ICE WARM) in Australia have been started to offer courses in blended mode delivery. Students follow the normal lectures by OCW and lecturers from Delft visit the universities several times a year to give lectures on key issues, to answer specific questions on the normal courses from the students, to discuss assignments and to give examinations.

The TU Delft is proud that the Dutch government recently approved substantial support for cooperation with ITB for the joint development of OCW in the field of Water Management. The project, which will start in 2010, was approved because of its strong developmental relevance.

Figure 9. Screenshot of the new OCW website (under construction) which will be launched in February 2010

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TEACHING THE FINITE ELEMENT METHOD

Wojciech Gilewski[1]

ABSTRACT

Several aspects of the Finite Element Method teaching on the two cycle civil engineering studies are discussed. The problem is crucial because the method is widely used but frequently not formally present in the curricula. After short introduction of the method, several aspects of the teaching process are discussed: aims and objectives, target groups, study programs, learning materials, etc. Finally, a model study program is proposed for B.Sc. and M.Sc. cycle.

INTRODUCTION

Finite element analysis (FEA) is a computer simulation technique used in engineering analysis. It uses a numerical technique called the finite element method (FEM). Finite element methods are used extensively by civil engineers and other modellers to analyse stresses in physical structures. Looking for the educational process on civil engineering it seems to be a critical point to define the right place for the FEM teaching.

There are several questions to be answered:

- At what stage and how should students be introduced to finite element analysis?
- What should be the balance between theory and practical applications?
- What should be the scope of the theory that we address? What should be the contents of the associated course?
- How could finite elements be used to support the understanding of physical phenomena?

The objective of the proposed paper is to describe the problems regarding the FE teaching-learning and to propose a model position of the FEM in the group of core CE subjects.

A COUPLE OF WORDS ON THE DEFINITION

The method of finite elements is a skill which every engineer should possess in view of the fact that it has become common currency in a wide range of fields (solids and fluid mechanics, thermal studies, electricity and magnetism). Finite element methods are used extensively by engineers and other modellers to

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analyse stresses in physical structures. These structures are represented quantitatively as finite collection of elements whose deformations can then be computed using linear algebraic equations. In order to design a numerical model of a physical structure, the modeller must decide the appropriate resolution for modelling each component part, a task requiring considerable expertise. Too fine a mesh will cause unnecessary computational overheads when running the model, whereas too coarse a mesh will produce intolerable approximation errors.

It is worth to define precisely the method from the point of view of engineers and mathematicians. One can find a lot of definitions. Let's start from the Wikipedia, the free encyclopedia definition: Finite element analysis (FEA) is a computer simulation technique used in engineering analysis. It uses a numerical technique called the finite element method (FEM). There are many finite element software packages, both free and proprietary.

Mathematically, the FEM is used for finding approximate solution of partial differential equations as well as of integral equations. The solution approach is based either on eliminating the differential equations completely, or rendering them into an equivalent ordinary differential equation. In solving partial differential equations, the primary challenge is to create an equation that approximates the equation to be studied, but is numerically stable, meaning that errors in the input data and intermediate calculations do not accumulate and cause the resulting output to be meaningless.

SHORT HISTORY OF THE FEM

The history of the Finite Element Method is less than 50 years old. It is important factor because we can teach the problems which are on the top level of the FEM state-of the art and the teaching programme is to be flexible for continuous changes.

The 1956 paper by Turner, Clough, Martin and Top [1] is recognised as the start of the current FEM, as used in the majority of commercial codes. Along with Argyris' paper [2] they prototype the first generation, which spans 1950-1962. The panoramic picture of this period is available in the textbook of Przemieniecki [3], which is still reprinted by Dover. The pioneers were structural engineers, schooled in classical mechanics. They followed a century of tradition in regarding structural elements as a device to transmit forces. Element developers worked close to the aircraft industry. Force method was dominated in stress analysis and the stiffness methods were kept alive by use in dynamics and vibration.

The next periods spans the golden age of FEM: 1961-1972. Melosh [4] showed that the displacement models are based on the minimum potential energy principle. Argyris [2] proposed dual formulation of energy methods. The workers thought of finite elements as idealizations of structural components. By the early 1960s FEM begins to expand into Civil Engineering. The first book devoted to FEM appears in 1967 [5]. Applications to nonstructural problems start by 1965. From 1962 the displacement formulation dominates. Other variational formulations, notably hybrids, mixed and equilibrium models emerged. The first book to focus on the mathematical foundations was the monograph of Strang and Fix [6].

The period 1972-1980 is consolidation time. Substantial effort is put into improving of the displacement elements by tools initially labeled "variational crimes" by Strang [6] but later justified. Textbooks by Hughes [7] and Bathe [8] reflect the technology of this period. Hybrid and mixed formulations record steady progress. Assumed strain formulation appears. A booming activity in error estimation and mesh adaptivity is fostered by better understanding of the mathematical foundations. Commercial FEM codes gradually gain importance. They provide a reality check on what works in the real world and what doesn't. Complexity is particularly dangerous in nonlinear and dynamic analysis conducted by novice users. A trend back towards simplicity starts.

The fourth generation begins by the early 1980s. More approaches come on the scene, notably the free formulation, hourglass control, assumed natural strain methods, stress hybrid models in natural coordinates as well as variants and derivatives of those approaches. Two common objectives appears:

- Elements must fit into displacement-based programs since that includes vast majority of production codes, commercial and otherwise.
- Elements are kept simple but should provide answers of engineering accuracy with relatively coarse meshes ("high performance elements").

REVIEW OF THE FINITE ELEMENT ANALYSIS

FEA of critical design components, be they in the early design stage or on engineering change list, can greatly enhance the overall product quality. This is accomplished by ensuring that the design can meet deformation, stress, vibration and/or temperature specification for specific worst case configuration. FEA can also reduce product costs significantly, especially if applied early in the design cycle. Analysis results identify critical areas which carry the bulk of stresses caused by deformation or vibration, as well as less important areas in which a material reduction may be possible. The number of prototypes required can usually be reduced. Finally, the cost of a field repair or replacement will usually be many times the cost of a finite element analysis.

To understand the problems of the FEM teaching it is necessary to define the three stages of the method: Pre-processing, Analysis solver and Post processing. In general there are three phases in any computer-aided engineering task:

<u>Pre-processing</u> – defining the finite element model and environmental factors to be applied to it. The first step in using FEA is constructing a finite

element model of the structure to be analysed. The input of topological description of the structures geometric features is required in most FEA packages. This can be in either 1D, 2D or 3D form, modelled by lines, shapes or surfaces representation respectively. The primary objective of the model is to realistically replicate the important factors of the structure under consideration.

Analysis solver (solution of the finite element model). This stage is – in fact – related to the FEM algorithm, not only to solving of the FEM equations. Computation of solution means in the simple static analysis the following steps: dividing the structure into finite elements; element analysis; transformations; element assembly; boundary conditions; solving a set of equations; calculation of displacements, strains and stresses for each finite element. For dynamic and stability analysis the algorithm differs in the last part.

Post-processing of results is realized with the use of visualization tools. This step can be similar to the pre-processing. It is necessary to express graphically the displacements and stresses in the structure – globally and locally. The most important and demanding part of this stage of the analysis is interpretation of the predicted response.

TEACHING FOR WHOM?

The crucial question is if the FEM teaching should be done for BSc students, for MSc students, for PhD students or for practicing engineers? Lifelong learning is also to be considered.

The teaching of finite elements methods and analysis at the undergraduate level lays down the foundation for our endeavours based on this methodology.

Originally, in most universities, finite element methods were only taught at the post-graduate level. As finite elements codes became more generally available and user-friendly, the teaching of finite element methods and analysis gradually found its way into undergraduate programs. Based on the textbooks that are being published, a wide spectrum of approaches to the subject is observed. This ranges from an almost purely practical approach with little emphasis on the underlying theory, to a highly theoretical approach with some reference to practical applications.

Despite the fact that FEA has become the world's most widely used numerical technique for predicting the behaviour of complex physical systems, it is not typically taught in the undergraduate engineering curriculum. There are two principal reasons for this deficiency. The first is that the introduction of new material into the curriculum by modifying existing courses or by creating new courses typically requires the removal of the other material from the curriculum. Often this material is deemed essential by the faculty. Also, while FEA is taught at the graduate level in civil engineering departments, graduate-level FEA courses are designed to teach the underlying mathematical theory (Ritz Variational Method, Method of Weighted Residuals, etc.), numerical techniques, and to lesser extent computer software implementations. Such courses prepare students to use FEA in research projects or to develop FEA algorithms and software codes. However, these courses are not designed to teach fundamental modelling principles and guidelines that design engineers and industry need to effectively use FEA to address real world design and manufacturing problems.

Consequently, undergraduate engineering curriculum give only minimal attention, if any, to teaching finite element analysis. Companies are forced to spend considerable time and money training newly hires engineers. However, the engineers attending these workshops are primarily taught the semantics involved in using a specific commercial finite element code, not the more important modelling concepts and guidelines required for effective utilization of FEA as a design evaluation tool.

AIMS, OBJECTIVE AND LEARNING OUTCOMES OF THE COURSES

Depending on the teaching level, it is necessary to precisely define the aims, objectives and learning outcomes of the proposed courses. Let's see some examples of course objectives in a couple of well known European universities:

Broad course objectives. Cover both the basic theory and practical applications of the finite element method. Theoretical work: Foster un understanding of the mathematics upon which the method is based; allow the student to purse the published literature to keep pace with this fast growing field. Practical applications: aimed at introducing basic modelling skills using the commercial finite element package. Upon completing the course, the student will have a greater understanding of the correct use of the FEM code and have a good understanding of the theory behind the development of the finite element method.

Learning outcomes. At the end of the course successful students should:

- Be able to do variational formulations of appropriate boundary value problems.
- Be able to formulate finite element methods for appropriate classes of equations.
- Be able to carry out elementary error analysis.
- Have knowledge of implementation of the method.

Main themes. The objective of this course is to teach the student the theory and practical use of modern finite element methods for solution of static problems. On completion the course the student should:

- Have a basic understanding of FE analysis-what can be achieved through its use.
- Be able to select an element type, materials, loading and boundary conditions.
- Be aware of the limitations and potential errors of FE modelling.
- Have a basic knowledge of how to interpret results provided by FE analysis.
- Be able to operate a standard FE analysis packages.
- Be aware of the range of applications of FE analysis.

Aim of this course. This course intends to teach some of the state of the art finite element methods. In an efficient manner, these methods can solve complex partial differential equations. This course contains analytical as well as practical elements. At the end of the course the student can:

- Make clear when to use a finite element method for the solution of a problem.
- Apply the Galerkin Finite Element Method.
- Solve a range of physically relevant applications with this model.
- Apply the Petrov-Galerkin Finite Element Method.
- Minimize linear energy functionals with the use of differentiation.
- Minimize non-linear energy functionals with the use of differentiation.
- Calculate Jacobians in order to apply Newton's method for the solution of the system of non-linear equations.
- Judge the properties of these Jacobian's.
- Solve the related linearized systems of equations in efficient manner.
- Compute a finite element approximation with the use of Matlab.
- Calculate an approximation error and corroborate it with the use of Matlab.
- Do all of the above for different of finite elements (spectral, degree 1 and 2 conforming) in 1, 2 and 3 dimensions.
- Judge the above process with the regard to efficiency.
- Judge the above process with the regard to stability.

Undergraduate course aims and objectives. A formal introductory undergraduate course on finite-element theory and applications. The module consists of an integrative project and homework exercises based on sophomore-level education in strength-of-materials. The objective of this module is to support the teaching of the finite-element method and to emphasize assumptions and limitations in the application of the technique. The project centres on a simply supported beam with geometric discontinuities. This beam is investigated using commercial finite-element software in five different phases. Each phase uses a different solution model, consisting of a hand calculation, beam, two-dimensional area, and three dimensional solid elements. The solution from each phase is compared to the solution from traditional strength-of-materials beam theory in terms of the following: weight and centre of gravity, deflection and stresses. Static-failure theories, stress concentrations and a redesign are also considered.

Undergraduate course aims and objectives. The lectures are addressed to students that are in the middle of their studies. No special previous knowledge is needed. The FEM technique is widely used in practice especially to solve structural problems.

The aim of this course is to present the fundamental aspects of this model, as a basic tool in modelling, and also to give the students points in reference in order to evolve in the environment of industrial codes. One of the original aspects of the course is its pluri-disciplinary bias as the teaching staff comprises applied mathematicians as well as mechanical engineers. It will therefore be possible to present the mathematical basis of the method and to show how it can be applied to realistic situations.

It is easily seen that aims and objectives of the Finite Element courses can differ strongly. They depend most probably on the experience of the teaching staff and their position in the faculties of civil engineering.

WHAT TO TEACH?

The author has been studied and analysed course programmes from several European universities and companies. Before a model course programme will be proposed let's have a look into the core of civil engineering knowledge proposed within the EUCEET Erasmus Network [9]:

In the Table 1 (subject names currently used in the curricula within European universities) we have the following subjects: "Finite Element Method", "Computational Methods in Structural Analysis", "Matrix Analysis of Framed Structures", which are or can be FE-oriented. In the Table 2 (general subject names) one can't find the above mentioned names of subjects. Table 3 is a draft core curriculum for civil engineering. Where to find the Finite Element Method in the core subjects? Let's try:

Year 1 - Applied Informatics and Computational Methods? – No – too early.
Mechanics – No – it's mechanics of rigid body.
Strength of Materials – No – too early.
Year 2 - Structural Analysis 1 & 2 – May be.
Year 3 - None.
Year 4 - Final Project – most probably YES.

What does it mean? It means that the Finite Element Method is out of core subjects, but most probably will be used in the final project prepared by the student. It means that it MUST BE an out of core subject dedicated to the Finite Element Method, no later than on the 3rd year of studies. Is it possible? Yes, but there are a lot of conflicts between the FEM lecture and other subjects.

The EUCEET core subjects were related to the 1st cycle of the studies. The finite element method should also be present as a separate subject on the 2nd cycle. Detailed presentation of the course programmes exceed the frames of this paper. Some representative examples will be presented during the conference.

One of interesting applications of the FEM modelling, which was found in course programmes in European universities, are virtual experiments. FE systems can be also used in courses not focusing on numerical methods, but to illustrate to the students certain physical behaviours in “virtual experiments” of solids and fluids. Instead of performing a laboratory experiment, the numerical simulation of the physical event is shown, and the students can directly ask “what if” questions, like what if the geometry is changed. FE systems can be used in “virtual experiments” in courses on structural analysis, elasticity, fluid flows, heat transfer, etc.

FINITE ELEMENT CONFLICTS

There are conflicts between the FEM teaching and two important subjects of civil engineering education: mathematics and mechanics. It is difficult to teach the FEM without a solid background of mathematics and mechanics. On the other hand the FEM programs and systems are usually user friendly and available to everybody.

<u>Conflict between mathematics and the FEM.</u>

If we want to have the FEM course which is mathematically correct it is necessary for the participant to have a solid mathematical background, for example: Integral and differential calculus; Variational formulation of boundary value problems; Function spaces; Abstract variational problems; Lax-Milgram theorem; Galerkin method; Error analysis; etc.

There are some recommended course prerequisites: Mathematical modelling; Scientific computing; Applied mathematics and numerical methods; Scientific computing in linear algebra; etc.

To conclude, one can say that it is impossible to make the sufficient mathematical FEM background for the students neither on the 1st cycle, nor on the 2nd cycle of studies in civil engineering. It means that the FEM courses are to be tailored without the use of advance mathematics.

<u>Conflict between mechanics and the FEM.</u>

Good background of course participants in the field of strength of materials and structural mechanics is necessary for the FEM course participants. Some knowledge of the theory of elasticity/plasticity is also recommended. Let’s assume that this is to be find in the core subjects. The conflict appears when we want to teach the applications of the FEM for geotechnics, advanced metal structures (geometrically nonlinear), concrete structures, etc., without the base student's knowledge in the field of geometrically and physically nonlinear mechanics, crack mechanics, contact mechanics, etc.

Serious question appears: to teach or not to teach?

Conflict between user friendly systems and the FEM theory.

The students prefer the practical computer lessons with the use of user friendly FE programs against solid lectures on the FEM theory. On the other hand it is not possible to use the FEM systems efficiently without the base knowledge of the theory. The correct balance can be difficult.

WHO SHOULD DO THE FINITE ELEMENT TEACHING?

The FEM teaching can be done by the university staff, by the FE software producers or external educational companies. What is the right solution and balance? The university staff is better to teach the FEM base and theory, as well as the external educational companies are better to teach how to use the FE systems. Lifelong learning and continuing education is strongly recommended.

FINITE ELEMENT BOOKS AND LEARNING MATERIALS

There are thousands of books and learning materials for FEM teaching and learning. Some of them are available with the use of open/distance learning methodology and/or Internet. The most widely used books are monographs of Zienkiewicz, Taylor [10] and Bathe [8]. It is worth to note the access to the learning materials in the Internet (http://www.fea-online.com, for example). It is worth to stress the distance learning courses – a good example is the Open University UK course T884: http://www3.ac.uk.

PROPOSAL OF MODEL FINITE ELEMENT COURSES

Let us assume the two cycle study programme. On the B.Sc. level the author recommends the FEM-1 course (30 hours of lectures) on the last but one semester of studies (after: strength of materials, structural mechanics, numerical methods in mathematics, metal structures, concrete structures; together with the subject: computational methods in civil engineering – 1, where the use of the FE system should be possible) with the following programme:

- Basic equations of the theory of elasticity in matrix form; Minimum potential energy principle; Matrix calculations; Timoshenko beam theory.
- Displacement FE model based on the energy principle (3D).
- Finite elements of Timoshenko beam: linear shape functions, exact shape functions, higher order elements. Spectral analysis of stiffness matrices.

- FEM algorithm and its numerical realization.
- Locking, reduced and selective integration (SRI)–Timoshenko beam FE.
- Bernoulli beam and truss finite elements.
- 2D finite elements of plain strain and plain stress or axisymmetric bodies.
- Isoparametric transformation. Numerical integration.
- FEM convergence: rigid body motion, constant strain motion, conforming and not conforming finite elements, patch tests.
- 3D finite elements of the theory of elasticity.
- FE for dynamics: mass matrix; equations of motion; frequency analysis.
- Selected aspects of the finite element modelling.

On the M.Sc. level the author recommends the FEM-2 course (30 hours of lectures + 15 hours of computer exercises) on the second semester of studies (after: theory of elasticity and advance mathematics; together with the subject: computational methods in civil engineering – 2, where advanced use of the FE system should be possible (physical and geometrical nonlinearities, dynamics)). The proposed programme is the following:

- Reissner-Hallinger and Hoo-Washizu variational principles.
- Mixed FE models based on the variational principles.
- Mixed finite elements for Timoshenko beam.
- Thin and moderately thick plate finite elements. Shear locking.
- Thin and moderately thick shell finite elements. Membrane locking.
- FE for dynamics: direct integration of equations of motion.
- FE for initial stability: geometric stiffness matrix; critical loads.
- Introduction to geometrical nonlinearities – FE formulation for large displacement problems.
- Introduction to physical nonlinearities – FE formulation for plasticity and visco-plasticity. Geotechnical problems.
- FEM convergence for non-linear analysis.
- Selected aspects of numerical methods in the FEM – solving on large sets of linear equations, eigenproblem, solving of nonlinear equations.
- Error estimation and adaptivity.
- FE modelling of nonlinear problems.

CONCLUSION

To conclude, it is recommended to teach the Finite Element Method on the 1st and 2nd study cycle on Civil Engineering Faculties. The basic FEM course (1st cycle) and advance FEM course (2nd cycle) should be present as separate subjects. It is worth to define a commonly accepted (European) standard of the FEM teaching for the 1st study cycle. This kind of standard will make easier the FEM teaching on the 2nd study cycle, which can and should differ between universities. The FEM applications can be included in the group of vocational subjects. Continuing FEM education is strongly recommended.

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IMPLEMENTATION OF A TRAINING MODEL ON CONSTRUCTION SITES USING MULTIMEDIA KIOSKS

Alfredo Soeiro[1], Fernando Santos[2]

ABSTRACT

Every year, approximately five thousand people die while working in Europe. The investment in prevention has not been directed to a great extent to the training of workers. Workers in construction typically have low or no formal education, a factor that does not facilitate traditional face to face training. Therefore, it is urgent to find solutions that suit the particular conditions of the construction sector and provide adequate training for workers. The causes of accidents in construction are two: lack of prevention and bad practices. Information is a fundamental tool for prevention, making workers aware of risks and accident prevention. Training is essential to create the necessary competences, to change behaviours and attitudes. A solution to accomplish information and training is the implementation of multimedia kiosks on construction sites, running an eLearning program for construction safety.

Keywords: Construction, safety, e-learning, kiosks, training of workers, automated training, construction site.

1. BACKGROUND

The rate of work accidents in the European Community is still very high. Every year, approximately 5500 people die while working. To lower this rate, it is necessary to reduce the exposure of workers to different risks. The construction sector is different from most other working sectors, due to the cultural profile of workers and also due to the variability of construction sites. Europe has made considerable progress in this area, concerning the organization and implementation of prevention measures, involving the different stakeholders of this sector. In fact, during the last years, the number of accidents and death by accident has been decreasing significantly as a result of these initiatives.

However, this investment in prevention has not been directed to the training of workers. Workers in construction typically have low or none formal education, a factor that doesn't facilitate traditional face to face training.

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Therefore, it is urgent to find solutions that suit the particular conditions of the construction sector, and provide adequate training in critical areas like safety.

2. CONSTRUCTION SECTOR

The construction sector has specificities that create obstacles to the implementation of prevention policies used in other industries. The construction site is always different, constantly changing due to construction on the outside, exposed to weather factors and poor lighting and hygienic conditions. Additionally, this sector usually has longer shifts and workers have to deal with dangerous machinery and high risk procedures. Workers motivation is also conditioned by poor contractual links and reduced training.

Official data regarding deadly accidents show that the contribution of the construction sector represent a large percentage of the total number. For instance, in Portugal, during the years of 2001, 2002 and 2003 there were 88, 103 and 156 fatal accidents in the construction sector. On the other hand, the total numbers of fatal work accidents in Portugal in all sectors during the same years respectively is 181, 219 and 280. These numbers are data provided by the official agency Inspecção Geral do Trabalho (Work General Supervision).

3. RATIONALE

The causes of accidents in construction can be divided in two groups: lack of prevention and bad practice. The causes of the first group are the ones where most of the investment has been made. Regarding the second group, information and training are critical measures to reduce the number of accidents, but investment in this area is still deficient.

Information is a fundamental tool for prevention, making workers aware of risks and accident prevention. Training is essential to create the necessary competences, to change behaviours and attitudes. Information and training, together, will make the worker acquire a better knowledge of the productive process, identifying risks and predicting accidents [1]. These tools should be easily accessible at all times, to all workers.

A solution to accomplish information and training just in time, at the right place, is the implementation of multimedia kiosks on the construction sites, running an eLearning program for Safety in Construction. Having in consideration the conditions of the construction sites and the profile of workers, the kiosks should be a support for information and training. The main training program will be based on an application developed for the European Project – E3 (e3.up.pt), which will be adapted and complemented to suit the needs of each partner. Learning objects previously developed or designed to purpose, accordingly to international rules and recommendations, will be available in a simple and accessible interface. An online connection will allow that updated information is always available.

4. OBJECTIVES

The objectives for this initiative are the following:

a) Development of a training model using ICT, based on the implementation of multimedia kiosks on construction sites.
b) Facilitate the access to critical information on the construction sites.
c) Improve the knowledge level of workers, regarding safety measures and procedures.
d) Evaluate the impact of the implementation of the kiosk system and the acceptance level among workers.
e) Analyse the viability to expand the system to a larger scale, including other areas of knowledge or other industries.
f) Evaluate the impact of this initiative on the number of accidents.

5. INNOVATION

The use of multimedia kiosks as a training and information system at construction sites is innovative [2]. To use in place computer based learning, in a self-paced system to train construction workers on a critical subject is not a usual strategy. Considering the characteristics of the sector, this model proposes an integrated system to pass knowledge, create competences and evaluate individual and group results.

Based on the expertise of eLearning specialists, experienced civil engineers and professionals from Continuing Education, this system will use rich media like audio, text, images, animations and interactive games, to create an appealing learning environment [3]. It intends to be a versatile tool that can be used mainly as a self-learning system but also to support for face to face training. Additionally, it can be used as a quick-reference on the subject of safety, present in place. The inclusion of assessment items will allow to measure impact of the system at the individual level but also will give an overall perspective of the implementation.

To extend its applicability use, this system will be available in different languages, and should incorporate European and National legislation and recommendations of the countries where it is implemented. For this reason, the collaboration with interested different partners from other countries is essential.

6. TARGET GROUPS

The target groups of this initiative are specially the construction workers. This is the main reason for this work that requires the change of the culture of safety among the construction workers [4]. Only with the training and education of the main actors of this subject the significant progress of the quality of safety is possible.

Other targeted groups are relevant for the success of this training. These are the construction companies as providers of the safety conditions and responsible for the construction workers performance [5]. A secondary type of targeted groups are the developers of hardware and of software for these kiosks that comprehend the continuing education institutions, eLearning communities, workers unions and government agencies responsible for safety of workers.

7. OUTCOMES

The initiative will have the following groups of outcomes:

a) Multimedia kiosks with application on Safety in Construction, based on an e-book produced by the University of Porto. It will be adapted to the new media, assuming the touch-screen as the preferential user-interface. A possible extension may exist to include versions in different languages and information from other countries involved.
b) International Knowledge base on Safety in Construction, as the result of the collaborative work of the different partners
c) User guides, to support the user and improve the learning experience
d) Assessment items will be created to complement the application, referring to each module. This will provide data to evaluate the impact of the initiative.
e) Training events, specifically addressed to familiarize construction supervisors with the project and the application. This event should be critical to the acceptance of the project by the workers.
f) Motivational strategies should be developed and applied during implementation to increase the acceptance of the kiosk by the workers.
g) Impact Report that integrates the results of the implementation of the project, as well as the assessment results.
h) Dissemination initiatives.
i) Project website with relevant information about the project.
j) Active participation in conferences.

8. FEASIBILITY

The initiative takes place with the support of a construction company that will support some costs, provide training for a group of pilot workers and use their own expertise in using training for the construction workers. A major important partner is the company that provides services of supervision of safety as external auditor that will contribute with independent analysis of the methods and of the tools proposed. A third important partner is a company involved in entrepreneurship that will perform the promotion and dissemination of the kiosks and of the learning materials. This company will also be engaged in the choice in the market of the hardware that will support the kiosk concept. Finally the contributor to the software creating the virtual training platform is the University of Porto through the office of E-learning support. It is a multidisciplinary team aiming at a complex product but with high expectations in terms of results. This has been a concern from the beginning of the project implementation due to the difficulty in having in the same set the necessary competences to achieve acceptable results. The project is in an early stage and difficulties are dealt by the management group that has all parties represented.

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AN ASSESSING ATTEMPT TO QUALIFY THE TEACHING – TRAINING PROCESS IN CIVIL ENGINEERING

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ABSTRACT: *<u>Scope</u> - A method is presented to establish the performance level of an educational institution that is focused on the teaching-training process. The method's tool consists on Fuzzy Logic Inference Diagram (FLID). <u>Method</u> - The fuzzyfication procedure is applied on the main components parts of the process. The resulted diagrams are combined using fuzzy rules of type "If……Then…..", so FLID is obtained. The fuzzyfication applied on the main component of the teaching – training process leads to a numerical index that can be combined by implication logical rules and the result is FLID. Defuzzyfication of the FLID based on Mandami algorithm leads to the output number which represents the global index.*

This diagram can be search for different input values, and corresponding index values resulted. <u>Results</u> - The magnitude of the license marks and its corresponding number obtained from the final examination illustrates the performance level of the teaching training establishment. <u>Conclusions</u> – The method allows a numerical quantification of quality of the component parts of teaching – training process even for the whole process. Such a qualification is an objective subscription without inherent self appreciation. The way is able to show the parts with much weight in the process and the features should be improved or changed.

1. INTRODUCTION

The quality of graduated students results from the quality of their work done, and it is transferred and assigned to the teaching – training institution. The graduates ability is checked during the professional practice, in other words the mark of teaching – training process is assigned a posteriori and outwardly. The graduates skill is a remark for the educational establishment that can be or not attractive for the newcomers. The teaching – training system should be periodically self – assessed in checking its correspondence with the market demands. The self – assessment is devoted to kinds of educational units, the new and the traditional ones. The assessment devoted to old units has to answer to the questions like this: i) What is the dynamics of the quality index? ii) Are the old shortcomings reclaimed? iii) Which is the result of management policy on the quality index? The assessment of the new promoted education units assume the answer to different question like: a) Are the graduates in new

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specializations claimed by the working market? b) Is the quality index of these graduates at the available grade? c) What are the scanty sections of the new units? d) Is there an intercourse among the new and traditional units?

The component parts of the educational institution are analyzed and assessed by different qualified committees. Often, special tests are performed on more or less homogeneous population. Is this an unbiased practice? The answer is not! The answer undergoes the emotional factor influence, the variation of environmental features and the biological rhythm. The quality classification is done by the help of linguistic terms which are not sharply delimited. A couple of such linguistic terms are the followings:

- in the positive range: acceptable, attractive, adequate, correlative, comprehensive, efficient, good, renewed, up graded, very good, excellent;
- in the negative range: insufficient, inadmissible, insignificant, loose, minimal, poor, one sided, obsolete;
- ambiguous meaning: adequate, old – fashioned, quite-right, fairly well;

A biased assessment is obtained, far of the engineering manner in treating the concrete data [1].

2. MAIN COMPONENTS OF TEACHING – TRAINING PROCESS

The main components of teaching – training educational process can be summarized in the flow chart illustrated in Fig 1. They are intrinsic connected in a natural manner.

The starting line of the teaching – training process consists in endowment of the educational institution. A couple of infrastructure elements can be numerically counted and the result is expressed as item/student, e.g. m^2/student, kwh/student and s.o. Others features are usually characterized only by linguistic terms: inadequate, acceptable, old, good, very good, exceptional, redundant and s.o.

Teaching staff is the most efficient component of the teaching – training process. The pedagogic ability and its professional skills are of a great importance. The educational process generally flows from the teacher to the student. Ideally, the teacher could become a life model for the students.

Didactic delivery firstly depends on the teaching quality of the teaching staff and then the environment provided by the infrastructure (printed papers, real examples, laboratory well equipped, interactive lectures and s.o.). On the quality of the didactic delivery, the students often give qualitative marks: fluently or jerky, lively or monotonously, under control, with or without feasible results, analytical or practical, and s.o.

Information assimilated by the student is based on the didactic deliverance and the natural endowment of the student, after graduation of a high school. Assimilation is done on different practice: i) one reading; ii) a profound study by reading and writing; iii) one or more recapitulation after a profound study, and s.o. Information assimilation is a criterion on students classification: poor, middle, good and very good. The student character, his ambitions, his social condition of life may or may not engage the student on a diligent study or a shallow one.

The professional skills of the students are doing during the teaching – training process. They depend directly on the didactic deliverance and the human features of the students: the will, the ambitions, the willpower and s.o.

Final examination is culminating phase for the process classification. A deep reasoning applied on the correlative engineering subjects, the skills proved, facility and eloquence communication should be exhibited during the final examination. For the self assessment the type of marks resulted and their corresponding number lead to decisive place of the teaching – training institution on the hierarchy scale.

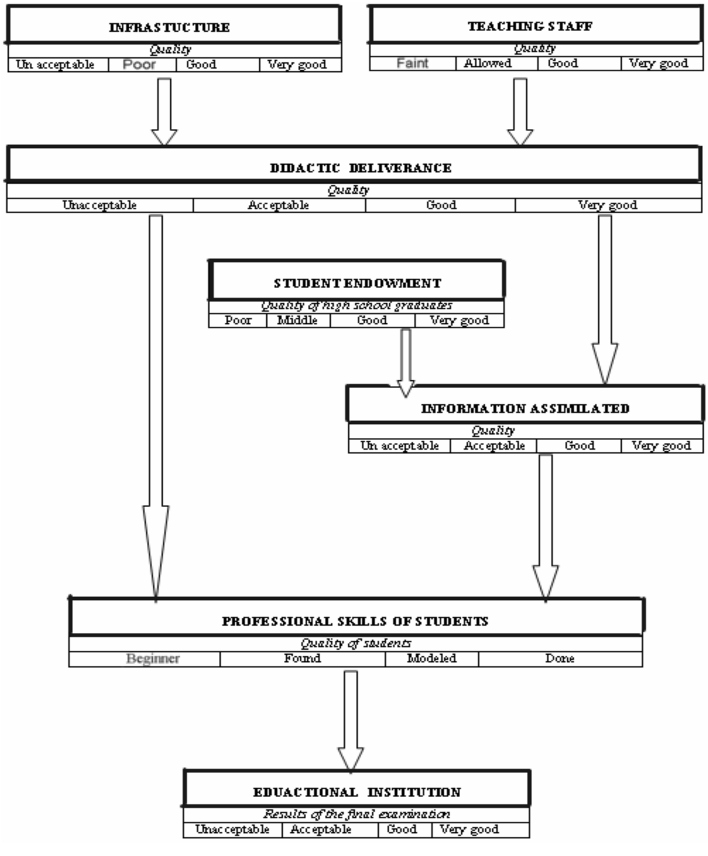

Fig 1. Self-Assessment Scheme of a Teaching – Training Institution

3. BASE DATA OF FUZZY LOGIC ANALYSIS

3.1 INTRODUCTION

Fuzzy Logic (FL) is a deduction system that utilizes concepts such as "degree of truth" and "computing with words". In fuzzy logic a statement could fractional true (ex. 0.75) and fractional false (ex. 0.25). Human brain usually processes large amount of uncertain data. In our daily decision – making tasks through analyzing statements is expressed in the words: "few", "many", "large", "probable", "quite impossible", "fairly well" and so forth. Fuzzy logic makes use of the fuzzy sets. A fuzzy set can be viewed as any collection of subjects with unfixed boundaries. To emphasize the advantage of FL, let analyze the traditional case of fixed boundaries of magnitude of damage and damage states in the classical performance-based seismic engineering framework [3].

Input Data Fuzzyfication [5] The Fig 2a is a scheme related to the seismic damage of a building. The interstory drift is taken as a criterion. Building is out of damage for any interstory drift less than 0.005, moderate damage for interstory drift ratios between 0.005 and 0.009, moderate damage for interstory drift ratio detween 0.009 and 0.015 and severe damage if the interstory drift ratio is greater than 0.015. A similar discussion can be done for the global damage indices and performance state. But in reality, the damage states of the a structure member are not strictly separated at the boundaries: 0.005, 0.009 and 0.015 and so forth, therefore membership functions of fuzzy logic becomes more adequataly.

Output Fuzzyfication The damaged construction, can be located in one of the four performance state above mentioned : immediate occupamcy - IO, life safety -LS, damage controled - CD and collapse prevented -CP. The domain of the global damage indices is considered is 0 – 1.0 To every performance state, a membership function is defined. The possible value of the function is in the range 0 – 1. All index considered are overlaid at the range margins, therefore fuzzy logic should be applied.

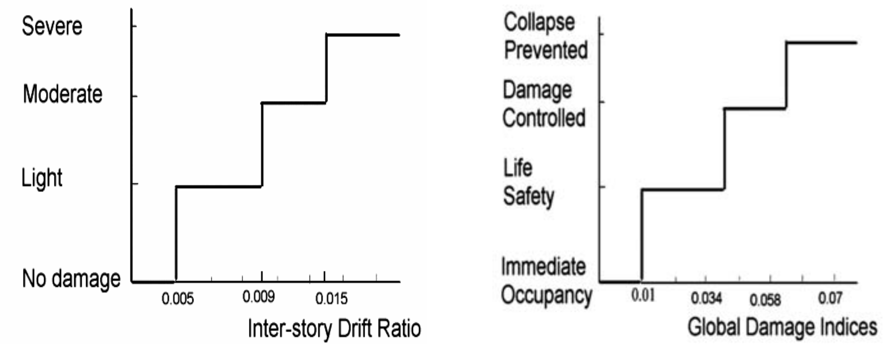

Fig 2. The damage magnitude and the damage state of a construction on ranges with fixed boundaries

3.2 FUZZYFICATION OF EDUCATIONAL PROCESS

In the Fuzzy Logic Toolbox, there are five parts of the fuzzy inference process: fuzzyfication of the input variables, application of the fuzzy operator (AND = fuzzy intersection and OR = fuzzy union) in the antecedent, implication from antecedent to the consequent, aggregation of the consequents cross the rules, and defuzzyfication, [1].

Input Fuzzyfication Let consider a main part of the teaching – training process, Fig 1: didactic deliverance. Let say that team of experts defined quality index I_{DD} and the its values for different types of quality, Table nr 1.

Table 1. Ranges of qualities given by quality index

Quality types	Unacceptable	Acceptable	Good	Very Good
I_{DD} values	0.00 – 0.50	0.25 – 0.75	0.40 – 0.85	0.60 – 0.100

Fuzzyfication of quality means to assign a curve showing different true value of the index with respect to different value of the index.These curves corresponds to so called membership function. They are connected to the possible quality and $\mathbf{I_{DD}}$ values. In Fig 3 membership function are polylines. But they can be shaped as a bell, sigmoid or Gauss curve. Table nr 2 exemplifies true value for the sentence: “didactic deliverance is of quality…….”, using Fig 3.

Table 2. True value for the sentence: “Didactic Deliverance is of ………quality”

I_{DD} value	True value of the sentence: “Didactic Deliverence is of…….”			
	Unacceptable	Acceptable	Good	Very Good
0.15	1.00	0.00	0.00	0.00
0.30	0.75	0.50	0.00	0.00
0.45	0.20	1.00	0.20	0.00
0.65	0.00	0.30	100	0.30

A noticed subject from academic curriculum has 24 lectures and 18 applications. It is supposed that didactic deliverance is composed as it is shown in Table nr 3, based on the test spread to the students.

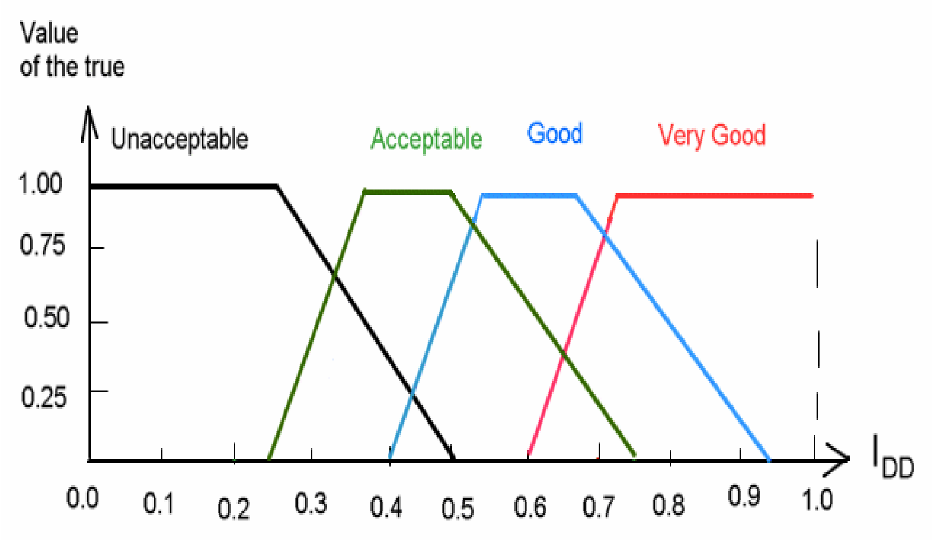

Fig. 3. Fuzzyfication of the Didactic Deliverance

Table 3. Qualities of teaching activity for a curriculum subject

Activity form	Activity quality			
	Unacceptable	Acceptable	Good	Very Good
Lectures = 24	-	4	7	13
Applications =18	2	2	6	8
Total = 42	2	6	13	21
Quality index	2/42=0.05	6/42=0.14	13/42=0.31	21/42=0.50

Didactic Deliverance of the subject may be obtained by a weighted average:

$$I_{DD} = \frac{1}{42}\left(2*0.05 + 0.14*6 + 0.31*13 + 0.50*21\right) = 0.375$$

According to Fig 3 the didactic activity for the noticed subject, “unacceptable” true value = 50% and “acceptable” true value= 80%. Let now consider the quality endowment of the students resulted from high school. Based on a specific psyhcologic test (for civil engineering profession) an expertizing team defines four chategories of student quality: poor, middle, good, very good. An index $\mathbf{I_{EDW}}$ of quality endowment of students is defined too. Let accept the membership curves for quality endowment of sudents shown in Fig 4.

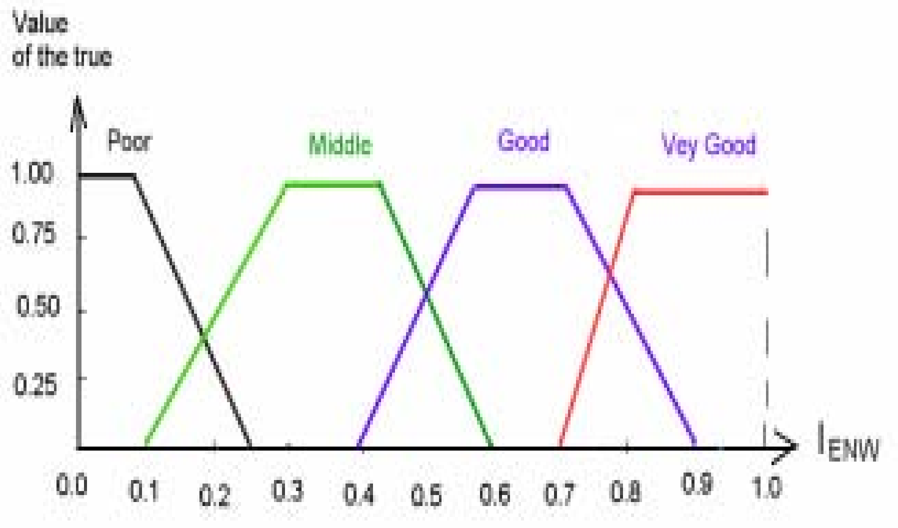

Fig 4. Fuzzyfication of the Students' Endowment

Output Fuzzyfication Professional skills is output watched by the teaching – training process, Fig 1. This part should be presented on the fuzzy set. The applicative subjects of the curriculum allows to form an hierarchical system, and a corresponding index $\mathbf{I_{SKL}}$. During the teaching – training process on applicative subjects, the students can assimilate professional skills. It depends on the qulity of student, his ambition and interest. On the other hand it depends on the teaching staff exigency. At the stage of studenthood the professional skills could be done, modelled, found or outward. Let assume the membership function of the students' skills shown in Fig 5.

3.3. FUZZY LOGIC RULES

Combination of the main part of teaching – training proces is made up by the logical rules. The membership functions of corresponding parts are combined using the operators AND, OR. If one considers a part much serious than other a weight factor may amplify the effect.

Concrete examples are further develped. Didactic deliverance can be provided under 4 quality states. The quality of the assimilated information depend on the students' endowment. Table nr 4 is presenting an alternative.

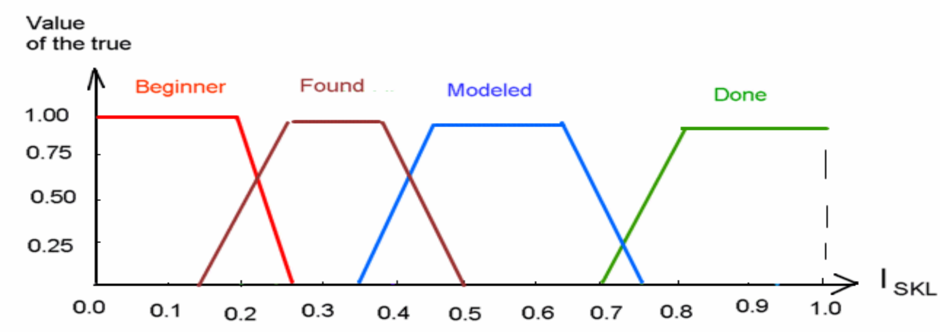

Fig 5.Membership functions of Professional Skills assimilated by the students

Table 4. Logic rules applied on Didactic Deliverance, Endowment of Students and Assimilated Information

Rule No.	**IF** didactic deliverance is	**AND** student's endowment is	**THEN** assimilated information is
1	unacceptabil	poor	unacceptablee
2	acceptable	middle	acceptable
3	good	middle	good
4	very good	good	very good

The performance of professional skills results from the combination of didactic deliverance and quality endowment of the students. An alternative of the combination rules are given in Table nr 5. Weighting factor is 1 for both tables.

Table 5. Logic rules applied on Didactic Deliverance, Students' Quality and Professional Skills

Rule Nr.	**IF** didactic deliverance is	**AND** student's endowment is	**THEN** professional skills are
1	acceptable	poor	beginner
2	acceptable	middle	found
3	acceptable	good	modeled
4	good	middle	modeled
5	good	very good	done
6	very good	good	done

3.4 AGGREGATION

Since decisions are based on the testing of all rules, the rules must be combined in such a manner in order to make a decision. Aggregation is the process by which the fuzzy sets that represent the outputs of each rule are combined into a single fuzzy set. The input of the aggregation process is the list of truncated output functions returned by the implication proces. The example in hand is illustrated by the Fig 6 .

3.5 DEFUZZYFICATION

Fuzzy inference is the proces of formulating the mapping from a given input to an output using fuzzy logic. The mapping then provides a basis from which decisions can be made or patterns discerned.The process of fuzzy inference involves all the pieces that are described in the previous sections: membership functions, fuzzy logic operators and if …then rules. Mamdani type inference system is used [3]. The input for the defuzzyfication process is a fuzzy set (the aggregate output fuzzy set) and the output is a single number. The most popular defuzzyfication procedure is the centroid calculation method.

Example nr 1. Figures 7, 8 and 9 represent Fuzzy Logic Inference Diagram that emphasize different value of the Assimilated Information Index resulted from combination of Didactic Deliverance and Student Endowment. The red lines of the graph allow to vary the magnitude of the corresponding index. On the Fig 7, the didactic deliverance index is 0.147, the students' endowment index is 0.395 and the resultant index of assimilated information is 0.361. Varying the pozition of red lines the data of Table nr 6 are obtained.

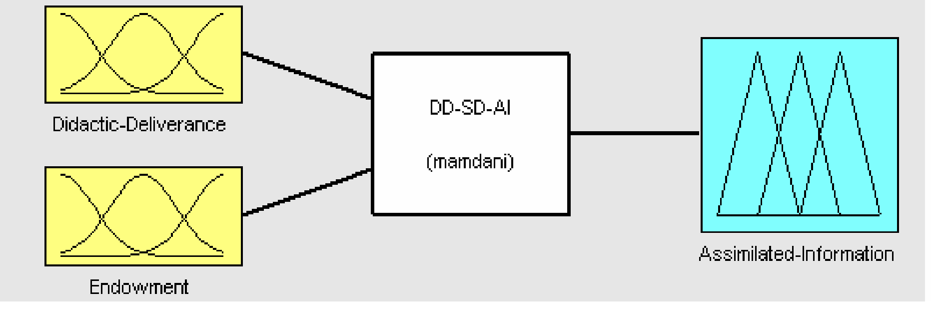

Fig 6 Aggregation of Didactic Deliverance – Students' Endovment and Assimilated Information

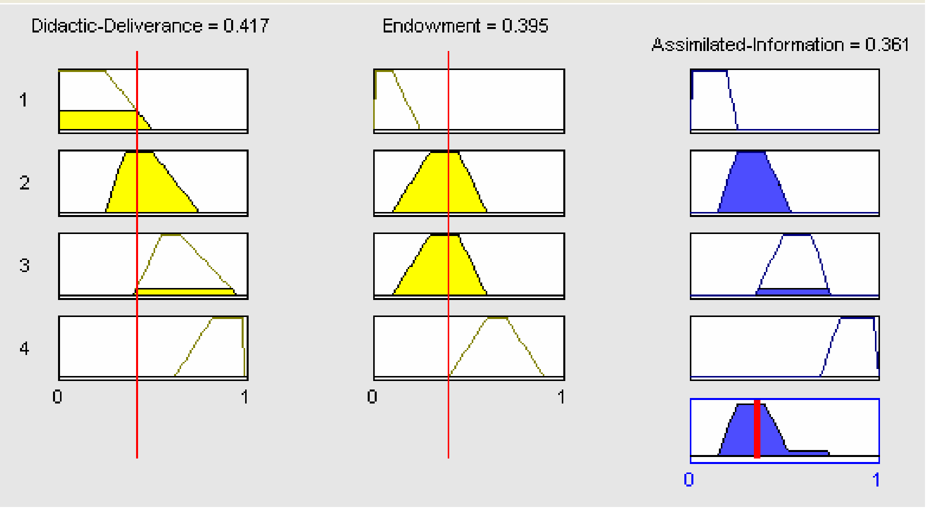

Fig 7. Fuzzy Logic Inference Diagram for 0.361 Assimilated Information Index

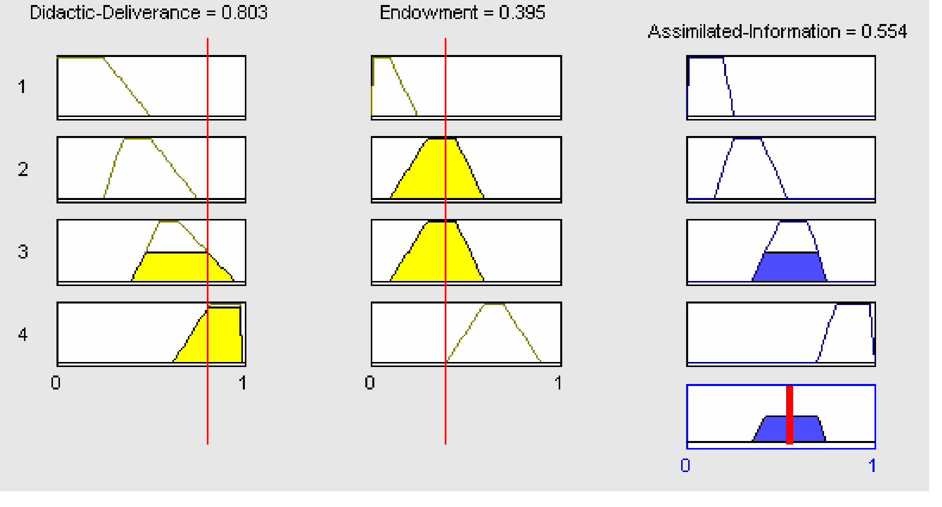

Fig 8. Fuzzy Logic Inference Diagram for 0.554 Assimilated Information Index

The Educational Institution considered offers modest assimilated information if the didactic deliverence is unacceptable or acceptable. A good or very good assimilated information is obtained for middle or good students' endowment. In the same educational unit, a modest assimilated information is realized for poor or middle students' endowment.

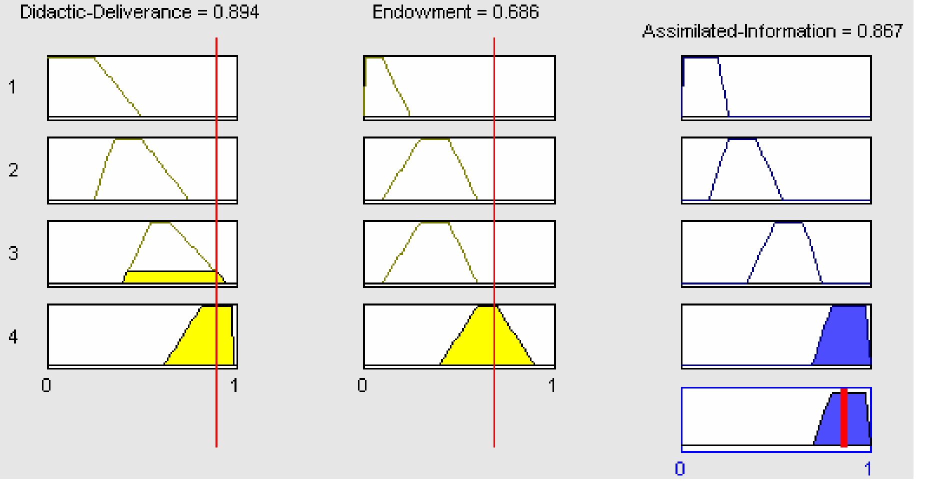

Fig 9. Fuzzy Logic Inference Diagram for 0.863 Assimilated Information Index

Table 6. Assimilated Information Index in different range of Didactic Deliverance and Students' Endowment

Didactic Deliver.	**Students' Endowment**	**Assimilated Information**	**Didactic Deliver**	**Students' Endowment**	**Assimilated Information**
0.188	0.09	0.115	0.096	0.114	0.116
	0.36	0.500	0.353		0.155
unaccept	0.55	0.500	0.54	**poor**	0.288
	0.85	0.500	0.849		0.549
0.45	0.114	01.29	0.290	0.386	0.500
	0.386	0.400	0.400		0.336
accept	0.532	0.436	0.436	**middle**	0.452
	0.859	0.500	0.500		0.552
0.65	0.141	0.449	0.449	0.532	0.500
	0.350	0.495	0.495		0.341
good	0.468	0.536	0.536	**good**	0.445
	0.686	**0.850**	0.850		**0.741**
0.894	0.114	0.549	0.142	**0.850**	0.500
	0.323	0.550	0.344		0.500
very	0.450	**0.702**	0.463	**very good**	0.500
good	0.640	**0.867**	0.858		**0.851**

Example nr 2 is focused on Didactic Deliverance, Students Quality and Profesional Skills. Membership functions for Didactic Deliverance are polylines, Fig 3 while membership functions for Students Quality are sigmoid and bell, Fig 11. The statement of the problem is illustratd by Fig 10. To this problem, 6 logical rules are considered in Table nr. 6. The Fig 12, Fig 13 and Fig 14 illustrates Fuzzy Logic Inference Diagram coresponding to different values of the Didactic Deliverance index and Students Quality index respectivelly.

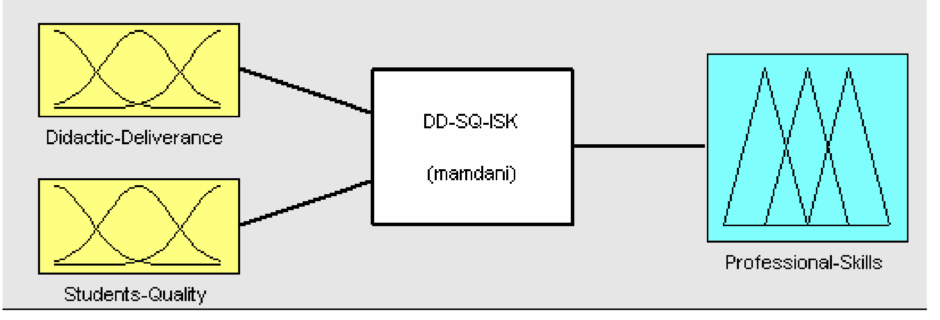

Fig 10 Statement of the logic problem among Didactic Delivereance, Students Quality and Professional Skills

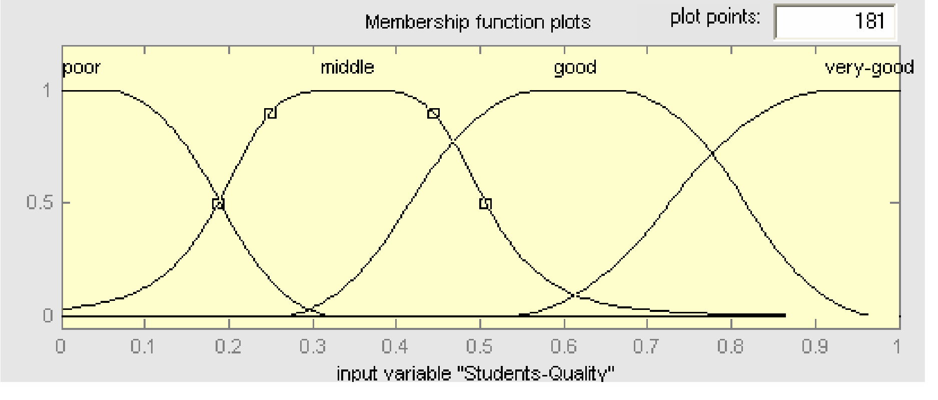

Fig 11 Membership functions of Students Quality

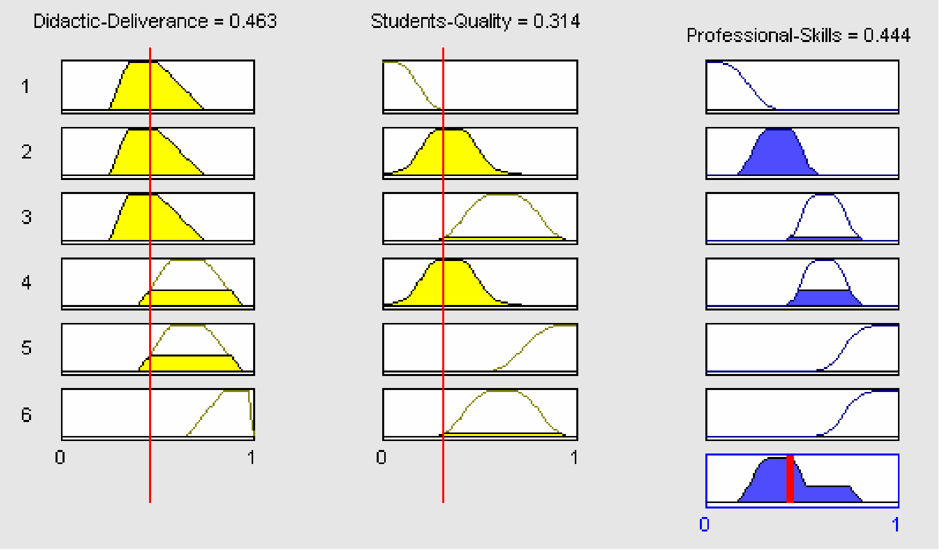

Fig 11. Image of FLID for a 0.444 Professional Skills Index

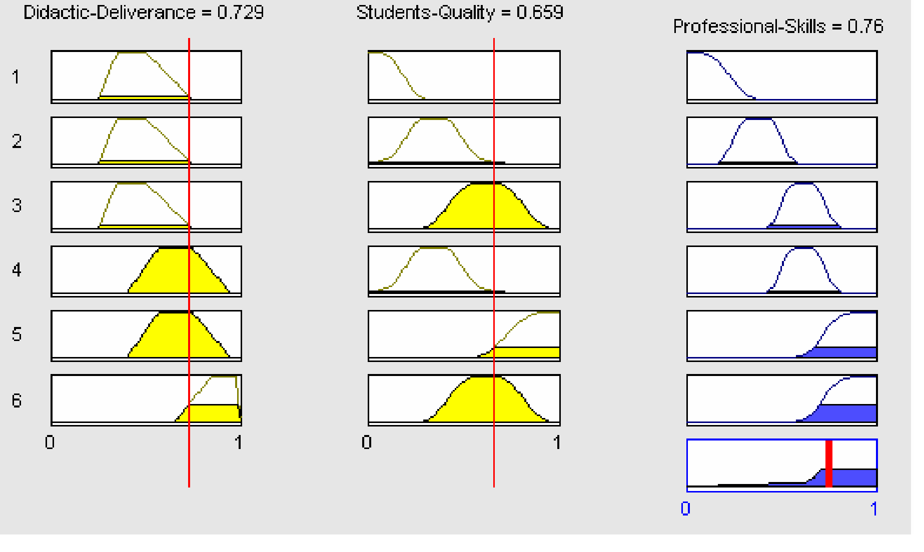

Fig 12. Image of FLID for a 0.76 Professional Skills Index

The analyses of the educational institution from Professional Skills index is ease to be done if the component logical parts are considered. On this aim Table nr 7 is drawn up. It is obtained by tranlating the red lines on the FLID for the input data. An input data ex. $\mathbf{I_{DD}}$= 0.335 coresponds to unacceptable class with true value =0.75 and acceptable class with true value=0.55 on the Fig 3. An input data ex. $\mathbf{I_{DD}}$= 0.555 corresponds to acceptableclass with true value = 0.75 and class good with true value=1.00. This is the reason why there are 2 classes for a number giving the Didactic deliverance index. Students' Quality is under the same rule.

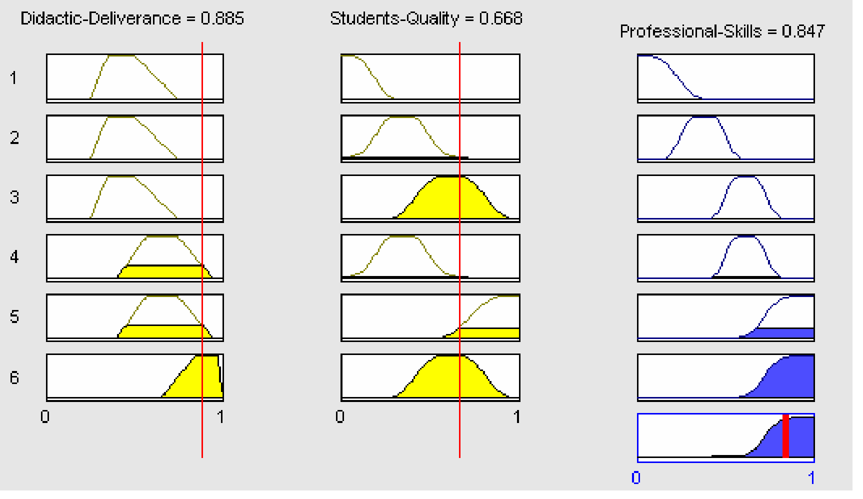

Fig 13. Image of FLID for a 0.847 Professional Skills Index

Table 7. Professional Skills Index in different range of Didactic Deliverance and Students' Quality

Didactic Deliver.	**Students' Quality**	**Profession al Skills**	**Didactic Deliver.**	**Students' Quality**	**Professional Skills**
0.335 **unaccept** **accept**	0.086 0.359 **0.595** 0.932	0.162 0.425 0.578 0.605	0.335 0.555 0.683 0.922	0.105 **poor**	0.171 0.236 0.334 0.621
0.555 **accept** **good**	0.105 0.359 **0.623** 0.932	0.236 0.496 0.617 0.841	0.335 **0.555** **0.683** 0.922	0.359 **poor** **middle**	0.419 0.496 0.587 0.737
0.683 **good** **very good**	0.068 0.350 0.623 0.932	0.284 0.587 0.638 0.845	**0.335** 0.555 0.683 0.922	0.623 **middle** **good**	0.590 0.617 0.638 0.839
0.922 **very good**	0.068 0.350 0.623 0.932	0.621 0.737 0.839 0.802	0.335 0.555 0.683 0.922	**0.932** **good** **very good**	0.605 0.841 0.845 0.802

4. CONCLUSIONS

FLID is a tool allowing the weak parts of teaching – training process into an educational institution. The actual procedure allows to simulate different alternative to reach the aim. It is also able to reveal the components that should be improved or changed.

5. REFERENCES

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INNOVATION IN BRIDGE ENGINEERING CONSTRUCTION

Jan Bujnak[1]

1. INTRODUCTION

For the same bridge design, there are several alternatives. They can satisfy its predetermined function, both in form and in style. The flexibility of engineering provides opportunities to innovate and create. There are multiple solutions to a single engineering problem. Our responsibility is to select the most appropriate solution for a given project. It is through this process of searching of the most appropriate solution that a designer as well as a contractor can introduce new ideas to increase safety, reduce cost, and improve the functionality and aesthetics of the structure. It is also possible to introduce new materials and unusual structural forms. We can also simplify construction procedure and accelerate the completion. Therefore engineering activity is not exact science, rather more about an art. It should make things to work. Exact science is about discovering the truth, which is always single and not able to be modified. The paper illustrates a progress in bridge construction, especially some contribution of our department to this development.

2. INNOVATION MISSION

Innovation can occur in several ways. It is not invention. However further development of conventional concepts and methodology to make them better, to provide more value for the basic cost. This added value can be an improved functionality, a reduction of cost, an increase in durability or in aesthetics. Innovation is a source of progress. Our life will not be agreeable, if we remain living the same way and doing the same things like in the past. We must introduce improvement, if we want next generation to have a more enjoyable life than we have actually.

A bridge design can be average, conventional or innovative. A designer has not fulfilled his duty if he does not try to incorporate improvements in each of his designs. The improvement must make things better, not necessary cheaper, and especially not riskier. Conservative is not old fashioned. It means also prudent. Bridges are built with public funds and are dealing with people's property and lives. Taking unjustifiable risk is not innovative, because a bridge must be safe and functional.

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Over the last few years many bridge projects, small and large or complicated, have been designed and constructed in relatively much shorter periods that were being achieved some years ago.

3. INNOVATION IN CONSTRUCTION PROCUREMENT

The shorter periods has encouraged procurement agencies to expect and demand ever-shorter period for delivery of a project, whilst at the same time expecting a high quality of the final product. The definition of quality varies. Quality in the expectation of a client can be the minimum design and construction period, a deliverance on time and within client budget, minimum use of material possibility, use of durable materials at reasonable cost, easy to inspect and maintain and aesthetical structure aspect.

It can be seen that some of the expectations may be contradictory and not all the expectations may be achievable on a given project. Clients have applied various forms of procurements for achieving all or some of their expectations. What is however common is that no project can be delivered by use of computers alone. Deliberate human input and thought to achieve all or some of the above expectations are required.

In this time, an extensive programme of highways construction as well as railway modernization is going on. The traditional method of bridge structures procurement is applied. Usually an engineering firm selected by highway authorities not only to design, but also to prepare the tender documentations, invite tenders, suggest the selected tendered to the client, and execute the supervision of construction. The selection of the consultant was obviously without competition and by direct appointment. The choice of the consultant is based on his experience verification and perception of the ability to produce the design and manage the construction. As there was not much experience of highways construction, the obvious design of bridges tended to prefer rather heavy reinforced concrete structures, and not necessarily visually attractive.

The design competitions especially for public construction sector provide public pressure on the procurement agencies to improve the quality of bridges. The participants in the design competition could be invited or selected from an initial expression of interest or submission of initial ideas. The jury assembled for judging the bridges is usually combination of client representative and well-known practising engineers. The design competitions by the nature encourage designers to create design out of the ordinary and activity into uncertain design territory. Clients are rather willing to accept new and unusual designs, but when on occasion designs run into problems, are not ready to accept any responsibility for choosing the design or contributing towards corrective actions. On the contrary, they are likely to make the designer fully responsible for the design. This attitude of course discourage designers from using new concepts and materials as the responsibility for problems arising from design has to be solely borne by designer. This aspect needs to be considered for procurement of bridges by competition method.

In order to use the talent and experience of designers and contractor an innovative approach can be used. The client can invite a limited number of design teams to take part in the design competition for the bridge construction. The competition is usually not only for ideas but require the construction method with a fairly accurate estimated construction cost. The client then may choose only two designs and invites designers of each design to develop the project documentation. The projects have to be delivered on time and within budget and without any claims. This means that initial ideas should be developed into a workable design with completely detailed general arrangements and member sizes. The final result is a design that the client chose and obtained at a cost that best used the skills and inventiveness of the designer and builder. It is a satisfactory outcome for all except of the unsuccessful designers who took part in the initial design competition, who had to expend a considerable amount of money at no recompense.

Another way of obtaining the expertise of a contractor but retaining the design that the client chooses is to involve the contractor in the final design development of a project, especially to achieve possible minimisation of materials and efficiency in construction. The design team includes engineers and architects, because special attention is paid to the aesthetics so that bridge would be in harmony with the environment. A special partnering mechanism set-up so that savings achieved compared to the contractors tender price would be shared equitably between the contractor and client. This methodology moves away from adverbial confrontation between the design, builder and client.

Design and build projects can be seen as a way to limit contractual conflicts and cost over-runs. The main objective in this form of procurement is minimisation of cost and more assured delivery on time. The designer in this instance in many cases is seen as a simple technician and as another sub-contractor who needs to be compressed on price by the main contractor. As contractors are usually badly equipped to manage design, generally with only limited design knowledge or appreciation of aesthetics and engineering quality, in many instances the resulting design is cost effective but rather routine. Designers are encouraged to use only the requirements of the design code in a manner to minimise quantities and choose materials that may not result in durable or reasonably maintenance free bridge during its exploitation life. The ultimate client has minimal influence on the choice of bridge type and aesthetics.

It is seen that there are a diversity of methods for procurement of bridges. However there is a common desire, because procurement agencies want quality in terms of aesthetically nice, low maintenance and durable bridge structures, and reasonably low price of design as well as construction. The requirements therefore can be contradictory and not always reasonable. An integrated design team of engineers and architects is necessary to achieve this objective. Adequate time needs to be given for the conceptual stage of the design and also adequate recompense to the designer for his intellectual effort, which should not be related to construction cost of the bridge. As design competition generates various ideas, there are needs to have mechanisms for payment to non-wining designers, should some of their ideas be incorporated in the detailed design. There should be also mechanism for sharing possible risks associated with new and unique designs between the designer, builder and owner.

4. PROGRESS IN BRIDGE CONSTRUCTION

As engineers, we should read many books, journals and various documents. We have to study various specifications and codes. However, these are not natural rules only their approximation. Thus, they can be changed. Really, they are changed from time to time. Consequently, we may understand that respecting them is not always correct. There is sometimes opportunity to introduce new ideas or overcome restrictions. When we are sure that we do not have to follow what other people have established, the opportunity is open. But it is not possible progress over certain boundaries purposely. We must understand if we care stepping out of our experience. We should verify that our innovation is enough safe and appropriate.

A conventional bridge deck consisted of stringers and cross beams, connected to the main carrying members (Fig. 1). The participation of these decks elements in carrying loads for the main truss or girders was usually neglected in design. Our research indicated that without special provision such participation could reduce stresses in the main members as much as 10 or 20 percent. The floor system is subjected to additional stresses, while certain elements of the main members are correspondingly relieved of some stresses. Detail calculation is given in [1].

Innovative deck system using concrete deck can act both as a roadway resisting local traffic loads and as an integral part of the bridge girders or trusses (Fig. 2). In such design, the concrete slab may act as an integral part of the compression flanges of the stringers, cross-beams, and compression flanges of girders. Detail requirements for advanced design of these composite steel and concrete structures are output of the research in [2], [3].

Bridge can use steel-plate floor acting as a flange for longitudinal ribs, the cross beams, and the main girders (Fig. 3). The design of such a deck system was simplified by replacing it by the orthotropic plate with different stiffness in the longitudinal and lateral directions. The deck must be design to resist both the effects of local loads and the effects of over-all loading carried by the bridge structures in which the deck acts as the top flange of the girder. Based on our theoretical and experimental research, appropriate solution for the orthotropic plates has been proposed [4].

Figure 1. Conventional bridge deck

A filler beam deck is essentially a concrete slab with stiff longitudinal reinforcement made of rolled or welded beams and transverse reinforcement of steel bars (Fig. 4). This type of structure responds perfectly to requirements of small and medium span bridges. Linear computer analysis of finite element model and our experimental studies are presented in this paper [5].

Innovative design does not mean to take extra risks. But conservative does not mean to accept less risk either. The appropriate risk level should always be used [4]. The actual design concepts are based on probabilities. Ninety percent safe is equivalent to ten percent of risk. Probabilistically, there is not fully safe structure. Many of structural elements are designed for loads with a certain probability, which is far from zero. But this is probability or risk, which society should accept. Reducing risk bellow accepted level not necessarily results to the safer structure. It may just mean to produce the structure unnecessarily more expensive. As a result, to be conservative is important, but being excessively conservative is not appropriate. Current design specifications, especially Eurocodes are based on limit states methodology. Appropriate partial safety factors to various types of loads and calculated members resistance are based on probabilities. Obviously the determination of the partial safety factors is not very sophisticated. There are the products of a time dependent compromise among the experts. Certainly, they can be also subject of our uncertainty.

Figure 2. Composite steel and concrete bridge structure

Figure 3. Orthotropic steel-plate floor

Figure 4. Composite encased beams

5. CONCLUSION

Progress is the result of the accumulation of innovations. Designers and researchers have a responsibility to society. They cannot be mediocre, but innovative so to build environment constantly improved. Structure must be better, less costly, and more beautiful than the previous one. At the same time, it should remain safe.

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PART THREE

CHALLENGES TO THE CIVIL ENGINEERING EDUCATION AND PROFESSION

STUDENT MOBILITY AND ECONOMIC SITUATION IN THE CONSTRUCTION SECTOR

Roode Liias & Tiit Koppel[1]

INTRODUCTION

Construction is and will remain one of the largest sectors in economy, covering a substantial part of capital expenditure.

During the recent years, Estonia favoured very fast economic growth and correspondingly the Faculty of Civil Engineering was very popular for young people. Unfortunately, in parallel many students left from the University to different placements in the companies not finishing their academic studies. Today, when the economic situation in Estonia has turned worse, the students are returning to continue and finish their studies.

This paper is going to study the trends in engineering education related to the trends in national economy. Any national economy requires professionals in engineering, in particularly having relevant university degree in civil engineering. At the same time employment opportunities in construction sector are highly dependent on the market situation. When economy is booming it will be attractive enough both for the contracting companies as the employers and for anybody who is employed for different specialised tasks.

Reasonable boom in the construction and property market gives the design, engineering and construction companies the possibility to be more successful on tenders when being slightly more cost effective as most of the competitors. The third or fourth year students who are not yet graduated – the nominal study-time is five years – receive reasonable motivation and incentives from the successful companies in the sector to act in the business. These students are already professionally quite adequately educated, but their wage-level when employed will be lower as it is for the experienced engineering professionals. Here we can see very clearly that both parties – the employer and the employee – are interested in this employment. Employer keeps down the costs, the employee gets practical training and income to support the studies.

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1. REFORMS IN THE CIVIL ENGINEERING CURRICULA IN ESTONIA

In Estonia, the classes, named special engineering courses, started on September 17, 1918. That date is being regarded as the foundation day of Tallinn Technical University (TTU).

At the beginning the courses taught were in mechanical engineering, electrical engineering, shipbuilding, civil engineering, hydraulic engineering and architecture, later chemical engineering was added. The courses were divided into junior and senior levels, both lasting three terms. The graduates of the junior level qualified as technicians and the graduates of the senior level qualified as engineers or architects after practising for a year.

The teaching-staff at the courses for the time was outstanding – highly experienced engineers and university lecturers were returning to their homeland (Estonia) from Russia. They started to re-design the existing curricula aiming at the university level. The goal was to train wider scope engineers as narrow specialisation would be too costly for a small state. The resulting curricula turned out to be of enormous volume, particularly so in civil engineering.

In November 1923, Tallinn Technical School was recognised as a higher educational establishment. That period coincided with the time of the general reorganisation of the educational system in Estonia, and as a result Tallinn Technical School was turned into an engineering school of secondary education. In 1936 Tallinn Technical Institute was founded; since 1938 Tallinn Technical University.

Department of Civil Engineering was the largest at this time and courses for diploma engineers were offered in five specialised areas: road engineering, hydraulic construction, civil engineering, structures and bridges. Theoretical courses were distributed for over 8 semesters, followed by the development and defending of the diploma paper in the ninth semester. The curricula included 47 disciplines. Students were required to pass 40 end-of-term tests and to pass 51 exams. The volume of lectures and classes was approximately 2920 academic hours, i.e. more than 30 hours per week. Later the volume of independent work increased. In 1939, as the semesters were short, there were 65-75 hours per week for the students; the semester system was introduced.

In June 1940 Estonia was occupied by the Soviet Union and another reorganisation of the educational system started. The structure, curricula and work organisation of the higher educational establishments in Moscow and Leningrad served as an example to be followed. Transition to strict year/course system occurred; the theoretical course was extended to nine semesters and the entire course of studies to five years.

The volume of curricula increased: socio-political disciplines, construction technology, testing of buildings, construction economics, etc. were added. The volume of general theoretical disciplines in the first years of studies increased substantially. The total number of hours for 9 semesters in the speciality of industrial and civil engineering had arisen to 4680 hours, which was almost twice the number of the hours in the previous curricula.

In August 1991 Estonia regained independence and the year 1992 was the starting point for the fundamental reform of the organisational structure and education in TUT. In 1992 the Soviet higher education system started to change in Estonia. This education gave for the engineers very good theoretical background, infirmity was lack of novel practical experiences.

Transition to university studies with three stages was made: bachelor, master and doctoral studies. Originally, until 1994, it required 5 years of studies to graduate with the diploma of a civil engineer. Following that, in 1995 bachelor studies, lasting 4 years, were introduced. The bachelor degree courses in civil engineering include three study fields: civil and building engineering, environmental engineering and transport engineering; the diploma courses include three specialities: construction design, real estate and applied geodesy.

In 2002 transition to new curricula was started at Tallinn University of Technology. The 3+2 system with the nominal time of 3 years for bachelor’s degree courses and 2 years for master’s degree studies. This could be followed by studies for doctoral degree for a nominal time of 4 years.

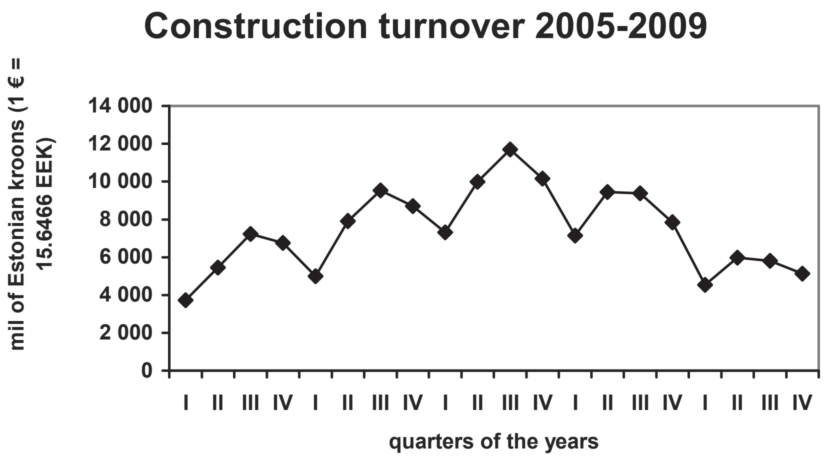
However, the Faculty of Civil Engineering introduced new 5-years integrated curricula for engineers. Completion of such a course will give qualifications equalling to that of the master’s degree. This could be followed by studies for a doctor’s degree for a nominal time of 4 years. The previous system had not allowed for providing civil engineers with adequate knowledge and skills by the time of graduation.

There have been minor amendments and changes in the integrated studies curricula introduced in 2002 ever since, but the main frame remains the same. Last changes took place in autumn 2009 when ECTS was introduced in TUT. Major changes in curricula have been the following ones – the share of academic lectures has decreased, e-learning and practical training has increased.

2. ECONOMIC SITUATION OF THE NATIONAL CONSTRUCTION SECTOR

Estonian economy has enjoyed a relatively long period of continued economic growth and prosperity dating back to the beginning of the 21st century. But economic conditions are in constant change and the conditions that created the prosperity and which we have enjoyed in recent years will not guarantee long term prosperity. If we are to have high standards of living into the future, we should adapt us also to changing of global conditions.

National construction market showed rapid growth at the beginning of the 2000ies supported by continuous decrease of interest rates for housing loans and dramatic rise in construction prices. During 2007 the market slowed down and turned to rapid decline at the beginning of 2008 followed by reasonable reduction of volumes in construction of dwellings in domestic market.



From the figure one can see that, in a relatively short period, the quarterly turnover of construction works in the national market has tripled, but then has fallen back. The average quarterly level in 2009 equals to that in 2005. Of course, it is also remarkable that the volumes have clearly cyclical nature where during the year we can follow reasonable increase of amounts.

In parallel to turnover one can also follow quick changes in the numbers of building permissions issued, assuming that most of the projects, after permission has been granted, will be started as well. Since the second half of 2007 the demand for new dwellings has been continuously decreasing. In the

1st quarter of 2008 building permits were granted for the construction of 1,128 dwellings, which is about 2.5 times less compared to the same period of 2007.

Correspondingly staff and employees are required for the companies and for the sites, or vice versa, it may become necessary to give off the employment. Official statistics show that at the beginning of 2008 in construction sector employment was slightly more than 80 thousands, whereas by the end of 2009 this number has decreased to 55 thousands. This change in employment is of course a social problem for the society, but also problem for the professionalism in the sector, as amongst the unemployed ones there are not only the workers, but also highly skilled professionals, engineers. Currently there is not yet clear information about the age structure of unemployment in the sector.

Professionalism in the construction sector is crucial due to high level of risks and responsibilities related to the whole process of development. Therefore professional qualification systems are required to link the educational system and the labour market and endorse lifelong learning and the development of professional competence, assessment, recognition and comparison. This system is developed and administered by the Estonian Qualification Authority.

The Objectives of the Qualification Authority are:

- Facilitating the establishment and development of an integrated and organised professional qualifications system.
- Establishing prerequisites for achieving comparability of the qualifications of Estonian employees as well as acknowledgement of other countries.

Professional Certificates give the evidence for the society that the person's skills and knowledge are conforming the set of professional standards. For civil engineers the professional certificate is issued by the Estonian Association of Civil Engineers, established in 1991 and currently the membership is about 400. The number of certificates given in the period 2005 – 2010 is:
Civil Engineer (Civ Eng) – 75
Diploma Civil Engineer (Dipl Eng) – 116
Chartered Civil Engineer (Chart Eng) – 58

These are relatively small numbers also for Estonia, but these numbers are clearly related to the economic circumstances. Rapid increase of the market will not motivate for proper certification to be carried out; recession of the market gives incentives to find different job possibilities.

2. STUDENT MOBILITY IN THE FACULTY OF CIVIL ENGINEERING

Relations between education and economy are interdependent and reciprocal. Education is a form of human capital; it is an intangible form of accumulated capital stock. Education may have many measurable forms, including the number of years dedicated to studies, also rates of enrolment, but also public and private education expenditures.

Unlike business cycles, which reflect short-term (< 10 years) aggregate fluctuations in output, incomes, and employment, economic growth is a long-term concept, depending on past investments in physical capital like industrial plants and machinery, human capital, and the pace of technological innovation. The effects of education on economic growth are to be distinguished from effects of the economy on educational expansion.

Empirical examining of the importance of construction sector in propelling economic growth rate in any national economy are the most common approaches advocated world-wide.

Recent global economic meltdown and foreclosure crisis has shown the lack of transparency and accountability at financial institutions, but also in the activities related to construction activities. Also reforms in the education, especially in higher educational sector will likely receive the most initial attention.

As mentioned above, the year 1992 was the starting point for the fundamental reform of the organisational structure and education in TUT. In parallel to course structure changes different initiatives have been introduced to liberalise the whole process of academic studies generally, not only in the field of civil engineering.

Always every individual when making choices keeps in mind mainly the compromise between time available and money/income to be gained. This is the most common and clearly defined model also for the students – the scholarships are rather miniature and not enough regularly to support the studies, but also the private expenditures. Constantly participating the academic studies takes much time; if any single hour step-by-step can be changed to mainly professional employment for reasonable/acceptable income, so the student will enjoy higher life-quality, but at the same time when employed by the sector related to the studies, he/she will get also practical knowledge and possible future placement.

Rather often 'the rules of the game' in the business and educational sector are not following similar patterns. When in business the contract based deadlines are short-term-ones (e.g. due for tomorrow, if not even for yesterday), then in the academic life the time-lags are measured with academic semesters or academic years. The students who have enjoyed the success when fulfilling the short-term tasks for the business carrier will fail fully in academic life when the required amount and style of work becomes not affordable for them.

And the activities are also different; when in business there are exact tasks given by a supervisor, then in the university reading, writing and knowledge accumulation is required. These are the activities one can not have any experience when in business and in the time left for the university the student will fail and finally will be expelled.

At the same time year-by-year the academic world is turning to be also more flexible. In earlier times it was nearly impossible for the ex-students to return to academic studies when expelled already. And the limiting condition was also the time lag – the number of years – during which the performance results of the former tests/exams became not valid any more. Therefore, when once dropped out from the university, one quite probably terminates his/her academic carrier.

Available data give real evidence that the situation with dropout level in the Faculty of Civil Engineering has really become an issue.

year of enrolment	number of students enrolled	number of students from them not graduated the studies	number of students breaking off the studies after fulfilling over half of the curricula
1995	131	61	43
1996	179	80	44
1997	232	128	47
1998	210	115	27
1999	218	141	41
2000	244	138	37
2001	175	110	33
2002	219	149	25
2003	222	167	11
2004	286	136	9

The numbers presented in the table show clearly that reasonable share of students fail the studies and the majority of them have problems at the very beginning of their academic studies in the university. During the first half of the studies mainly basic know-how is provided for the students, but also the academic mentality is developed for working. Sorry to say, but quite probably these students who have dropped out at the very beginning of their studies are not yet ready for academic and independent professional work.

At the same time, these students who have terminated their studies later – during the second half of their curricula schedule – are quite probably the 'victims' due to economic circumstances. Successful employment opportunities supported with reasonable income and access to mortgages have created the situation when these 'victims' lack time for studies to be continued. But the majority of them are still employed by the construction sector.

A newly initiated and founded programme by Estonian authorities TULE (Estonian acronym TULE means "Come Again, Graduate Successfully") is initiated to apply for the students who had not finished their studies in the Estonian public universities during the recent 5 years. This programme itself is intended to be implemented starting from January 2010 and will terminate in November 2015.

For sure, this scheme can be assessed two-fold. For the professional sector and for the national education funding schemes it may be favourable to call back and support financially these students who are anyhow working for the sector. In parallel to this, one can argue that this scheme is socially fully not viable for these students who in spite of any economic problems have continued their studies. Support is provided for these who have enjoyed the benefits of booming economy.

This can be considered as the alternative viewpoints and only afterwards, when the scheme is carried out and relevant results will be available for anyone, to give an assessment. Anyhow, this kind of a scheme designed to 'call back' the dropped out students increases students mobility and assures that individuals in business are academically and professionally fully experienced. They are given the possibility to graduate from the academic studies to have more favourable situation in the market for professional services.

CONCLUSION

Substantial and growing body of international research shows that investment in human capital – in educational programs from early childhood through to mature age of the staff – offers substantial social and economic returns for economies as well as for individuals.

Therefore, based on the ideas listed above, the following inter-relationships of special importance can be studied:

- unemployment in the sector related to the number of applications to be enrolled to the university
- enrolment of students to universities related to the national economic growth and the growth in the sector

Accordingly, the principles of organising academic studies in the universities and especially in technical fields with reasonable applied output are to be synchronised keeping in mind the 'business' interests of both of the parties.

Currently the academic schemes have become somehow more commercialised – there are the schemes when the formerly not graduated students are even invited free of charge to continue his/her academic studies and the expenditures are to be covered by tax-payers funding. And the performance indicators – credit-points, grades – will be valid 'forever' if meeting the description of current syllabus.

Estonia has become more integrated with an intensely competitive global economy and we have to find new sources of competitive advantage. Our investment in human capital is essential for creating an innovative, productive workforce that can adapt to a rapidly changing world. The successful advanced economies of the future will be those that can add most value, through human effort and ingenuity, to their traditional strengths in every sector.

RESEARCH INTERNSHIPS IN THE ENGINEERS' EDUCATION

Víctor Gómez Frías[1], Teresa Sánchez Chaparro [2]

ABSTRACT

Engineering methods have been generally perceived as fundamentally different from research: they both share a scientific basis, but engineering seeks efficiency in problem solving while research deals with solid theoretical constructions. However, since the last two decades, the number of engineers enrolled in a PhD is increasing and many engineering programs include some research trainings.

Does the society need a profile called "engineer-researchers" or there are two different profiles? Is it useful to try to produce engineer-researchers, or else, they are too different profiles and we risk to train worst engineers and worst researchers? Even if it is possible to "produce" some good engineer-researchers, is it worth training all student on research or the actual matter is how to identify the good candidates?

The answers should take into account that engineering curricula are already very busy, and the choices have to be compared with other options that might prove a better "pedagogical efficiency". Our suggestion takes into account that not 100% engineers must be researchers, but 100% must understand what research is in order to be able to work with researchers.

More over, we believe on innovation as the engine of society and economy improvement. But innovation is not learnt in an "innovation" course, but from practice. When an engineer is in the university, this practice must consist precisely on research internships. Research and innovation are not the same activities, and the strongest economies need to be excellent in both not just in one, but some research and innovation share an important number of intellectual and scientific tools, and that's the reason to justify that all engineers should be in contact with real research during their studies.

1. INNOVATION AND RESEARCH

Innovation and research are not the same activities but they share some common aspects. First, they represent a continuum in industrial development. Research (including development) is directly or indirectly intended to provide new scientific elements that might be used by companies to improve production efficiency and product quality, innovating in their processes and products.

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Moreover, both activities, research and innovation share some common intellectual tools, such as observation, communication, prototyping, testing… In other words, being trained in one or the other develops competences which might be used when working in the other. If we consider this from the point of view of education and learning outcomes in engineering curricula, we can consider that a research experience for all students is not just a way to lead them to research careers (a goal that can only be intended for around 10-15% at most) but a powerful instrument to learn them how to work together with researchers and, mostly, how to be better innovate (a goad desirable for 100% of engineers).

2. RESEARCH EXPERIENCE IN ENGINEERING CURRICULA

What is a "research experience" in an engineering curriculum? In fact, we can imagine not just one research experience throughout their studies but a combination of progressive experiences. It is quite useless to submerge an engineering student in a laboratory for some months, if he has never read an article before: he would lose too much time understanding the research work until being productive and getting a scientific and pedagogical outcome for him.

Each curricula needs to adapt this training to research to their chronology and different pedagogical constraints. There is not a magical formula, we will just indicate some points that we consider important.

First, contact with scientific research is a useful way for students to discover the subjects that passion them and get deeper into their study. There is a core of studies that every engineer must learn, but it is very important that a margin is left for students to differentiate one from each other, learning more on what they are more attracted for. In the future, this will be extremely useful not just to learn what they want but what they need: the professional world is very wide and they do not learn at the university everything they need for working, and it gets worst as time passes since their diploma and knowledge and practices evolve.

In other words, university makes students to learn (not just pure knowledge, but also how to do, and how to be) but must make student learn how to learn. Making place for some research (15-20% of student's time) in engineering curricula is the best instrument to obtain it. However, university managers must be conscious that research involves individual (or small groups) tutoring which needs more human resources that traditional teaching:

- one teacher prepares on average 1 hour for teaching 1 hour, for approximately 30 students that need to study another hour for themselves, so 2 hours of teacher make 60 hours of student work (efficiency ratio 1/30);

- while a teacher tutoring students' research needs to discuss with them an hour every 10-15 hours of individual work.

In bachelor level, the "research experience" must consist in not only reading books or slides but also articles: some of them historical or basic knowledge to be read by everyone, but always giving a choice on some intensification on a chosen list of articles (selected by the teacher so that they are not too difficult). Assessment of their comprehension must be undertaken not just in the exams, but also in synthesis notes of their lectures, so as to train them as well in their writing skills.

Later, students may choose articles to be read by themselves (for which they need to be trained by libraries' services on how to find what they look for) but always with the contact of teacher that may orientate them and be able to read their synthesis notes or discuss with them the aspects they do not understand.

Laboratory internships and practices are then just the final step of this research experiences. The research subject must be presented by the laboratory, which knows well the research programs (both in the scientific and financial programs) but the student must freely chose its interest and even adapt the aspect to develop to his competence and interest in agreement with the laboratory. In effect, a student that has been trained in research before is not be considered as an executor of a series of essays, but a true (beginner) researcher who will be responsible of the progress of the research he carries on.

Most in particular, a laboratory internship is not fully achieved if it does not end by writing, in the form of an article that can be submitted to scientific review. This needs at least 4 months of full-time involvement and a team-work environment. Ideally, the student could prepare his choice and start reading on the subject before these 4 months in order not to lose time defining the research object or because he arrives at a moment when the research cannot be undertaken due to practical conditions.

3. INNOVATION TRAINING

In parallel to these scientific experiences, students can also be specifically trained for innovation during their studies, not just for developing links with research intellectual tools but also showing them specifically the importance of innovation in their professional career.

For instance, they can participate in projects which consist in companies demand to innovate in their products and/or processes. They can also work on their own ideas (issued from the daily "disappointments" about what can be improved): this is probably a good exercise for team working and dealing with some basic tools but they can hardly get very deep without the real data that companies have on prices, demand, technology… In addition, some innovation may require quite expensive prototyping which needs company support.

At the end of their studies, an increasing number of schools, in partnership with financing bodies (private such as business angels or public agencies) develop entrepreneurship programs, so that some students may develop the innovation projects they have defined and "refined" throughout their studies.

It is an excellent initiative but we must not confound this programs that are directed for just a few students with the necessity for all student to be trained in innovation sensibility and practice, as they all will need them later.

4. "ENGINEER-RESEARCHERS"

Finally, we would like to precise that we believe that there are three different profiles: engineers, researchers and engineers-researchers. The engineer is trained for working in operations and design, being able to get the best solutions in terms of feasibility but also budget and time constraints. The researcher deals with problems where a rigorous comprehension and full verification is needed as the goal is to contribute with a solid brick in the construction of the sciences' wall. The "engineer-researcher" is most precisely a researcher in engineering, which requires a basis of engineering education.

They all need to know how to work together, as their activities are not meant to be isolated but on the contrary in constant relation. As we have said, the engineer must learn research also to better innovate and to learn to learn. But this does not mean at all that all engineers must be professional researchers, not even for a part of their life, neither do a Ph.D. Engineer degrees are and must still be exigent curricula that train student in the competences and skills they need for being good professionals. Being a researcher (eventually in engineering, which is not as much developed as in other field) is another career that needs a professional involvement and specific training.

EDUCATION AND EMPLOYMENT OF CIVIL ENGINEERS IN GREECE: CURRENT TRENDS, EVOLVING CHANGES AND THEIR MUTUAL RELATIONSHIPS

Pericles Latinopoulos[1]

ABSTRACT

The present paper addresses the general theme of existing relationships and developing synergies between the academic and professional worlds in Greece with specific reference to civil engineering. To this end all important factors which affect this crucial issue for the country's higher education and economic development, are examined and presented. This integrated approach is employed with the aim to identify the effects of various agents from the educational and labour market systems, as well as to highlight the most important relationships between them. Within such a framework, the following discussion evolves around three major issues: a) the main features of the national education system available to prospective and young professionals civil engineers, b) the past and present employment practices, including recent trends in career decisions of young professionals as well as some emerging impacts on the profession from the current economic crisis, and c) the particularities and especially the mismatches between higher education and the labour market, together with the actions and developments needed in restructuring and reforming university curricula.

1. INTRODUCTION

In the 21st century the global environment demands engineers who are not only designers, planners or constructors. They should also be producers, decision-makers and quite often leaders. There is also an emerging need for engineers who will connect with the society in a different way than they did in the past, by working across borders and cultural boundaries and above all by collaborating and working effectively with many other people and especially with non-engineers. In order to succeed in such a multifarious ensemble of professional and societal tasks the engineer should acquire a somehow different education, and especially one that is available as a lifelong process.

In light of these issues this paper presents an integrated picture of the two major systems that influence the education and professional profiles of a modern civil engineer in Greece: the higher education system and the labour market system. Particular characteristics of each one system, relationships and interactions between them and with the economy of the country are examined in a time

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frame spanning along the second half of the 20th century up to today. Next, the future prospects of employment of civil engineers are discussed in view of a changing environment of employment and opportunities. Finally, the new education tasks and their potential reforms to enable the successful training of civil engineers are presented.

Apart from relevant formal bibliographic references, selectively drawn from the national and international – mainly European – literature, opinions and information presented in the paper originate from findings and discussions found in a variety of other types of texts, such as newspapers and magazines articles, institutional reports and meetings summaries. A significant part of this second ensemble of written evidence draws its data and conclusions from surveys that have been recently conducted using samples from different, yet related, populations, among which engineering professionals, graduates and prospective students consist the dominant groups of respondents.

2. FORMAL AND NON-FORMAL EDUCATION

2.1 Higher education in civil engineering

Higher education in Greece follows a binary one-tier education system for studies up to the doctoral level and a one-tier doctoral structure. The minimum duration of undergraduate studies in universities is four years for most disciplines, five years for all engineering branches and six years for studies in medicine. Some particular disciplines can be also studied at the Technological Education Institutes, which are non-university higher education institutions that provide study programs of three and a half up to four years of duration. Master-type postgraduate programs, usually of one to two years long, are available to graduates for the continuation of their studies in most scientific fields. Finally, the doctoral degree can be obtained after a mix of at least three years of study, research and a public defense of a thesis.

Entrance to higher education in Greece is attainable for students who have attended lyceums, or, in other words, for those who have already received 12 years of formal pre-university education. Lyceum study constitutes the upper three-year cycle of secondary education, which totals six years, as many as it also does the elementary education. Entering higher education requires the successful participation in general nationwide examinations, a system based entirely and exclusively on the lyceum curriculum. Candidates should select one of the major fields of study, each of which is offered by a specified set of higher education institutions and then declare their preferences for specific schools/departments within these institutions in a hierarchical way. Civil engineering studies are offered by five universities, with courses running for ten semesters and several technological institutions, with courses running for seven to eight semesters (Latinopoulos 2004).

Under the above described system of examinations, access to higher education in Greece is considered as highly competitive one, at least for some disciplines (e.g. medicine, law, engineering etc.), of which the number of available university places is not sufficient to meet the extremely high demand (Saiti and Prokopiadou 2008). This particular condition is mainly driven by the conception of Greek students and their parents that university education offers increased opportunities for a good job, and thus for greater economic benefits, a steady career development and, last but not least, an upward social mobility (Saiti and Mitrosili 2005, Saiti and Prokopiadou 2008). This is why many of those who were not successful in entering a national university at all or, at least, their preferred department, opt for enrollment in much more expensive university studies abroad, instead of reconciling to study in the "inferior" technological institutions or in non-preferred university departments at home.

Civil engineering stands among the first preferences of candidate students who select the group of major fields that comprises all branches of engineering, the natural sciences, information and computer technologies and so forth. During recent years, more than 60% of successful entrants in the country's civil engineering university departments have declared this discipline as their first-choice one, while more than 90% of them have included it in their 1-3 most preferable disciplines. Given the relatively high number of places offered by all five civil engineering departments, the annual total output of domestic university graduates fluctuates around 1,000, to whom another 200-250 are added from those immigrating after completion of similar studies abroad. It is worth noting that before entering the labour market about 40% of all these graduates continue for postgraduate studies, almost half of them in Greek institutions. From the other half of civil engineers, who go abroad for further studies, two out of three choose a British institution (TCG 2009a).

Recent trends regarding postgraduate studies in Greece show an upward shift in the number of graduates that select to study at home, not only to avoid the extra financial costs incurred by studying abroad but also because the number and quality of Greek postgraduate courses increased remarkably during the last 10-12 years. As far as the level of the chosen postgraduate study is concerned, the majority opts for specialisation, MSc-type courses, which are more professional- than research-oriented, and only a small percentage of graduates go for a doctoral program of study (for Greek civil engineering graduates this last figure is around 9% of their total number). This fact reflects a more general situation in Europe, where data on recent evolutions of engineering doctoral and postdoctoral education, which is crucial to the conduct of research and innovation in the continent, are not satisfactory: the flow of PhD's and postdoctorates in Europe is smaller than the relevant flows in Asia and North America (Moguérou 2005).

2.2 Continuing professional development of civil engineers

Lifelong learning is an issue that has given a lot of attention all over Europe, particularly during the last decade, with specific emphasis put on a more active involvement of universities as providers of various forms of lifelong learning modules, especially of the non-formal types (Osborne and Thomas 2003). Formal (university) education differs a lot among the continent's institutions regarding the adequacy of the initial professional training provided to their graduates. This is the main reason of distinct variations observed in the development of graduates once in employment and in the consequent demand and supply rates of additional non-formal training, mainly of the work-related type (Little 2008). For graduate engineers, either at the initial or at a later stage of their professional career, the lifelong learning forms of continuing education and continuing professional development are the most demanded ones. Both are considered as the necessary means to the broadening of knowledge and experience as well as to maintaining and enhancing personal and specific professional skills and competences (Montesinos and Romero 2003).

The worldwide prevailing contemporary view regarding the educational pathway of a civil engineer is that a major emphasis should be given to a broader initial formal training, followed by a continuing education and/or continuing professional development training throughout his professional engagement. Such a process can enable him to be updated and learn effectively and efficiently various subjects, according to his personal aspiration and career decisions and his professional needs (Latinopoulos 2006). Moreover, this educational pathway could most probably overcome the inherent drawbacks of many university curricula, through which the teaching of technical subjects often fails in properly preparing their graduates to face all problems encountered in practice as well as to allow them to develop self-sufficient learning skills.

Although quite respected and fairly-high demanded by young professionals, continuing professional development is not widespread in Greece. Recent surveys among young engineering graduates but also among more experienced professionals show that an overwhelming majority of them considers that such an education is quite necessary for their initial placement in the labour market and their career development (TCG 2009a). At the highest level of their preferences for specific training subjects stand information and technology, renewable energy sources, business administration and management, and protection and management of the environment. Civil engineers show additional interest in some issues related to construction, like new materials and rehabilitation and restoration of old/historic buildings.

Unfortunately, universities have not yet been seriously involved in this kind of educational activities, leaving thus ample space mainly to the Technical Chamber of Greece, which represents all registered professional engineers in the country and acts as an advisory body to the government. In fact the Technical Chamber is the only example of good practice as an integrated provider of continuing professional development to engineers, by successfully operating a relevant service that offers short courses and seminars on a wide range of subjects to its members. Much fewer similar activities are undertaken in a rather incidental way by some university departments, private educational bodies and private companies.

3. EMPLOYMENT AND CAREER OPTIONS

3.1 Professional status and employment of civil engineers

Civil engineers used to be among the most active and prosperous professionals in Greece, first of all during the three decades following the second world war, when they undertook a major role in the nation's big reconstruction enterprise. Most of the profession's long-lasting nationwide popularity owes a lot to that particular "golden age" of the construction industry, in which the post-war housing shortage together with the need for new public infrastructure created a huge demand for civil engineers. In the following period (i.e. from late 1970's to late 1980's) the construction rate of public infrastructure declined. Yet, practicing civil engineers continued to be quite busy working either as self-employed individuals or engaged in numerous small-to-medium size engineering firms, mainly supported by private sector funds invested in housing, real estate enterprises and other projects (e.g. for the development of many tourist regions) (Patrinos and Lavoie 1995).

A second period of blooming of the construction industry, that initiated in mid 1990's and lasted up to 2004 when the Olympic Games took place in Athens, was marked by high investments, particularly by European Community Frameworks' and national funds, in the construction of several major public works, some of which reshaped in a very positive way the transport infrastructure and services, mainly in the area of the country's capital. After 2004 public investment in the construction industry declined significantly and relevant activities were confined mainly to private construction, which was supported by low interest rates of mortgage loans. However, in 2007 the provision of private housing exceeded demand while in 2008 the situation got even worse because of the world financial crisis creating thus severe problems in many construction firms.

A particular characteristic of the period up to the 1980's was the small number of civil engineers working in Greece: it was only half of those employed during the 1990's and almost a quarter of today's workforce. Thus, the apparent prosperity of those professionals was due also to their high personal share in the construction business. This share became much smaller during the next years, as a result of a rapidly increasing rate in the number of young civil engineers entering the profession, the main driving forces for this being: (a) the quite attractive, still fictitious, picture of an occupation that seemed to secure economic benefits, and (b) the beginning of the massification in higher education, which quite shortly doubled the output of graduating engineers.

The current workforce of civil engineers in Greece amounts to about 24,000 university graduates, a significant percentage in the population of the country and substantially above the relevant EU average rate. Overall unemployment averages 6-7%, but a steep upward trend at two-digit figures holds exclusively for the new generation of civil engineers. A recent nationwide survey conducted by the Technical Chamber of Greece showed that the rate of unemployment among engineers graduated from 2006 onwards averages a high 23% of the total (all branches) engineering manpower (TCG 2009a), whereas a similar survey three years before had shown only a 14% rate (TCG 2007). With no exact measures available it can be indirectly estimated that unemployment of young civil engineers is a little less than 20%.

There is notable evidence that, mainly in the private sector, unemployment rates of civil engineers may vary depending on the institutions from which they graduated, on the city in which they live and look for job etc. (NTUA 2007, AUTh 2008, TCG 2009a). Still, all these rates are relatively low when compared to those concerning lots of university-degree holders from other disciplines. Misemployment of engineers rests also at non-alarming levels and far below the national average of educated professionals (ACEG 2008, TCG 2009a). In real figures a 76% of employed civil engineers declared that they are working on the very subject of their specialisation alone while an additional 19% of them are professionally engaged not only in civil engineering-related business but also in business related to other engineering branches.

The dominant type of employment of civil engineers working in Greece is private enterprise. 19% of the total workforce runs consulting and/or construction firms of various sizes in which many other civil engineers are employed. The second group together with those who are self-employed sums up to 65%. On the other hand about 10% of civil engineers are working on a permanent basis and another 6% under limited time contracts in the public sector. The main subject of work of all these people is the design and/or the construction of private and public buildings, whereas only few of them deal with other types of works and infrastructure.

3.2 Trends in career decisions of graduate civil engineers

Civil engineering as a profession has undergone analogous fluctuations over time, as the one described above, in most European countries. Depending mainly on how important is the construction sector for the economy of a country, the attractiveness of the civil engineering profession is also related to other facts and issues of smaller but not negligible effects. The society's either positive or negative impressions on where and how a civil engineer works and behaves, what he contributes to society and whether he is associated with environmental damage or not, among others, create either favourable or unfavourable opinions that affect first career decisions of young people, i.e. to study civil engineering or not. Various surveys and data (e.g. Baron *et al*. 2006) show that, in general, European prospective students do not reject in general the idea of studying civil engineering as a result of being negatively influenced by society. On the contrary, the academic standards of entrance to relevant courses are holding up well and in general, enough people are going into the profession.

In Greece, as stated above, civil engineering is for many years considered as one of the steadiest and high-valued career decisions. Several surveys conducted either by the Career Services Offices of major Greek universities (NTUA 2007, AUTh 2008) or by national professional organisations (ACEG 2008, TCG 2007, TCG 2009a) confirm that employed civil engineers are at high percentages satisfied by their work. Still, there are variations in the level of satisfaction, which declines with reference to some specific issues like competitiveness with other engineering professionals, low remuneration, and incomplete higher education, especially as far as acquired practical training and skill development is concerned.

What indeed has changed today, as compared to the recent past, especially the years before 2004, is the type of employment. At that time the big consulting and construction firms were continuously expanding, as opposed to the detriment of many traditional small to medium size ones, a fact that triggered a constant since then decline in the creation of new firms. Under those conditions, big firms profited a lot by not only undertaking huge projects at home but also by extending their business in the neighboring Balkan countries. The dominance of big enterprises in a so-formed construction oligopoly refrained young engineers from the traditional, still already financially insecure, self-employment practices and directed them mainly to short-term contracted, non-permanent job engagements in the big firms. Unfortunately this very productive period did not last for long. To the worse it was almost immediately followed by a rising recession that lasted up to our days when the global financial crisis multiplied the already existing negative impacts on self-employment practicing and on entrepreneurial venturing.

As a consequence, in today's real world career planning of new civil engineers is mostly affected by sound insecurities as to the future prospects of a profession that does not seem to be a quite lucrative one any more. Although average figures of unemployment and misemployment of civil engineers are significantly lower when compared to other educated professionals, the relevant trends in the younger age-group are alarmingly worse. Thus, in relation with the first professional engagement, a rather typical decision path is being followed: a larger than usual number of fresh graduates opts for a permanent employment in the public sector or, if this is not possible, for a limited-time contracted job with it. But the number of relevant available places is not sufficient at all. From those who do not succeed and, of course, from all the rest who don't apply for public service some (very few in our days) try self-employment, risking thus serious intermittent periods of professional inactivity, while the rest (the majority) settle for various types of employment offered by an unstable private sector and at the cost of low remuneration, sometimes even less than that of the already low-paid public sector.

3.3 The impact of current economic crisis

Despite a general view holding within the country, the importance of the construction sector in Greece is less than in most European countries. However, it stands among the more significant economic factors nationwide, with a direct share of 7% in GDP and of an 8% in employment (the whole activity contributes directly and indirectly up to 15% in the country's GDP and up to 17% in its employment).

Construction and industry are the two economic sectors that were most badly affected by the recent global economic crisis all over Europe and suffered the strongest contraction in employment. With a production rate decreasing at double digits during 2009, the building sub-sector of the construction industry seems to be a serious problem in the continent's immediate development process (EC 2009). Obviously the outlook for construction activity differs considerably from country to country and in countries which did not experience a house bubble before the crisis this particular activity is expected to recover fairly quickly. Greece's construction industry has been affected from early 2009 (TCG 2009b). As house prices have not yet started to decline substantially and also because of high transaction costs, taxes etc., it is rather unlikely that the construction sector will continue to account any time soon for a share of GDP as large as it was before the crisis.

It is beyond any reasonable doubt that the current economic downturn will continue to seriously affect the country's industry in general. Signs of its harmful impacts relate to numerous Greek enterprises, among which quite many from to the construction sector. Not only the public sector has reduced existing and planned funding in infrastructure projects but also the private sector seems quite helpless in risking new investments, as they already massively report declining turnovers. For civil engineering professionals, who used to be predominantly involved in traditional construction and building activities, yet much less in RD ones, it is probable that the crisis might generate a positive opportunity for a shift in other new activities and technologies which, after all, would benefit the country's development.

However, up to the time that the whole system will be reorganised and conformed to the new reality, the difficulties of young engineers in finding the employment of their choice are not likely to improve at all. Apart from this immediate consequence to the current workforce, such an ominous prospect could adversely affect the previously described traditional high demand for civil engineering studies, at least from among the most qualified graduates of lyceums.

4. THE EDUCATION-EMPLOYMENT RELATIONSHIPS

4.1 Mismatches between higher education and labour market

Although civil engineering graduates are in general not dissatisfied in making their way through the labour market (TCG 2009a), a more careful insight into their professional status and rewards provides some additional points for a further discussion. This discussion is confined herein to existing mismatches between the education, which any individual entrant to the labour market has already received, and the qualifications associated with the particular occupation, for which he is applying. The most apparent occupational mismatches in relation to Greek university-degree holders, apart from their oversupply and misemployment already commented, are excessive schooling duration (and, consequently, excessive acquired degrees), a redundant theoretical-academic background, low payments and a shortage of various skills specifically required by the private sector (Patrinos and Lavoie 1995, Patrinos 1997, Liagouras et al. 2003, Lianos et al. 2004, Saiti and Prokopiadou 2008).

First of all, the phenomenon of overeducation dominates all over Greece. As mentioned before, the number of those who proceed with a further upgrading of their formal qualifications (i.e. for postgraduate degrees) either at home or at foreign institutions is significant. This massive trend is justifiable when considering the unemployment rates of young graduates, the rather lengthy period between completion of basic studies and finding a job and the tough competition terms for entry in the public sector. Especially for the last case, current figures reveal a steadily increasing population of graduates who apply for employment in a more or less decreasing in size public sector. As a result, the hiring policies of the public sector favour the recruitment of almost solely university graduates. Still, it can be easily substantiated that the majority of public servants are overqualified for the service they provide, or, in other words, that all these workers' educational capacities and skills are underutilised. This mismatch between the acquired high education qualifications and the relevant low demands in the public service constitutes an important loss for economic growth and can have a negative effect on productivity because overeducated civil workers may exhibit adverse behaviour (e.g. reduced work effort and absenteeism).

Monetary rewards are also low when associated with education, especially at the higher levels, when the high costs, which the quite lengthy study period of young professionals has incurred to their families, are taken into account. Medium to low remuneration of educated young people is the rule rather than the exception not only in the public but also in the private sector. In addition to that, the private sector in Greece does not appreciate extra education qualifications, like master's or higher degrees, with the exception of some specialisations, which, depending on the case, can be considered useful to some businesses. Normally, a first (undergraduate) degree is considered adequate for a usually low-paid employment of young graduates in small engineering firms, as the leading preference for them is to have enough working experience in order to be immediately productive.

As far as the knowledge and skills acquired during their rather long period of university studies is concerned, young Greek employees of the public sector and, even more, of the private one admit that they were substantially oriented towards a solid traditional model of civil engineering education (e.g. TCG 2009a). Such schooling, albeit it provides students with a probably more than adequate theoretical knowledge and sufficient technical skills, it lacks some specific elements that are of high value within various job environments. This is the case appearing not only in Greece but in several other European countries, where significant differences between acquired and required skills and competences are depicted (García-Aracil and Velden 2008). Above all, a mono-disciplinary education shapes a classic engineer profile, which is, more or less, out-of-date, considering the complexities and uncertainties of modern techno-economic systems. Of course, discrepancies between contents of studies and employment vary, depending not on the type of occupation alone but on the diversities of academic curricula offered by different institutions. Still, practically all Greek university syllabi are to some degree inadequate concerning the provision of certain specific knowledge topics and skills and they therefore need to change somehow, most probably as presented in the following section.

4.2 Required changes and developments in education

Education and the professional practice of engineers are linked to economy and the labour market at a degree that depends on both the structure and dynamic development of the economy and the timely adaptation of university curricula. However, this arduous relationship should be as tight as possible at any time. To this aim, higher education civil engineering studies should provide: (a) a sound scientific-theoretical background, (b) a related to the discipline at hand technical knowledge, (c) knowledge and practice on ICT applications, (d) a basic inter-disciplinary background on topics useful in the current professional activities, and (e) a well-designed and dictated by the labour market needs training for the development of specific skills, especially of non-technical nature (Angelides and Loukogeorgaki 2005, Sanchez-Vila et al. 2006, Boswell 2006, Papayannakis et al. 2008).

Surveys administered to new employees and their employers show that the last three items of the above list need, at varying degrees, a proper enhancement. Most respondents suggest the introduction of new or the improvement of existing courses and training modules in the topics of law, economics, management and entrepreneurial venturing. Such a curriculum development could benefit not only the graduates who will choose to be employees but also those who would select self-employment. As already mentioned, the great many self-employed civil engineers in Greece, who used to be quite useful to the country's economy, are lately declining in number, particularly because of the reluctance of younger professionals to initiate such an occupation under the current difficult and unsafe professional conditions. To a certain degree, the hesitation to establish their own small firms is attributed to the lack of sufficient entrepreneurial capabilities. Therefore, the provision of additional education and training in the three specific topics above would much probably result to more self-confident and self-efficient prospective young professionals.

Additional suggestions for further educational changes and curricula reforms, declared both in surveys and expert meetings, include: (a) an interdisciplinary learning about a wide spectrum of environment and energy issues and (b) general training modules in information and computer technologies plus a selection of specialised computer applications (for all sub-disciplines of civil engineering), which are routinely used in the practicing professional world.

5. CONCLUSIONS

In the years to come civil engineers will continue to work in Greece in the traditional professional subjects and mainly in the construction business, which is more or less expected to regain in the not so distant future a significant role in the country's economy. However, other developments and technologies may emerge for the sake of the national development that could also professionally absorb a part of this important human capital, the large workforce of Greek civil engineers. On the other hand, what is rather urgently needed for the successful placement in the labour market of the new breed of engineers is a reform in the higher education system, mainly in respect with curriculum content and orientation. Civil engineering education and training in the years to come should combine technical aspects with some other critical non-technical ones in order to make the future civil engineer quite capable to serve the public and the environment.

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CIVIL ENGINEERING EDUCATION: A GREEK PERSPECTIVE

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1. INTRODUCTION

The word university has the same origin as the word universe, which means all or everything. The Greek word for education is *paideia* (παιδεία). In ancient Greece, the word paideia did not just mean education as it had a deeper meaning that included the concepts of perfection and excellence. One way the word paideia manifests itself in the English Language is through the word encyclopaedia, which has been adopted from the Greek *enkyklios paideia* (εγκύκλιος παιδεία). The Greek word enkyklios means a complete system/circle. An encyclopaedia is a book of many volumes dealing with the whole range of human knowledge. From word origins, it could be inferred that a "university education" means a broad based education that considers and covers everything. Therefore, a university education represents a specific way of thinking that could be explained through the words or phrases global, non-specialised, multidisciplinary, beyond knowledge, cultured, etc. A student lucky enough to be accepted for a university education should not expect anything else and the suppliers of such an education should aim at providing nothing less.

Education in Greece was founded in ancient times and has a long tradition of meaning more than just accumulating knowledge. Ancient Greeks believed that ethics and moral virtue could be taught. Furthermore, the belief was that personal wealth included richness of mind and knowledge and, in modern terms, represented an investment in human resources. In ancient Greece, after completing basic education followed by military training, Greek citizens commonly returned to higher education in order to prepare for public life as an alternative to a military career. The Academy and Lyceum of Plato and his student Aristotle were examples of these early centres of higher education and provided the model for today's modern universities. This is just one example of how ancient Greek thought concerning education has drifted down through time and demonstrates how the influence of the ancient Greek education system on western civilization continues today. Nothing has changed in Greece, as the beliefs and concepts concerning education expressed by the ancient Greeks remain in the minds of modern day Greeks.

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2. CIVIL ENGINEERING AND THE SOCIAL ENVIRONMENT

Technological advances have had considerable unforeseen consequences [1]. For example, nowadays, nobody is unaware of the reasons for and the effects of global warming and environmental pollution. It could be said that engineers have unwittingly played a leading role in arriving at the present situation. When considering how engineers react with their social environment, Tassios [1] distinguished the two opposite views of technocratic and Archimedean attitudes.

Technocracy is a kind of fascism in science where all the parameters of human life are ignored with the exception of priorities. The problem is that the technological specialist only solves the next problem and is unable to see the more global unforeseen consequences of solving the problem.

By way of explaining how technocratic, engineering and moral aspects may interact, figure 1 [1] presents the engineering process structure together with contact points of social interest that "*may generate problems of a moral nature*" [1]. Initially, the process starts with a plan, "*a plan of intervention into the world*" [2]. Figure 1 shows that social needs create the motivation for an appropriate engineered solution or design. Immediately, a moral-political problem may arise at the optimisation stage due to the preference of low cost over functional or aesthetic requirements. Further down figure 1, according to Tassios: "*Several side effects due to cheap engineering have in fact produced enormous economical burden for Society, and or lowering of quality of life*" [1]. Tassios continues by stating: "*On the other hand, direct or indirect pressures on the users through marketing may generate additional fictitious needs to be subsequently "served": The thirst of some Engineers for prestige and power under some conditions cannot exclude such an eventual (essentially technocratic) behaviour.*

Last but not least, education may become dangerously one-sided under the influence of engineering "imperialism" so to say. However, this problem does not depend on the will of an Engineer as a person" [1].

In a final warning when considering the dangers of technocracy, Tassios states: "*Short-sighted solutions (ecologically harmful), cheap engineering "technocratic" dictatorship, economically unbearable projects and many other unhappy events may result out of this technocratic situations. It is perhaps not a mere coincidence that political dictatorships, of any colour, are grounded on a large participation of Engineers…*"[1].

The alternative is an Archimedean attitude towards engineering where, according to Tassios when quoting German philosopher Herbert Marcuse: "*only the politicians decide for the aims, and the Engineers simply handle the means, being in substantial inability to check the aims*" [1].

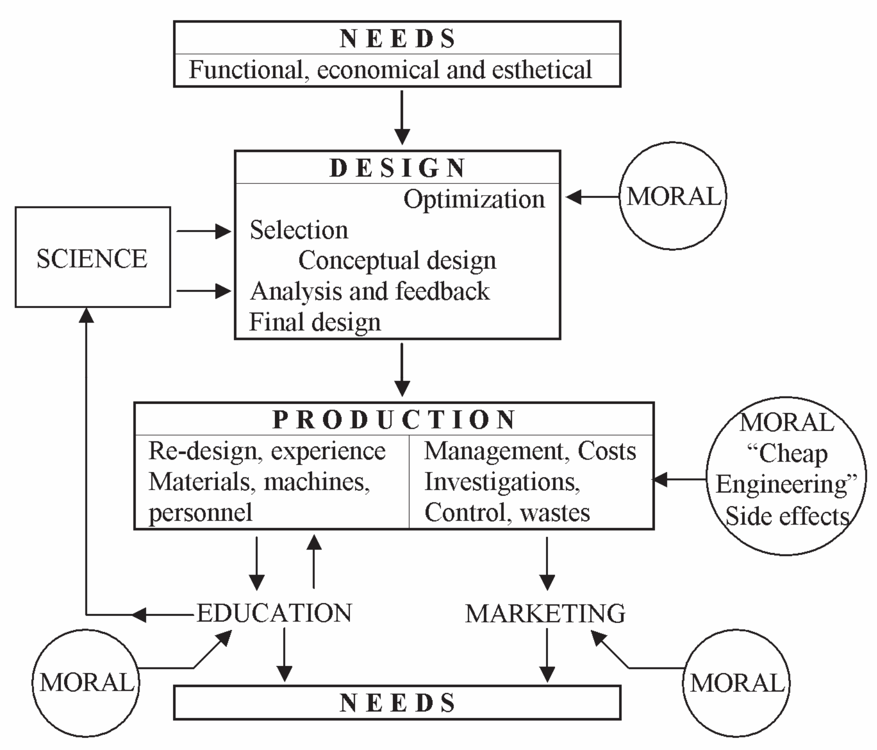

Figure 1. The anatomy of the engineering process
and its contact points with moral problems [1]

Archimedes can be considered as a strong anti-technocrat and a remarkable engineer. The simple application of rotating a spiral inside a cylinder in order to pull water up had a major impact in irrigation projects and other applications of the time [3]. The invention was a result of understanding practical needs and the principle is still in use today. As far as being an anti-technocrat, according to Plutarchus [4], Archimedes had to be persuaded by the king of Syrakuse "*to spare a bit of his theoretical science for practical applications*" during the defence of his own city during a two year long Roman siege. The result was a surprising collection of defensive machinery arranged inside the city walls, which included catapults [4], massive cranes [4] (with the ability to lift the enemy ships out of the water and destroy them by dropping), reflective mirrors [5]arranged in such a way and powerful enough to make the enemy ships catch on fire, etc.. The defence of Syrakuse was so effective that, concerning Archimedes, Polybius [6] was prompted to write: "*in some cases, one soul is more useful than a crowd of workers*". Archimedes was so disinterested in the events of the time that, when the city finally fell and the Romans burst in on

Archimedes, he turned back to the mathematical problem that he was solving and was promptly killed by a Roman soldier.

Tassios, when quoting Plato (Laws, 747b) states: "*mathematics is the most powerful knowledge related to economics and political and technical sciences*". "*Therefore, both traditional and modern realities seem to invite Engineers to be engaged not only in technological facts, but also in the social significance of these facts*" [1]. An engineer should be employed in a position "*which fits the Engineer's character much better than the elected post, (and which) will place him in a position to develop longer lasting and stronger influences upon the politics of his city, state or country*" [7].

In order to avoid the dangers of technocracy, Tassios [1] recommends that the engineer should "*Take special care of his general culture and education, so that his valuing conscience may hold open the bridges of direct communication with his fellow citizens*". Tassios [1] concludes by stating that such an attitude "*will also offer to the Engineer some additional circumstances for creative achievements and personal fulfilment*".

By understanding the Archimedean engineering attitude, it can be understood from the above analysis that the engineer has to be involved globally and a high level background in the civil engineering environment is required.

3. EDUCATION, TRAINING AND QUALIFICATIONS IN CIVIL ENGINEERING

Civil engineering is fundamentally different to the other scientific disciplines because the theory never perfectly fits the design problem and approximations have to be made. Most civil engineering projects are unique and there is rarely a chance to test a prototype. Therefore, the uncertainty in civil engineering is high. How a civil engineer deals with uncertainty is critical because of the high standards of safety required by the public. Civil engineers have to make decisions regardless of the uncertainty. According to Tassios: "*in assessing a Technology we come face-to-face with enormous value-conflicts Technology is urging us to solve*" [2]. In addition, "*the new with Technology is that it brings about much more numerous, collective and everyday dilemmas, the solution necessitating an enormous amount of special and certain knowledge on the many contingencies under compariso*n" [2]. Here, it is worth noting that the Greek word for engineer is *michanicos* (μηχανικός), derived from *michanevomai* (μηχανεύομαι), which has the meaning of trying to find a solution.

The work of civil engineers has had a huge impact on modern society. Evidence of civil engineers at work can be seen all around. Civil engineers planned and designed the motorways and roads we drive on, made sure the buildings we live and work in do not fall down, ensured that the water we drink is clean, plentiful and comes out of the tap at the right pressure, etc.. It could be said that sometimes the work of mostly unseen civil engineers has had a higher impact than that of medical doctors, architects and lawyers. For example, the achievement of supplying clean drinking water to the cities has saved millions of lives through the eradication of disease.

In civil engineering, there is a real need for personnel with a diversity of qualifications to serve at a variety of levels throughout the industry. At the base of the industry are the invaluable unskilled or semi-skilled labourers. Above these are the skilled tradesmen and their apprentices. These are the craftsmen and masons and include carpenters, steel fixers, steel erectors, welders, etc.. In most European countries, skilled tradesmen and apprentices have received some form of vocational training. Moving up the ladder, there is the clerk of works. The clerk of works normally has the background of being an experienced tradesman and has a wide knowledge and understanding of the construction process. The clerk of works is employed by the architect or engineer to serve on site in the role of looking after the best interests of the client by ensuring a high quality of materials and workmanship.

Moving further up are personnel that normally have an engineering qualification. Within this latter group, there are a number of different needs. At one level, there is a need for well-qualified engineers to supervise and be involved in the work on site. At this level, there in not a need for a deep theoretical background as the role is to be involved in making on site decisions and supervision. Civil engineers of this type may need to specialise perhaps, for example, with a Masters degree in hydraulic engineering, marine engineering or railway engineering. In addition, at an even higher level, there is a need for well-educated civil engineers with a very strong theoretical background. These engineers should be capable of giving solutions to any civil engineering problem during both the design and construction stages.

There is a requirement for any educational system to produce all the above types of civil engineering personnel with different individual qualifications. Many of the functions of the civil engineer can be provided for by a two-tier educational system. The first cycle, leading to a Bachelor’s degree, should produce the lower level type of civil engineer. The second cycle, leading to a Master’s degree on top of the Bachelor’s degree, should produce the more specialist type of civil engineer. However, in addition to the two-tier educational system, there is a need to keep the integrated system, traditional to many European countries, to produce the high-level civil engineer or “Master Engineer” with solely a Master’s degree.

A Bachelor plus Master’s degree obtained from a two-tier system cannot be considered as equivalent to a Master’s degree obtained from an integrated system. Civil engineers with the latter type of qualification need to have not only a strong and very firm background in many sciences such as mathematics, physics, materials, etc. but also require a global education and a broad knowledge of other disciplines such as the environment, sustainability, etc. This is required in order to address the negative impact that engineers may have in their social environment and to avoid short sighted and cheap engineering solutions that in the past has unwittingly lead to many of the current World problems. In the previous chapter, the need for a broad background was explicitly analysed concerning the social environment with considerations to moral implications. Therefore, in civil engineering education, two systems must exist in parallel. This in not just the opinion of the authors, as the FEANI Statement on Bologna and Prague Declarations says amongst other things: "*FEANI recommends that the existing European system of longer integrated engineering curricula leading straight to a Master's Degree should be maintained in parallel with a two-cycle Bachelor/Master system*" [8]. FEANI is the European Federation of National Engineering Associations. FEANI is not alone as CESAER and SEFI, in their second recommendation, state: "*In the context of the new first and second cycle degree structure, the engineering community of Europe agrees that in order to attain a high level of scientifically oriented competencies, engineering graduates need to be educated to a level corresponding to second cycle Masters level degrees. It is thus important that any new procedures and regulations do not compromise the number and quality of such graduates. In particular, there must continue to be provision for an integrated route through to the Masters level as this preserves the coherence and efficiency of the formation*" [9]. CESAER is the Conference of European Schools for Advanced Engineering Education and Research and SEFI is the European Society for Engineering Education. The statement by CESAER and SEFI is reiterated in their second joint communication on the Bologna process when they state: "*The 3+2 model has become a standard reference in engineering. This should not exclude other possible paths towards the second-level degree, such as an integrated 5 years curriculum or a 4+2 scheme or a 4+1 model*" [10]. Further evidence for this opinion can be found in the 4th EUCEET Volume. For example, it is stated: "*the integrated degree courses are compatible with the Bologna spirit and should not be replaced unless there are serious reasons in favour of such a replacement*" [11]. Finally, the prevailing opinion in Greece on this matter has already been stated by Prof. Themistocles Xanthopoulos during the opening session of the first General Assembly of EUCEET II in 2003. To quote in full from the 4th EUCEET Volume: "*Any splitting of the existing structure into two cycles, the undergraduate and the postgraduate, de facto downgrades the undergraduate cycle to that of the Schools of Higher Professional or Vocational Training, given that it is not possible to equip with substantial professional skills in the short period of this cycle without at the same time the shrinkage of the background scientific knowledge, that is without the actual betrayal of the scientific substance of the University degree.*

It is, besides, at least unreasonable to claim that it is possible to decrease the duration of studies without downgrading their university nature, at a time of *pressing demands, both from students and academic staff, for an increase of the duration of university studies due to the explosive increase of knowledge in the applied sciences and technology, as well as the recognition by the relevant professional bodies of the inadequacies of the Bachelor's degree, as a university diploma, in the labour market.*

We reject explicitly the main objective of the Bologna Declaration, namely the compulsory and universal division of all University courses into two cycles..." [11].

In other words, in Greece the two-tier system is opposed as a compulsory and universal division of all engineering university studies. In reality, a two-tier engineering education system already exists in parallel with an integrated education system. As described by Latinopoulos [12], a first tier type degree leading to the qualification of technological engineer offered by the Technological Education Institutes (TEI). Obviously, professional qualifications awarded by TEI are limited. It is then possible to continue in education by specializing. This leads to a technological postgraduate degree of specialization. This system could be considered in fact as a two-tier system. Running in parallel with this system is an integrated system leading to the qualification of engineer. This is the main system of engineering education offered by the universities in Greece. Again, specialization is possible leading to postgraduate diploma of specialization. It is to be noted that the two-tier system is by no means considered equivalent to the integrated system. These two systems exist in parallel because of the general opinion that this is what is required in practice. Reasons for this situation can be found by referring to the report of EUCEET Working Group F in the 3rd EUCEET Volume [13], which outlines the demands being made on the civil engineering profession. Specific requirements for civil engineering considering the relatively new environmental and sustainable development matters can be found in the report of the Working Group for the Specific Project 3 in the 5th EUCEET Volume [14]. In addition, the need for additional subjects to be taught from outside the traditional topic areas of civil engineering is presented in the report of the Working Group for the Specific Project 4 in the 5th EUCEET Volume [15]. It is impossible to see how these "new" discipline requirements for the high level civil engineer of today, let alone the future, can be obtained outside of an integrated educational system.

4. PECULIARITIES TO GREECE

Every country has its own peculiarities and Greece is no exception. The Greek individualistic nature expresses itself in the form that there are very few large Greek civil engineering companies. Rather, the Greek engineering office consists of two or three persons that work together and at times it is only a single person. In this situation, specialisation is an exception, as Greek civil engineers must be familiar with all the aspects of civil engineering. This situation promotes the need for highly educated civil engineers capable of dealing with all the demands of civil engineering.

The Greek individualistic nature can be expressed by the usual saying that "no two buildings in Greece are the same". The Greek public demands something architecturally different for every structure or building. This means that any new construction starts from scratch, as it is not just simply a matter of copying and then adapting the last design. In addition, this means that a Greek civil engineer must have a creative flair similar to that expressed by an architect.

The fact is that Greece also has a highly unskilled workforce. Most of the carpenters, steel fixers, welders, bricklayers and other construction workers receive no training before commencing an occupation in the Greek construction industry. Although such workers may in time gain considerable experience, the basic technical background is always missing. The role of the civil engineer as supervisor in this situation is critical due to the need to keep standards high, particularly with regard to the high seismicity of the country.

Greece is a country that is still developing and much of the infrastructure is still to be built. Moreover, most of the serious earthquakes that occur in Europe occur in Greece. This means that any structure in Greece, no matter how small, by law requires the structural analysis to take into consideration earthquake effects. In the subject categories established by working Group A of EUCEET I [16], earthquake engineering is an "Engineering Specialisation" (Category D), meaning that most European civil engineering students may not even study the topic. Earthquake engineering in Greece is the "Core Civil Engineering Subject" (Category C), meaning that every civil engineer in Greece must have a strong structural engineering background in anti-seismic design.

In Greece, the complex topic of earthquake engineering encompasses a whole section of studies and must be studied in addition to and on top of the civil engineering subjects covered by most other European countries' universities. It should be noted that knowledge concerning earthquake engineering is far from complete as, after every strong earthquake, lessons are learned.

It must not be forgotten that the subject of earthquake engineering does not only cover new construction. Anti-seismic guidelines, codes and specifications have been continually upgraded as relevant knowledge has increased, particularly in recent years. The direct consequence of this is that the vast majority of the structures and building stock in Greece and other seismic prone countries is inadequately designed and is in danger of experiencing serious damage or even collapse during a strong earthquake. This is a problem that is not going to go away and is only going to get worse as time goes on. The strengthening before an earthquake or the repair and strengthening of structures after an earthquake is a little known topic in Europe outside of a few earthquake prone countries. A Greek civil engineer must be well acquainted with the subject of seismic retrofitting. This is because the design and planning of an intervention is far more difficult and complex than that of designing a new construction. There is the strong possibility that a badly planned intervention may actually have a negative effect on the whole seismic capacity of the structure. Therefore, the subject represents a unique challenge to the civil engineer and requires a high degree of judgement and prudence.

Clearly, due to the earthquakes, Greece requires multidisciplinary civil engineers that have been broadly educated in many matters. Obviously, civil engineers working in Greece need to be highly educated in seismic design, assessment, retrofitting of existing structures, etc.. This promotes the need for an integrated civil engineering education system running in parallel with a two tier system.

5. CONCLUSIONS

Education in Greece was founded in ancient times and represents a specific way of thinking. When considering the whole Greek view from ancient times, the words or phrases universal, non-specialized, cultured and beyond knowledge spring to mind. Following the above aspect, civil engineers need to have not only a strong and very firm background in many sciences such as mathematics, physics, materials, etc. but also require a global education and a broad knowledge of other disciplines such as the environment, sustainability, etc. This is required in order to address the negative technocratic impact that engineers may have in their social environment and to avoid short sighted and cheap engineering solutions that in the past have unwittingly lead to many of the current World problems. The alternative of a Archimedean attitude has been emphasised in the text. Society requires engineers with strong personalities that are able to take responsibility and are capable of giving solutions to any civil engineering problem during both the design and construction stages are required. Any university education must be geared towards the projected needs of the workplace. However, it is believed that a two-tier system alone is not capable of educating civil engineers to the appropriate levels of knowledge and expertise required. From a Greek perspective, as analysed throughout the above text, an integrated education system is necessary to run in parallel to satisfy the requirements of not only Greek but, more importantly, European society.

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CIVIL ENGINEERING PROFESSION AND EDUCATION

Vassilis P. Economopoulos[1]

A **Civil Engineer** is considered to be a person possessing the skills and the knowledge to combine analytical and synthetic approaches for detecting problems in order to find and to apply reliable, safe, economical and environmentally, socially acceptable solutions. From this point of view the **Civil Engineer** is a producer, as well as a decision maker.

The **Civil Engineer** is the designer, the constructor, the producer, the supervisor, the leader of the integrated projects, those that build the quality of life of the humanity.

The **Civil Engineer** must act as a professional within a framework of high morale and ethical standards seeking the sustainable development and the protection of the natural environment, with compatible construction activities for a modern and a viable urban environment.

Civil engineers serve the public interest and the humanity needs

We must reveal, explain and promote our Profession's Public Interest Character. We can analytically present this **public interest character** in a broad range of Civil Engineering Activities as following indicatively referred:

- Safety and quality of the building constructions
- Conservation and restoration of the world cultural heritage
- Anti-earthquake protection
- Energy efficiency of buildings
- Sustainable development of infrastructure
- Safety of the dams
- Quality of the life with adequate water supply
- Quality of the life with sustainable transport
- Quality of life and environmental protection with upgraded and innovative sewage and waste water treatment plants
- Spatial planning for a sustainable urban environment
- Water resources management
- Renewable resources of energy
- Road safety
- Transportation plans, public transport infrastructure for sustainable cities
- Developing of railways and highways infrastructure, connecting peoples, enhance the sustainable development

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- Facing the greenhouse phenomenon and the CO2 emissions
- Public health with advanced sanitary and social infrastructure

The above indicative catalogue must be enlarged and specified by ECCE and the European/International Engineering Organizations. All the arguments, the works and the activities proving that our engineering profession has a vital and critical role serving the public interest and the quality of the people life should be emerged and promoted by the engineering organizations in our societies. That should be achieved in the National and European level.

The civil engineering profession is an “open” and not “close-restricted profession” and the engineering chambers must control and regulate the access to the profession as well as the whole professional engineering evolution in order to ensure the quality of the providing services to the clients and consequently the safety and the quality of the life of the people.

The engineering chambers serve of course the general public interest on the developmental and sustainability matters in all their countries and in the europe.

The engineering chambers are not unions or associations of undertakings/enterprises that they have the only targets to protect the interests of their members.

The European engineering organizations and the national engineering chambers should establish a strong alliance for demonstrating and presenting their critical role to the society and promoting their engineers’ activities in the European union level. This strong alliance can ensure the safety and the quality for the European citizen lifes.

We must consider and define many successful schemes and initiatives, to inform and inspire the society for our Civil Engineering critical and vital role, of many actions for enhancing the visibility of our profession can be organized and launched in the national and in the EU level.

In the USA a great dialogue and a proposed big transformation is held in recent years concerning the Civil Engineering Profession and the correspondent educational and professional requirements for access and career evolution in the profession.

In that broad dialogue, coordinated by the American Society of Civil Engineers (ASCE) they participated International Engineering Organizations, Universities, National Engineering Organizations, Technical Universities, the biggest multinational construction and design companies, senior professional Civil Engineers, futurists et al.

The ASCE announced on 2006-2007 the **"Aspirational Vision for Civil Engineering for 2025".** The basic outcomes of that great continuing elaboration for the big transformation in the education prerequired for the profession are the following:

In a world of 6,5+ billion people

- 1,6 billion do not have safe drinking water
- 2,6 billion do not have basic sanitation
- 1,6 billion do not have adequate shelter
- 1,6 billion do not have reliable power
- 3,4 billion do not have adequate access to information or communication

In an increasingly demand and conflict competitive world we need

- Sustainability
- Research and development expected benefits
- Managing risk
- Innovation and integration
- Reform in the preparation of engineers

Civil engineers are entrusted by the Society to create a sustainable world and enhance the global quality of life. The engineers are and will be:

- Master planners, designers, constructors and operators of society's economic and social engine-the built environment
- Master innovators and integrators of ideas and technology
- Master stewards of the natural environment and its resources
- Managers of risk and uncertainty cause by natural events, accidents and other threats
- Leaders in discussions and decision making and shaping public environmental and Infrastructure policy

The modern profile of the civil engineer needs:

- Knowledge
- Skills
- Attitudes

The civil engineer should be knowledgeable:

- Mathematics, physics, chemistry, biology, mechanics and materials
- Design
- Sustainability
- Public policy and administration
- Business basics
- Social sciences
- Ethic behaviour

The civil engineer should be skilful:

- Apply basic engineering tools

- Learnt about, assess and master new technology
- Communicate
- Collaborate
- Manage
- Lead

The civil engineer should embrace attitudes:
- Creativity and entrepreneurship
- Commitment
- Curiosity
- Honesty and integrity
- Optimism
- Respect and tolerance
- Thoroughness and self-discipline

All the above lead the Future Vision of Civil Engineers to a new long and strong educational background required for acting as a professional called the **body of knowledge (BOK).** The BOK needs absolutely three categories of knowledge (foundational, technical and professional). For that the Technical Depth and the Technical & Professional Breadth of the BOK should be surely founded on Basic Sciences, Mathematics, Humanities and Social Sciences.

ASCE's great proposals for the big transformation underline also the **leadership in engineering.**

We can find some indicative components of the subject as following:
- Leadership begins with our engineers/members
- Building leaders
- Personal qualities of a leader (driven by a vision, able to inspire others, committed to motivate the team, recognizes opportunities to help make vision a reality)
- Leaders motivate others
- Engineers/members sharing expertise
- Informing the public and inspiring the society
- Being prominent
- Spreading the world
- Our infrastructure message
- Leading the nation in infrastructure action
- Leading in public policy advocacy
- Leading in technical expertise
- Finding Transportation and development solutions
- Building international alliances
- Promoting innovation
- Protecting critical infrastructure
- Reaching out to kids

- Inspiring achievement
- Engaging students
- Recognizing achievement and sharing excitement

For all the above the well preparing our civil engineering profession is needed. It is underlined: "ASCE's Vision includes preparing our profession for the future. ASCE has long been an advocate for elevating standards for a career in civil engineering. Future Civil Engineers will face an increasingly demand world requiring more professional specialization. At the 2006 Annual Meeting of the National Council of Examiners for Engineering and Surveying (NCEES) delegates voted to encourage States to strengthen educational requirements for licensure. The change strongly backed by ASCE calls on States to increase their educational requirements".

ASCE released in 2008 the second edition of the **body of knowledge**. This new report defines knowledge, skills and attitudes necessary to enter the profession. Implementation will lead to the revision of current undergraduate and postgraduate education.

On August 2009, the National Council of Examiners for Engineering and Surveying (NCEES) decided that the MSc degree will be (in the future) the pre-requisition in order to be a candidate eligible for the Professional Examinations for obtaining the professional title and to act as a Civil Engineer.

In that strong educational background the Engineering Professional Recognition and the Access to the Profession should be strongly founded. The Engineers Chambers and the relevant organizations should control and keep strictly the quality of the provided Civil Engineering services for their Members in order to protect and upgrade the Public Interest and this can be achieved mainly with the exams for accessing to the profession and taking the professional license.

Within this framework the Mobility of Engineers could easily and effectively be faced. The Mobility is not a self-target, the safety and quality in the provided services, in the built environment must be ensured for all European people. The Engineers Chambers should keep and upgrade their critical role of assessment of the access and the career evolution in the Engineering Profession. It is our mission to the Society; it is our duty for our Members.

Engineers Chambers should assert the above critical role in order to express and ensure it clearly in the European Legislation (the dialogue for the possible reform of 2005/36 EC Directive will start from 2010). We must prepare on that and our strong alliance must present its strong arguments for the Engineering Profession serving the public interest under strong educational and professional prerequisites.

For my personal view we must consider very seriously any proposed approaches about “automatic and mechanistic” formulas of mutual professional recognition. These “automatic mechanisms” surely degrade the quality of provided Engineering services in Europe. Apart of that, these systems seem fully unrealistic concerning the diversities in our Europe of 27.

The Engineers Chambers should keep high up the flag of the safety & quality protecting the public interest

The Human Resources and the investment on them is the main factor of the Society Development. This has an important special meaning for Engineering. We cannot allow the degradation of our human resources by the deregulation of the workforce market (concerning the educational and professional prerequisites).

The following paragraph from the Common Opinion/Position Paper on “Small Business Act” issued by the European Council of Civil Engineers (ECCE) and European Council of Engineering Chambers (ECEC) is important and clear:

“ECEC and ECCE would like to stress that-in view to consumer protection and public interest/public welfare-it has to be part of SME policies to safeguard the quality of services provided by professionals. The financial crisis has yet again clearly shown that there is no need for “deregulation” but for better “regulation”. The academic Engineers that are represented by ECEC and ECCE provide services that are very often of crucial interest for the public, for the functioning of daily life, for technical progress and sustainable development.”

Our Engineering Organisations represent the professional interests of academic chartered engineers at European level, promoting simultaneously the highest educational, professional and ethical standards within the Engineering Profession in Europe.

The development of the Europe is a result, amongst the others, of the strong and qualitative educational system of its engineers. For me personally is unbelievable how it was attempted to depreciate this effective and successive long cycle educational system and the pressure to “accept” the low cycle educated persons as “professional engineers” by the absolutely wrong interests putting only “mechanistic formulas” and producing rules apart of the safety & quality requirements of the modern societies and the needs of the future.

I followed up strictly for many years all this international dialogue concerning the educational and professional pre-requisites in engineering and I strongly believe that we must re-establish the common EU Education Area & the relevant policies on the basis of a strong and long prerequisite educational background to meet the future needs of the new competitive society of knowledge.

Continuing Professional Development (CPD) is also a critical factor in the whole civil engineering professional formation and evolution.

Continuing Professional Development (CPD) can be defined as the planned acquisition of knowledge, experience and skills and the development of personal abilities necessary for the execution of professional and technical duties throughout an Engineer's professional life. It encompasses both technical and non technical matters.

Our Engineering Organisations can play an important role on their Engineers/Members CPD.

A big dialogue for the above CPD has been developed in the European Engineering Federations and main focus is given also in many national engineering organizations. Our experience about the engineering CPD implementation in many EU Member States with the involvement of the Engineering Organisations is deep and broad. Some current questions on the subject to be discussed furthermore are:

- Actively encourage the development of CPD policy and infrastructure both at EU and national levels
- Initiate and coordinate our actions
- Benchmark good practice and disseminate information on the latest trends, developments and research findings
- Initiate, encourage and coordinate joint ventures for SMEs with higher education and large industry and promote training for SMEs managers in definition of skill needs and the filling of these needs in practice
- Enhance CPD policy by encouraging collaboration by all parties
- Examining for introducing CPD data in our Chambers' title registration
- Recommended methods accepted for the accreditation of CPD providers
- Initiatives undertaken on Engineering CPD and mutual cooperation between engineering organizations in the national and in the European level.

All the above are my personal views on the civil engineering profession and education, based on my experience and my participation in the International Engineering Organizations.

THE EUR-ACE® ACCREDITATION SYSTEM OF ENGINEERING EDUCATION: ORIGINS AND CURRENT STATUS

Giuliano Augusti[1]

ABSTRACT

The EUR-ACE system is a decentralized accreditation system of engineering education programmes, in which a common European quality label (the EUR-ACE® label) is added to the accreditation awarded by a national Agency, under the condition that the EUR-ACE Framework Standards are satisfied. This system is run by the European Network for Accreditation of Engineering Education (ENAEE), proprietor of the EUR-ACE® trademark. Seven Agencies (CTI, ASIIN, Engineers Ireland, Ordem dos Engenheiros, RAEE, MÜDEK, EC-UK) in seven EHEA countries (France, Germany, Ireland, Portugal, Russia, Turkey, UK) are at present authorized to award the EUR-ACE label: approximately 420 programmes have been EUR-ACE-accredited by the end of 2009.

The seven countries of the present EUR-ACE system are already a significant and varied sample of the European Higher Education Area (EHEA) but their number is still a fraction of the 46 EHEA countries: therefore, ENAEE is now committed to spread the EUR-ACE system into other countries and coordinates the EC-supported project EUR-ACE SPREAD that aims at bringing more countries into the system.

***Keywords**:* accreditation, engineering programmes, quality assurance, qualification

1. INTRODUCTION

In this paper, like in all EUR-ACE and ENAEE documents, “accreditation” of an engineering educational programme is defined as the “primary result of a process used to ensure the suitability of that programme as the entry route to the engineering profession” (ENAEE, 2008b). That is, “accreditation”, referred to a specific engineering programme and not a Department nor Higher Education Institution (HEI), ensures that the relevant programme has attained the standards required for its graduates to acquire the necessary educational qualifications to enter the engineering profession.

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"Accreditation" involves a periodic assessment against accepted standards of engineering education. It is essentially based on a peer review process, undertaken by appropriately trained and independent teams comprising peers from both academia and engineering practice. The process normally involves both scrutiny of data and a structured visit to the HEI running the programme, and must be carried out by properly constituted national accreditation agencies or institutions or consortia thereof. It can be said that "quality assurance" (QA) is a pre-requisite of discipline-specific accreditation: therefore, while it refers to individual educational programmes and not to Departments or HEIs, it does not exclude and, on the contrary, can be facilitated by an overall system of QA that authorizes only quality HEIs to deliver academic degrees.

Engineering has always been in the forefront of discipline-specific accreditation, which in many cases has preceded general QA systems. Therefore, several national Engineering Accreditation Agencies throughout Europe have a long tradition: examples are the French 'Commission des Titre d' Ingénieur' established by a 1934 Law, and the Engineering Council-UK, an organisation set up by Royal Charter in the 1980s to coordinate 36 Engineering Institutions, some of which date back to the 19th Century, and regulate the engineering profession.

Most of these national Engineering Accreditation Agencies, including CTI and EC-UK, were partners of the EUR-ACE (EURopean ACcredited Engineer) project (2004/06), that formulated European Standards for the accreditation of engineering programmes and indicated the main lines of a decentralized accreditation system in which a common European quality label (the EUR-ACE label) is added to the accreditation awarded by a national Agency. The European Network for Accreditation of Engineering Education (ENAEE) has been established in February 2006 to run this system.

The successive stages of EUR-ACE and ENAEE have been illustrated in Journals and books, and at several Conferences (Augusti, 2005-2010; Augusti et al., 2008): therefore this paper, albeit being self-contained, focuses on the latest developments.

2. THE EUR-ACE FRAMEWORK STANDARDS

The EUR-ACE project set as its first and foremost task the compilation of a set of shared standards and procedures (EUR-ACE Framework Standards) for the accreditation of engineering programmes, including relevant QA requirements.

A preliminary detailed survey of the standards used by the partners revealed striking similarities behind different façades, which made this task comparatively easy.

Unlike the old national rules that prescribed inputs in term of subject areas and teaching loads, all the most recent Standards, and consequently the EUR-

ACE Framework, define and require learning outcomes, that is, what must be learned rather than how it is taught. This approach that has several direct advantages, like:

1. it respects the many existing traditions and methods of engineering education in Europe;
2. it can accommodate developments and innovation in teaching methods and practices;
3. It encourages the sharing of good practice among the different traditions and methods;
4. it can accommodate the development of new branches of engineering.

The definitive text of the EUR-ACE Framework Standards was finalized in 2006 after successive versions had been commented on by the project partners and other stakeholders, both academic and non-academic, and trial accreditations were run in a number of EHEA countries to test their efficacy. Minor modifications have been made in 2008 (ENAEE, 2008a), while a thorough revision should be completed in 2010 (but not many significant changes are expected).

In accord with the European Qualification Framework (EQF, 2005), the EUR-ACE Standards distinguish between First and Second Cycle degrees, and identify 21 outputs for accredited First Cycle degrees and 23 for Second Cycle Degrees, grouped under six headings:

- Knowledge and understanding
- Engineering analysis
- Engineering design
- Investigations
- Engineering practice
- Transferable skills

The EUR-ACE Standards also contain guidelines and procedures that include the assessment, among other requirements, of the human resources and facilities available for the programme. The Standards are consistent with the whole "Bologna Process", and in particular with the Dublin Descriptors (JQI, 2004), the Framework for Qualifications of the European Higher Education Area (in short European Qualification Framework) (EQF, 2005) and the Standards and Guidelines for Quality Assurance in the European Higher Education Area (in short European Standards and Guidelines, ESG) (ENQA, 2005), and also take into account the EU Directive on the Recognition of Professional Qualifications (EU, 2005). Indeed, the EUR-ACE Framework Standards address the five generic qualification dimensions of the EQF on each level by specifying and expanding them with regard to engineering. For a detailed critical comparison, see (Feyo, 2009)

In order to be as flexible and comprehensive as possible, and not to exclude any European-compatible accreditation system, the EUR-ACE Standards encompass all engineering disciplines and profiles, and distinguish only between First and Second Cycle degrees (FCD, SCD). However, the Standards are also applicable to the accreditation of programmes leading directly to a degree equivalent to a Second Cycle Degree (conventionally termed 'Integrated Programmes'), which constitute an important part of European engineering education, and not only in the oldest continental Technical Universities Schools.

In some European countries, in addition to the distinction between FC and SC degrees, engineering degrees are characterised by profiles; moreover, accreditation distinguishes between engineering branches (disciplines) in some countries, and not in others. The EUR-ACE Framework Standards can accommodate all these differences but they must be interpreted, and, if necessary, modified to reflect the specific demands of different branches, cycles and profiles. However, they leave to Higher Education Institutes (HEIs) the freedom to formulate programmes with an individual emphasis and character, including new and innovative programmes, and to prescribe conditions for entry into each programme.

A major difficulty in establishing programme outcomes, and of differentiating between cycles, is that of specifying an absolute standard. This is particularly so in engineering because the standard must apply consistently to the many different and overlapping branches, and should also be applicable to new branches that will emerge as a result of continuing scientific and technical developments.

The EUR-ACE Framework expresses the standard to be achieved by FC and SC graduates in the three direct engineering requirements (Engineering Analysis, Engineering Design and Investigations) by the phrase "consistent with their level of knowledge and understanding", and this level is described using the concept of the forefront of the particular branch of engineering. For instance, in the requirement Knowledge and Understanding the relevant phrase is for First Cycle graduates, "coherent knowledge of their branch of engineering including some at the forefront of the branch" and for Second Cycle graduates "a critical awareness of the forefront of their branch".

It would be extremely difficult, if not impossible, to obtain an agreed specification of the forefront for all engineering disciplines, and, even if this could be obtained, a fixed specification would inhibit innovation in programme design and teaching methods. Nor would it be relevant or applicable to new and emerging technologies. The identification of the forefront of the branch is the responsibility of the members of the accrediting panel who are experts in that particular branch of engineering, while the body responsible for the final accreditation verdict will review and assess the rationale for their decision.

3. THE EUR-ACE SYSTEM

The EUR-ACE Framework does not intend to substitute for national standards, but to provide a common reference framework as the basis for the award of a common European quality label (the EUR-ACE label).

Consequently, the EUR-ACE accreditation system was envisaged as based on a bottom-up approach involving the active participation of national accreditation agencies and leading at the end to a multilateral mutual recognition agreement. No supra-national Accreditation Board was ever proposed: accreditation is and will remain the task of national (or regional) agencies; the EUR-ACE label will be a complement to the national accreditation. This decentralized approach, now being implemented, appears to be rather novel in the world-wide panorama of programme accreditation systems.

Indeed, the variety of educational situations and of degrees awarded in Europe makes trans-national recognition of academic and professional qualifications rather difficult. The already quoted "Bologna Process" is working towards the creation of a *transparent system* of easily readable and comparable degrees in the European Higher Education Area (EHEA), but as far as professional accreditation and recognition are concerned, no generally accepted system or agreement exists on a continental scale: notwithstanding the prestige of national systems and academic titles, this deficiency weakens the position of the European engineer in the global employment market.

The significance of 'accreditation' (using the word as defined in the Introduction) has been felt for quite some time, although the term 'accreditation' did not appear in European documents. As early as 1994, the European Commission issued a communication on the possible synergies between the recognition of qualifications for academic and professional purposes (EC, 1994). In 1998-99 the Thematic Network "Higher Engineering Education for Europe (H3E)" organized three 'European Workshops for Accreditation of Engineering Programmes', that lead to the establishment in September 2000 of the 'European Standing Observatory for the Engineering Profession and Education' (ESOEPE). ESOEPE promoted the EUR-ACE project, and in order to run the system, was transformed into the international not-for-profit association 'European Network for Accreditation of Engineering Education' (ENAEE), founded in February 2006 by 13 Associations and Agencies interested in engineering education throughout Europe. ENAEE has registered the EUR-ACE® trademark and authorizes national Agencies to add the EUR-ACE label to their accreditation (this authorization may be defined "meta-accreditation"). Further information is available at www.enaee.eu.

In November 2006, ENAEE assessed that six Accreditation Agencies (CTI, ASIIN, Engineers Ireland, Ordem dos Engenheiros, RAEE, EC-UK) from six countries (France, Germany, Ireland, Portugal, Russia, UK), all active partners of the EUR-ACE project, already fulfilled the requirements set by the Framework Standards; hence, they were authorized to award the EUR-ACE label for a period of two years. Their meta-accreditation has been renewed at the beginning of 2009 after a rigorous re-assessment process including site visits by multi-agency teams.

Two other EC-supported projects (EUR-ACE IMPLEMENTATION and PRO-EAST) have been active between 2006 and 2008, and greatly helped to start up the EUR-ACE system, respectively in the EU and in Russia. Seventy-three (73) programmes obtained the EUR-ACE label in the first year (2007), although only three agencies (ASIIN, Engineers Ireland, RAEE) contributed; the number of labels raised to 420 by the end of 2009.

4. SPREADING THE EUR-ACE SYSTEM: CURRENT INITIATIVES

Although the six countries constituting the initial core of the EUR-ACE system are a significant sample of the European Higher Education Area (EHEA), their number is only about one-seventh (1/7) of the total 46 EHEA countries. Therefore, ENAEE is now committed not only to strengthen the EUR-ACE system in these six countries, but also to spread it into other EHEA countries.

A document indicating the conditions to be fulfilled and the procedure to be followed by an Agency to join the EUR-ACE system has been elaborated (ENAEE, 2007) and a new two-year EU-supported project with the self-explanatory name of EUR-ACE SPREAD has started on 1st November 2008. This project is targeted mainly to Turkey, Lithuania, Romania, Italy and Switzerland: a “national” partner in each of these countries participates in the project, while ENAEE is the coordinating partner. Other partners are the University of Florence (contracting partner), SEFI, FEANI, EUROCADRES and ASIIN.

The University of Florence coordinates also another EU-supported 3-year project, namely EUGENE (EUropean and Global ENgineering Education), that started in November 2009 and is expected to contribute to further strengthening and spreading of EUR-ACE. In fact, within the general EUGENE objectives of “improving the impact of European Engineering Education (EE) on competitiveness, innovation and socio-economic growth in a global context” its workplan includes a whole Activity Line lead by ENAEE and aimed at “improving trans-national mobility of engineering students, graduates and professionals, also through contacts and synergies with the International Engineering Alliance and the Washington Accord”.

ENAEE is also active, either directly or through “experts”, in the successive stages of the OECD initiative for “Assessment of Higher Education Learning Outcomes (AHELO)” aimed at “assessing Learning Outcomes on an international scale by creating measures that would be valid for all cultures and languages”. In the preliminary stage of the AHELO initiative, the experts indicated by ENAEE have been instrumental in formulating the “Conceptual Framework of Expected/Desired Learning Outcomes in Engineering” (OECD, 2009), that draws heavily from the EUR-ACE Framework Standards.

5. THE EUR-ACE SPREAD PROJECT

Since the start of EUR-ACE SPREAD, there has been already a new addition to the EUR-ACE system: the Turkish 'Association for Evaluation and Accreditation of Engineering Programmes (MÜDEK)'. MÜDEK began accrediting programmes on behalf of the Turkish Engineering Deans Council in 2003, joined ENAEE in 2006, became an independent Association in 2007, and in 2008 applied to be EUR-ACE-accredited. After a careful evaluation of the application vs. the ENAEE Standards (ENAEE, 2007) and site visits by an ENAEE-appointed panel, on 21 January 2009 MÜDEK became the seventh Agency authorized to award the EUR-ACE label and within that year awarded 29 FCD labels.

The conditions of Romania and Lithuania with regard to quality assurance in higher education are rather similar to each other. A national Agency for the whole higher education has been recently established (respectively the 'Romanian Agency for Quality Assurance in Higher Education' (ARACIS) and the 'Center for Quality Assessment in Higher Education' (SKVC)) and are moving their first steps. ARACIS and SKVC have joined the EUR-ACE SPREAD project with the ultimate aim of being admitted into the EUR-ACE system for what pertains to accreditation of engineering programmes. The EUR-ACE SPREAD project coordinator has nominated two groups of three foreign experts (defined 'mentors') who will follow and advise respectively ARACIS and SKVC in order to bring them to satisfy the ENAEE Standards.

A first two-day meeting of the mentors with ARACIS took place in Bucharest in February 2009. At present, ARACIS is working in order to make its standards and procedures for engineering, now under revision, wholly compatible with the EUR-ACE Framework Standards.

SKVC submitted a pro-forma application to join the EUR-ACE system already in December 2008. Comments on this application have been exchanged between the mentors and SKVC officials; a three-day visit of the mentors to Vilnius took place in December 2009.

For both ARACIS and SKVC, it is hoped to conclude the process and include the Agencies into the EUR-ACE system within the two-year lifespan of the project.

In Italy, the "Agenzia Nazionale per la Valutazione dell' Università e della Ricerca" (ANVUR) was the object of a 2007 decree, that however has not been implemented yet; thus no quality assurance system or accreditation body for Italian higher education exists yet. However, the 'Conference of the Deans of the Italian Engineering Faculties' (CoPI) has been concerned with accreditation for a long time: indeed, in the late '90s CoPI elaborated a "National System for Accreditation of Engineering Study Programmes' (SINAI), that unfortunately remained at the stage of proposal. CoPI was one the founders of ESOEPE in 2000, and one of the most active partners of the EUR-ACE project (2004-2006): as a matter of fact, the general model behind the EUR-ACE Standards coincides with the model behind the pilot projects of HE evaluation 'Campus' and 'Campus*One*', run between 1995 and 2004 by the 'Conference of the Italian University Rectors' (CRUI) with CoPI's collaboration. The EUR-ACE proposals have been summarized in a Volume published by CoPI (Augusti & Squarzoni, 2008) and illustrated in a two-day Workshop held in May 2008 (Borri & Tesi, 2009). Now, CRUI and CoPI, together with the Italian Engineers' Association 'Consiglio Nazionale degli Ingegneri' (CNI) and the Industrialists' Association (Confindustria), are working to set up an Agency dedicated to the EUR-ACE accreditation of engineering degree programmes. EUR-ACE SPREAD will follow closely this initiative.

Several among the EUR-ACE-accredited Agencies accredit engineering programmes also outside their own country: they have been authorized to award the EUR-ACE label to these programmes as well.

This has allowed to award the EUR-ACE label, thanks to an accreditation by ASIIN, to a few FC programmes in the German-speaking Switzerland, while some programmes in the French-speaking Switzerland are already accredited by CTI and can now obtain also the EUR-ACE label. However, EUR-ACE SPREAD is try to set up and implement a more systematic way to spread the EUR-ACE system into Switzerland: a grant with this specific objective has been received from the Swiss Government, and concrete proposals are being elaborated.

ENAEE aims also at spreading the EUR-ACE system into other EHEA countries: contacts to this effect regard e.g. Denmark and Poland. Another concrete possibility is offered by the contacts with the Dutch-Flemish official Accreditation Organization NVAO (the only body legally authorized to accredit HE programmes in the Netherlands and Flanders): some difficulties have arisen (e.g. due to the fact that NVAO does not accredit directly, but through Agencies) but it is hoped that they will be overcome and Dutch and Flemish engineering programmes will soon obtain the EUR-ACE label.

Anyway, single HEIs from any EHEA country can apply, either to a specific Agency or through the ENAEE Secretariat, to have their programmes awarded the EUR-ACE label. This may be another way to start spreading the system into some countries.

In principle, the EUR-ACE label may also be awarded outside the EHEA. Indeed, signals of interest for this possibility have already reached the ENAEE Headquarters and will be pursued in the near future.

6. THE GLOBAL CONTEXT

Besides the European context, EUR-ACE must confront the global scene, primarily in relation to the Washington Accord, an international agreement originally signed in 1989 by national bodies that accredited engineering programmes in countries following a system of the Anglo-American type (a first cycle [Bachelor] degree after three or four years of study and a second cycle [Master] degree after one or two additional years). At present, full members of the Washington Accord are agencies operating in USA (ABET), UK, Ireland, Canada, Australia, New Zealand, South Africa, Japan, Hong Kong China, Chinese Taipei and Korea.

The Washington Accord recognizes the substantial equivalency of programmes accredited by the signatory bodies and recommends that graduates of programmes accredited by any of them be recognized in the other countries. In this regard, the Washington Accord is analogous to the EUR-ACE system. However, the EUR-ACE system mutual recognition stems from a common quality label awarded by the participating agencies on the basis of shared standards and procedures (the EUR-ACE Framework Standards) while the Washington Accord relies on comparable accreditation procedures, independently applied by the participating agencies.

In most Washington Accord countries one degree is the academic basis for entry into the engineering profession, therefore, the Accord recognizes only the Bachelor degree. However, this scheme is at present being questioned and there are pressures for the Washington Accord to move toward a two-tier system analogous to the Bologna/EUR-ACE scheme. Indeed, the Engineering Council UK and Engineers Ireland (that are among the original signatories of the Washington Accord and also participate in the EUR-ACE systems) have accredited Master (SC) degrees for a number of years. Beginning in 2009/2010, ABET will also allow accreditation of engineering programmes provided by a higher education institutions (HEI) at two levels (Bachelor and Master).

The Washington Accord prescribes at least four years of study for an engineering Bachelor degree. In parallel, standards have been developed for three and two-year programmes, leading respectively to ‘engineering technology’ degrees and ‘engineering technicians’ qualifications that are recognized within the so called Sydney and Dublin Accords. The rigid and formal connection of outcomes with years of study and semantic definitions of technical professions in this three-accord (Washington - Sydney - Dublin) system, causes difficulties in the mutual professional recognition for programmes defined within the Bologna two-cycle scheme, as well as for the academic recognition of such programmes for graduates applying for admission to graduate studies.

Indeed, such problems should not exist in an outcomes approach. The assessment of certified learning outcomes and gained competences should be independent from the ways of their achievement and the time it takes. In this regard, the EUR-ACE Standards, consistent with the Bologna Process and the EQF, provide a more flexible connection between outcomes and duration of study than the Washington - Sydney - Dublin accords.

A comparison between the EUR-ACE and the Washington Accord requirements will be a crucial element in making the EUR-ACE label fully recognized globally, if for no other reason than that two members of the EUR-

ACE core are also founding signatories of the Washington Accord. Such studies are being promoted by ENAEE, that has established appropriate contacts with the International Engineering Alliance (IEA) that embraces the three Accords.

7. CONCLUSIONS

If coupled with rigorous Quality Assurance rules, as it should always be, programme accreditation assures that an educational programme is not only of acceptable academic standard, but also that it prepares graduates who are able to assume relevant roles in the job market. The participation of no-academic stakeholders in the process is a guarantee to this effect. An internationally recognized qualification like the EUR-ACE label, added to the national accreditation, will facilitate job mobility as well (Augusti *et al*., 2008).

It is fair to state that the EUR-ACE system, compared with the Washington-Sydney-Dublin accord system is at the same time simpler and more flexible; EUR-ACE does not create a rigid barrier between ‘engineers’ and ‘technologists’, which would be against the spirit of the Bologna Process and in many languages even not understandable; at the same time, EUR-ACE allows national differences and appropriate distinction between the cycles (Augusti, 2010).

Benchmarking the two systems will indeed be a major challenge for EUR-ACE; another will be testing the consistency and actual applicability in our specific discipline (engineering) of Dublin Descriptors, EQF and EU Directive on professional qualifications (Feyo, 2009).

But, apart from technical and operational difficulties, creating a pan-European scheme like the new-born EUR-ACE system certainly finds major difficulties in the great differences between educational practices, legal provisions and professional organizations across the different European countries. These are, however, the typical difficulties encountered in building a unified, but not homogenized, Europe. The fact, that common Standards could be written and can be now implemented from Portugal to Russia, in continental and Anglo-Saxon countries, is a matter of great pride for us, the initiators of EUR-ACE.

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DOCTORAL STUDIES IN CIVIL ENGINEERING AT T.U. IASI, BETWEEN TRADITION AND SOCIETAL NEEDS

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ABSTRACT

Doctorate developed initially as the coronation of a complex and lengthy research activity that should always end up with a significant and break-through approach comparing with well-known theories/methods. As society changed from being economical oriented to the knowledge-based society, societal needs are to acquire sustainability and a certain quality of life. Both of them are developed based on competences of the society members through education at various levels. Doctorate is nowadays designed to acknowledge and certify the research potential the student can develop in order to contribute in various assignments later on to the society progress. The paper presents the perspective of the doctoral programs when designing the 3rd cycle of studies according to the Bologna agreement, to accommodate the future societal needs once these ones are precisely identified.

1. TRADITIONAL APPROACH OF THE DOCTORAL STUDIES

In the early days of 1938 to 1949, the Romanian doctoral candidates in civil engineering, without any previous mandatory preparation and presentation of some technical reports, have had only to defend directly their thesis in front of a scientific committee appointed from the well-known civil engineers and acknowledged as the most representative members of this technical domain.

1.1. Organizing the doctoral studies in civil engineering

Beginning with 1950, the doctoral studies were organized and recognized as such, following the rules were a candidate for the Ph.D degree should apply for a specific field in civil engineering, register for supervision from a certain Ph.D. advisor – a full time university professor with the accreditation as to offer research guidance to a doctoral candidate.

The full time doctoral candidate was never acknowledged as a student, but as a civil engineer post-graduate from the integrated-5 year programmes.

The doctoral candidate could enroll in a full-time 4 year doctoral program without a specific financing support or as a part-time 6-8 year program, the last one being actually the one chosen by all candidates.

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Most of the candidates were mainly mature and only some young members from the research institutes, design companies or sometimes field engineers. Some of the Ph.D. advisors did not accept candidates without at least 10 years professional experience and proven skills of continuing training in the field of interest.

The doctoral system consisted of 2 mandatory stages:

- Stage 1, during the first 2 years for the full-time candidates and 3-4 years for the part-time candidates, with 3 examinations on subjects chosen by the advisor related to the fundamental research background of the theme of interest and 3 technical reports on the state-of-the-art, comparative studies and analyses in the field of interest. These activities were acknowledged and evaluated by 3 member technical committees appointed from the university professors or highly recognized members of the research community.
- Stage 2, during the last 2 years for the full time candidates, 3-4 years for the part-time candidates respectively, the work was dedicated to extensive research, to finalize and present at the end the new approach/method/methodology as the solid contribution to the existing knowledge in the field of interest.

The doctoral thesis was defended by the candidate first in the audience of the entire department to be granted acceptance for the final presentation as a public defense in front of a scientific committee appointed by the Ministry of Education at the proposal of the organizing institution.

The committee consisted of 5 members, the Dean of the Faculty as the president, the scientific advisor of the candidate, and three distinguished members from other national universities or research institutes.

Each member presented his/her report related to the thesis scientific value and after a private deliberation over the candidate work, the president of the committee presented the end result as the votes of the members. The title as Ph.D. degree in the specific field of civil engineering was granted to the candidate based on the full agreement of the committee members, and a diploma was issued by the Ministry of Education.

1.2. Specific features of traditional Ph.D. work

The doctoral candidate as never being acknowledged a student was considered a mature and solid representative of the civil engineering profession. He or she started the doctoral work for two main reasons:

- as a natural continuity in pursuing the professional development always ingrained as a driving force;
- as a professional recognition of a high professional status to access a career development in the academic or research environment.

Since all candidates were enlisted as part-time doctoral attendants of the university doctoral program, there were no scholarships granted but also no tuition fees to pay during the doctoral studies.

There were no specific courses, seminars or lectures exclusively organized for doctoral candidates, but they were given free access to any type of undergraduate courses they would have liked to enroll onto at some point during their studies.

Research was dedicated to three main approaches available at that time:

- a theoretical approach, to contribute in changing the perspective of some fundamental background in terms of mathematical or physical modeling of phenomena related to the field of civil engineering;
- an empirical approach, to contribute by experimental data in ensuring the correlation between important parameters and thus characterizing the behavior of civil engineering works in specific situations;
- a numerical approach were simulations of real conditions in civil engineering works concluded in qualitative and quantitative prediction regarding anticipated behavior.

Beginning with 1950 and continuing until 2005, many doctoral theses have given their contributions in improving design codes for all types of engineering works in local conditions instituted by the climate, the seismic area, the soil specific attributes and the restricted technologies available in our country.

Small scale and full scale tests have been performed for doctoral works where the subject was of significant interest for industry, or when new construction materials were introduced and acknowledged as options by comparison to the traditional ones.

Some experimental tests induced the awareness of introducing optimization criteria related to seismic retrofit, thermal protection and complementary measures to accommodate civil engineering works to potential dangerous site conditions.

The available literature on the subject of interest was limited and not always up-to-date by comparison to the rest of the scientific world and expensive to be acquired by personal financing means.

There were no specific requirements regarding papers to be written by the candidate but all of them were publishing their contributions during mostly national scientific events and some in international ones as well.

There were cases when doctoral candidates did not complete their studies since they could not contribute significantly to the area of interest according to the academe standards.

Many Ph.D. graduates have contributed by several technological novelties, being granted innovation certificates, wining national and international awards of innovation on a specific civil engineering subject.

Beginning with 1990 and continuing for 10 years, the political changes came with many consequences on the academe perspective over the doctoral studies such as:

- European funds via TEMPUS and then SOCRATES/ERASMUS programs ensured possibilities for the doctoral candidates to perform a training program at a representative university from abroad well-known for the specific field of interest of the thesis;
- publications from all over the world became available for the university libraries, although with limited access even for the interested candidates;
- software and hardware of IT applications slowly became available and numerical simulations started to become the main approach for doctoral candidates to work on their scientific work;
- the downfall of this easy access to IT applications was unavoidable followed by performing sometimes calculations based on models with errors in the input data and running evaluations in the "black-box" system the results ended up with errors as well;
- the research infrastructure in laboratories increased its capacity and experiments can be widely performed by the interested doctoral candidates, although the ingrained skills for such experimental programs are rare and specific courses were not available at that time.
- as the scientific interest has been widely developed on many more subjects than the previous time, scientific events both national and international ones have increased many times over and consequently the need for writing papers and reports accommodated the newly developed situation.

1.3. Changing from doctoral candidate to doctoral student

Beginning with 2000, the doctoral studies undergone the first major change which acknowledged the full-time doctoral candidate as a doctoral student, enrolled in a 4 year university program based on scholarship financing, with the same two stages: the first 2 years for 3-4 examinations and 3-4 scientific reports and the next 2 years dedicated exclusively to research activities and writing the thesis. The Ph.D. degree was granted based on the same procedure as presented previously. The part-time doctoral students were not funded by the program and the duration of the studies remained extended to 6-8 years.

Starting from 2005, there was the second major change related to the doctoral program consisting in reducing both the full-time and part-time doctorate from 4 to 3 years. The full-time doctoral students were budgeted students of the universities, whereas the part-time doctoral students were paying a yearly fee to continue their studies. The program changed as structure in the following aspects:

- the 1st year was dedicated exclusively to an intensive and advanced study program related to their field of interest;

- the 2nd year was dedicated to research activities, starting with a research project and continuing every 6 months with the presentation of a research report on the work progress;
- the 3rd year continued and completed the research, presenting the thesis following the same procedure as in the previous period.

At this point there are 2 important aspects as consequences to these changes:

- the attitude towards the doctoral level changed from being the coronation of a life-time research to a proven research potential throughout the professional life-time of the candidate;
- the students that for some reasons could not graduate were not penalized financially only that they would have never been granted access for another doctorate program.

One of the most positive aspects of the graduation procedure for all doctoral studies since the beginning is related to the mandatory distribution of at least of 30 abstracts of the thesis (with an average size of 50 pages) among professional representatives (academe, professional bodies, research institutes, industrialists) under the request of sending an individual report with comments over the value of the research results.

2. THE CURRENT STATUS OF THE DOCTORAL STUDIES AT T.U. IASI

In 2008, the doctoral studies have been subjected to a new form of both financing and administration status. Technical University "Gheorghe Asachi" from Iasi (TUI) as the project coordinator together with the University of Bacau as partner was granted access to a national competition and won an institutional project – BRAIN - included in the Sectoral Operational Programme for Human Resources Development 2007-2013 (SOP HRD).

The BRAIN program is dedicated to doctoral scholarships and responds to the first objective of SOP HRD which is promoting good quality initial and continuous education and training, including higher education and research, priority Axis 1 Education and training in support for growth and development of a knowledge based society, 1.5. Doctoral Programs [1].

BRAIN is financed for 3 years by the European Structural Funds (ESF) 85%, the Romanian Government 13% and the Universities 2%, to financially support the education and mobility costs for 142 doctoral students [2]. The BRAIN program is now operating for the 2nd year, with non-Bologna graduates, since Bologna undergraduate program successfully completed the first cycle in July 2009 and the Bologna Master Programs started this academic year – October 2009.

In 2009, another application was made by TUI and consequently the same type of project to financially assist the doctoral studies for 3 year duration started under the name of EURODOC.

In comparison to previous doctoral financial support, these projects are better funded both in terms of scholarships and mobility grants and consequently the main advantages of these projects are considered the followings:

- Developing the human resource educated and trained to use efficiently the newly acquired research infrastructure in the university laboratories;
- Training the graduates to become more independent/confident/creative in decision making and acquiring more professional independence;
- Exploring interdisciplinary research and triggering new approaches in fundamental research;
- Attracting young graduates towards science/research/academe, contributing to the long life learning goal;
- Developing the teamwork and efficient communication skills across distanced research areas;
- Reducing the knowledge gap between universities/societies/countries across Europe;
- Introducing innovation into society at large.

The structure of the programs financially supported by ESF is very well and tightly controlled both as administration assistance and results oriented research. In this respect, each student presents the followings:

- A monthly activity report with details of each category of educational and research activity performed;
- The results obtained during the 1st year of the advanced study program;
- A yearly evaluation and presentation of the entire activity with quantifiable results during a dedicated conference within the BRAIN program but with open access to the interested people from university and/or industry representatives;
- A research project at the beginning of the 2nd year, continued by extensive reports every 6 months over the work in progress as proposed initially;
- A mobility research program during the 2nd or the 3rd year of the doctoral program for a 3 month period, with a corresponding report at the end of mobility with the main results obtained at the end;
- A list of references, research equipments and software to be acquired by the university when needed by specific research activity.

One strong issue considered as a program constraint is that 95% of the enrolled student must graduate by the end of the 3 year scheduled research. The consequence of drop-outs is the re-imbursement of the full scholarship. Until now, the program is running as planned with occasional financial discontinuities related to bureaucracy.

3. THE EUCEET CONTRIBUTION TO THE FUTURE OF DOCTORAL STUDIES IN CIVIL ENGINEERING

European Civil Engineering and Training Network and lately reunited into Association have been particularly supportive of providing the opportunity and support to present, discuss, debate, exchange experience and share good practices among representatives of the civil engineer profession at large. Long life learning is the only way a member of the present knowledge-based society is actively and efficiently performing his/her tasks, providing sustainability and quality of life.

Doctoral studies, although not specifically needed/required by the industry representatives, remain the main contributor in providing high level analytical and critical thinking, creativity and innovative solutions, autonomy and the "engineering state-of-mind" to problem solving our society implicitly needs and rely upon for its progress into the fast changing future.

Workgroup C focused on doctoral studies in particular where the main contribution is represented by the issue of transferable skills of the future graduate, sharing good practices in providing courses, seminars and documented material in the university programs [3]. The awareness and the importance of such transferable skills is the key driving factor to reinforce the present doctoral programs, somehow with reduced attractiveness among the graduates of the master programs in civil engineering.

Workgroup H as mainly dedicated to the synergy between academic and professional world has been many times the inspiration needed among the university representatives to continue and support the doctoral studies, vulnerable at present, by reduced enthusiasm among civil engineers [4].

4. CONCLUDING REMARKS

The EUCEET experience as a Network program will continue and be enhanced by the development of the EUCEET Association where sharing good practices in all aspects of the civil engineering world remains the best input for a secure and sustainable future of our society.

Education and training provided by doctoral studies will have to be designed to accommodate skills useful for an engineering career (intellectual, academic, technical, and research-related skills) and skills useful for any career development as well (relational, leadership & change management and self-management skills). TUI although providing the first category of skills/competences intends to develop efficiently the second category as well, and respond efficiently to our society needs for future development and progress.

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DIVERSE SYSTEM OF EDUCATION FUNDING

Jan Bujnak[1]

1. INTRODUCTION

The university education system was created in medieval times. The Europe was amongst the first regions spreading academic institutions and forms of tertiary education, including technical fields of study. Then the period of previous century can be characterized by the autonomous evolution of the established institutions and their substantial expansion. A form of undefined and unconscious partnership could be seen. From the 1970´s, the massive expansion of higher education has started, and also, unfortunately, in many instances, the lowering of standards. Economic growth is increasingly related to the capacity of regional economies to change and to innovate. Efforts should therefore be devoted to creating an environment that supports research; development and innovation, thus facilitate the transition to a knowledge economy.

My University of Zilina was established in 1953. Owing to its fifty-eight years long history, the university became one of important teaching and research institution in Slovak educational system. Not only with number of students and offered accredited study programmes, but with a significant research and international activities based on extensive co-operation with companies and institutions both in the country and abroad. However, the university had to be engaged in regional development processes by providing services to the community, by transferring and promoting new technologies and creating regional brand, attracting new firms, capital and talent to the region. To date, however, in my country this is the case only to a limited extend, because only the car industry is effectively exerting a great influence on technical education, as this is indeed the main source of employments for graduates. Currently Slovakia has really become the leading European producer in the car industry and the situation seems favourable to the students, the institutions and the employers. However, in a global environment, long-term sustainable development is impossible to guarantee, particularly when one industry holds such a dominant position. The necessary adaptation and transformation measures as well as potential problems to overcome are given in this paper.

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2. ACTUAL CHALLENGES IN HIGHER EDUCATION

European universities are traditionally financed by the state. However, the public financing is not actually sufficient, especially in the case of greater establishments of higher education. Even though, the educations of young generation as well as the backing up of research activities are important responsibilities of governments. Thus, the additional resources for budget have to be identified. European university system is still rather diverse. In the same time, in most countries it is facing common problems and pressures. A comparison of European countries shows considerable differences with regard to the percentage of the Gross Domestic Product, which is spent on education and flowing into tertiary educational institutions from public sources. The above-average proportion of public spending on higher education exists in the Scandinavian countries, famous by progressive taxes systems. In contrast, the lowest expenditures are in central European regions, especially in the new EU countries. If these countries agree that, in the future, they want to spend at least European average percentage on higher education, then they must take a closer look at how to increase the portion of other financial resources.

Market pressures have become more acute and broader roles are expected from higher education institutions. Accountability to a wider range of stakeholders is linked with potential threats to sustainability. Core funding has been partially replaced by contract or incentive funding. State funding is declining as a percentage of universities income. Research costs sometimes have exceeded income. Even some teaching expenditures are significantly more than funding. Education institutions risk deficit, if include full economic costs. Capital investments in building or equipments are generally insufficient. Much infrastructure is inflexible, and poorly utilised. Investment also is needed in people and modern working methods. In light of shortages in public budgets, relatively high taxes and less developed philanthropic traditions in most European countries, a combination of both higher public investment and higher non-governmental financing appears to be the most effective and most realistic path to a clear and lasting increase in higher educational investment.

Several examples show that foundations and companies are more than willing to lend financial support to the universities. The creation of the university's special units, financed in large part through industrial partner's investment testifies to this approach. But these groups want to be presented with concrete projects which inspire them emotionally and which contribute to the improvement of teaching, studying and research. No abstract calls for donations, no complaints on shortage of money, but rather concrete plans awaken the willingness toward private commitment.

Universities and institutions are thus embedded in a versatile environment of academic philanthropy which offers considerable potential for supplementing state financing with private support. Nonetheless, this cannot and does not change the priorities that state financing must take. This extra funding alone cannot solve the problems of financing universities. However, it can contribute to the solution. To that end, improved tax incentives, autonomous structures and systematic efforts by the institutions themselves are necessary. Law-making incentives would be appreciated to motivate stakeholders to complement public financing. But a public university would remain dependent on governmental financing that is in accordance with its tasks and guarantees the freedom of teaching and research. Private sources present only desirable and necessary contributions to fulfilling its tasks. The importance of extra financing is likely to increase in the future. Academic community, however, expects the governments to neither reduce nor limit the public financing of the universities. We need above all governmental financing that should be in line with our responsibilities, if universities are supposed to contribute to the development of a knowledge society.

3. STRATEGIC UNIVERSITY MANAGEMENT FOR SUSTAINABILITY

It was once the role of governments to provide for the purposes of universities. It is now the role of universities to provide for the purposes of governments. A fundamental shift in the relationship between the state and higher education is thus expected. Dependence on state is very limited and substituted by autonomous model. Higher educational institutions did an excellent job, but were a long way from full strategic management for sustainability. There exists always a culture of lack of priority for long-term problems, and hope that government would fund if it gets bad enough or be willing to pay full economic cost. Only few universities have real finance or capital asset strategies. Therefore, leadership and management could be an issue, especially in traditional universities. To update university, it is inevitable to change its culture. Cash funding on needs basis is replaced by portfolio financing and investing for the future. It is not sufficient to have university activities only administrated, but essentially rather managed, including a range of risks. New strategic activities should be rather market-driven, not only supply-led.

Sustainable university developments mean to work today in a way which does not make it more difficult to do so tomorrow. This implies to attract income for its teaching and research and other activities which would be sufficient to cover the actual expenditure and to permit the institution to invest in future physical infrastructure, staff, innovation, enabling it to compete at appropriate level. It is about academic innovativeness, the strategies and management capability to manage the long-term investments and to ensure that institution would generate an adequate financial return. Achieving sustainability is a significant long-term culture change for many higher education institutions. This is achievable also in the university, even if this business is not typical of a public body or of a rather liberal group of scholars. It needs consistent support by academic community and careful strategic management. A lot of money could be invested, but not all wisely from sustainability point of view. Activity and infrastructure may grow. The worst backlogs that were preventing appropriate quality of teaching and research should be addressed. Most of university units now have to act more strategically with improvement in utilisation and efficiency. Thus, the answer is partly money, but also culture change. Increasingly, the finance will not come from government. It is necessary to rationalise and take hard decisions for improving significantly position.

University management may focus mistakenly only on growth and neglecting existing infrastructure. Over-ambitions would not always allow finance own strategy, but there is no willingness to change it. Dependency culture sometimes prevails believing that government should fund us.

4. ADAPTED UNIVERSITY STRUCTURE TO RESPOND ACTUAL NEEDS

The latest transformation and development of the University of Zilina can serve as an example of how private initiative of academic staff and financing can become of great importance for a public university. The university has strong industry links with priority focus on science and technology.

My University of Žilina strategy has been heavily determined by the massive inward investment by multinationals companies. Rapidly growing demand for high-skilled labour has thrown up problems, particular in the areas of human resources, research infrastructure and interface with industry. The university's response has been multi-stranded. Active commercialisation strategy with innovations and non-traditional structure were originated for revenue targets for all academic and non-academic units. The dedicated technology transfers office, a science park and specialist high-tech research institutes have been created. The unconventional forms of training have been introduced, all working under umbrella agency responsive to the strategic imperatives of institution and region. A complex funding mix-national, institutional, corporate and European sustains an appropriate level of activities. The principal reasons were inadequate state funding, need to diversify the revenue sources, necessity to network with external partners to pool resources in discovery and exploitation and urgency for institutional streamlining and reform.

- The Institute of Continuing Education (ICE) was established at the University of Zilina already in 1996 as an output of Joint European project. It is an integral part of university providing the system of continuing education for all age categories following the latest trends in technology and science. Flexible educational programmes can use the university technical background as well as contracting partner's cooperation with the support of information and communication technologies. Through new methods of delivery, it could have a major impact on regions in various ways, including engaging dispersed populations, and offering high quality international education. Coordination of continuing education in the region and preparation of the system of life-long education for local firms and industrial enterprises present the next aims of the institute.

- Centre for Transport Research (CETRA) at our University of Zilina, as the recognized centre of excellence by the European Commission, is active in several areas of the basic and applied research. Especially in road, rail, waterborne and air transport, design and construction of transport infrastructure, electronics, signaling, machine building, safety and security of transport, even transport problems related forensic engineering. Thanks to this unit, the university can participate in the projects of the Framework programmes of the EU as contractor, coordinator or to be participant in the network of excellence on the above topics. The efforts of CETRA are recently concentrated on the support of the University` faculties and departments preparing international project and links.
- Slovak Productivity Centre (SLPC) is an open, national organization established at the University in 1998. The activities of the Centre are focusing on the support, extension and propagation of the new knowledge and skills in the field of productivity and competitiveness into national industry. At the same time, stimulation and support of companies in productivity increasing area might contribute to the economic development of the country.
- Science and Technology Park (STP) has been set up at the University of Zilina in 2001 as an association of legal entities. The aim is to promote international and regional cooperation between innovative entrepreneurs and researchers or students. Facilities with all needed services and the necessary logistics functions provide conditions to create incubators for innovative actors or contact potential investors.
- Institute of Competitiveness and Innovations (ICI) has been set up in 2004 to support Zilina region development by creating and implementing technology, processes and innovated products and to transfer then in industry. The actions implemented are many, varied and often sophisticated (Figure 1). Research projects are set up on request and specialized programmes per technology sector aim to make the regional actors more competitive. There are also international projects helping self-financing and benefiting from opportunities of global market. Research-based learning, where mainly doctoral students do more to educate themselves trough project solving is the preferable learning system in this institute.

Figure 1. ICI activities

Figure 2. CEIT premises

- Central European region with the rich technical and technological history represents a market of about 150 million consumers. Many industrial companies are settling in this region. It is important to manage and further develop high-tech areas with a large and significant potential of economic growth to become successful on the future international markets. This is the mission of the Central European Institute of Technology (CEIT) which started its activities in 2004 and officially established two years later, as the centre of excellence in research and development, technological processes, support of entrepreneurship, innovations and knowledge economy, to create a basis for productivity and competitiveness growth. CEIT is located in the neighbor of the main campus of the University of Žilina with the purpose to integrate theoretical knowledge basis of academics with the industrial experience through research and developments on the base of the private-public partnership (Figure 2). This open professional company, which would work on further development of co-operation with all institutions, prepared to contribute to the development of the region aims to become a part of the European Institute of Technology, directly integrated to the European Research Area.

5. CONCLUDING REMARKS

The higher educations institutions must today demonstrate their capability to manage an evolution that cannot be ignored. Knowledge, ideas, innovation, understanding, adaptability and creativity are the foundations on which today's economy should be built. Past success should not be an excuse for doing nothing. There is no activity, which cannot be improved by the application of knowledge and ideas. What will happen should not be the product of fatality or the random combination of diverse external forces. The strategic goal is to create a knowledge society where effective learning, understanding, creativity and ideas add value to everything.. We should act with determination and vision to set conditions which would stimulate and support the activities, which would contribute to further development. The universities should now act, not in splendid isolation, but with the support of all public and private partners, for remaining what it has been through the centuries, a place of light and learning.

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HIGHER EDUCATION SYSTEM AND ITS RESEARCH CAPACITY

Jan Bujnak[1]

1. INTRODUCTION

The European University Association (EUA) has been commissioned to evaluate the universities and higher education institutions in Slovakia. Organization and structures for carrying out the principal missions, effectiveness of internal quality processes as well as the internal mechanisms, frameworks were examined.

A total of 52 experts from 24 European countries participated in this evaluation, based on the self-evaluation reports of the institutions and the two visits to the institution. They provide opportunities for change of the institution. The interviews with system actors and stakeholders were to benefit from qualitative and quantitative data providing.

The more detail of recommendations might have more general meaning and could support the others higher education institutions, including Civil Engineering institutions in the continuing development, in order to meet best standards and practices. Thus the recommendations are given in the paper.

2. GENERAL STATEMENT

Globalization is becoming a prominent preoccupation of actual society, including researchers and educators across Europe. It is associated with economic realities of an increasingly interdependent world. In the world of scientific research, characterized by the high degree of international competition for funds and talented individuals as well as international comparisons and rankings were emerging with considerable speed and growing impact on universities´ activities. The increasing international mobility of knowledge resources also includes university research in particular. The research intensive universities should respond to this growing competition and new demands with a whole set of aims and measures.

Our higher educational system compares unfavourably to the already low European average with respect to research and innovation investments. It was recommended to provide opportunities for rewarding performance and initiatives, to reduce the fragmentation of research system both in terms of funding and structures, to foster institutional alliances, networking and creating

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critical mass, to incentive private investment in public research and to provide adequate competitive infrastructure for research.

The EU commission proposed the creation of a European Institute of Technology for improving the impact of research in the innovation process. The Central European Institute of Innovation and Technology created at our University of Zilina two years ago could be integrated in networks of highly competitive research group of actors involved in technological innovation and transfer of knowledge as well as experience produced in the knowledge triangle.

3. STRUCTURAL FUNDS ASSIGNMENT

Our research and innovation system should use the European Structural Funds as a unique window of opportunity in the six coming years by making full and effective use of the substantial means for renewing the research infrastructure, networking and framework conditions for all actors in order to build the international competitiveness. The usefulness of these major funds is dependent on the ability of the national ministry and regional agencies to coordinate the competences, to design flexible funding channels and to make sure the budget ends up in the most promising areas with long term structural effects. The central role of the universities as providers of research competences and of the research foundation for innovation should be recognized and supported.

4. EDUCATIONAL CHALLENGES

Three cycle degrees structure according to the Bologna reforms should reach even farther than the simpler restructuring of curricular content. The greater international comparability of qualification should be allowed as well as a deeper change from a teacher-centered to a learner-centered approach has to be executed. A new educational approach and culture is an actual challenge. Teachers should be able to change roles. From being the authority and communicators of knowledge they should become a creator and facilitator of learning. With diverse flexible learning possibilities offered to a variety of students groups. As part of the reforms and for the benefits of the overall improvement, our educational system faces the challenges of introducing a more trust-based and more systematic approach to quality assurance within higher education institutions and moving away from methodologies of external control of minimal standards toward internal improvement-oriented processes of quality enhancement.

In the light of needs in industry and universities, a considerable increase of doctoral degree holders for a wide range of different function is expected.

Universities and funding agencies should ensure that sufficient attention is paid to the attractiveness and international orientation of doctoral education in order to prepare candidates for internationally oriented career and to provide them with a supportive and stimulating research environment that foster interdisciplinary and prepares them for a variety of career tracks in university or industry,

5. MARKET REQUIREMENTS

The Slovak higher education system has done an enormous effort to increase higher education participation. Universities remarkably expended their teaching provision and research activities. At the same time, the quality of educational and research activities has suffered from the insufficient financial coverage of that expansion. The fact that institutional grants are mainly based on student numbers causes further disincentives to differentiate among different target groups and qualification profiles. A major disproportion of student numbers in subjects of scientific or technical orientation can be seen when compared with those in economics or social sciences. Supply is especially scarce in civil and electrical engineering or computer science. Therefore it is difficult to find graduates, especially for more remote locations or less paid jobs. The highest concentration of graduate demand can be found in the automotive industry which makes up 33 % of economic production. To underpin the rising Slovak economy and to foster its knowledge intensity and productivity in the above key sectors, the government has to enable its universities and other higher education institutions to educate and train more graduates in natural and technical sciences and more organizational social subjects, which implies not only for the number and qualifications or professors but also for the provision of up-to-date scientific infrastructure.

6. UNIVERSITY STAFF

The renewal of the academic body is another major challenge, linked to widened access as well as supply of sufficient science and engineering graduates. Moreover, the age distribution of the academic staff is a serious issue. While the imminent need to renew a major part of the academic staff is an important threat to the future teaching and research development of the universities, it could also present opportunity for implementing new ideas, qualifications and culture for the future development of the university sector. This possible intellectual renewal will require a major investment to create competitive conditions for academic careers in terms of salary, infrastructural support, research possibilities and further benefits in comparison to other professional options.

The gap between Slovak research and development expenditures and the rest of EU member states is considerable. Recent increases of higher education expenditures by the government are commendable but insufficient to close the gap. The current growth of the economy in the country could be sustainable provided there is greater investment in research and innovation, and commitment to the production of highly qualified labour. This also requires favourable framework conditions for research production and knowledge-intensive industries.

7. RANKING OF HIGHER EDUCATION INSTITUTION

The higher education system has seen a decade of remarkable expansion, which has been shouldered both by existing universities, many of which have doubled or tripled their student numbers, as well as through the founding of new universities or the merging of existing smaller institutions or faculties into new universities. While the universities differ in disciplinary profile, they are alike in basic institutional types, missions, and core functions, though very different in size and research intensity. Apart from differentiation through disciplinary orientation and size, there are differences in the three basic functions, i.e. teaching, research and service to the community. In order to establish the institutional type of a given higher educational institution, the new university act, which was drafted and ratified in the course of the previous year, foresaw that Accreditation committee would make a proposal to the Ministry of Education, which would then make the final decision. The three types are called university, higher education institution, and professional higher education institution and are distinguished by the level of teaching provision and the kind of research. Systematic attention should also be paid to a differentiated set of financial and other incentives to promote the quality of teaching, research and innovation respectively.

8. GOVERNANCE WEAKNESS

The higher education system would benefit from being granted higher degrees of autonomy with respect to the internal organization and governance structures of higher educations institutions. The national law goes into too much detail with respect to decision-making processes and internal bodies, preventing universities and other educational institutions from developing structures that fit their purposes and allow them to respond flexibly to their needs. The educational system would also benefit from more reliable long-term legal conditions which are not dependent on party and coalition changes but which. University activities usually extend over several years, and both research projects and educational programmes need several years of continuity to bear fruit. Universities policies should be designed, implemented and adapted within a long-term perspectives and vision.

The national law defines the internal decision-making bodies both at institutional level as well as at faculty level. Firstly, there are academic senates with wide-reaching decision power. Within the faculties, there are also departments as substructures. In addition to the senate, there are scientific councils at both levels, essentially responsible for academic decisions and strategic perspectives. The faculty deans and the rector of the university have rather limited strategic power and are not allowed to be members of the senate. Hence, there is a division between actual power and responsibility. The senate has the power to approve the rector's decision in almost all areas. As a 39-member body with representatives of all faculties, it cannot be held accountable for these decisions. Conversely, the rector is held responsible for all matters of the university without being able even to influence the decision-making sessions. While rectors can initiate strategic changes, their powers are limited by the senates. Even the budget is decided upon by the senate, although senate members have no particular competence with institutional financial management. Of late, the budget also has to be approved by the board of trustees.

Such diversified management may satisfy a need for democratic participation in all aspect of daily institutional life but also reduces the efficiency and effectiveness of university adaptation to change and the university's ability to seize new opportunities. Before decisions are made in the public senate sessions, it is necessary to convince many people, one by one. Hence, it can be seen that many new initiatives result in the creation of new additional units or centers rather than in the redefinition of existing ones. The university members should allow more initiative and room for action to their academic leaders, because they are generally selected on the basis of their institutional leadership competences and academic credibility. If the senates are to be taken seriously as decision-making bodies, they will have to pay more attention to the institutional development competences of their members. Otherwise the senates simply act as a brake on urgent development. A more centralized administrative structure would also improve the efficiency and effectiveness of administration.

9. QUALITY ASSURANCE

Current decision-making is mostly consensual, collegial and favors average treatment thus preventing building on strengths and faster changes. In order to create an environment where excellence will prevail and to enable institutions to set real priorities, build on their strengths, help areas with potential, support urgent and promising development initiatives, strategic reserves have to be made available at institutional level. Universities should also commit themselves explicitly to the development of a culture which recognizes the importance of quality and its assurance in their work. To achieve this, institutions should develop and implement a strategy for the continuous enhancement of quality. The quality evaluation system would have to shift the focus from central quality control mechanisms, which currently dominate, to a more coherent internal quality culture within everyday institutional life of higher educational institutions.

10. RESEARCH CHALLENGES

Our higher education landscape is highly diverse in its research performance and in the connectedness to international research environments. While individual faculties stand out in several research areas, the top institutions are noticeably better placed in their international research competitiveness. Moreover the many research groups which conduct more industry-oriented research especially at the technical universities have different priorities from excelling in international research competition. Both universities and industry need bright innovative people with good research and entrepreneurial skills. Research activities are generally conducted with an extremely low base budget provided through institutional grants. A second obstacle hindering involvement in research activities consists in the remarkably low time budget, which university researchers have at their disposal. The university teachers have an unusually high teaching load because of the high number of contact hours, unusually high amount of exams and other performance controls around which courses are structured, as well as limited synergies and common offer between faculties. Moreover, in the funding formula, the number of students is still the most weighted factor. Since a higher number of students implies less time for research. The funding methodology, at the moment actually sets stronger disincentives than incentives for research. Thus, our educational system has to establish appropriate incentives for university research in terms of available time, financial support, research management support, as well as less bureaucratic grant regulations. At national and institutional level, more resources should be made available, on rigorous and hard competitive basis, to maintain and renew research equipment and infrastructure. Before the establishment of the Slovak Research and Development Agency, two other funding agencies have been available for university research and cultural activities grants, i.e. VEGA for research activities and KEGA for cultural, artistic and educational projects. Being still severally under-resourced, university research suffers from a high degree of fragmentation between the funding agencies and their funding instruments, a still insufficient degree of competitive performance criteria of grant distribution and unnecessarily high level of bureaucracy and delay in funding grant administration. Within the next decade, the structural funds should allow a significant increase of resources for this purpose. Such use of the structural funds is likely to bring a high return on investment.

11. NEXT GENERATION PREPARATION

Given the need to renew a majority of university professors in the next decade, national and institutional programmers or incentives are also needed to foster the independence of young researchers. Industry may be willing to support such programmers, given their vested interest in qualified labour. International and national mobility of researchers should be fostered systematically since it could contribute substantially to the innovative potential of individual researchers. Return schemes are recommended to develop to make return of young researchers from international stays attractive. We should urgently address the considerable challenges in research training and in doctoral education in particular. From financial conditions to incentives for mobility and merit-based young researcher awards in order to attract the most gifted individuals and prevent brain drain.

In order to increase the attractiveness of university research for enterprises, universities should allow and encourage interdisciplinary research activities. Regional clustering initiatives or even mergers of universities, to create clearer and innovation profiles with critical mass, should be rewarded. It is also vital that higher education institutions can get some financial support for the establishment of technology centers, incubators and centers of excellence as well as for research and innovation service support at universities

12. REGIONAL AND INDUSTRY LINKS

A particularly difficult issue is the limited interest of the private sector in research and innovation investments. The entrepreneurial thinking is not rewarded enough within university activities and careers. In addition, applied research is actually insufficient because basic research is favoured at universities. No coherent innovation policy framework was established including measures for university-industry links. Relevant funding agencies should therefore develop funding and facilitation instruments for university-driven innovation and university-industry cooperation.

Regional development became a central concern of innovation policy. Knowledge transfer is recognized as vital assets of a knowledge economy. In this context, the role of universities is regarded as essential, both with respect to its research production and in its training and education of qualified workers for the regional economy. Cluster policies and networking between universities, private companies and government agencies should be intensively facilitated in order to act as motors of regional development.

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ENGINEERING EDUCATION IN A CHANGING WORLD

Tugrul Tankut[1]

1. INTRODUCTION

As a young man, the author was quite a successful instructor thirty years ago. He is still teaching the same subjects, and no doubt, he is doing his job much better than he used to do in the past. Alas, he is a total failure today. Why? That is the question.

The above statement does not carry much meaning, unless the success criteria are clearly stated. In very simple terms, the object of engineering education is twofold; (i) **teaching** – laying the foundation stone on which an engineering career will be built, by teaching the basic principles of the related subjects and the methods to apply these principles in the professional practice and (ii) **educating** – improving the intellectual capacity, in particular the reasoning power of the student, so that he/she can critically evaluate and use the information gained in the former phase in solving problems.

The author attributes prime importance to the latter objective and measures his success as an instructor with the extent he achieves this objective. He has always tried to improve the reasoning capacity of his students. His lectures, his discussions, his exam questions, his home works etc. have always been arranged to serve this purpose. It is true that this objective has never been fully accomplished. However, a reasonable progress could be achieved until about two decades ago.

Year by year, students appear to grow more reluctant to bother about their reasoning capacity and more enthusiastic about learning the use of engineering software available in the market. Consequently, they more dislike this old man asking them exam questions which require reasoning, instead of asking questions on well classified, well tabulated, thus easily memorised, good-for-nothing information. The author is quite convinced that his students would have been quite happy, if he assigned 20 pages of telephone directory and asked 20 telephone numbers out of these pages. He fears that only a few, if any, students would question the relationship between the telephone numbers and reinforced concrete structures. Obviously, this is an exaggeration but, no doubt, it reflects some truth like all exaggerations.

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The reason why the author is not successful any more as an instructor, most probably lies in the fact that his educational principles, his teaching approach, even his educational objectives which have been appropriate thirty years ago, are now outdated vis-à-vis the changing social, economical, political, educational and most importantly technological conditions. A careful study of the changing conditions and their effects on engineering education is a prerequisite for a correct diagnosis of the present problems and for proposing effective remedies.

The author is overwhelmed with the changes he observes and is of the opinion that the problems of engineering education cannot be solved by simple modifications in the present system, unless significant paradigm changes are introduced. He goes even further and fears that the classical university may even cease to exist, giving rise to different kinds of educational institutions.

Thoughts expressed in the present paper are efforts to identify causes and consequences of the present problems of engineering education voiced by the author and apparently experienced by many other professors of engineering worldwide. The paper also makes reference to the recent efforts in this area in the European Council of Civil Engineering and in the World Council of Civil Engineering.

2. CHANGES AFFECTING ENGINEERING EDUCATION

In the last few decades, enormous changes have taken place in various conditions affecting engineering education. Although changes are observed in countless areas related to engineering education, in the present paper important changes are classified into a few major categories:

- Changing character of the profession (Example: civil engineering)
- Changing student characteristics
- Changing educational tools
- Changing educational policies

Before treating these categories one by one in the subsequent sections, factors leading to these changes are briefly reviewed in the following section.

3. FACTORS CAUSING CHANGES

Some of the factors leading to these changes are global; their effects are observed everywhere, although they may differ in extent from one country to the other. However, there are some other factors that are specific to a given country, although some of them may be similar to some degree in certain other countries.

3.1. Universal Factors

- **Rise of the computer** – The incredible progress of electronics in the last few decades has influenced almost all aspects of life on this planet. Computer is the most characteristic item of this new world, and the generic term "computer" is used in this paper to refer to the information and communication technologies in general, not to the specific instrument on your desk. The "chip" has penetrated not only into the computational world, but also into the scientific and technological, educational, communicational, economical and financial, medical, social etc. etc. spheres, even into the private lives to a great extent. It has affected everything to such an extent that the world is not the same old world any more. It has not only affected the planet itself, but also its inhabitants, especially the human beings and especially their mental and intellectual character.

- **Rise of the Internet** – is probably the most striking manifestation of the computer age. The Internet has become an incredibly powerful medium of communication and store of information. Besides providing a very practical and easily accessible source of endless information free of charge, it is claimed that it also causes a kind of information pollution.

- **Changing nature of industrialisation** – The nature of industrialisation has greatly changed. Heavy industry is largely transferred to the less developed or developing countries where labour is cheap, while underlying RTD (research and technology development) is given priority in developed countries, since intellectual property gets the lion's share from the added value produced.

- **Globalisation and engineering beyond borders** – Following the disintegration of the Soviet Union, a world scale transformation took place leading to globalisation. This recent development is presented by some as a very positive change, a kind of unification of the world, while it is also interpreted by some others as a new kind of colonisation. In any case, it has affected all aspects of life, including engineering practice. Not only international engineering companies are operating worldwide, but also the individual engineer can easily be employed in various countries other than his/her native country.

- **Political and economical changes** – Since the end of the Second World War, some significant events have taken place and affected the world politics to a large extent. The following are a few examples: Dissolution of the Eastern Block ending the Cold War and changing the bi-polar world into a uni-polar one and making some of the former Eastern Block countries members of the European Union and NATO. Demolishing of the wall dividing Berlin eventually leading to the unification of the two Germanys simultaneously with disintegration of Yugoslavia leading to creation of numerous small countries. The terror attack on Twin Towers leading to the occupations of Afghanistan and Iraq. The worldwide financial and economical crisis causing a major global recession etc.

- **Social and cultural changes** – Gradual social and cultural changes are usual and natural. However, social and cultural changes have been seriously accelerated by the rapid and significant advances in information and communication technologies.

3.2. Local Factors

The following observations have been made primarily in Turkey. However, the author has the impression that some of them apply at least to some of the countries in Europe to a certain extent.

- **Unrealistic demand for university education** – There is an unrealistic demand for the university degree, especially for a degree in engineering. The society appears to be unaware of the demand and supply balance. Indeed, the level of university education has been lowered and the university degree downgraded as the number of certificates issued has increased in the last few decades. Engineering used to be one of the most respected professions. As a result of low level engineering education, a large number of unqualified engineers have been produced, consequently engineers are underpaid and even unemployed today.

- **University entrance examination** – Each year, the number of applicants seeking admittance exceeds by far the total capacity of the universities. Consequently, a certain elimination mechanism is needed. An examination which consists of multiple choice test questions appears at the first glance as the only feasible technique that enables computer evaluation of hundreds of thousands of papers. Over the years of application, this examination has become the major target of the basic education. Not only schools, but also private tutors are training thousands of students for this examination by teaching them how to solve problems by using simple techniques without understanding the problem and how to pick up the correct choice by simple elimination. Students accustomed to this kind of training find it very hard to adapt themselves to reasoning based university education. They ask for tools leading to the solution without understanding the problem; thus, they are very interested in learning the black box type software more than anything else.

- **Populist administration** – To please their electorate, politicians do not hesitate to degenerate well established, well operating systems without paying much attention to the consequences. In order to satisfy the unrealistic demand explained above, dozens of new universities were founded on political grounds, universities were required to substantially increase their student intake and the standards of education have been intentionally lowered in the last few decades.

4. CHANGING CHARACTER OF THE PROFESSION

4.1. Nature of Engineering

All kinds of engineering deal with physical problems. In this endeavour, they use practical, experimental and in most cases analytical techniques. Almost all the problems dealt with are too complicated in nature to be treated with mathematical methods; the complicated material properties, geometry, loads, boundary conditions, ambient conditions etc. make the analytical solution generally impossible. A two-stage approach is therefore unavoidable:

- **Constructing a mathematical model (Task A)** – The physical problem in hand is carefully studied, its nature is clearly understood and the primary and secondary parameters affecting it are identified. Then a mathematical model is constructed on the basis of a set of simplifications and idealisations. The mathematical model has to be able to represent the physical problem as realistically as possible, yet it has to be simple enough to be treated by common mathematical methods.

- **Performing analysis on the mathematical model (Task B)** – The mathematical model is then analysed to obtain the required results. Once the results are in hand, the mathematical model is forgotten; after all, it is not a real problem, it is merely an imaginary mathematical tool; once it serves its purpose, it can be discarded. The results are then applied to the real physical problem as if the mathematical model has never existed.

The above understanding reveals two important points:

- There are no exact or correct solutions in engineering; all engineering solutions are approximate, despite the fact that the degree of approximation varies from one problem to the other. Even if an exact mathematical method is used in the second phase, there is always a certain amount of approximation introduced through the idealisations made in the first phase.

- The operations A and B described above are the two major tasks of the engineer.

In the past, both tasks A and B used to be equally important; a good engineer was expected to have a strong insight into the problem and to be able to propose a good mathematical model reflecting the physical problem satisfactorily, and at the same time, he/she was expected to perform the analysis skilfully.

Today, the second task appears to have been taken over by the computer to a great extent, whereas the first task gained importance since the problems dealt with are getting more sophisticated. Under these circumstances, engineering education would have been expected to emphasize the importance of the physical problem and to concentrate on the development of the intellectual capacity of the student. Similarly, engineering practice would have been expected to concentrate on the first task.

Alas, it never happened. Both the younger generation faculty and most of the engineering students are impressed with the incredible capabilities offered by the computer technology and convinced that powerful computers and sophisticated software developed by other people can solve all of their problems; thus all they have to do is to develop skills to run these programs. Most of the young engineers and engineering students are not keen to learn the physical problem; they generally are very reluctant to reason, to discuss, to criticise, to innovate etc. They are interested in the engineering software available in the market; they seem to have the misconception that operating the computer makes them engineers, even if they do not have a clue about the physical problem and the way it is treated by the inbuilt software. Despite the university degrees they hold or will soon obtain, the author calls them computer operators, not engineers.

4.2. Scope of Civil Engineering

As the name implies, civil engineering initially included everything that remained outside the scope of military engineering and almost all other branches of engineering stemmed from civil engineering. In other words, the scope of civil engineering has always been very wide. However, significant changes have taken place in its scope in the last few decades. Some of the major changes noticed by the author are briefly explained in the paragraphs below.

- **Computer aided analysis and design tools** – have reached such a level that task B of the engineer explained above in subsection 4.1., has been taken over by the computer to a great extent. This support is no doubt an enormous advantage for the civil engineer, provided that he/she is aware of the assumptions and limitations of the software used. In order to have a better insight into the structural behaviour, civil engineer can now perform repeated analyses merely by striking a few keys.

- **Large scale projects** – have significantly grown in number as a result of improving technological capacity. Although project management has always been one of the civil engineering activities, smaller scale projects did not require high level of managerial expertise. Increasing number of large scale multi-dimensional, multi-disciplinary projects requiring expert management made this area a major task for the civil engineer.

- **Globalisation and international competition** – have also affected the nature and scope of civil engineering.

- **Sustainable development** – has become a major consideration behind all activities of civil engineering. Half a century ago, engineering was roughly defined as “exploitation of natural resources for the benefit of humanity”; over the years, it transformed into “sustainable use of natural resources…”. It definitely is a very important issue to pay attention to environmental protection, optimal use of energy and other natural resources in all civil engineering applications.

- **Social and cultural needs** – now have a significant influence on civil engineering design and construction practices besides physical needs. In the past, the prime concern of the civil engineer was the physical needs of the people; now social and cultural needs have also gained importance.

- **Protection of heritage** – has also become an important issue affecting civil engineering activities. Today’s civil engineering operations have to pay much more care and attention than they did in the past to the cultural and architectural heritage and even to minor historical artefacts. Months long interruptions in the construction of submerged tunnel crossing the Bosporus are a typical recent example.

- **Disaster management** – involves a large number of disciplines among which civil engineering is one of the most important and effective areas. When it comes to seismic risk mitigation, civil engineering naturally plays the most important part. Earthquake has always been a major challenge for civil engineering. However, enormous progress has taken place in the last forty years towards understanding the seismic behaviour of structures and seismic strengthening of existing structures. Today, seismic considerations constitute a major part of the structural design.

- **Seismic codes** – were significantly improved in the last few decades in line with the widening area of disaster management. These codes now lead to a much better seismic safety than they did in the past. However, they are criticised to have grown sophisticated and extremely analysis oriented. This character of the code puts the engineer out of contact with the physical behaviour and encourages blind use of the black box type software.

- **Lifecycle infrastructure risk management** – has become a critical issue. The concept refers to natural and technological threats to the infrastructure as well as the slow but steady failures due to deterioration and neglect.

5. CHANGING STUDENT CHARACTERISTICS

5.1. Effects of the Computer

For the older generation (students in the seventies and eighties) civil engineers, computer is a powerful tool, a capable assistant carrying the heavy workload of the engineer. Engineer is the master, computer the slave.

The younger generation (students in the last ten years) owes their existence to the computer; they do not exist without it. Computer has become the master and made the engineer slave (or it will be the case in the near future). It did not only make the engineer slave, but it seems that it is also transforming the engineer’s intellect (the human intellect for that matter). The author has the impression that brains of his present students operate on the same principles as the computer. They try to store in their memories as many solved examples as possible. When they face a problem, they scan through the contents of their memories. If the problem matches with one of the solved examples, they are lucky. Otherwise, they are helpless and hopeless, simply because they never try to understand the physical phenomenon and to digest the basic principles and physical implications of the method of solution they have memorised.

The author observes, in despair and disappointment, the changes in his students’ intellectual characteristics which closely follow the changes in the computer technology. Memory is increasing exponentially in each consecutive computer generation, whereas no indication of reasoning is yet observed, apart from the IF and GO TO logic in programming loops. Likewise, the reasoning capacity seems to decline and even to lose its meaning in each consecutive student generation where memory dependence appears to be growing.

5.2. Motivation and Expectations

Engineering used to be one of the most desirable professions. Students of the past were full of motivation and they used to strive to become engineers. Today's students appear to have lost their motivation. This situation may be stemming from the fact that engineering has lost its charm and is not very popular any more. As a result of populist education policies, too many engineers were supplied without paying attention to demand. There are more mediocre engineers serving as technicians than necessary; yet there is a great demand for qualified engineers. Engineers are not well paid anymore and unemployment is presently a serious threat. Consequently, students cannot have high expectations from their future, and they naturally lose their motivation.

This process leads to a vicious circle. Inadequate education produces mediocre engineers. Excessive number of engineers and lower level engineering practice make the profession lose its popularity. Less popular engineering cannot attract the top notch students. Dealing with middling students, standards of education cannot be improved. In simple terms, engineering loses its popularity as the level of education deteriorates; the level of engineering lowers as engineering gets less popular. And so on…

6. CHANGING EDUCATIONAL TOOLS

Technological developments in the last three decades led to enormous changes in tools of education. The following list is by no means complete; however, it gives an idea about the nature of changes in this category.

- **Blackboard** – is replaced by Power Point presentation. Most instructors prefer to use this high tech tool in their lectures instead of the archaic blackboard which, in the author's opinion, has a charm and effectiveness of its own.

- **Slide rule** – the instrument that makes a man an engineer is replaced by calculator and even by Excel spread sheet. This handy tool which ingeniously carries the logarithm concept into practical life, forces the user to keep track of the order of magnitude and to round off the numbers meaningfully. The younger generation do not hesitate to take "$g = 10$" and "$\pi = 3$" irrespective of the problem and then to put the resulting number in seven digits after the decimal point as displayed in their calculators. That is the difference between an engineer and a non-engineer.

- **Engineering Drawing Course** – is replaced by AUTOCAD training. Drawing simple sketches is the most important communication tool among engineers. No doubt, AUTOCAD is a powerful instrument for the designer; but it cannot be satisfactorily used, if the engineer cannot immediately visualise the plan, elevation, cross-section etc. of the body in question.

- **Library** – was a temple where students used to spend a good deal of their time. The atmosphere there inspired intellectual activity and concentration on the subject studied. Today many students do not know where the library is; they are fully satisfied with what they can get from the Internet.

- **Term papers** – required literature survey and study of a few papers. Even if it was unintentional, student learnt many things during compiling the material and drafting the paper. Copy and paste from the Internet settles the matter. A glance at the document is enough; one does not need even to read the text, leave alone understanding it.

- **Copying friends' notes** – is replaced by telephone-camera shots. Some students took notes and some others concentrated on the lecture instead of taking notes. The latter copied their friends' note books and reviewed the lecture during the process.

- **Copying exam solutions** – is replaced by telephone-camera shots. Examination is a very effective stage of education; student heavily concentrates on one or two problems for a while; correct solution given immediately after the exam makes the student understand the method of solution and realise his/her mistakes. Writing down the solution on the notice board helps the process, but carrying a photograph of the solution home does not have the same effect.

- **Past exam solutions** – are available at the photocopy shop for the price of a beer. Students are always interested in the problems asked in the past years. It is indeed a sensible thing to have an idea about the type of questions and to have a few solved examples. An effort was necessary in the past; now they are readily available.

To cut the long story short, acquiring information was not easy in the past. However, many things were learnt during the process; student had a chance to catch one or two points when copying the blackboard into the notebook or writing down the solved exam problem posted on the notice board. A meaningful term paper required a critical study of the material concerned which enabled the student to understand a few important items etc.

Today, acquiring information is very easy; a click of the telephone-camera is enough to file the material on the blackboard. But filing the information does not mean anything, unless the material acquired is carefully studied, understood and applied. In other words, the brain work is still needed, it still is essential. Unfortunately, that stage seems to be missing today.

7. CHANGING EDUCATION POLICIES

Social, economical and political developments in the last three decades led to significant changes in education policies. Since the end of the Second World War, two tendencies are observed worldwide concerning university education; (i) a gradual **increase in the number of students** that encouraged administrators to adopt populist policies in the countries where politicians feel obliged to please their electorate and (ii) a gradual **lowering of the level of education** which is naturally related to the increasing number of students and the populist policies.

Two items are briefly explained below as typical examples (from Turkey) of populist policies concerning university education. It should be realised that the populist policies include, but not limited to these two items; many more similar approaches can easily be cited.

- **Unplanned growth** – In order to satisfy the unrealistic demand mentioned above, dozens of new universities were founded on political grounds and the universities were required to substantially increase their student intake in the last few decades. This growth would have deserved appreciation, if it was well planned considering the actual needs and employment possibilities and if it was well prepared in terms of faculty and infrastructure. Alas, this is not the case. Many of them are lacking relevant qualified faculty; some of them have title holding unqualified instructors.

- **Graduation warranty** – With the same concerns, success criteria were lowered intentionally. In some universities, normal statistical distribution based evaluation is compulsory; that is, the pass or fail verdict is taken by the software in registrar's office, not by the instructor. In other words, the number of failures remains at 5% level no matter what the class performance level may be. Yet in other words, the lower the class performance, the easier to pass. Once the student gets admission to a university, his/her graduation is almost guarantied. He/she can take a course or exams repeatedly. It is almost impossible to dismiss an unsuccessful student; even if he/she is somehow dismissed, he/she will most probably be coming back soon with a governmental decree in his hand. The peculiar concept of “student amnesty” is a bright invention; every now and then, a student amnesty is issued to forgive the unsuccessful students; they are given another chance to return to their universities or to have supplementary examinations in the courses they have failed.

8. NEED FOR INNOVATIVE REMEDIES

As clearly stated in the Introduction, the reason why the author is not a successful instructor any more probably lies in the fact that his educational principles, his teaching approach, even his educational objectives which have been appropriate thirty years ago, are now outdated vis-à-vis the changing social, economical, political, educational and most importantly technological conditions. After reviewing the reasons behind the problems encountered in engineering education, one should start searching solutions for these problems and should make proposals towards effective remedies.

A careful study of the changing conditions and their effects on engineering education is a prerequisite for a correct diagnosis of the present problems and for proposing effective remedies. The European Council of Civil Engineers has recently initiated a project to inquire into these problems. This project is briefly introduced in the following section.

The changing conditions, especially those concerning students’ intellectual characteristics and educational tools are so essential that the author can not imagine the present university concept and university structure adapting themselves to and coping with the new conditions. In other words, he is convinced that an effective and feasible solution can never be achieved by introducing certain modifications in the present system. **Paradigm changes seem to be unavoidable** in the concept of education, methods and even objectives of education, in the definition of engineering, possibly in the concept and structure of university. In the author’s mind, it is probable rather than possible that the university may be replaced by a totally new educational institute operating on totally different principles within 50-100 years. Even if the name is maintained, the University of the Second Half of the 21st Century will probably not be the same as the University of the 20th Century.

The above philosophical comments may possibly have long term implications. However, some immediate actions need to be taken urgently, since the engineers of the coming few decades are being educated in the universities of the present. Therefore, short term realistic remedies to be implemented within the present conditions need to be proposed, discussed and realised as soon as possible.

In spite of the long term anticipations he dared to express above, the author is a simple minded, pragmatic engineer having his feet on the ground. Considering the student material, the faculty material, the tools of education and infrastructure presently available, the only short term remedy he consider feasible is a two-level engineering education. If all schools of engineering in a country are obliged to train engineers of a common level, following a common curriculum, that common level is bound to be a very low one. If different institutions are assigned with training engineers of different qualifications for different job categories, a far more effective education can be realised.

The author occasionally jokes with his students by saying that only about 20% of the students in the class may eventually become civil engineers; about half of the rest will probably serve as computer operators blindly using the black box type design software and the other half will function as foremen in construction sites. If this sarcastic remark reflects a bit of truth, it is sensible to separate the 20% that have the potential to become better engineers from the rest and to give them a better engineering education, while the rest receive the standard education of the present.

Obviously, it would be neither nice nor practical nor even acceptable to have two different levels of engineering education in the same university. However, it would be perfectly acceptable, if a few universities which have the appropriate faculty and right infrastructure are assigned with the duty of training the qualified engineers. These universities will most probably accomplish their mission successfully, if they are provided with better financial resources and if they are privileged to admit a limited number of students carefully selected by their own criteria and screening techniques.

The idea of two-level or even multi-level system of engineering education is by no means a new idea. The present system of engineering education in some countries can very well be classified in this category. And indeed, the above mentioned problems of engineering education seem to be less critical in those countries where this system is successfully implemented.

9. ECCE-WCCE-TCCE PROJECT “EFFECTIVE EDUCATION”

The author presented his above explained observations concerning problems of civil engineering education at a General Assembly of the European Council of Civil Engineers. Following this presentation, a Task Force was formed to carry out a project investigating into the problems mentioned(1). The World Council of Civil Engineers was also interested in the subject and the project was later converted into a joint activity.

A Core Group coordinates the work and prepares proposals to be discussed in the usual task group meetings to take place during the General Assembly meetings. The proposals are finalised in the light of the discussions in the task group meetings and executed by the Core Group. Each participating country has an active and responsible representative in the task group who plans and coordinates the local activities in their respective countries.

The project has been designed as a three-stage work. The scope of the work is intentionally made flexible; realisation of various stages will depend on the amount of financial resources raised. The basic stage of problem identification will be realised in any case; the evaluation workshop of the second stage requires a rather modest funding and will probably be realised; the foresight study is naturally a rather expensive activity and it will be carried out in the case if a sufficient financial support can be obtained from an international funding agency.

- **Problem Identification Survey** – Nature, extent and possible solution alternatives of the problem will be investigated in the participating countries. A series of questionnaires will be applied and a critical and comparative evaluation will be based on the survey results.
  - Questionnaire 1 - Faculty(2)
  - Questionnaire 2 - Senior students(3)
  - Questionnaire 3 - Practicing engineers(4)
  - Questionnaire 4 - Employers of civil engineers(5)

- **Survey Findings Evaluation Workshop** – Findings of the problem identification survey will be elaborated by a few experts together with the task force members in a one-day workshop.

- **Foresight Study** – The problem is to cope with the changing conditions; to readjust or to reorganise or even to redefine the educational system to educate the most appropriate (not only professionally successful, but also intellectually and socially fit) engineer for the coming few decades. One of the recently favoured methods of planning the future is the foresight study. A group of experts and stakeholders will come together, discuss various aspects of the problems of engineering education vis-à-vis the survey findings and try to define the best model for the future.

Results of the work will be collected in a report. Besides, a position paper reflecting in a nut shell the ECCE views based on the project findings will also be published and presented to the institutions concerned.

10. CONCLUDING REMARKS

The views expressed in this paper should not be misinterpreted as a criticism of the young generation by an old professor. On the contrary, it is a self criticism more than anything else. The paper starts with an observation; the author admits that he is not a successful instructor any more. He blames himself for not being able to adapt his education techniques to the changing conditions.

He never suspects that the recent students are less bright or less industrious than the earlier generations. He is convinced that the problem is related to their education both at school and in the society, not to their intellectual potential. This observation makes the situation even worse and his disappointment doubles when he observes the potential in his students being wasted due to their inappropriate education.

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DOUBLE DEGREE AGREEMENTS: THE ECOLE NATIONALE DES PONTS ET CHAUSSEES EXPERIENCE

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ABSTRACT

Over the course of its 250 year history, the École Nationale des Ponts et Chaussées (École des Ponts ParisTech) has forged academic links with many institutions of higher education throughout the world, especially in the fields of civil engineering, mechanical engineering and urban planning. Within the last 20 years this tradition has reached new dimensions with the signing of 30 double degree agreements and more than 50 academic cooperation agreements. This article aims to present an historical overview of the evolution of academic agreements at the École des Ponts ParisTech to date and provide an assessment of the double degree agreements. While all the agreements define the procedures for both outgoing and incoming student mobility, in this article we shall mainly focus on the latter. We shall also explain in detail the methodology of implementing this type of agreement, by illustrating the strategy and means of functioning for building, maintaining and improving these agreements.
Twenty years of experience in Double Degrees have enabled us to put in place the structures and procedures for accompanying students and have allowed us to assess over time the difficulties and benefits of this type of student exchange, not only from an administrative point of view but also academic and cultural.

1. HISTORICAL OVERVIEW

The École des Ponts ParisTech has since its inception and particularly in the 19th century welcomed numerous foreign engineering students and engineers.
These include Colonel Rives, who built part of the Potomac Aqueduct in Washington, DC, Honorio Bicalho, who designed the junction on the Rio do Janeiro-Minas Gerais railway line as well as the port infrastructure in Rio Grande, and Ionel I.C. Bratianu who was named minister several times and served twice as President of the Council of Ministers in Romania.
But the most emblematic figure of this period remains Agustin de Betancourt, an engineer in the service of the King of Spain: he was an exceptionally creative genius and a talented designer. He travelled throughout Europe (between 1784 and 1807) with the goal of establishing links between scientists, engineers,

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designers and entrepreneurs. The time he spent at the École Nationale des Ponts et Chaussées left a long-lasting imprint on him and led him to found the Civil Engineering School of Madrid (1802) on the model of the École des Ponts. Betancourt was its first director. He founded also, on the same model, the Engineering School in St. Petersburg (1809).

The beginning of the 20th century marked a decline in the development of exchanges, due in part to the establishment of technical universities in Europe and to the consequences of the World War I with the rise of nationalism and the predominance of isolationist positions.

Student exchanges began to increase markedly again after World War II with the building of the European Union. The École des Ponts ParisTech signed its first Double Degree agreement in 1988 with Escuela de Caminos, Canales y Puertos in Madrid. Since then more than 120 students have been awarded the double degree Ingénieur de l'École Nationale des Ponts et Chaussées/Ingeniero de Caminos de Madrid.

2. THE SITUATION IN 2010

Over the last 5 years the number of foreign students enrolled in the double degree programme at École des Ponts ParisTech has increased from 45 to 60 students per year. Thirty double degree agreements have been signed (cf. list in the appendix).

The first objective of the École was to cover EU countries. Sixteen agreements have been signed with European universities; two others are in preparation with Poland. The next step for the École was to open its network to countries to which it is culturally and historically close: Canada, Lebanon, Morocco, Tunisia and Viet-Nam. Finally, the network was extended to Asia (Japan, China, Iran and Singapore) and Latin America (Brazil and Argentina).

The École des Ponts ParisTech wishes in the near future to sign agreements with Chile, Russia, Turkey and Scandinavian countries.

3. BUILDING DOUBLE DEGREE PROGRAMMES

Academic and scientific networks are mutually linked and interconnected. As a general rule, exchanges between researchers tend to precede academic and institutional exchanges. As the quality of scientific research at an institution is a fundamental indicator of its ranking, the École des Ponts ParisTech relies on links developed through its research network to initiate academic exchanges. One-off student exchanges (research internships and Erasmus-type student exchanges of one or two semesters) are then followed by exploratory educational visits to evaluate the pertinence of establishing a double degree programme. Certain specific factors are necessary to justify a double degree agreement: compatibility of curricula and scientific fields, the quality of incoming student reception, the presence of a resource person in the partner institution who is committed and possesses the influence necessary to implement the agreement and keep it operational on the academic level. At times, the way in which curricula are structured, certain national requirements or even a wide in cultural gap make it difficult to reach an agreement. In this case, it is better not to push for a double degree programme and look to other options for developing exchanges, since a solid non-degree exchange is always preferable to a poorly designed double degree programme.

L'École des Ponts Paris Tech has focused its strategy on the Master's degree level. Students at this academic level have acquired the personal maturity necessary to benefit the most from their experience in another country; in addition they have acquired and consolidated the scientific background needed to undertake a more technical curriculum; finally, their area of specialization is more defined, and even justifies their departure to a partner institution where that area is more fully developed than at their home institution.

Validation is done semester by semester, on a global basis. It would be extremely risky to try to achieve this on a course by course basis for the following reasons:

- Given that École des Ponts ParisTech is a small-scale institution, it would be impossible to guarantee a sufficient number of individual courses to cover and correspond to each Master's level course in the partner institution. Inversely, it would be a pity not to allow École des Ponts ParisTech students to profit from partner institution courses in their areas of specialisation and which offer innovative teaching methods.
- The main interest of a double degree is to offer students the possibility of following a curriculum which is different from and complementary to that of their home institution, both in terms of course content and methodology. A simple "cut and paste" of individual courses in the home institution curriculum would provide no added value.
- Students could find themselves in an awkward position with respect to both institutions if a course is cancelled, or if there is a change in teachers or in programme/content. Changes of this sort occur regularly given the constant evolution of our educational programmes.

Selection of participating students is done by the home institution within the limits set by the agreement, and with final approval from the host institution. The latter may choose to intervene in order to better orient a student in his choice of department or courses or even to indicate possible difficulties the student may have in following certain curricula in light of his previous studies. Twenty years of experience in this area have led us to conclude that it is largely preferable for selection to take place in the home institution, which has a better knowledge of the subtleties and methods of assessment and marking in its own institution as well as of the individual student profiles, motivation and maturity. In addition, with a wide variety of partner institutions and large numbers of incoming students, it becomes difficult for the receiving institution to mobilize the human and financial resources necessary for conducting interviews or setting up selection juries abroad as well as being able to fully evaluate the pertinence of each application.

Our experience has led us to a certain number of conclusions concerning how best to integrate incoming double degree students:

- Proficiency in the French language, even in scientific and technical disciplines, is important. The École des Ponts ParisTech has instituted intensive French language courses which take place before the start of the academic year. In addition, in certain disciplines, the teachers have provided students with a glossary of technical and scientific terms in order to facilitate their comprehension.
- The variety of backgrounds has proven to be beneficial. Even if this is not always easy for teachers to manage (marked differences of academic level in certain disciplines), the weaker students are in general assisted by the best ones towards excellence.
- As group project work is commonly practiced at École des Ponts ParisTech, special attention has been given to making sure that students from different backgrounds and nationalities are mixed together to avoid imbalances. In this way, each student brings to the group his own particular skills and knowledge.
- Cultural differences are generally more evident than academic ones. Learning strategies, approaches to problem solving, student-teacher relations, personal initiative taking as well as relations with the school administration, all vary depending on the students' origin. Students must apply significant effort to ensure their integration and success in their studies. École des Ponts ParisTech has created a special task force for incoming international students in order to facilitate this process, particularly as concerns administrative hurdles, accommodation, social conventions and key contact persons.

CONCLUSION

Taking a broad view, it hardly seems necessary to demonstrate the validity of double degree programmes: they are amply justified by the economic and business realities that will confront our future engineers. Representatives from the corporate sector who sit on École des Ponts ParisTech governing boards have always pleaded in favour of a sustained effort to develop and promote double-degree programmes.

This type of agreement is equally beneficial in other ways:

- The receiving institution's image and prestige are reinforced by an ambitious and far-reaching international relations policy, as evidenced by the rankings published in the press and by specialized institutes.
- Innovative teaching methods can be transmitted via student mobility and have a positive influence on partner institutions.
- Faculty members constantly improve their teaching by adapting to a new student public.
- Alumni associations break through national boundaries and multiply professional opportunities for students who have followed a joint-degree curriculum.