ATTI, REPORT E CATALOGHI

– 43 –

# TREE

## TEACHING AND RESEARCH IN ENGINEERING IN EUROPE

SOCRATES Erasmus Thematic Network

# Re-engineering Engineering Education in Europe

Claudio Borri and Francesco Maffioli editors

Firenze University Press
2007

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FOREWORD

# Re-engineering Engineering Education In Europe ■

*by Claudio Borri*
School of Engineering - Università di Firenze
President and Legal Representative of TREE Thematic Network

*Re-engineering Engineering Education in Europe:* what is that all about? Why such a puzzling title for a 3-years long work by more than 110 Engineering schools all over Europe? Let me try to introduce to the reasons for this title (and why we have decided to adopt it for the publication of the TREE Thematic Network outcomes), by quoting the Education Ministers of the countries of the "Bologna process": "… As we look ahead we recognise that, in a changing world, there will be a continuing need to adapt our higher education systems to ensure that EHEA remains competitive and can respond effectively to the challenges of globalisation…" (art. 1.3., The London Communiqué of the European Ministers of Education, "Towards the European Higher Education Area: responding to challenges in a globalised world", May 2007). Thus, the need for any branch of Higher Education to dynamically adapt its profile to the continuous challenge of the society becomes evident: European Universities, at the dawn of the 3rd Millennium, face the extraordinary task of reshaping (or, as we like more: *re-engineering*) their educational profiles and mission statements in order for their graduates to be skilled and ready to respond "*effectively to the challenges of globalisation…*". What does all this mean?

Higher Education Invitations (HEIs) should be well prepared in order to face: i) the ever fast developing framework of the work market & stake holders environment, ii) to follow the tough competition within the education sector between public and private sector, iii) to adapt to the radical changes in the higher education (HE) studies and curricula in general (and, more and more, in particular, in Engineering and Technology sector), iv) to set-up a reliable, internationally recognised system of quality assessment and v) to improve the attractiveness and competitiveness world-wide of the European University system.

Therefore, issues like *Mobility, Internationalisation of studies, Degree Structure, Recognition of degrees, Qualification Frameworks, Lifelong Learning, Sustainability of competencies and Professional development, Quality Assurance (and European Register of Quality Assurance Agencies), Doctoral studies and students, Social dimensions (social cohesion, reducing inequalities, raising the level of knowledge, etc.)* need to be analysed, implemented and monitored at European level, in order to continuously improve the current situation and to promote good practice. Furthermore, there is an increasing awareness, that a "*significant outcome of the process will be a move towards student-centred higher education and away from teacher driven provision*" (Art. 2.1 of the London Communiqué, see above).



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Thus "*Re-engineering Engineering Education in Europe*" means all the above for the Engineering and Technology sector; isn't that too demanding and pretentious target? How can a simple TN-project within the SOCRATES II programme, even if with a very large number of participating engineering education (EE) schools, try to afford such an ambitious goal and what is concretely the beneficial impact on the European Higher Education Area?

I shall avoid (not even try) to answer the questions above by describing the content of this volume, the work, the results and the perspectives for the EE sector in Europe: this will be the task and the deserved privilege of the scientific Coordinator of TREE, Prof. Maffioli, who to hold the reins of such a large group of schools and colleagues, i.e. the work of 4 activity lines and 30 Special Interest Groups (SIGs), the managerial meetings, and others: a huge amount of work. For this purpose, I specifically address the Reader to the next Chapter 1 (TREE: Development, Results and Challenges).

Nevertheless, I shall not miss the opportunity to give some general comments on what TREE has represented and has achieved in terms of impact on HE in Europe, promoting the international dimension of EE and dealing with almost all critical issues of the globalised market of education as stated above.

My first comment deals with the intrinsic nature of "Thematic Networks" projects (SOCRATES II programme): I believe, one can definitely affirm that they contribute largely to the improvement and to the implementation of the new and innovative strategies and policies of HEIs, as a part of the strategy and development plan of internationalisation. This is why the University of Florence, School of Engineering, decided to continue the successful experience of the previous TN project (Enhancing Engineering Education in Europe, E4, 2001-2004) and selected again as the Contractor of TREE in 2004. The University of Florence (UNI-FI in the following) has recognised it again as an opportunity for strengthening its role as a strongly "ERASMUS committed" Institution: this engaged commitment is also concretised in direct financial support to the TN project which has been yearly awarded to the School of Engineering by the central administration. I shall therefore acknowledge here this substantial contribution and express our gratitude to Rector Marinelli and Pro-Rector Givone, together with the enthusiastic support of the recently appointed Dean of the School of Engineering (Prof. Tesi). Nevertheless, the commitment of the Contracting University alone would not have ensured the successful accomplishment of the project: the Coordinator (F. Maffioli) and the 4 Promoters (the true scientific "souls" of the project: G Augusti for Line A; A. Avdelas for Line B; K. Hawwash for Line C; M. Markkula for Line D) have to be gratefully acknowledged for their personal commitment and devotion.

Commenting on the impact of TREE on European HE policies in the Engineering sector, I see at least four different levels of beneficial outcomes from the activity of the Thematic Network:

1$^{st}$: at the level of individuals (teachers, students, corporate representatives, professionals, etc) who have the chance of an interpersonal cooperation and mutual enrichment, although with completely different origins and traditions; the "transversality" of this effect (teachers with students, teachers with corporate and professionals, etc) is the truly added value of the TN Activity

2$^{nd}$: at the level of a single HEI, in particular those ones in countries that only recently joined the SOCRATES programme and the Bologna process (or even the EU) and, in some cases, participated for the first time in such a large pan-European project in EE

3$^{rd}$: at the level of EE associations and stake-holders societies in Europe: the TN TREE has resulted into a *network of networks* (or *double networking* effect), bringing together (or better: bridging across) different associations including CESAEER, SEFI, IGIP, BEST, FEANI and ENAEE allowing a unification of the efforts and coordination of initiatives and good practices.

Furthermore, looking to the "Progress towards the EHEA" (again by the London Communiqué, Sect. 2) all the issues raised there have been dealt with thoroughly within TREE, coming to some very innovative and surprising outcome:

- the *mobility* issue: as a true "*Network of Networks*", TREE has acted continuously as a think-tank and resonance forum for all those projects and initiatives to foster mobility of students, teachers and professionals, always listening to the voice and expertise of the students and of many teachers involved in mobility programmes. Very often, the meetings and the work within the TN project gave rise to newly established links and flows of mobility between HEIs which never came in touch before;
- *degrees and recognition*: the Attractiveness Line (Line C) has put in evidence the increasing beneficial effect of the joined degrees and of many recognition agreement, which may favour the trans-national recognition of titles and mobility of graduates; synergy with TEMPUS projects has been also looked for, especially for those initiatives of joined curricula between Institutions
- *doctoral studies and students*: the Education and Research Line (Line B), the central activity of the project intentionally focused on the alignment of the two main component of the Humboldt-kind of University education, developed a deep analysis of the doctoral studies and contributed to the discussions on the 3rd level of the Bologna scheme; Engineering and Technology sector shows here some reluctant in capturing the Ph D studies under rigid curricular frameworks/standards
- *lifelong Learning:* European competitiveness depends more and more on professional competencies, productivity and creativity for innovation. Different aspect of knowledge society development have been studied especially by Line D "Sustainability of competencies".
- *quality Assurance and Register of Quality Assurance Agencies*: Line A has contributed decisively to the development and implementation of the new standards and qualification framework of the EUR-ACE® label, which has been recognised as "the" European Quality Assurance label for the engineering education sector.

- *social dimension*: - some priority issues of social relevance like “Continuing Engineering Education” and “Open and Distant Learning” have been widely and deeply dealt with by Line D while most recent advances in “Ethics in Engineering” and ways of attracting learners from non-traditional background analysed and critically complemented in Line C.

Nearly 117 partner Institutions involved, 4 Activity Lines, 30 working groups, some service actions to the whole project structure, a Management Committee of 14 members, 1 Project manager at the TN-Headquarter (at the International Relation Office of the School of Engineering in Florence): these are the figures that give an overall idea of the dimension of the project work and effort, both at scientific and managerial levels. Such effort has made it possible for TREE to become the true voice of higher EE schools in Europe: I am confident, this voice will now find the attention of all relevant policy makers and stake holders of Education in our Continent.

But, before this happens, let me spontaneously conclude these few words with a statement of full satisfaction: it has been a great honour and a privilege to serve as President of a truly innovative and challenging project for a better future of EE in Europe!

Chapter 1

# TREE: Development, Results, Challenges

*by Francesco Maffioli*
Politecnico di Milano
Co-ordinator of TREE

## 1.0 Introduction

I hope that you, the reader of this volume, can forgive me if I address you so directly in this Introduction. You are certainly interested in Engineering Education (EE) and its evolution in Europe and in the world. *The First message* I would like to convey: **This volume (and its companion CD) is for YOU!** You may be directly involved in EE as a teacher or student, or indirectly, as an employer, a professional, a young graduate, an employee of a Ministry of Education (or of University and Research), or a member of the European Commission, for instance of the DG Education and Culture, a syndicate expert. The product you have in front of you is the result of three years of intensive work from one of the largest Thematic Network (TN) Projects supported by SOCRATES II devoted to the many issues of transversal interest and believed to be of paramount relevance for EE in Europe. This TN was denominated TREE, for "Teaching and Research in Engineering in Europe". The first section of this chapter is devoted to trace the "roots" of this initiative. I believe that the work done is of very high value. Hence my *second message*: **USE IT!** This does not mean asking you to agree with every advise/guideline contained here, but rather to evaluate them, and compare them with your views on the key issues in EE in Europe today. *Third message*: **FEEDBACK!** i.e. please send us your comments, proposals, and suggestions. EE is evolving much faster than in the past in Europe (and in the whole world), therefore even the best possible set of instruments for enhancing its successful development is bound to become in some years, at least in part, out of date. It is easy to anticipate the need for continuing the effort to innovate EE in Europe. Hence my *fourth message*: directly or indirectly, **SUPPORT THIS EFFORT!** The big themes, the many facets of which have been studied by the 30 Special Interest Groups of TREE, are here to stay with us, presenting new challenges to the higher education community (and its many stakeholders) in the near future. Some examples: the evolution of the so-called Bologna Process; the need for improving (and augmenting) Life Long Learning opportunities; the importance of an accreditation system applicable for the whole Europe; the role of an ethical formation; the instruments for attracting to engineering (and by and large scientific) studies the best minds coming out of secondary education, and to offer them the best possible learning environment; enhancing the employability of graduates at all levels, taking into account the effects of globalisation; the need to maintain a strong autonomy of higher education institutions.
And now let me try to introduce you into the rich set of outcomes of TREE.



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## 1.1 Historical roots of TREE: a summary

Thematic Networks (TN)[1] have been introduced in the SOCRATES-ERASMUS programme of the Directorate General (DG) Education and Culture (EAC) of the European Commission (EC) in the nineties and "*aim to define and develop a European dimension within a given academic discipline or other issues of common interest … through cooperation between university faculties or departments, academic or professional associations, and other partners … A successful TN project might help provide a more favourable environment for a deeper understanding of the discipline concerned … Furthermore … TN projects should: work towards assessing the quality of cooperation and curriculum innovation; promote, within an active forum, discussions on improvements in teaching methods … ; foster the development of joint European programmes … and improve the dialogue between academic and socio-economic partners* ".

During a General Assembly it appeared immediately mandatory for SEFI[2], the largest and oldest of European associations devoted to Engineering Education (EE), to take advantage of such a challenging proposal for enhancing EE in Europe. The first TN with this general mission was denominated H3E, for "Higher Engineering Education for Europe", was financed under SOCRATES I, and was managed via a EEIG (European Economic Interest Grouping). It was soon realised that H3E had only begun the study of such a complex and dynamic field as EE in Europe and a second TN was proposed, this time (according to the new rules of SOCRATES II) having the "Università degli Studi di Firenze" (University of Florence for short from now on) as contractor: this new TN was denominated E4 for "Enhancing Engineering Education in Europe". It spanned the period from 2001 to 2004, and its results have been collected in a box containing six volumes (and a CD-Rom). It can be safely maintained that the most important topics of transversal interest for EE, with its rapidly evolving dynamic, are studied in-depth in the six volumes produced by E4[3]. However any effort, as good as it may have been, is bound to become obsolete, at least in part, in some years because of the rapid evolution of EE.

Stimulated by the DG EAC, the management team of E4 began therefore in 2003 to shape a TN which could be a valuable successor of E4. A shift from the study type of work of E4 towards something able to suggest real "instruments" for the development of EE in Europe was identified as likely to offer a strong motivation for a new TN, which was denominated TREE for "Teaching and Research in Engineering in Europe". It was felt mandatory in fact to stress the importance of synergies between research and formation activities in all European higher engineering education institutions, considering as their most

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1 For the convenience of the reader acronyms are introduced in parentheses when used for the first time.

2 SEFI is the European Society for Engineering Education ( *www.sefi.be* ).

3 The main results of E4 may also be found in the web site of TREE under Archives ( *www.unifi.it/tree* ).

important mission that to form the leading technical and managerial figures of European enterprises in a more an more globalised economy.

It was decided to structure TREE following four "lines", denominated respectively the *Tuning line* (A), the *Education and Research line* (B), the *Attractiveness of EE* line (C), and the *Sustainability* line (D). The intention was to articulate each Line into several Working Groups, giving to each of them the task of developing a specific instrument, be it a real tool, a study, a survey, or a set of guidelines. Such a structure was estimated functional to the new mission of TREE with respect to E4.

As it was for E4, the TN TREE also decided to rely on an International Advisory Board for on-going advise and monitoring of the progresses of the TN. Four highly qualified experts were appointed, representing different types of stakeholders. Their contribution has been not only very valuable but also continuative and challenging for the numerous activities of TREE.

## 1.2 The General Conference in Rome

After a few months devoted to ensuring that the TN managerial and administrative structure were well in place, a General Conference of experts representing the more than 100 universities having declared their interest in actively participating in the TN project, was convened and hosted by the Faculty of Engineering of "la Sapienza", the first University of Rome. During this very successful event the enthusiastic support of the attendees from all European countries was exploited to arrive at a definitive structure of TREE, articulating it into 30 Special Interest Groups (SIG), each one devoted to develop a particular "instrument" (or "tool" as they were familiarly called) for contributing in a concrete way to the enhancement of EE. It was decided that the size of each SIG should be kept flexible but limited, and that each SIG should have a Leader. The SIGs were subdivided into the four Lines of TREE, under the co-ordination of a Line Promoter. The four Line Promoters have been permanent members of the Management Committee (MC) of the TN, thus ensuring the timely updating of the status of the project and the "transmission chain" between SIGs and the management. The reader is referred to the Appendices of this Volume for more detailed information on the managerial structure of TREE. In order to arrive at a (provisional) "mission" for each SIG, the Rome conference was split into several working groups, one for each Line, plus others devoted to special aspects, like e.g. the structure of the web site of the TN.

In retrospective it can be safely said that the General Conference in Rome was indeed the "birth" or "kick-off event" of this ambitious project, establishing the grounds for its work in the following years. It was a substantial financial effort, but paying off well, as far as what we have been able to judge in the sequel. In Rome it was also decided to set up another managerial structure, of paramount importance for the progress of TREE, namely the possibility to meet, at least once every year, with all SIG Leaders. This was denominated the Scientific Committee (SC) of TREE. The SC has met 2 times marking the various phases of development of the project. The first meeting of this committee was held at Villa Vigoni in Loveno di Menaggio (Italy) on 16-19 February 2006 while the second one took place at Arenberg Castle of the Catholic University of Leuven (Belgium) on 19 and 20 March 2007.

## 1.3 Milestone events

For a complete list of meetings and main events during the life of TREE the reader is again addressed to the Appendices. The purpose of this Section is only to recall the most important ones as a way to illustrate the overall evolution of the project. Even before knowing if the application for TREE would have been successful, a first meeting of foreseen SIG Leaders and of the MC took place in Leuven end of October 2004. It was followed in February 2005 by the plenary meeting of all TREE partners held at the School of Engineering of the Università "la Sapienza" in Rome. Other important events have been the two SC meetings mentioned above, which grouped together the Line Promoters and the Special Interest Groups leaders of the Network, and the TREE dedicated sessions within the SEFI annual conferences (September 2005 in Ankara, June 2006 in Uppsala, and July 2007 in Miskolc). Moreover it appears worth recalling the strict cooperation between TREE and the engineering students community, underlined by the link with BEST. An example of this cooperation has been the TREE session within BEST Academics and Companies Forum held in Brussels in March 2007. TREE has also taken part actively in 2004, 2005, 2006, 2007 in the events organised by TechnoTN[4], and was deeply involved in the First Engineering Deans Convention organised in Florence in November 2005.

## 1.4 Introduction to the results of TREE

The results of TREE are reported in full in the enclosed CD-Rom, under the heading of each SIG whereas, for seek of readability, they have been grouped by chapters of this volume. These chapters intend to provide a guide for the users. In this section a brief outline of each chapter is offered to facilitate the task of

4 TechnoTN is the Archipelago of TNs in Scientific and Technological fields whose main task is to organise every year a Forum for discussing together hot topics in education relevant for all these fields. For more information see the web-site *www.upv.es/TechnoTN* .

the reader. The editorial board of this volume decided to organise it not reflecting strictly the subdivision of the TN into the four Lines already mentioned, in order to enhance its coherence and readability. For the majority of topics considered each SIG includes also examples of good practice in the relevant subjects.

Most of what has been studied in the *Attractiveness of EE* Line (C) is the subject of **Chapter 2**, titled ***Tools for Enhancing the Attractiveness of EE in Europe.***. A first group of topics is concerned with attractiveness in a strict sense: from instruments to promote higher EE with secondary school students, to suggestions of instruments for widening the participation of underrepresented groups to engineering studies, and to attract female students. One of the strongest instruments for retaining students is the promotion of pedagogical abilities of engineering teachers: in an ad-hoc section a survey of the situation across Europe and suggestions for its improvement are provided. An important role in enhancing attractiveness is played by extracurricular activities: a special section is devoted to their role, as viewed by a distinguished group of engineering students. Two other more specialised topics treated here are instruments for enhancing Tempus Projects and the status of double degrees in engineering in Europe.

**Chapter 3** is about ***Innovative Learning and Teaching* Methodologies**. The need for innovating the curricula is felt from the very first semesters in particular for what concerns the mathematical formation of engineering students, hence a section devoted to the core curriculum in mathematics for EE. Active learning, problem-based, project-oriented, techniques are some of the most important ways to innovate the EE and are the subject of ad-hoc sections. The relevant presence of virtual universities in Europe is increasing: a section is surveying the European situation with its many new challenges. Related to the innovative learning topic we can find mentioned in other chapters the development of the Bologna process (see chapter 5) as well as the importance of the ethical formation for engineering students (see chapter 6)

**Chapter 4**, titled ***Education and Research Synergies*** is devoted to the various ways research and education positively interact. This topic is treated in general in section 1. Other sections are concerned with: a survey of third level (i.e. PhD) studies in Europe, presenting and evaluating a very diversified situation; the importance of stimulating research activity also at the undergraduate level, if nothing else for its pedagogical potential; and the tools for facilitating international/interdisciplinary projects in teams, which provide a very stimulating experience for students, but present often difficult organisational/ financial problems.

***Quality and Accreditation of EE in the framework of the "Bologna Process"*** is the title of **Chapter 5**. A survey of National systems of EE, QA and Accreditation is the topic of the first section. It is also devoted to the progresses of the so called "Bologna Process", updatiyng the survey preposed

some years back by E4. The complex picture of accreditation systems in EE in Europe is presented, then, in section 2 and the proposals of the project EUR-ACE[5] are given an opportunity to be known by the largest audience possible. Suggestions and guidelines for quality assurance and assessment are offered in the next section. The evolution of ECTS towards a tool for a complete profiling of engineering graduates is the subject of section 4. The main motivation for a European accreditation system is the enhancement of mobility of engineering professionals within the EU. It is then natural to include in this chapter the results of two other SIGs, one inquiring about the real needs of European industries as far as internationalisation in the formation of future engineers, the other aiming at a survey of demands and offers of the European labour market, especially focusing on the engineers' competencies required, to enhance wide employability.
The IGIP[6] System of accreditation for programmes in engineering pedagogy is also presented in the final section of chapter 5.

The importance of offering strong possibilities to continue to learn even after the completion of universities studies is a well known necessity and has seen strong developments in the recent past worldwide. A lot remains however to be done for enhancing the role of European higher education institutions in offering, as efficiently as possible, Life-Long Learning opportunities to engineering professionals operating in their regional area of influence. ***Sustainability of Engineering Competencies through Continuing Education*** is then the title of **Chapter 6**. Main subjects considered are: how Universities can manage CEE (acronym of Continuing Engineering Education) effectively; a state-of-the-art report on the sustainability of engineering competencies in today's knowledge society; Ethics and Social responsibilities as key topics of EE; new ICT-based forms of continuing professional development, stressing a list of critical success factors and guidelines for the integration of ICT in the learning process; major challenges for CEE resulting from the ongoing and future changes in the working environment, and recommendations on how to comply with them. The final part considers adult education model for European universities, in particular, but not only, the tools to validate non-formal learning in CEE.

**Chapter 7** collects results of general relevance for European EE. One of them is the ***Glossary*** of terms and definitions in EE in English, with an annex reporting translations in some of the main European languages: this effort updates the incomplete one done under E4, and is a "must" tool for improving transparency and circulation of opinions about EE. Another section is a ***Guide of Engineering Schools in Europe***, in the form of a fast access tool to the relevant web sites that each higher education institution offers: in a certain sense a "guide to guides".

5 www.enaee.eu

6 IGIP: the International Society for Engineering Pedagogy (www.igip.org)

A final section is presenting the results of the analysis of a questionnaire inspired by TUNING within TREE Partners.

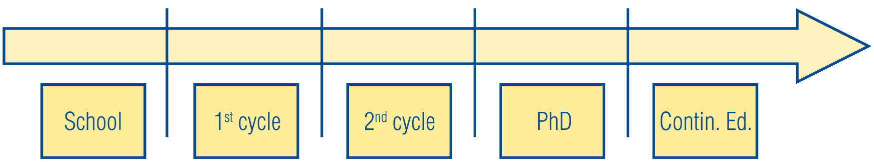
Concluding remarks, recommendations, future challenges are offered in **Chapter 8**, trying to anticipate the needs of the European Higher Education Area (EHEA), of the European Research Area, and more generally of European economy and labour market, to which the Engineering schools must respond. Indeed the need to adapt the European higher education systems to ensure that EHEA remains competitive in our globalised world has been stressed in the London Communiqué (LC) resulting from the meeting of Ministers responsible for HE in the countries participating in the Bologna Process in London in May 2007. The results of TREE match very well with the challenges outlined in the LC, but it is quite obvious that a lot remains to be done. The LC can in fact be looked at as a source of suggestions for further work in all fields of HE, but in particular in Engineering formation, given the key role that EE plays in the development of European economy.

The final Chapter of this volume consists of the ***Appendices***. Some report the data of the TN project, the list of partners, and other important (but perhaps not of general interest) data. Another contains the report of the International Advisory Board on the activity developed by TREE during its 3 years of life. Instructions on how to take advantage of the search engine included in the CD to interrogate it from various points of view (see also below) are also mentioned, but only briefly since the user of the CD is guided interactively when opening it.
In fact the enclosed CD-Rom is provided with a search engine, which allows for different consultation possibilities. The most obvious one is of course by the titles of the Sections and/or the Chapters, i.e. following the Index of this volume. We have provided a list of keywords and another consultation form is by using them. A third consultation possibility is by Target Audiences: they are listed in Table 1. Another form of consultation is suggested by the life-long formation of today's engineers: the stages of this process have been subdivided as reported in Figure 1.
Other consultations are also possible and are illustred in the welcome page of the CD-Rom.

**Table 1**

| Target Audience |
|---|
| Industry/Enterprises |
| 1° & 2° level |
| PhD and Research level |
| Accreditation/Quality Assurance |
| General audience |
| Students |
| International activities |
| Disadvantaged communities |
| Management |
| Learning techniques |
| Continuing Education |
| National and International Authorities |
| Pre-university level |
| Teachers level |
| Actors in implementing Bologna demands |
| Applicants to engineering study programmes |
| Admission tutors |
| Recruiting committees |
| University Officiers |

**Figure 1**



CHAPTER 2

# Attractiveness of Education

*by Kamel Hawwash*
University of Birmingham
TREE Promoter Line C

The author of this chapter is Kamel Hawwash with the Line C Special Interest Group (SIG) leaders as collaborators

SIG C1 Rüdiger HÖFFER, *Ruhr University Bochum, Germany*
SIG C3 Laszlo SZENTERMAI, *University of Miskolc, Hungary*
SIG C4 Gunther KURZ, *University of Applied Sciences Esslingen, Germany*
SIG C5 Urbano DOMINGUEZ, *Universidad de Valladolid, Spain*
SIG C6 Kamel HAWWASH, *University of Birmingham, United Kingdom*
SIG C7 Joanna DAUDT, *Technical University Delft, Netherlands*
SIG C8 Ömer HANTAL, *BEST*

## 2.0 Introduction

The overall aim of this chapter is to report on the main outcomes of the work of seven Special Interest Groups (SIGs) which have worked to identify ways of enhancing the attractiveness of EE to potential stakeholders. It does not seek to prove that there is a shortage of engineering graduates in Europe but rather to identify tools that can help improve the recruitment of appropriately qualified candidates. Understanding the reasons which may deter potential students from studying engineering is a complex matter, particularly in the context of Europe where educational and cultural issues may vary from country to country or region to region. However, it is possible to identify areas of good practice which may be shared and to suggest some tools that may be helpful to those working to enhance the attractiveness of EE in their countries. The outcomes from the work of the line are reported in the following sections under the SIG headings and a more detailed report on each can be found in the accompanying CD-Rom.

The work of the Line was undertaken by the following SIGs:

SIG C1 Promoting Higher EE in Europe
SIG C3 Identification of tools for enhancing TEMPUS projects
SIG C4 Promotion of pedagogical abilities of engineering teachers
SIG C5 Multiple and joint degrees in EE in Europe
SIG C6 Widening participation in EE for under-represented groups
SIG C7 Attracting and retaining female students
SIG C8 The role of extra-curricular activities



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## 2.1 Promoting Higher EE in Europe

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**Key words**: recruiting strategies, illustrative teaching methods, preliminary orientation, image improvement of engineering careers, life-long learning, participations to exhibitions on technology to young pupils/families, interest end-users by asking them to set problems, attract professional interest by offering seminars and/or conferences

### 2.1.1 General

The SIG has considered the factors that make Higher Engineering Education attractive to potential students, and, amongst other, the following issues:

- coordinated education programs
- internationality of courses within and outside Europe
- research links
- language support
- academic support for students, and others.

Examples on the problem how these factors can be communicated to the target groups have been worked out.

### 2.1.2 Long term strategies to change the image of engineering work in the public opinion

Concerning the target groups a long term and a short term strategy is necessary. The long term strategy is focussed on the public, on the opinion formers. It seems to be necessary to change the image of engineering work in the public opinion. This may be done by contacting the political parties, big newspapers, TV and others. Of special effect are conferences and exhibitions arranged by eminent technology-oriented commercial groups and associations aiming on the interest of young public. A similar strategy can be seen regarding TV shows about physical experiments on partly common but highly non-trivial problems. Related activities undertaken by the German television programme ARD, the German technology group Thyssen-Krupp, and the German Association of Physics DPG are demonstrated by video-films, photographs and descriptions in the full report on DVD and can be seen as examples of good practice. Ruhr-University Bochum contributed to these activities.

### 2.1.3 Short term strategies

The short term strategy is focussed on pupils and on students from foreign countries as well. The first get in touch with pupils should be at an early stage of age, say 13 years. If lectures are presented to late in time (as it usually is) the overall alignment is already settled. Local newspapers seem to be useful for transporting the ideas into the public. A further stimulation of interest for engineering education in the target groups can be reinforced through the following items:

- Prepared lectures in schools with power point support
- Videos Connection with Museums of Science and Technology
- Competition on technology applications with paper models etc.
- Videos
- On- and offline engineering games (e.g. bridge-design)
- Internet web pages

### 2.1.4 "Killer applications"

What is urgently needed is a "killer application" in engineering, which attracts the interest of the public. It seems that the topic risk management could be a very good focus at least for civil engineering.

### 2.1.5 Removal of barriers

Methods for removing barriers should be developed not only stimulating ones. For the long term process the above mentioned groups should be contacted. A context to Europe and the European engineering history seems to be important in this process.

Students from other faculties should have a simple formal possibility to change into engineering schools. The concept of the Summer-Schools may be adopted for pupils.

Foreign students do have other problems. They already decided to study in engineering. The barriers are low. Normally they do have problems with the language. An effective language support is essential for the success of the program. The lectures and courses shall be coordinated concerning the topics, the terms, coordinate systems, and other items.

### 2.1.6 Investigation into the motivation of students in engineering studies

Experiences are reported in the full report on CD Rom which presently are made in the framework of (a) presentations of the study offers of the Faculty of Civil Engineering at the Ruhr-Universität Bochum to the public, and (b) the regular consultations between potential students and the professional contact at the faculty. An assessment of the advertisement measures is based on an evaluation of questionnaire indications made by new students in October 2007. The inquest is conducted distributing the newly developed questionnaires in English and German language to groups of students at the Faculty of Civil Engineering at Bochum in each study course, i.e. the master course “Computational Engineering” (teaching language is English) and “Bau- und Umweltingenieur-wissenschaften” (teaching language is German). Both questionnaires and the evaluations will be available in the full report on CD Rom.

## 2.2 Attracting and retaining female students

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**Key words:** Gender, diversity, higher engineering education, interdisciplinary engineering programmes, best practices attracting and retaining women and female students.

### 2.2.1 Introduction

Despite a lot of effort in the past to attract more female students and female staff in institutions and universities for higher engineering education, the results are still disappointing. Male students and male staff mainly populate institutions and universities for higher engineering education. Although a lot of men realise that technology should be a matter for women too and are willing to contribute to actions to attract more women, the results are poor. In most European countries less than 10 percent of the students that study traditional engineering programmes are female students.

The full report in the accompanying CD-rom has the following content:

1. General relevant statistics in Europe concerning the participation of female students in higher engineering education
2. Detailed trend reports with statistical information from Finland, Germany, Sweden and the Netherlands
3. General recommendations to increase the female participation in higher engineering education
4. Activities that may improve the lack of female students in engineering programs
5. Link to bibliography
6. Link to all interesting internet sites.

### 2.2.2 Female participation

First this report shows you some interesting facts and figures concerning the participation of women in relation to other professional fields of science. Table 3.2 shows clearly the difference in female participation between the different countries and between the different fields.

Table 3.2. Proportion of female grade A staff by main field of science, 2004

| | Natural sciences | Engineering and technology | Medical sciences | Agricultural sciences | Social sciences | Humanities |
|---|---|---|---|---|---|---|
| EU-25 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| Austria | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| Belgium | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| Cyprus | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| Czech Republic | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| Denmark | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| Finland | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| France | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| Germany | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| Italy | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| Latvia | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| Malta | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| Netherlands | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| Norway | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| Poland | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| Portugal | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| Slovakia | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| Slovenia | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| Sweden | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| United Kingdom | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| Switzerland | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| Turkey | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |

Table 2.1: Proportion of female PhD (ISCED 6) graduates by broad field of study, 2003

### 2.2.3 Trend reports

In the trend reports of Finland, Germany, Sweden and The Netherlands the following questions are answered:

1. How is the System of Higher Engineering education organized?
2. What is the prerequisite profile in secondary education to be able to enter an institute of Higher Engineering Education?
3. What are critical ages when pupils have to choose the right profile/qualification which is compulsory or highly recommended to enter an institute of Higher Engineering Education?
4. Is there an entrance exam?
5. What is the percentage/number of male and female students leaving secondary education and to study an engineering programme?
6. What is the percentage/number of male and female students leaving secondary education and to study an engineering programme?
7. Can you mention three programmes which attract the largest number of female students and three programmes which attract small numbers of female students (1999- 2005)?
8. How many students (male and female) drop out during the study (give the number and percentage)? What is the conclusion: decrease or increase?
9. How many students change their programme?
10. What is the number and percentage of male and female students doing a PhD?
11. Can you mention figures and facts concerning the (un)employment of engineers that have finished their studies in the last 5 years?

The detailed trend reports are included in the accompanying CD-rom.

### 2.2.4 General recommendations to increase the female participation in higher engineering education

The low participation of female students in higher engineering education is mainly a problem in Western European countries and has a historical and cultural background. Most women in Belgium, Denmark, France, Germany, The Netherlands, Scandinavian countries and U.K. did not have to contribute to the household income in the past few centuries. Although engineers often have very good prospects in the labour market, engineering programs and the profession have a nerdy image and are considered as difficult. To change culture is a long process that requires long term projects and especially the support of industry.

After having read a lot of publications concerning the female participation in higher engineering education, the following conclusions can be drawn.

- most activities in this field are organized in short term projects and in general are not imbedded in a long term strategy of an institute of engineering.
- adequate process and product evaluation have not been executed and they often lack effective project management and the support of the board of directors of the institute.
- only little research into the effects of activities has been executed and, if so, the population was too small to draw general and convincing conclusions.

To increase the female participation in higher engineering programs we would like to give the following provocative and wishful recommendations.

Make the profession visible

Show its usefulness so that the profession is considered as normal.
Use television as a medium to show how engineering is fun, creative and important. For example the television series with a female pathologist in the main role has improved the participation of female students in Medicine programs.

## The push of industry

If industry acknowledges that half(50%)of their buyers of products are women and that therefore they need more women in research and development, they can force and subsidize institutes for higher engineering education to make the programs much more attractive for both female and male students.

An interesting project in Germany is FEMTEC *http://www.femtec.org/content/0/2070/1085/*

Another interesting initiative is: http://www-5.ibm.com/nl/extremeblue/

## Technology in context

Institutes for higher engineering education should be forced to collaborate with general universities to develop programs in which technology is combined with for example Biology, Medicine, Languages, Business administration and marketing. In the trend reports it can be read that programs in which technology in context is offered the participation of female students is almost 50 percent.

### Positive discrimination

As long as institutes of higher engineering education are male dominated little will change. The character and image of engineering programs will only change when more female professors will have been appointed as role models and experts to motivate women to start an engineering program.

### Attract female students from abroad

In Southern European countries and other parts of the world like Asia and China the engineering profession has a different image and female participation is balanced. In the long run this bypass policy will also lead to a better representation of male and female scientific staff members in Western European institutes of higher engineering education.

## 2.2.5 Activities that may improve the participation of female students in engineering programmes

General interesting reports:
From the USA: Land of plenty, Diversity as America's Competitive Edge in Science, Engineering and Technology
*http://www.nsf.gov/pubs/2000/cawmset0409/cawmset_0409.pdf*

From Sweden: five gender-inclusive projects revisited
*http://www.myndigheten.netuniversity.se/download/3324/x/wistedt_five_gender-inclusiveprojectsrevisited.pdf*

Project Tackling Stereotypes: maximising the potential of women in SET, led by WITEC – Women in Science, Engineering and Technology.
*http://www.tackling-stereotypes.org/bstprctc.htm*
In the 'final report of the women's experience in college engineering project' (Goodman, Irene F. Ed. D. , 2002), *http://www.grginc.com/WECE_FINAL_REPORT.pdf*, the following reasons have been mentioned

why women may leave engineering. Activities and websites are added for activities which can prevent and/or repair the lacks mentioned.

| Gender and societal issues |
|---|
| Visibility and Image of engineering<br>Best practice:<br>Magazine with female role models (Finland)<br>Website with female role models (Germany, B-ing)<br>Technology days<br>Discovery channel<br>Musea of Technology and Science<br>Engineering soaps<br>Robotlab Frauenhofer institute:<br>*http://alex.ais.fraunhofer.de/zeno/web?action=content&journal=16413&rootid=15465*<br>From Engineering is difficult and nerdy to Engineering is creative work and highly paid! |
| Lack of self confidence and engineering efficacy |
| Research indicates that the best 20% of the female students receive less support from professors (Germany)<br><br>Best practice during study:<br>Fem-tec program (Germany): mentoring, training, coaching and networking for the top 20% female student during their study:<br>*http://www.femtec.org/content/0/2070/1085/*<br><br>Mentor projects<br>TiNA project Finland:<br>*http://tina.tkk.fi/english/index_eng.htm*<br>Ada Lovelace Project (Germany):<br>*http://www.uni-koblenz.de/~alp/projekt_en.htm*<br><br>Best practice primary and secondary schools:<br>Technika 10 (The Netherlands):<br>*http://www.technika10.nl/technika10/summary.htm*<br>Girls days:<br>*http://www.lin.ca/resource/html/lt26.pdf*<br>Special summer courses (IBM) |
| Lack of pre-college experience and knowledge in engineering |
| Best practice:<br>*http://www.adventureengineering.org/references/paper.1.pdf* |

| Curricular focus, pedagogy and climate in engineering |
|---|
| Best practice:<br>*http://www.asee.org/acPapers/2002-2019_Final.pdf* |
| Lack of female peers and role models |
| Best practice:<br>Germany, appointment of female professors GENDER STUDIES IN engineering education to research and promote the recruitment and retention of female students at Universities of Technology. |

*Paragraph 5*

Link to bibliography
*http://umbc.edu/cwit/itgenderbib/*

*Paragraph 6*

Link to all interesting internet sites:
*http://www.evaluieren.de/infos/links/gender.htm*

## 2.3 Widening participation in EE for under-represented groups

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**Key words:** Widening participation, widening access, disadvantaged groups, non-traditional students, disadvantaged learners.

### 2.3.1 Introduction

The declining numbers of applicants to engineering programmes from traditional backgrounds has resulted in initiatives to address this which are targeted at potential students from the indigenous population. However, a number of EU countries have also been considering how to attract more female student and more recently how to attract students from no-traditional backgrounds. The issue of attracting more female students is discussed in section 2.3. This section therefore considers a wider pool of non-traditional students.

### 2.3.2 Survey

*Scope*

SIG C6 Thematic Network organized the survey for widening participation in engineering in Europe. The questionnaire was sent to 114 TREE partners. Altogether 31 answers were returned by mid-October 2006. The answering per cent was 27. The answers came from the following countries: Belgium (1), Bulgaria (2), Czech Republic (1), England (1), Finland (3), France (2), Germany (3), Greece (1), Hungary (3), Iceland (1), Italy (2), Latvia (1), Malta (1), Norway (1), Poland (1), Portugal (1), Slovak Republic (1), Sweden (1), Turkey (2), and United Kingdom (2). The following analysis is based on the given answers in each question. This means that per cent shares presented in figures reflect the distribution of answers given in that question.

*Target Group*

The aim of the target group question was to find out which are the groups each educational unit has interest in. The group options were the following:

- gender
- low-income groups
- people with disabilities
- people in rural, isolated or deprived areas
- minority ethnic groups
- migrants, refugees & asylum seekers
- adult learners
- those with vocational qualifications
- work based learners
- other (please specify)

The type of interest was also asked to be specified. Those options were:

- specialist knowledge, e.g. initiatives, practical examples, case studies
- research interests in Access, Widening Participation and/or Lifelong Learning
- general interest in Access, Widening Participation and/or Lifelong Learning

*Conclusions From the Survey*

Specialist knowledge target groups concentrated clearly on those with vocational qualifications, adult learners and work based learners. These three groups were also on the top of general interest. Exceptional was that the role of migrants, refugees and asylum seekers was very small in the case of research interest and general interest, and no target was seen in specialist knowledge. Some research interest in target groups were shown in almost all the target groups, except minority ethnic groups.

In the question of department's strategy the pursued issues were splitting among all categories, except that there were no research interest in acknowledgement of prior learning and experiences. Distance learning or e-learning was pursued in all target angles, i.e. specialist knowledge, research interest and general interest.

The main types of research dealing with widening participation were practise related, survey, action and case-studies/profiles.

In department, institution and country level the priority to increase access to non-traditional students was two-fold. Some prioritised non-traditional students and some did not.

### 2.4.3 Examples of good practice and useful resources

This section draws on developments in the United Kingdom over the past few years and it is hoped that good examples from other European countries can be collected and presented during the TREE dissemination period.

It is not an exhaustive list of useful resources but readers may find the developments in the UK helpful when considering strategies or policies for widening participation in HE. The UK has made substantial progress in developing policy for widening participation in Higher Education (HE) which has resulted in HE providers developing strategies for meeting this challenge. This is partly in response to UK Government strategy to see 50% of 18-30 year olds in higher education by 2010.

In addition to general funding to support the widening participation agenda, the Higher Education Funding Council (HEFCE) has offered funding to increase recruitment to strategically vulnerable subjects such as engineering, science and mathematics. The HEFCE website contains a wealth of information on widening participation www.hefce.ac.uk/widen/. An extremely useful document is the Higher education outreach: targeting disadvantaged learners which can be accessed at www.hefce.ac.uk/pubs/hefce/2007/07_12/. The document provides guidance on effective ways to target outreach activities at people from communities under-represented in higher education. It refines the definition of the target group for Aimhigher and outreach activity; provides a methodology to make targeting more effective; and sets out a process for measuring the effectiveness of the targeting process.

*AIMHIGHER*

Aimhigher is a national HEFCE programme which aims to widen participation in higher education by raising the aspirations and developing the abilities of young people from under-represented communities. Overwhelmingly these are people from lower socio-economic groups and disadvantaged backgrounds.

Funded activities include summer schools to give school pupils a taste of university life, taster days, masterclasses, visits to higher education providers and one-to-one mentoring programmes. Further information can be obtained from www.aimhigher.ac.uk/practitioner/home/.

While the various initiatives described above are intended for widening participation in HE in general, the Higher Education Academy's Engineering Subject Centre website at www.engsc.ac.uk contains resources that many stakeholders in engineering education would find useful but in particular www.engsc.ac.uk/er/wp/index.asp has an excellent section containing information and resources on widening participation.

A good example of engineering specific projects is the London Engineering Project http://www.hefce.ac.uk/aboutus/sis/stemprojs/londeng.htm. The project intends to widen and significantly increase participation in engineering in higher education for four target groups: women, minority ethnic students, students from families where there is no experience of higher education, and adult learners.

There are four elements to the project:

- to engage with 9 -19 year old students in 15 secondary schools in South London and 35 feeder primary schools
- to use face to face and other targeted marketing to promote engineering higher education courses to students in the target groups, including adult learners
- to engage with selected higher education institutions to develop new or improved engineering curricula that will attract more students from the four target groups
- to demonstrate real and achievable engineering career destinations for students of the project.

UK Universities' Response

The response of universities in the UK to the widening participation agenda has been to develop schemes to encourage potential students from the target groups to consider higher education as an option after completing their pre-university education. A quick search of the Internet will reveal a variety of schemes that universities have developed including the Acess to Birmingham Scheme (A2B) which is the University of Birmingham's response to this. Details of the scheme can be found at www.studyhere.bham.ac.uk/teachersandcareers/a2b.shtml. The scheme is aimed at students from the West Midlands region of the UK who have little or no experience of higher education. The scheme was created in 2000 and is designed to help students find out about what studying at university involves.

To apply for the scheme, students must be from a state school or college that has signed up to the A2B scheme with the Outreach Office at the University of Birmingham and meet one or more of the following criteria:

- students are from a family with little or no experience of higher education
- the main income earners in the family are not in professional occupations, i.e. not teachers, doctors, solicitors
- the school or college students come from does not have a high rate of progression to university
- teachers recommend the student to apply via the A2B route because there has been significant disruption to the student's education due to personal circumstances.

Applicants apply through the normal process but have to complete an additional application form to join the A2B scheme. Once accepted applicants complete the A2B Higher Education Learning Module (HELM) which is designed to help students make the transition from school to university. The HELM has three elements:

- an online study support module to help with academic writing skills
- a student shadowing experience, which will help students find out more about the style of teaching they can expect at university,

- an essay specific to the course applied for, set and marked by university tutors, completed after summer exams.

In return, applicants receive a reduced entry offer.

The above example is by no means unique but is presented as an example of the development of the widening participation area in the UK. Other examples can be found at:

*http://www.bristol.ac.uk/wideningparticipation/*

*http://www.bournemouth.ac.uk/accessforall/access_and_wp/summer_schools_2006/06_buss.html*

*http://www.city.ac.uk/careers/wp/index.html*

*http://dbweb.liv.ac.uk/cll/section.asp?section_id=864*

*http://www.open.ac.uk/widening-participation/p2.shtml*

*Journal Resources*

A number of journals have been established over the past few years which have provided opportunities for practitioners to publish in the area of widening participation and lifelong learning. They include:

International Journal of Lifelong Education http://www.informaworld.com/smpp/title~content=t713747968~db=all

*International Journal of Widening Participation and Lifelong Learning http://www.staffs.ac.uk/journal/Volume1(1)/contents.htm*

*Journal of Access Policy and Practice http://www.niace.org.uk/publications/Periodicals/JAPP/Default.htm*

*Conclusion*

Widening participation is a rapidly developing area. In the UK the lead has come from the Government as it seeks to increase participation in Higher Education. Within the general area efforts are also being made to widen participation in science and engineering. There are now a number of examples emerging of good practice in the area both in terms of Government funded initiatives and the way universities have responded to the challenge.

## 2.4 Promotion of Pedagogical Abilities of Engineering Lecturers

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**Key words:** Teaching and learning, pedagogical and didactical competencies, improving teaching skills, scientific continuing education, research and development in higher education.

### 2.4.1 Introduction

The required qualification of academics in higher education used to be mainly research oriented. The excellence is measured by the number of scientific publications, the pedagogical abilities are usually less important.

This attitude seems to change now. Learning has become in the focus of higher education; as a consequence of the Bologna declaration. The work load of the students is mirrored in the credit points for a module in the respective curriculum. But learning needs the coaching of the teachers and there is a world wide move to improve the teaching abilities, described as didactic and pedagogical competencies.

A specific goal of the Bologna declaration is to promote mobility amongst engineering students in Europe. As a consequence, universities will have to engage in an international competition to attract students. This results in a growing interest for improvement and innovation in engineering education. All over Europe 'Centres of Expertise on Learning and Teaching' are being established or, in case of older existing institutes are re-installed. The position of a centre of this kind within the university organisation varies as well as tasks and responsibilities. Some establishments are divided into a research group and a teacher-training and consultant division.

Excellence in teaching is of interest of all involved: the university to sharpen its profile, the students to safe time and efforts and the teacher herself/himself to be rewarded with happy clients.

Changes are slow, but it is interesting to note, that teaching competencies are beginning to be incorporated even in the respective laws. E. g. the act on higher education of the State of North-Rhine Westfalia in Germany states in § 46 (dated 1 April, 2000):

"Conditions for an appointment as professor in higher education institutions (besides the general regulations for state employees) are

1. A degree in the respective field; in general a Ph.D.
2. Pedagogical skills stated in general by a certificate on a respective preparatory education or in special cases during the appointment procedure."

Item 2 waives the so far common practice to state pedagogical skills merely by experience in having conducted lectures or other forms of teaching. The applicant has to reveal his/her individual level of skills, certified by successful participation in special courses or continuing education offered by centres for teaching and research of a university or equivalent offers by the institutions of higher learning.

The German State of Bavaria requires a mandatory introductory course for every newly appointed professor at a Universities of Applied Sciences (usually coming from an industry employment).

Some institutions require a certified additional qualification during the probationary period (see the example of good practice taken from Monash University, Australia).

As any courses/seminars/workshops/ … offered are targeting prospective participants of a respective country it proved difficult to gather information in English. The respective programmes are offered in the mother tongue; thus only little information could be gathered from the internet.

Upgrading the competencies in teaching became a main issue of 'Research and Development in Higher Education'. The terms and concepts are divers and by no means unique: 'Research and Development in Higher Education', 'Didactics', 'Faculty and Staff Development', 'Continuing Scientific Education', … .

For some countries exists a kind of national umbrella institution (usually non-commercial) distributing information about ongoing activities in the respective country. In some countries the government supports a nationwide organisation of this kind.

In general any kind of 'teaching certificate' is an additional qualification but not mandatory for an academic career.

For any kind of a teaching certificate there seems to be an unwritten international rule to cover about 200 (traditional) contact hours (with an hour equivalent of 45 minutes).

The offers yielding a certificate are mostly comprised of three to five modules and require about 200 contact hours. The most consistent curriculum was presented by IGIP – the International Society for Engineering Education. The curriculum is Bologna conform and structured in Credit Points (total of 20 ECTS for the certificate 'International Engineering Educator – ING-PAED IGIP)

Activities to improve the pedagogical and didactical abilities of lecturers and professors are available on all levels, from an individual school (especially for large universities), on a State level (in particular if education is assigned to the States as in the Federal Republic of Germany) up to a national task.

Most of the programmes address a general audience in higher education. Contents overview: Pedagogy in Theory and Practice, Aspects from Psychology and Sociology, Media and Learning Technologies, Intercultural Competences and Ethical Aspects … .

One – usually final – module is field specific, dealing with a real situation in lecture or laboratory.

Specific aspects of engineering education are addressed by the Engineering Pedagogy Curriculum offered by the 'International Society for Engineering Education – IGIP'.

Presented are the outcomes of a, however, limited survey in Europe and practical examples of good practice, covering the range from an individual (large) university up to a certificate 'International Engineering Educator – ING-PAED IGIP'

### 2.4.2 Outcomes of a survey in European Countries

The content of the headlines marked by a bullet can be found in detail on the TREE CD-ROM.

• Germany: Centres for Research and Development in Higher Education

Presented is a comprehensive listing of the manifold of higher education centres fostering and supporting teaching and research (collected by Gunther Kurz, Esslingen University of Applied Sciences)

• Czech Republic and Slovak Republic

Presented is a listing of the lifelong programmes of technical teacher training for university lecturers (collected by Dana Dobrovska; Czech Technical University in Prague, Masaryk Institute of Advanced Studies).

• The Situation in the Nordic Countries

The outcome of a symposium held in Denmark on faculty development in Nordic Engineering Education. The book referred to is published by Anette Kolmos et. al. (Aalborg University Press)

• Agencies/Consortia operating on a National Level

On the national level organisations in Denmark, Germany, The Netherlands and the UK are presented

*Denmark*

• IPN – Pedagogical Network for Engineering Education in Denmark

The Pedagogical Network for Engineering Education in Denmark – IPN is an educational network between all Danish engineering education institutions. The network group consists of representatives from all institutions, who educate engineers. The network is financed by the engineering education institutions of Denmark.

*Germany*

• AHD – Arbeitsgemeinschaft Hochschuldidaktik – Association for Research and Development in Higher Education.

The AHD is located at the University of Dortmund and is engaged in all aspects of higher education.

*The Netherlands*

• VOR – Vereniging voor Onderwijs – Netherlands Educational Research Association (NERA)

The Netherlands Educational Research Association (NERA), or – in Dutch – Vereniging voor Onderwijs Research (VOR), is the official professional association for educational research in The Netherlands. NERA has also Dutch-speaking members from Belgium.

*United Kingdom*

• The Higher Education Academy is the UK central body to support the enhancement of learning and teaching in higher education.

The HEA is the umbrella organisation for 24 centres in a subject network, one of them is dedicated to engineering.

• The Engineering Subject Centre

The Engineering Subject Centre's Mission is to improve the student learning experience in partnership with the UK engineering community.

### 2.4.3 Examples of Good Practice

An example from Germany for continuing scientific education offered on the level of a (large) university is the Technical University of Berlin with strong faculties of engineering and natural sciences.

• Technical University of Berlin: Centre for Cooperation and Scientific Continuing Education

The examples of state-wide programmes are also taken from the German system of higher education.

Responsibility for higher education is with the Laender (Federal States). They are offered by respective consortia of universities (State of Baden-Wuerttemberg) and the Universities of Applied Sciences (State of Bavaria)

- Consortium of Universities in Baden-Wuerttemberg 'Alliance for Teaching' – The certificate 'Teaching in Higher Education'. A modularized programme yielding a recognized certificate requires about 200 hours of study.
- Centre for Research and Development in Higher Education of the Universities of Applied Sciences in the State of Bavaria. A compulsory introductory basic course for newly appointed lecturers and a modularized advanced course yielding a certificate 'Dozent für Weiterbildung an Hochschulen' – 'Lecturer for Continuing Education in Higher Education'.

An international accepted certificate focussed on engineering is offered by the

• International Society for Engineering Education – IGIP

IGIP awards the certificate 'ING-PAED IGIP'. The ING-PAED IGIP curriculum is modularized and equivalent to 20 ECTS.

- IGIP Criteria for Accreditation in Engineering Education Studies
- Recommendations for Studies in Engineering Education Sciences

A Master-degree course designed for acquiring competencies for engineering staff is the

• Master in Problem Based Learning in Engineering and Science, MPBL at the University of Aalborg (Denmark).

The MPBL is a two-year part-time programme, organised as technology-supported distance education.

From the international scene an example from Monash University – a large research university in Australia - is presented.

• The Graduate Certificate of Higher Education – GCHE

All newly appointed lecturers have to fulfil the requirements of the programme during the probationary period. The certificate is offered by the Centre for the Advancement of Learning and Teaching – CALT.

## 2.5 Extra Curricular Activities in Engineering Education

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**Key words:** extra curricular activities, non-credited activities, student clubs, student societies, student associations, volunteer, technical club, social club, student motivation, personal development

### 2.5.1 Introduction

In today's society the requirements for higher education graduates to enter the professional world become more and more complex. The knowledge is gained through enrolling in the educational system but the skills, the experiences and the practice are more and more often gained through the participation in extra-curricular activities. This section reports on the work conducted to analyse of the role of extra-curricular activities in the formation of engineers today, to produce documented research of good practice in this field and to propose solutions and ideas on how to integrate this issue in the European higher-education.
During the work two events were organised by Board of European Students of Technology (BEST). The following is a short summary of the reports of the events in Rome organised by Local BEST Group Rome Tor Vergata and in Istanbul by Local BEST Group Istanbul.

### 2.5.2 The meaning of Extra-Curricular Activities

Students' lives are mostly balanced between study and family. However, education is more than credits and grades. In all disciplines of the education, there is a need for more dimensions than what only lectures provide. Especially engineering education needs to have a higher standard than the one achieved by simple lectures. Since so many depend on their work, future engineers have to be ready to overcome any challenge with which they are faced.
At this point, the extra-curricular activities arrive to complement the academic education. These are optional and usually non-credited educational activities, that can be related or not to the field of studies and conducted during the students' free time and in the same time these activities are useful for their personal development. In all European Universities there are many examples of extra-curricular activities like: students' clubs, faculty clubs, music and movie clubs, volunteer associations. Even if the number of clubs or unions is high, the students experience difficulties because the amount of information is increasing and the really useful information is getting lost.

An extra-curricular activity for student A could be a simple curricular activity for student B, so extra-curricular activities can be classified considering each of these skills. Participants agreed that forced and compulsory activities can't be included in the extra-curricular activities. However, it has to be taken into consideration that students who work are also self-developing through that and their jobs might be sometimes considered extra-curricular activities.

### 2.5.3 The role of Universities

The universities need to focus their attention on promoting these activities in a better way and one solution proposed was that student unions in each faculty should also have this task, of promoting extra-curricular activities to students. When it comes to the number of members in these organisations, clubs or unions, the recognition of the activities [assignment of ECTS] plays an important role. In the same time, the students' behaviour has to be taken into consideration: there are some that only attend lectures and other that are active members in various extra-curricular activities. These students recognize the potential of such activities, where they learn how to solve challenging and real problems, using skills and knowledge. Some of these activities are thought to be very useful in promoting international cooperation, in spreading a new mentality that companies are looking for, so that students can actually get better internships or first jobs. Usually, companies prefer people with working experience, especially international, but on the other hand it is very difficult to have such experience before graduating. It is agreed that extra-curricular activities are all activities out of academic curriculum that contribute to self development. European Universities offer a wide range of activities, among which there are: radio stations, political clubs, social clubs ( such as associations for welcoming new students, volunteering, cooking, wine tasting, health), arts clubs (photography, culture, writing, handcraft), technical clubs (such as Linux Interested Communities) and sports groups (such as sailing).
Here at that point, universities can play a key role by providing students with information about all activities available, by promoting also the possibilities coming from outside the university, by supporting the groups with facilities (like offices, money), by showing flexibility for students involved, for example with exams and with class attendance. Universities can work together with the associations which can encourage involvement of students. There are universities where companies are very much involved in the educational system, being close to students since the start. Still, paid internships are more similar to jobs than to extra-curricular activities, although they contribute to self development. On that point, three environments for students can be defined: study, extra-curricular and job. Some universities have it compulsory for students to take extra-curricular activities and this is important because it increases the value of the activity. On the other hand, some people just register and never get involved. This is why students would like to have these activities recognized and strongly encouraged, but not compulsory.

The universities can promote extra-curricular activities or motivate students for some areas and projects. To motivate students, they can give a diploma or for some activities, they can give credits, only if the university decides which skills are necessary for students and which activities related to these skills. Extra-curricular activities recognition is possible by assessing credits and permitting replacement of elective courses, based on these credits. Another way is to mention them on the university diploma, combined with a certificate given by the university. The process of recognition should be application based and voluntary. The student would provide the proof of involvement, like references, and the description of experience and skills achieved. After an evaluation done by relevant professors, the conclusion would have the form of "pass/not accepted" and only for courses also grade.

Students should be allowed to describe such activities themselves. This self-assessment would imply that the student understands the importance and the relevance of these activities to his/her personal development and knows how to value the acquired skills and competencies. Such assessment would contain: a description of the activity, with all the necessary details, and a description of the outcomes achieved through them. The assessments of all activities performed by students would go in their personal "portfolio", a document that gathers the non-academic experiences of the student. The guidelines for compiling such document would be provided by the university; in the same way institutions provide citizens with guidelines on how to compile a CV.

After recognising the need for such self-assessment, participants asked themselves how this document could be used to officially certify the student's experience. At European level, nothing could be done since the level of bureaucracy would be too high; the differences in type and value of extra curricular activities from country to country would constitute a further obstacle. Furthermore, it would violate the autonomy of the universities. This is why the participants proposed the recognition to be done at university level by a recognition unit that was referred to as "Unit for accreditation of prior and experiential learning". Such unit would be responsible for: promoting them, gathering the self-assessments of students; implementing the final recognition (i.e. official certification) of such activities.

All the students' experiences would be valued on an individual basis, with the optional use (decided by the university) of international guidelines for the assessment of XCAs. It should be kept in mind that different activities require different assessment types and therefore a mapping should be done among them. Such unit would have a similar role to what the Erasmus office in the universities belonging to Socrates countries has now. The comparison comes from the fact that Erasmus offices deal with the recognition of academic experiences (abroad and under particular conditions), whereas the "Unit for accreditation of prior and experiential learning" would take care of non-academic experiences. Therefore, such unit should have trained personnel and a coordinator, as in the case of Erasmus offices.

The final recognition (i.e. official certification) could be done by including the outcomes of the XCA, self-assessed by the student and approved by the recognition unit, in the Diploma Supplement of the student. Participants also stressed the fact that not always credits (local credits, ECTS credits, or any similar) should be given for XCAs, but always the outcomes should be included in the final official certification of the student (i.e. Diploma Supplement).

## 2.6 Multiple and Joint Degrees in Europe

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**Key words:** multiple degrees, joint degrees, recognition,

### 2.6.1 Introduction

The guide will be an informative document clarifying the present status of Joint Degrees (JD from now onwards) in Europe, which has been deeply modified in the last years, once most of the countries have set up new Degrees according to European Higher Education Area and the requirements of the Bologna process. It will contain useful hints on how and where to look for existing JD. Also, a set of guidelines will be provided for those wishing to set up a new programme on the field of JD, stressing those related to quality assurance and attractiveness.

### 2.6.2 Definitions

Multiple (or double) degrees refer to when several (or two) Higher Education Institutions (HEIs) award each its own degree after an agreed course of study, usually involving periods spend at every participating Institution. On the other hand, it has been agreed[7] that a JD should be understood as referring to a higher education qualification issued jointly by at least two or more HEIs or jointly by one or more HEIs and other awarding bodies, on the basis of a study programme developed and/ or provided jointly by the HEIs, possibly in cooperation with other institutions. A JD may be issued as: a) a joint diploma in addition to one or more national diplomas; b) a joint diploma issued by the institutions offering the study programme in question being accompanied by any national diploma; c) one or more national diplomas issued officially as the only attestation of the joint qualification.
Because of this complex definition, many different situations fall within the scope of JD. In most of the cases this is done in the form of an unofficial certificate or diplome and only in some situations the student gets more than one Degree fully recognized by each country implied in the study programme. So the first thing to do if one is to join or to set up one of those programmes is to identify which of those properties are going to be fulfilled.

7 UNESCO and Council of Europe, Recommendation on the Recognition of Joint Degrees. Adopted on 9 Jun (2004). Available on http://www.enic-naric.net/documents/recommendation-joint-degrees-2004.en.pdf. Seen on 15.04.07

### 2.6.3 The benefits

For students, JD stimulate new ways of thinking and generate new multicultural opportunities for learning, with new intellectual horizons, better employment prospects through the added value to his/ her CV and broader professional perspectives.

Academics can find in JD programmes professional opportunities for development in an international context, ties within a network build on solid basis of cooperation, facilities for new research contacts and an insight on the application of innovative teaching and learning methods. Staff could also benefit from opportunities derived from working on different academic traditions and methods.

The institutions would benefit from JD by learning on policy and practices over Europe, and also have the opportunity of getting synergies obtained by combining their individual efforts. Moreover, their involvement in collaborative programmes may enhance their international reputation on quality related issues and attract new students from abroad.

At European level JD are considered as a fast way for implementing Bologna reforms. Moreover, they are able to respond to European professional development requirements. JD also encourages the retention of best European students and the attraction of others from abroad. Finally, they are crucial in building a truly European community and facilitating intercultural understanding.

### 2.6.4 Main problems

Different surveys[8] carried out so far have identified the main problems which could be found when joining or setting up a JD programme. One group of problems relate to quality since those issues are left mainly to the hosting institutions while specific procedures are demanded. On the other hand, the responsibilities of each HEI participating in JD programmes, both in the quality as in the administrative aspects, are not clear in many cases. A lack of adequate financing previsions and its maintenance through time has sees as a problem which could hamper seriously mobility of teachers and, specially, of students.

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8 A good analysis can be found in Developing Joint Masters Programmes for Europe. Reults of a EUA Joint Masters Project. European Universities Association, Brussels (2004). Available on http://www.eua.be/fileadmin/user_upload/files/EUA1_documents/Joint_Masters_report.1087219975578.pdf. Seen on 15.04.07.

But perhaps the main problems have been found on international recognition, which it is far from being widely guaranteed according to the Lisbon Convention[9].In spite of the time passed since then, and the growing number of people implied on JD experiences, the advances in the line to solve them are not impressive up to now. Although all the countries manifest their deepest interest on JD, and announce compromises to pass legislative changes required, most of them have not been implemented, according to a recent survey[10].

An analysis of main topics to consider on JD has been prepared. Information on these issues useful to students wishing to joint an existing JD programme or for lecturers intending to set up a new one will be a part of the C5 Outcomes document.

### 2.6.5 A key reference. The Erasmus Mundus[11]

Erasmus Mundus programme is widely accepted as a clear and good reference on JD, and has proved successful during the years it has been in operation. Because of its importance, a brief review on this programme is included in the Outcomes.

It is an initiative of the European Commission aiming at. Up to 100 Masters programmes on different field of knowledge are on offer in European Universities for European as well as overseas students coming from all over the world. Erasmus Mundus is a cooperation and mobility programme in Higher Education aimed at raising the quality of European Education, to enhance intercultural understanding thanks to cooperation among different countries. It intends to strength and to create links among European and the rest of the World countries by setting up and financing high quality Master courses through mobilising students and scholars not only from European universities but from all over the world.

The process followed in their selection appears as a quality guarantee for the students. Moreover a common information package answers the most frequently asked questions.

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9 Convention on the Recognition of Qualifications Concerning Higher Education in the European Region, Lisbon 11thApr (1997). Text available on *http://www.bologna-berlin2003.de/pdf/Lisbon_convention.pdf*. Seen on 15.04.07

10 A survey on JD in different countries will be incorporated to the Outcomes.. Source of data: *http://www.dfes.gov.uk/bologna/index.cfm?fuseaction=content.view&CategoryID=1*. Seen on 15.4.07

11 Erasmus Mundus *http://ec.europa.eu/education/programmes/mundus/index_en.html.*

### 2.6.6 Information providers

Information is the most crucial issue when deciding on JD matters. Up to the moment there are not accepted guidelines or rules on what information would be provided on informative leaflets/ Web pages and how to distribute the information to achieve extensive diffusion. Moreover, generally it is not known who is responsible for the information circulated and for how long it will be valid.

Usually the best information is provided by European programmes (in this respect is outstanding that issued by the Erasmus Mundus), and by networks of HIEs as, for instance, Top Industrial Managers Europe[12]. Finally, Web pages of most of the Universities provide information on JD programmes on which they are engaged.
Because of the relevance of this topic it will be analyzed in the Outcomes, trying to identify main criteria for the evaluation of JD programmes from the point of view of a prospective student.

12 *https://www.time-association.org/dd/*. Seen on 15.4.07

## 2.7 Identification of Tools for enhancing TEMPUS projects in EE

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**Key words:** Tempus III, Eastern Europe, Central Asia and the Caucasus, the Western Balkans, North Africa and the Middle East, co-operation in engineering education, University management, restructure engineering education.

### 2.7.1 Introduction

#### Background

The new era of democracy in Central/Eastern Europe encouraged the European Communities/Commission in 1990 to establish a new programme entitled TEMPUS which is the acronym of "Trans-European

Mobility Programme for University Studies". The term tempus means time in the ancient Latin language, thus it refers to fast technological and scientific changes. Originally TEMPUS was a part of PHARE programme which was first dedicated as Poland Hungary Assistance to Restructure Economy but later on it was expanded to other former Eastern European countries. TEMPUS I expired in 1996 and was composed of (Structural) Joint European Projects (S-JEPs), Individual Mobility both for academic staff and students. TEMPUS II was running between 1997 and 2002 involving in addition to the previous components Institution Building, Structural and Complementary Measures and University Management projects. Student mobility later on expired and since 1998 student mobility was amalgamated into other EC schemes.

TEMPUS III 2002-09 envisaged in a smaller financial scale co-operation with Western Balkans (CARDS), Eastern Europe/Central Asia (TACIS) and the Mediterranean Region (MEDA). At its beginning candidate countries could not participate in the programme only individual experts could join by invitation.

Each year requirements for the composition of Consortia, priority areas and expected achievements were decided by the EC in co-operation with national TEMPUS Offices. Both the selection and evaluation took place in close agreement by both parties.

Over 200 higher engineering education institutions have been participating in TEMPUS I, II and III. The last deadline for TEMPUS III application was 15 December 2006 with two years duration of a project. It is well worth mentioning that while during TEMPUS I and II higher engineering education enjoyed priority in many areas TEMPUS III are mainly dedicated to other specialities however environment protection which is an important integrated engineering discipline still has priority in some countries.

TEMPUS IV is expected to be approved by the European Commission in the coming months.

The only negative aspect of TEMPUS programmes is the decreasing financial aid: Central European/Asian and other target countries have less EC money and fund is not enough to provide the expected TEMPUS costs from their budget.

### 2.7.2 Joint European Projects outcomes

The most significant outcomes are: • approach to European higher engineering education standards, • improve quality assurance in engineering education, • steps to establish smaller scale thematic networks, • provide graduates to industry/economy responding to challenges of 21st century, • familiarisation of staff and students with culture of various sort existing in other countries.

*1. Curriculum development, introduction of updated and new programmes and courses*

1.1 Existing curricula in engineering education were updated in many conventional engineering fields with the involvement of information technology/computing science application.

1.2 Emerging technologies initiated by up-to-date industries were introduced into the curricula like computer-integrated manufacturing, bioengineering, new material engineering, mechatronics, telecommunication, info-communication, digital process control, digital microelectronics, and many others.

*2. New teaching materials and methods preparation*

1.1 New curricula, programmes and courses introduction needed new teaching materials for long-distance education, individual study, man-machine dialogue, evaluation sheets and others.

1.2 New teaching methods replace the conventional chalk and talk teaching by the use of internet, live communication between the teacher and the student, project work, learning by doing/research, individual tutorials, practice in industry and others.

*3. Staff exchange/development programmes*

1.1 Staff exchange in foreign countries included visiting professor/lecturer activity, staff improvement by tutorials, monitoring students' laboratory practice, participation in conferences, seminars, workshops, paper writing for such events.

1.2 Staff development programme at home institution based on TEMPUS workshops, seminars hosted by the home institution, visits to multinational companies, virtual staff development programme by the use of Internet and others belong to this outcome.

*4 Student exchange programmes*

Between 1990 and 1998 the students at European institutions participated in training abroad programme for a semester or so, prepared diploma thesis by working on projects, took steps in the preparation of PhD theses by doing research activities. On the contrary, students of EU institutions usually participated in industry practice gaining experiences in the preparation of their diploma thesis in the candidate countries.

Since TEMPUS excluded student exchange, other programmes involve their mobility flows abroad with similar targets.

*5 Modernisation of infrastructure, laboratories, equipment*

Higher engineering education institutions in Central and Eastern European/Central Asian countries, countries on the Balkan peninsula, in the Mediterranean Region, were not able to furnish the premises and laboratories by modern equipment partly due to several Western restrictions.

TEMPUS projects provided the chance to finance the procurement. Since EU institutions could not take benefit of equipment purchase, the partner countries approached EU standards also in this respect.

*6 Preparation, running and management of short intensive courses, workshops in international sphere*

One participating institution usually hosts workshop, seminar, short intensive courses on the TEMPUS topic involving all members of the Consortium and other institutions having co-operation scheme of various sort. Such an event provides a good forum for disseminate the outcomes, to provide tools for management, lecturing in foreign language.

*7 Accreditation, quality assurance*

TEMPUS projects contribute to programmes accreditation to a large extent: new curricula, teaching materials, teaching methods, experiences of staff members abroad, students' training abroad programmes are indispensable components of accreditation. Quality assurance depends on the international recognition of academic staff members, quality of teaching, evaluation processes, introduction of new teaching and learning methods. Within TEMPUS III Russia and Lebanon can provide new tools in this particular topic.

*8 Integration of non-engineering courses and European Integration Studies/Dimension into engineering programmes*

Familiarise both academic staff and students with state-of-the-art of European Integration and with technology, culture and engineering education in Europe.

### 2.7.3 Other TEMPUS projects: Institution Building, Structural and Complementary Measures, University Management

The main outcomes are:

- establish new, effective institution and engineering education structure and management,
- contribute to quality assurance by new structure and management,
- enlargement of professional and friendly contacts with Consortium members.

• Establish new, effective structure and management in the partner countries institution

One important component is the computer communication between Faculties, Departments, staff members and students.

• Administrative staff development

One important component of development is the staff exchange to gain experiences in EU institutions.

• Modernisation of office infrastructure

Purchase and install new office equipment, familiarisation of staff with equipment use.

#### Sustainability of outcomes

The new objectives referring to European higher engineering education institutions are to contribute to the creation of knowledge-based society, the information society and will serve the communities as centres of excellence. To implement the objectives the following activities should be envisaged:

- maintain the respective TEMPUS Consortium small-sale network by the preparation or modernisation of joint curricula, teaching materials, to work on joint scientific projects, and disseminate their outcomes at international conferences, workshops, symposia, seminars,

- make joint efforts both in engineering education and research being significant actors in the European Higher Education Area (EHEA) and also on the European Scientific Research Area (ERA) by various means like staff and student mobility, application for joint research projects, organising joint seminars, submitting and publishing papers for SEFI, IGIP and various professional type events,

- searching continuously the chances to present the achievements by publications in books, textbooks, periodicals, conference Proceedings; *all in one to demonstrate that the TEMPUS projects contributed a lot to the quality improvement of engineering education*.

CHAPTER 3

# INNOVATIVE LEARNING AND TEACHING METHODS

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## 3.0 Introduction

The character of the challenges an engineer faces during a life long career have changed markedly over the past hundred years. The impacts of this change over the recent 20 years have been very concrete as a result of fast ICT development and globalization. Relevant questions for those in charge of the strategic development of universities are, how have you responded to this change and have you been able to tackle the paradigm shift from industrial to knowledge society, where the core of competitiveness is learning.

In order to be able to comprehend how big a change this entails and, above all, what immense opportunities for learning are brought forth by the technological development and the development of ICT, in particular, we should address a few fundamental issues related to teaching and learning. The human mind and insight have indisputably paved the way for major ruptures all throughout the history.

At the start of the last century an engineer was identified by his practical and analytical skills. At the annual lecture for the former students of the Polytechnic School, on January 25 1903, the French mathematician Poincaré asked himself the question what could explain the successful careers of the schools graduates in so many different fields. Overlooking the evidence he came up with the knack for mechanics as the common denominator, the "factory stamp" uniting the mathematicians and physicians[13].

Even though no one would deny the importance of analytical skills for the modern engineer, it is clear

13 Galison, Peter.: Einstein's Clocks, Poincarè's Maps. London: Hodder and Stoughton, 2003.



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the profile of required competencies has changed. Present day engineers need, especially, to be able to communicate effectively, to collaborate in multidisciplinary teams and to be able to deal with intercultural aspects. This development results, first and foremost, from enormous global information resources being technically available to every knowledge worker anywhere in the world. The need for deep collaboration is undeniable – in the global markets the output of one person can in no way measure up to that of a systematically organized networked collaboration. The high-flyers are those capable of managing the technological and mental methods of networked collaboration and of mastering timing. This learning of productivity and innovativeness must be started young – especially engineering institutes play a key role as they are in the position to integrate experiences acquired from different players into the latest scientific and technical development.

Guidelines for the accreditation of engineering curricula like the Dublin descriptors or the Abet criteria stipulate specific learning objectives with respect to knowledge from non-technical domains and transferable skills. The Engineering curricula have had to adapt to the changing criteria, in terms of content as well as in terms of educational formats.

The Bologna Process constitutes one of the main driving forces behind the push to innovate the learning style of our technical schools. The need to innovate the curricula is felt from the very first semester, in particular for what concerns the mathematical formation of engineering students. The first section of this chapter is devoted to the core curriculum in mathematics for engineering education. Next, some of the most important approaches to innovation of engineering education are discussed: Active learning, problem-based and project-oriented learning methodologies. As, the presence of virtual universities in Europe is steadily increasing the last section presents a survey of the European situation with its many new challenges.

## 3.1 Mathematics education for engineers in the changing world

*Introduction*

The role of mathematics to engineering is that of a common language, a tool for the expression of ideas. Mathematical thinking gives engineers a means of formulating, analysing and solving a wide range of practical problems. The current rapid pace of technological change has increased the importance of mathematics to engineering. Alongside this rapid technological change, there have been significant social changes particularly in terms of the availability of higher education, the impact of the internet on student approaches to learning and the attractiveness to teenagers of certain academic disciplines.

Implementation of the Bologna Declaration has produced several unforeseen difficulties, in particular for mathematics. For instance, the number of contact hours available for mathematics teaching in 3-year bachelors programmes has been greatly reduced compared to the 5 year programmes they have replaced. Many Masters programmes do not contain any further mathematics and, as a consequence, all engineers (both bachelors and masters) receive considerably less mathematics teaching than they did before the implementation of Bologna.

The main problems relating to the mathematical education of engineers can be summarised as follows:

- a tension between ensuring basic skills are mastered and developing conceptual thinking and modelling skills;
- appropriate use of new software (such as computer algebra systems) so that mathematical education is improved;
- developing assessment methods that focus on higher level abilities not just routine application of standard methods.

Besides that, there are some issues of a more general nature, relevant for all higher education. First, there is the importance attached to the quality of teaching in comparison to research – many universities recruit staff primarily because of their research record not because they are good teachers. Pressures to produce research publications limits the time that many staff are willing to spend to develop their teaching skills. As a consequence of the increasing number of students studying in higher education the homogeneity of undergraduate cohorts has decreased. The gap in background knowledge between the best prepared students and the least well-prepared students is often so great that it becomes very difficult to develop an adequate teaching strategy. Also, engineering education tends to conservatism. The lecture is still the primary teaching instrument in too many subject areas and in too many universities (particularly for engineering mathematics) and this may not be particularly suitable for freshmen who are used to shorter, less intensely concentrated learning experiences. Many students undertake several hours of part-time paid employment in order to help finance themselves and to get practical work experience. This limits the number of hours they can devote to their studies.

*The position of mathematics in the engineering curriculum*

The interface between mathematics and engineering is not clearly defined. However, in the students' minds there is often a very clear division with mathematics being thought of as a closed, complete body of knowledge which is essentially abstract but which may be used as a tool (or as a series of tools) to solve certain kinds of engineering problems. A good mathematical education will challenge such thinking in a number of ways:

– Engineers should view mathematics as a way of thinking and communicating rather than as a set of tools.
– Students need to develop skills in using mathematics to solve problems and they also need to see mathematics as an integral part of engineering applications and not as residing in a separate compartment.
– Mathematical modelling is a fundamentally important engineering activity which is neither purely abstract nor necessarily deriving from an existing complete body of knowledge.
– Engineers may sometimes need to develop new mathematics in order to solve certain problems (for example, fuzzy logic and finite element methods).

Addressing these issues requires good co-operation between mathematics staff and their colleagues teaching engineering applications. As the time available for mathematics education in the engineering curriculum is limited, it is important that the mathematicians underpin their contribution to engineering. Particularly at the Masters level, students should have the opportunity to follow optional modules allowing them to pursue specific interests.

The expansion of higher education across Europe has brought with it a change in the general attitude of the student body. Many students attend university with a primary objective of 'getting a degree' rather than to learn about the subject they are studying. This brings with it a series of challenges, which may perhaps be addressed by adopting new approaches to teaching. There is a need to engage students so that they actively participate in learning. At a basic level, in many institutions, there is a need to promote greater attendance at classes. At a higher level, in most institutions there is a need to move students from passive recipients of knowledge (people who have education 'done to them') to active gatherers of understanding (people who seek out learning). Assessment has a key role to play in determining student approaches to learning. Much student activity is driven by assessment. So, it is essential that we assess those aspects that we want students to master, such as mathematical thinking. This is often considerably more difficult than simply assessing mastery of a particular mathematical technique.

*The Bologna process and a core curriculum in mathematics*

Splitting long engineering programmes into two programmes results in many European countries to decrease in the number of contact hours for mathematics teaching. The implications of Bologna for the curriculum must be considered, as well as the likely effects this would have on the mathematical education of engineers. The Agreement calls for Bachelor programmes of 180 European Credits (ECTS), taken over about 3 years or 6-7 semesters, followed by 120 ECTS up to masters level (taking about 2 years or 4 semesters). The decision to opt for this was political and dictated by the aim of transference in academic study between European institutions.

In 2002 the SEFI Mathematics Working Group produced “MATHEMATICS FOR THE EUROPEAN ENGINEER, A Curriculum for the Twenty-first Century”.[14] This document divided the necessary knowledge of a future engineer into different levels. The Core Zero contains the basic knowledge that should be gained during the secondary education; Core Level One brings the content of the first years of engineering study. Level Two is devoted to the list of advanced mathematical topics that different branches of engineering students should get. The mathematics curriculum document was prepared during the time when most of the European Higher Education Institutions had undivided engineering degree programmes (mostly 5 year programmes). The changes due to Bologna process, primarily the dividing of the long programmes into two consecutive self-contained programmes, have resulted in a reduction of available time for mathematics teaching. Some necessary adaptations are proposed in the detailed report of TREE SIG B7.

## 3.2 Active learning in basic and continuing education

Active Learning Methods are teaching strategies resulting in student activities. For quite a number of people Active Learning is identical to Project Organised Learning or other approaches embracing the principles of learning by doing[15]. In reality, the concept of Active Learning is much broader encompassing the methods mentioned above, but also including other educational strategies. As the level of active involvement of the learner varies, we can differentiate teaching methods in terms of the degree of activity they incite. An important dimension in this respect is the degree to which the teacher directs the learning process[16]. In fact, projects or practice assignments can range from completely teacher driven to almost entirely student controlled. The degree of control is to be decided by the teacher based on the specific learning objectives, taking into consideration environmental factors. When the objective is to make sure all students get enough practice to reach a certain level of proficiency the teacher may hand out a series of specific assignments. In order to achieve an objective like: ”to be able to take responsibility for the planning of a project”, the students will need to be allowed to run their project on their own.

Combining this dimension of Direction of the learning process with the variable of group size results in the following grid (see Figure 7) In continuing education, where participants want to be as effective

14 MATHEMATICS FOR THE EUROPEAN ENGINEER, A Curriculum for the Twenty-first Century, Mustoe, L R and Lawson, D A (Eds), (2002), published by SEFI HQ, ISBN 2-87352-045-0

15 Graaff, E. de & Kolmos, A. (2003) Characteristics of problem-based learning. IJEE 19, 5, p. 657-662.

16 Graaff, E. de & J. Longmuss (1999) Learning from project work: individual learning results versus learning in a group. In: Andres Hagström (ed) Engineering Education: Rediscovering the centre. Proceeding of the 1999 Annual SEFI conference.

in learning as possible, the use of different forms of Active Learning has already for years been a must. However, as a result of the fast ICT development universities should do much more in taking new learning formats to active use in all of their education. The experiences gained with working life professionals should be transferred and applied to basic education.

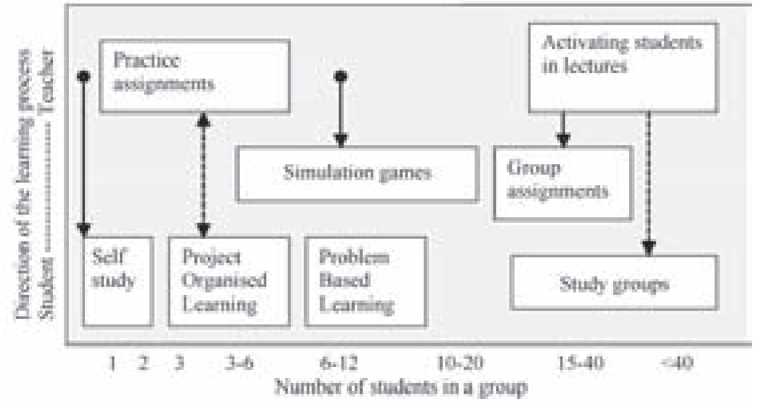


**Figure 7: Different formats of Active Learning**

In the grid a number of Active Learning formats are positioned. First of all, a teacher can activate students through individual assignments (home work) resulting in self-study. Next, the teacher can divide the students into small groups to work with projects or practice assignment. The most effective size for a project group ranges between 4 and 6 members. With less people the group becomes very vulnerable. In a larger group, the risk grows of people hiding in the group and not sharing an equal part of the work. The ideal group size for problem-based learning is a little bigger, ranging between 8 and 12 members. In order to have effective discussion, the group needs to be big enough to represent different knowledge background and views. If the group becomes too big, some members will tend to drop out or become passive members.

The factor group size may vary widely depending on the type of simulation, ranging in fact from individual work to groups of several dozens, collaborating as divisions in extended simulation games. Also, simulation games are positioned in the middle on the control dimension. Actually, the room for decision-making by the students may vary from one simulation to the next. It could vary all along the spectrum from fully teacher controlled to completely self-directed learning. In most instances the teacher (developer) retains a substantial level of control. However, there are some examples were students are challenged to define their own learning space in the virtual environment. For instance learning in Second Life could occur without any specific direction from a teacher.

All methods mentioned so far share the advantage that students learn from each other as part of the group communication process. It has been shown that this is the most effective task for anyone who wants to learn. For more Active Learning see also the full report of SIG D9 on the TREE CD-rom.

## 3.3 Problem and Project Based Learning

*Introduction*

Problem-based learning (PBL) is an instructional method where students "learn to learn," working cooperatively in groups to seek solutions to real world problems. PBL prepares students to think critically and analytically, and to find and use appropriate learning resources. PBL implies both a specific way tot organise a curriculum and a particular way to look at the learning process. The curriculum consists of problems that demand from the learner acquisition of critical knowledge, problem solving proficiency, self-directed learning strategies, and team participation skills. PBL alters traditional teaching and learning patterns. The process of presenting a topic so that students assimilate the various pieces of knowledge and hopefully apply them to personal and professional problems have not been shown to be effective. PBL allows students to explore relevant sources of knowledge.

PBL aims to enhance students' competence in the following area's:

– adaptation and participation in change,
– application of problem solving in new and future situations,
– creative and critical thought,
– adoption of holistic approach to problems and situations,
– appreciation of diverse viewpoints,
– successful team collaboration,
– identification of learning weaknesses and strengths,
– promotion of self-directed learning,
– effective communication skills,
– augmentation of knowledge base,
– leadership skills,
– utilization of relevant and varied resources.

The report of SIG B7 presents an account on the history and characteristics of Problem Based Learning, based on the book: Management of Change – Implementation of Problem based and Project-based Learning in Engineering, by Erik de Graaff and Anette Kolmos[17].

17 Graaff, E. de, and Kolmos, A., eds., (2007), Management of Change – Implementation of Problem-based and Project-based Learning in Engineering, Sense Publishers

*PBL Varieties*

Starting of the learning process by presenting problems makes sense as a didactic principle. However, it can easily result in misunderstandings, because of different interpretations of the word problem. As Geoff Norman points out clearly the "problem" in PBL does not need to be very difficult or exceptional[18]. The PBL problem should be an incentive to learning, a challenge, triggering the student's curiosity, resulting in a student centred learning process. Several authors differentiate between problem-based and project-based learning. According to this view Problem-based learning is defined by open-ended and ill-structured problems that provide a context for learning. Project-based learning is interpreted in terms of an assignment or task that the students have to perform, creating a concrete product.

Based on the historical development of both problem-based learning and project-based learning, the various models are based on the same type of didactic principles. The common element in problem and project-based learning is that in both cases, learning is organized around problems. A problem as incentive for the learning processes is a central principle to enhance students' motivation. Therefore, it is important which problems the students are attracted to on the basis of their own experiences and interests. It could be any type of problem, for instance, a concrete and realistic problem, or a theoretical problem. Merging the characteristics of PBL and project learning, de Graaff and Kolmos suggested to differentiate different formats based on varying degrees of self-direction by the students[19]:

- The Task project is characterized by a very high degree of planning and direction on the part of the teacher (teaching objectives) to the point where this most of all resembles a large task to be solved. Both the problem and the subject-oriented methods are chosen in advance, so that the students' primary concern is to complete the project according to the guidelines provided.
- The Discipline project is usually, though not necessarily, characterized by a rather high degree of direction from the teacher's side (study programme requirements), in that the disciplines and the subject area methods are chosen in advance. It may, however, still be dependent on the groups to identify and define the problem formulations within the guidelines of the described disciplines. These subject guidelines are described in the theme descriptions.
- The Problem project, finally, is a full-scale project, for which the course of action is not planned in detail by the teachers. The problem formulation directs the choice of disciplines and subject area methods, and the problem formulation arises from the problem-oriented theme. In other words, based on one work environment theme, the group can, for instance, actually work with widely different disciplines and subject methods.

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18 Norman, G. (1988) Problem-solving skills, solving problems and problem-based learning. Medical Education, 22(4) p. 279-86.

19 Graaff, E. and Kolmos, A. (2003). Characteristics of problem-based learning, International Journal of Engineering Education, Vol. 19, no. 5.

Explores the differences between PBL and other teaching strategies Savin-Badin classifies active learning strategies as follows[20] (see Table 2):

**Table 2. PBL versus Other Active Learning Strategies**

| Teaching Strategy | Description |
|---|---|
| Lecture | Information presented and discussed by faculty instructor. |
| Case-based | Written case histories provided prior to lecture and followed with in-class discussion about content and concepts. |
| Case method | Written case histories provided prior to class, studied and then discussed in class (typically in small groups) |
| Modified case method | Incomplete, written information provided and studied prior to class. Within groups, determination made as to additional information needed. Sometimes additional information provided in class. |
| Problem-focused | Students provided with a simulated problem/scenario. |
| Problem-based | Incomplete, written information provided and studied prior to class. Focus is on identifying learning issues applicable to resolution of the problem. Content and concepts relevant to learning a key component. |

The report of the SIG B5 on Problem Based and Project Organized Learning presents a series of Best practices of PBL in Europe, listing:

- Aalborg University, Denmark
- Maastricht University, The Netherlands
- Vitus Bering University College, Denmark
- Işık University, Turkey
- University of Rome 'La Sapienza', Italy

*Effects of PBL*

PBL works. A survey carried out in the years 1995 and 1997 among 36 Danish companies and 269 American companies shows the demands on personal qualifications of their employees or future employees[21]. The most important of these demands are summarised below:

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20 Savin-Baden, M. (2000). Problem-based Learning in Higher Education: Untold Stories. Buckingham, SRHE and Open University Press.

21 Moesby, E. (2004). Reflection on making a change towards Project-oriented and Problem-based learning, World Transactions on Engineering and Technology Education, 2(3), 2004.

- *Communicative skills.* The ability to communicate a message clearly is crucial. Particularly in the light of increasing needs for working in teams. Being able to communicate knowledge in an understandable language is especially important for cooperative organisations comprising specialists.
- *Ability to work in teams.* As a result of the technological development and increasing competition employees must possess specialised knowledge within relevant professions. At the same time they must realise, that the correct solution to a given task can only be achieved in cooperation with groups of people, who jointly possess the needed cross disciplinary competencies.
- *Flexibility.* Employees must be willing “to move”, not only physically but also mentally. They must be prepared to break up inveterate habits in order to cope with changes in organisation, tasks, fields of production etc.
- *Initiative.* A property connected with the development towards a “flat” organisational structure and extended responsibility given to employees. If people are responsible for certain tasks/areas, they are also expected to take initiatives.
- *International orientation.* Understanding and accepting other cultures is crucial for work on an international competitive market even if a company is oriented towards the domestic market. The markets are global and it is hardly possible to survive locally. Deep knowledge of different cultures is important. An international orientation e.g. for Danes therefore means proficiency in at least one of the main languages plus detailed knowledge of at least one foreign culture.
- *Interpersonal qualifications.* Being responsible, quality focused, adaptable, communicative, ability to work in a team, work discipline, reliability.
- *Analytical skills.* It is increasingly important for professionals to possess highly developed analytical skills. These are prerequisites in order to deal independently with new complicated problems or work processes, to divide complex tasks into manageable sizes and to see process relations.
- *Management skills.* It is important to educate/train people within managerial aspects. Companies and organisations dealing with international projects (construction, research, development etc.) often seek cross border cooperation and form project organisations (e.g. matrix) with both professional and functional management.

The above list is very much in line with ABET criteria for engineering programme outcomes and assessment. Evidently PBL is a solution to help us meet the current learning needs in engineering education. European higher education institutions should consider shifting to PBL. However, the shift to PBL cannot be accomplished as a sudden change. It should be considered as a strategic change and the necessary measures should be taken for successful completion of change.

Changing to PBL involves training of teachers to help them acquire skills to facilitate the learning process. However, this call has a wider ring. The report of SIG C4 signals an increase in attention for pedagogical abilities of engineering teachers. As a consequence of the Bologna process the focus of higher education has shifted towards learning. There appears to be a worldwide movement to improve teaching abilities, or pedagogical competencies.

## 3.4 Virtual Universities

Over the last few years there has been a European wide interest in building up virtual universities. Two main approaches can be found: the business oriented open distance university model familiarized by the Open University UK and the co-operation focused Virtual University model of Central and Northern European countries. The report of the SIG D4 on Virtual campuses and their global network aims to present best practices, co-operation and agreement models and tools for successful collaboration between different co-operation based virtual university organizations.

Co-operation based virtual university can be defined as follows:

- The main function of the virtual university organization is to support traditional universities who have decided to co-operate. Typically a virtual university is formed as a national asset including all universities in one country or state. In these cases the virtual universities have strong political support from the government or ministry of education.
- One of the main goals is to promote e-learning or ICT supported learning.
- The virtual universities do not award degrees or qualifications.
- The virtual university organization does not have the structure or legal position of a traditional university.
- Virtual universities serve the whole higher education sector including universities and polytechnics

Virtual Universities emerge in a context of innovation of communication technology and e-learning methodologies. Mega trends sustaining this development are:

- Boundaries between working and learning are disappearing: engineers 'learn-from-work' and 'work-to-learn'.
- Engineers are faced with a more and more demanding context: being innovative, creative at the one hand, while being at the same time professional, structured, and organized.
- Half-time life of knowledge shortens continuously, and technology (in particular ICT) trends are going faster than ever.
- ICT introduces new paradigms (working clock-around, shaping own objectives, being responsible for own competence development).
- ICT also introduces a possible danger for widening the digital divide (digital illiteracy) and for information overload (information illiteracy, skills filtering information).

- Networks of human beings, of universities, companies, associations, networks are becoming more and more important for collaboration, trust, knowledge creation and sharing, etc.
- There is a need for multi-cultural and international (global) knowledge, attitude, skills and an even greater need for meta-cognitive skills to interpret, to translate and to adapt to local situations and contexts.

Presently, there are around ten organizations in Europe fulfilling the criteria of a virtual university. The report of SIG D4 focuses on six typical European co-operation based virtual universities:
- Bavarian Virtual University,
- Estonian e-University,
- Finnish Virtual University,
- Polish Virtual University,
- Swedish Network University and
- Swiss Virtual Campus.

## 3.5. Future prospects

How to accomplish the targeted change? All throughout Europe we must seek to develop answers leading to the materialization of the necessary measures on the level of both political decision-makers and education institutes as well as in the activities of each teacher and learner.

The shift from industrial society's working culture and methods towards knowledge and innovation society's new work processes and earnings logic requires focused investments in the creation of new knowledge. This means, as well, that investments in higher education per student should increase, but unfortunately that is not a reality in most countries. In addition to that, there is huge demand not only to increase the enrolment per age group to initial higher education but to change the perspective from education to lifelong learning. This development means that technology has to be harnessed to support the learning and to new productivity-enhancing activities as diversely as possible. The buzzwords like technology-enhanced, open, distance and flexible learning or e-learning are concepts developed to tackle these challenges. The advantage of the use of information networks - e-learning in general - in comparison to conventional learning is the fact that one can find a lot of challenging and useful new information and set his/her goals as high as they wish.[22]

22 Markku Markkula, Success through Networking and Knowledge Management in e-Learning, Asia-Europe Colloquy, Seoul Korea, 24-28 September 2006.

The same applies to universities and nations as well. We can learn by benchmarking the others – a few countries try to make a giant leap in conceptualizing their educational system in a new way. And in addition, within each nation, those who wish to be the engines of development can compare their insights and learn from congenial developers in other countries. The decisive success factor has been learning to learn and as part of it, abilities and skills in multidisciplinary knowledge creation. The foundation of all this is the determined change towards innovative teaching methods activating learning. The focus is pointed more and more in the direction of motivating the learner to actively contribute to several learning communities as their member.

The European Open and Distance Learning Liaison Committee[23] has addressed two policy papers (2004 and 2006) to European and national policy makers in charge of education and learning: "Distance Learning and eLearning in European policy and practice: the vision and the reality" and "Learning Innovation for the Adapted Lisbon Agenda". The message today is clear: it is not possible to bring ICT-supported learning innovation into mainstream education and training if the supportive environment and the right context are lacking. Sustainable improvement can only be reached if the use of ICT and flexible focus of learning are proposed not as a specialised theme in the periphery of policy discourse, but at the heart of it. Universities play a key role also in this respect: the global information networks and the networking working culture provide the prerequisites for a new university-oriented mindset whose core lies in learning by developing and learning by research.

What are the key elements of e-learning for the next few years at the EU policy level? The answer can be written in short by quoting what the EU Commissioner Jan Figel stated in his opening speech of the EU eLearning conference in 2006 in Dipoli Finland:

- e-learning in Europe is at a crossroads,
- the political drive comes from the Lisbon Strategy 2000 – we need to put more stress on investments in knowledge and innovation,
- everyone needs skills to live and work in the Knowledge Society,
- the EU Recommendation for Key Competences in Lifelong Learning includes entrepreneurship, learning-to-learn and interpersonal competencies, and
- urgent reforms to ensure the development of education systems are needed.

As a new sphere of activities, European and national e-learning have already for about ten years been characterized by a large number of small dedicated pilot projects. It is obvious that the pilot approach has not been able to serve the needs of the multitude of users waiting in educational institutions and in the

23 *www.odl-liaison.org*

maturing market, in general. With the field gradually maturing, it is now natural to move from individual pilot projects to make the desired educational reforms to happen through large projects identifying different actor roles and implementing the new kind of teaching and learning methodologies and practices needed in universities, and elsewhere. Future e-learning opportunities are primarily not associated with innovative pilot undertakings, but, rather, with transferring the existing knowledge and competence to process practices that can generate concrete benefits. European universities must be able to convert innovativeness into a permanent renewal of teaching and learning.

CHAPTER 4

# Education and Research Synergies

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## 4.0 Introduction

In modern European Universities Education and Research are closely connected. Even more so, since the research activity of a University and its staff are one of the most important criteria for the evaluation of the quality of a Higher Education Institution. The European goal of promoting the synergy between the European Higher Education Area (EHEA) and the European Research Area (ERA) created the need to focus on research oriented teaching and learning. Graduates at all levels must have been exposed to a research environment and to research-based training in order to meet the needs of Europe as a knowledge society. Enhancing European collaboration and increasing mobility at all levels including the doctoral one, for example through the promotion of international projects in team or joint postgraduate and doctoral programmes, are essential, as a further means of linking the EHEA to the ERA.

In his famous book, "*Growth and interaction in the world economy: the roots of modernity*", Angus Maddison states that one of the major intellectual and institutional changes in the West before 1820, that had a fundamental impact on economic performance and that had no counterpart in other parts of the world in this period, was the recognition of human capacity to transform the forces of nature through rational investigation and experiment… As he further says, thanks to the Renaissance, the seventeenth century scientific revolution, and the eighteenth-century enlightenment, Western elites gradually abandoned superstition, magic, and submission to religious authority. The scientific approach gradually impregnated the educational system. Circumscribed intellectual horizons were abandoned. A Promethean quest for progress was unleashed. The impact of science was reinforced by the creation of scientific academies and observatories which inaugurated empirical research and experiment. Systematic recording of experimental results and their diffusion in written form were a key element in their success.

In the short paragraph above, the importance of knowledge for the creation of development and prosperity is obvious. It is only logical that the search for competitive advantage in the global knowledge economy has led modern-times policy-makers, in Europe and elsewhere, to focus on education as a key factor in strengthening competitiveness, employment and social cohesion. In Europe, this has led to the well-known initiative of the convergence of the European Higher Education Area (EHEA) with the European Research Area (ERA) by the year 2010, and the development of an optimal research environment to make Europe the leading knowledge-based economy.



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Chapter 4 has six parts. The first is related to *synergies between research and education activities*, the next three to the *status of doctoral (PhD) studies in engineering in Europe*, the fifth to *facilitating international projects in team* and the sixth to *stimulating undergraduate research*. Five of the parts are closely related to research activities. Part 4.5 studies an issue important for all three levels of Engineering Education.

## Synergies between research and education activities

Research is essential in institutions that claim to educate academic engineers. Further, active participation in “on the edge” research guarantees that the teaching staff is up to date. On the other hand, involvement of students in research (e.g. through master thesis work or PhD) guarantees that they develop the necessary attitudes towards creating new knowledge, new technologies, innovation, etc. University education is largely an education through research: teaching is carried out by those who create new knowledge and are in close and continuous contact and interacting with their peers throughout the world.
Part 4.1 explores how students at undergraduate, graduate and post-graduate (doctorate) level can participate in this research. The outcomes are recommendations on the integration of research activities in: the engineering curriculum, teaching (course work, lecture notes, applications, project work etc), MSc thesis/ final project research and in staff development. The recommendations are supported by a document including chapters on the definition of research, the types of research etc.

## Status of doctoral (PhD) studies in engineering in Europe

In the last years, there has been a general discussion for the setting-up of structured doctoral studies, including provisions for quality assessment and for making employability a criterion also in the design of doctoral studies. Although the Bologna Declaration explicitly mentioned the doctorate, the discussion on postgraduate degrees has so far focused largely on Master degrees. In the Berlin Conference on 19 September 2003, the ministers considered it necessary to include the doctoral level as the third cycle in the Bologna Process and to promote the synergy between the European Higher Education Area and the European Research Area. As a result, an ongoing discussion started in Europe about the character of the Doctorate. In Parts 4.2 to 4.4, a “Survey of the status of doctoral studies in Europe”; a “Reference Guide for Doctoral (PhD) Studies in Europe” based on the findings of the Survey and on good practice examples and a document on the “Working Environment for an Effective PhD” are presented.

## Facilitating international projects in team

An engineer today must be able to cope with a broad scope of disciplines. Some competencies like teamwork, interpersonal skills, and ability to work in international team with students of different disciplines, nationalities and study levels are of special importance for the live-long employability of engineering graduates. For this reason, many engineering faculties implement in their curricula Problem Based Learning in the form of projects. Especially interdisciplinary projects solved in international teams develop the skills expected by the globalised world. Part 4.5 presents the materials to help to design and run multidisciplinary projects in international teams (MPIT):

- Manual of good practice in organisation of MPIT- Guide for Providers
- Guide for courses and project design and supervision - Teachers' Guide.
- Students Guide.
- Seminar propagating the organisation of teaching based on interdisciplinary projects performed in international groups

## Stimulating undergraduate research

Providing students with the possibility to conduct research already at undergraduate level is an interesting option that potentially not only encourages students to continue later with research activity, but also contributes to the their overall motivation. The aim of Part 4.6 is to examine the possibility involving undergraduate students in research activities in combination with their normal studies. This is presented in:

- A state-of-the-art report on undergraduate research in European HEIs, based on two surveys, one among TREE members and one among members of BEST
- Guidelines for implementation of undergraduate research programmes in EU HEIs, based on: a report of the BEST Symposium held in Ljubljana and a report of a BEST Academics and Companies Forum held in Brussels.

## 4.1. Synergies Between Research and Education Activities[24]

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**Key words**: engineering education, research, undergraduate studies, graduate studies, postgraduate studies

### Introduction

A fairly large amount of literature has been produced on “research led teaching” or “research-based teaching” from many different points of view but mainly pedagogical. Not so many papers has been written on research based teaching in engineering where “research” is often related to industrial or design problems. This report should fill the gap.
Because of possible overlap with SIG B2, the focus here is on the bachelor and master level and not on the doctoral level.

### What is Research?

There are many definitions of Research. According to the BEST students and the web-based encyclopaedia Wikipedia (http://en.wikipedia.org/wiki/Research), research is an active, diligent, and systematic process of inquiry in order to discover, interpret or revise facts, events, behaviours, or theories, or to make practical applications with the help of such facts, laws, or theories. It can be divided into Basic (Fundamental) research and Applied research. Basic research has as a primary objective the advancement of knowledge and the theoretical understanding of the relations among variables, while Applied research is carried out in order to solve specific and practical questions, and gain knowledge for its own sake.
It must however be realized that the borders between “fundamental” and “applied” research are sometimes unclear and vague, and that the distinction between the two, in some way, becomes gradually outdated. In many disciplines the advancement of fundamental science is an absolute requirement for engineering applications (e.g. nano-science and nano-technology, material sciences and engineering,…) and therefore in many Universities, nowadays fundamental and applied science oriented departments and faculties to some extent are becoming integrated or cooperating closely. E.g. K.U.Leuven (the faculty of sciences,

24 Presentation of outcomes from SIG B1.

engineering and bio-engineering are clustered within one “group”), Princeton University (Princeton institute for computational science and engineering, Princeton Institute for the Science and Technology of Materials, Princeton Program in Integrative Information, Computer and Application Sciences), Similarly, the difference between “applied research” and “development” is not always clear.

The Humboldt university model has strongly influenced European and other Western universities. In this model, research has to be interwoven with teaching: teaching is carried out by those who create new knowledge and are in close and continuous contact and interacting with their peers throughout the world.

Traditionally, and since the early existence of “universities”, a university is a “universitas”, a “community” of teachers and students, who share questions and answers, learn from each other and, together, search for new knowledge and new answers to new (and old) questions. Without researchers and research activity, there is no university; one may have a school but not a university.

Active participation by university staff in “on the edge” research guarantees that the teaching staff and the material that they present are up to date. “Students expect their teachers to be actively involved in research. Research contributes to the enthusiasm and credibility of the teacher and the up-to-date character of the course material”.

However, one should realise that there are different kinds of “research” and many different levels at which it is performed. Obviously, not all universities can perform research at the highest level. In the USA there are only 50 (to 100, depending on the threshold) comprehensive research institutions i.e. universities carrying out excellent research in a number of fields. The Association of American Universities (AAU), which is the association of the ‘research intensive’ universities from the USA and Canada, has 60 members only (by invitation). The League of European Research Universities (LERU) has actually only 12 members (by invitation). It groups European research-intensive universities, committed to the values of high quality teaching within an environment of internationally competitive research.

Of course, that does not mean that no good research is carried out in other universities, but it shows that there is a huge variety in quality and quantity of research and in the number of fields covered. In any university, at least some research activity should be present. In some places it will be high level, edge cutting fundamental research in many fields, in other places excellence will be reached only in a few disciplines; still other universities will focus on applied research or development, but the notion of searching for new knowledge, new solutions, and new answers should always be present.

## Research based learning or teaching

Research based curricula/ programmes aim explicitly at the creation of knowledge, of which the confrontation with research results and the participation in the research process are indispensable components. There are different ways of achieving this: e.g. by

- confronting students with results of research processes
- explaining research methodologies by the teachers
- inciting the students at having a critical attitude
- letting the students work independently on assignments where they will be confronted with raw, unprocessed data
- having students participating in research activities of the teachers: research activities of staff members and learning activities by the students are integrated.

**Integrating research and teaching at different levels**

Research should be introduced in the curriculum gradually by confronting students throughout the curriculum with gradually more complex problems. In the final year, they should effectively carry out independently a research project (final thesis or project work).

**• At undergraduate level (Bachelor programmes)**[25]

Traditionally lecturers organize their courses in a linear way, incorporating an incremental progression in which research comes near the end of a degree course. In their opinion, the first job of a student is to acquire knowledge and, later, to develop more of a critical thinking stance in the post-graduate phase and to start the creation of knowledge. Research components are then reserved for the graduate level.

Therefore, “Research at undergraduate level has for a long time been neglected”, now “undergraduate research is staple of most universities’ curricular vocabulary”. Engineering is ahead of many other disciplines. n the USA research is reserved for the best students only.

The relation between research and research based teaching depends on how the terms “research” and “teaching and learning” are conceptualised. Undergraduates are likely to gain most benefit from research items in terms of depth of learning and understanding when they are involved actively, particularly through various forms of inquiry-based learning. There is a need for finding new ways for staff and students to work together.

**• At graduate level (Master programmes)**

It is obvious that at the Master level, research should play an even bigger role than in the bachelor education: most of the courses should be taught by project or design work, introducing to a large amount individual research by the students; however, the students should be guided and assisted by the staff and their progress should be monitored closely. At the end of the master programme the final thesis should be the ultimate proof that the students have the capability to work independently to do research and to report, present and defend the own findings.

25 For reasons of clarity in this document “undergraduate” is used in relation to the Bachelor programmes, “graduate” in relation to the Master programmes and “post-graduate” for the doctoral programmes.

As far as the master thesis is concerned, it is important to note that not only the product or the results are valuable but also the whole process. By going through the process and by doing research, the student not only acquires new knowledge, but also important skills and competencies.

**• At Post graduate level (Doctorate)**

The Doctoral Track (research seminars, doctoral seminars) is a unique opportunity to share knowledge, discuss a variety of topics, refine your research questions and shape your research proposal. In addition, the workshops provide an excellent networking opportunity through all sorts of social events enabling future collaborations. The participants will also get to know many peers that are currently reviewers and/or editors of well-established journals in the field.

One of the most direct ways for allowing the (doctoral) students to reach the edge of current research (science development) and to help them in their doctoral research is the introduction of specialised courses at doctoral level (research schools, graduate schools, doctoral schools). Because of the high level of specialisation and the relative low number of interested doctoral students, these highly specialised courses should preferably be organised at a European level. The EU could contribute in providing more funding for mobility of researchers

### How to integrate teaching into research? Teaching led research

"Teaching stimulates disciplinary research through questioning by students, and through the results of the research and inquiry projects that students engage in. Teaching also stimulates pedagogical research projects as academics question the effectiveness of teaching strategies and approaches and the learning experiences of their students. Teaching also influences research behaviour as academics discuss the implications of their pedagogical findings for research and knowledge generation in the subject, for example the value and types of clear communication, the use of reflective practice etc".

## Recommendations

**• On the integration of research activities in the engineering curriculum**

Research is essential in institutions that claim to educate academic engineers. Active participation in "on the edge" research guarantees that the teaching staff is up to date. Involvement of students in research (e.g. through MSc thesis work, project work or PhD) guarantees that they develop the necessary attitudes towards creating new knowledge, new technologies, innovation, solving of problems that have not been solved before, (to be completed)

**• On the integration of research activities in teaching**

Course work, lecture notes, applications, project work, etc (to be completed)

**• On the integration of research activities in MSc thesis/ final project research**

University education (graduate studies) is largely an education through research: teaching is carried out by those who create new knowledge and are in close and continuous contact and interacting with their peers throughout the world. (to be completed)

**• On the doctoral programme**

One of the most direct ways for allowing the (doctoral) students to reach the edge of current research (science development) and to help them in their doctoral research is the introduction of specialised courses at doctoral level (research schools, graduate schools, doctoral schools). Because of the high level of specialisation and the relative low number of interested doctoral students, these highly specialised courses should preferably be organised at a European level. The EU could contribute in providing more funding for mobility of researchers.

## 4.2 Status of Doctoral Studies in Europe: a Survey[26]

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**Key words**: Doctoral Education, Engineering Education, Research, Bologna Process.

### Introduction

Although the Doctorate is mentioned in the Bologna Declaration of 1999, it is in the Communiqué of the Berlin Conference[27] that it is explicitly stated as the third level in the Bologna Process. As a result, an ongoing discussion started in Europe about the character of the Doctorate. It is now an established fact that Doctoral programmes are not only the third cycle of higher education, but also the first stage in the career of young researchers. The essential difference between the two first cycles and the Doctorate is that it focuses on original research with the aim of producing new knowledge.

In the EUA Bologna Seminar on "Doctoral Programmes for the European Knowledge Society", ten basic principles have been established:

i. The core component of Doctoral training is the advancement of knowledge through original research (plus the needs of an employment market)
ii. Embedding in institutional strategies and policies (Universities must meet new challenges and include appropriate professional career development opportunities)
iii. The importance of diversity (including joint Doctorates)
iv. Doctoral candidates should be recognized as early stage researchers
v. The crucial role of supervision and assessment
vi. Achieving critical mass (innovative practice; graduate schools; international, national and regional collaboration between universities)
vii. Duration (three to four years full-time as a rule)
viii. The promotion of innovative structures (interdisciplinary training, development of transferable skills)
ix. Increasing mobility (geographical, interdisciplinary, intersectoral mobility and international collaboration within an integrated framework of cooperation)
x. Ensuring appropriate funding.

26 Section 4.2, 4.3 and 4.4 present outcomes from B2.

27 Commission Communication (2005). "Mobilising the brainpower of Europe: enabling higher education to make its full contribution to the Lisbon Strategy".

In the Communiqué of the London Conference of 2007[28], the Ministers recognised the value of developing and maintaining a wide variety of doctoral programmes. They appreciated that enhancing provision in the third cycle and improving the status, career prospects and funding for early stage researchers are essential preconditions for meeting Europe's objectives of strengthening research capacity and improving the quality and competitiveness of European higher education. They further invited HEI to reinforce their efforts to embed doctoral programmes in institutional strategies and policies, and to develop appropriate career paths and opportunities for doctoral candidates and early stage researchers. They also invited HEI to share the experience on innovative doctoral programmes and mentioned transparent access arrangements, supervision and assessment procedures and the development of transferable skills.

## The Survey

In the Survey presented below, the following features have been considered: Structure and organisation models, Acceptance criteria, Quality Assurance, Innovation, Financing, Joint international Doctoral studies. In the Survey participated 38 Universities from 26 countries, while 11 universities contributed to the call for best practice examples, in addition to what had been included in the replies to the Questionnaire.

### • Structure and Organisation Models

There are two models of Doctoral Studies in Europe. Let us call "First Model" the one including mainly individual supervision and tutoring and "Second Model" the one including taught Doctoral courses plus individual work. Although there is a general feeling that the more traditional first model is not suited to contemporary European Higher Education, it is still an open question whether European Higher Engineering Education should shift to structured Doctoral studies. According to the findings of the Survey, 73% of the participating Institutions use Introductory Courses. In general, 59% of the participating Institutions apply the Second Model, 33% apply the First Model and 8% apply other models. It must be pointed out here that about 14% of the Institutions apply both Models. Further, 81% of the Institutions replied that there is a national model in their country.

Another issue that is currently discussed in the engineering academic community is whether a credit transfer system (e.g. ECTS) should be applied to the structured part of the Doctorate. The two major European engineering higher education associations, CESAER and SEFI have repeatedly expressed their view on this matter. In their Joint Communication of March 2005, it is stated: "*ECTS credits should not necessarily be applied to the PhD*

28 Communiqué of the Conference of Ministers responsible for Higher Education in London (2007). "Towards the European Higher Education Area: responding to challenges in a globalised world". *http://www.dfes.gov.uk/bologna/*.

*since an essentially curriculum based PhD-programme cannot fulfil requirements concerning the personal independence, the research experience and alike.*" In the SEFI Position on the Doctorate in Engineering of May 2007, it is stated: "*SEFI acknowledges the necessity of a continuous process of optimization of PhD projects, e.g. by offering integrated and structured PhD programs. Nonetheless, this must not turn them into educational programs. Any credit system should be used only in order to enhance the mobility of Doctoral candidates and the internationalisation of Doctoral Programs, but not lead to formal accreditation.*" In the question "Do you use ECTS in the Introductory Courses" 46% of the Institutions gave a positive reply, 27% answered No and 27% replied that they do not have Introductory Courses. Further, it was taken for granted during the preparation of the Questionnaire that no Institution would use any credit system for the research part of the Doctorate and we did not receive any information suggesting that some Institutions do.

**• Acceptance criteria**

Acceptance criteria are one of the factors ensuring the quality of Doctoral Programs. The replies give as the five most important criteria: "Grades in previous studies": 86%, "Relevance of previous studies": 84%, "CV": 81%, "Interview": 73% and "Open call": 70%. The other criteria listed in the Questionnaire were: "Examinations": 53%, "Recommendation letter(s)": 59%, "Research experience": 51%, "Experience from practice": 27% and "Others": 8%.

The acceptance of graduates from other engineering specialisations and from non-engineering schools together with the entrance level to Doctoral Programs has also been investigated: 94% of the participants accept graduates from other engineering specialisations, 65% accept graduates from non-engineering schools and 13% accept First Cycle (Bachelor) graduates.

**• Quality Assurance**

The following criteria related to quality assurance have been investigated: monitoring the progress of Doctoral candidates, quality of supervision, quality and originality of the results, innovative nature of the thesis, employability of Doctoral graduates: 89% replied that they monitor the progress of Doctoral candidates, 8% that they do not and there was no reply from a 3%. The quality of supervision is monitored by 81% of the Institutions whilst 14% do not and no answer was available for the rest 5%. As it is self-evident, 97% of the Institutions monitor the quality and originality of the results, a 3% (one Institution) did not answer. The same percentages are valid for the monitoring of the innovative nature of the thesis. The employability of Doctoral graduates is not monitored by 61% of the Institutions; a 33% monitor it and a 6% did not reply. There were also questions on how the various forms of monitoring are realised. The answers were very varied and could not be included in this summary.

Another factor affecting the quality of Doctorates is mentoring (supervision). The presence of the Tutor and of external examiners in the examination board has been registered, together with the existence of criteria in the selection of the examination board. In the first, 86% replied that the Tutor participates in the examination board, 11% said no and a 3% did not reply. In the second, 43% mentioned the presence of external examiners while 57% did not. Finally, 75% have criteria for the selection and the composition of the examination board, 22% said that there are no criteria and a 3% again did not reply. Here again there was a question about the criteria applied in the formation of the examination board with very varied and answers that could not be included in this summary. There was also a question on whether the Doctoral dissertation is presented in a public session. 89% replied positively, 8% negatively and 3% did not reply.

**• Financing**

The very important issue of financing the Doctorates has also been investigated. Most institutions- 89% are financing them. An 8% do not and a 3% did reply. The main source of financing for 83% of the institutions is the government, for an 8% industry for another 3% EU projects and for a 6% other sources. One institution did not reply. There was also a question about the payment of fees. A 49% of the replies were negative, another 48% replied positively and a 3% did not reply.

**• Mobility and Internationalisation**

There was a set of questions related to mobility and one to internationalisation:

• Mobility: In the question what is the position of the institutions on the possibility of doing part of the Doctoral thesis abroad, a 6% of the Institutions replied that this is compulsory, a 72% encourage this mobility, for a 22% it is indifferent and there was no Institution forbidding mobility. It was also asked whether mobility is allowed during the introductory courses period and/or during the preparation of the thesis. In the first case, 68% allow mobility, 8% do not and a 24% do not have introductory courses. In the latter, 97% replied positively and 3% did not reply. There was no Institution forbidding mobility during the preparation of the thesis. The procedure used for the recognition of the study abroad period involves the use of ECTS for a 41% of the Institutions, while the rest 59% use other procedures, usually a case-by-case one. Of course, this should be connected with the fact that a 27% of the Institutions do not apply ECTS in the Doctorate and another 27% do not have introductory courses.

• Internationalisation: It was asked whether the Institutions coordinated or participated in joint international Doctoral programmes with either European or non-European Universities. For the European, 56% replied positively, 41% negatively and there was also the now familiar 3% that did not reply. For the non-European, 32% replied positively, 60% negatively and an 8% did not reply.

## Conclusions

• *Structure and Organisation Models:* The majority of the Institutions tend to use a structured model of Doctorates. Yet, the majority of the Institutions are reluctant to introduce ECTS in the structured part of the Doctorate.

• *Acceptance Criteria:* All Institutions apply acceptance criteria. It must be pointed out that the prevailing ones focus on the educational and not the research background of the candidates. The interdisciplinary is restricted inside the engineering "family". The acceptance of non-engineering candidates should be bigger. On the other hand, most Institutions tend to keep to the model First Cycle -> Second Cycle -> Doctorate, not allowing direct access from the First Cycle to the Doctorate.

• *Quality Assurance:* The majority of the Institutions monitor most of the factors affecting the quality of Doctoral Theses, with the exception of the employability of Doctoral graduates. Another factor where the current status might need to be changed is the presence of the Tutor and the non-presence of external examiners in the examination board. The application of criteria in the selection of the examination board should also be enhanced.

• *Financing:* Governments are still the main source of financing for the Doctorates in European universities. If this does not change, with a bigger involvement of industry, attaining the goal of technological innovation and competitiveness might not be easily feasible. It must be pointed out that it is up to the Institutions to find ways for such a financing without losing their autonomy and their control over Doctoral education.

• *Mobility and Internationalisation:* In the Mobility issue, the results look satisfactory, but we have not asked for actual numbers of the mobility of Doctoral candidates. In Internationalisation, the results are not satisfactory in both the European and the international level.

## 4.3 Status of Doctoral Studies in Europe: A Reference Guide for Doctoral (PhD) Studies in Europe

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**Key words**: Doctoral Education, Engineering Education, Research, Bologna Process.

## Introduction

The aim of the guide is to provide a good practice document for the Engineering Doctorate in Europe. Based on the results of the Survey and in agreement with the recent EUA recommendations and the positions of CESAER and SEFI, a list of recommendations to the stakeholders involved in Doctoral education, such as Universities, Faculties and Departments, Tutors and Doctoral candidates, Industry and Governments have been included. Those recommendations are summarised in the following in the form of a matrix.

| Recommendations for: | UUniversities Faculties Departments | Tutors | Doctoral Candidates | Industry | EU & Governments |
|---|---|---|---|---|---|
| Introduce the appropriate structures within the institutions by developing and modifying policies and standards for PhD education | X | | | | X |
| Define clear and transparent entrance qualifications with flexibility and interdisciplinarity | X | | | | X |
| Support quality assurance through transparent procedures for the supervision, monitoring and assessment of Doctoral programs | X | X | | | X |
| Provide the appropriate working environment and facilities to conduct the Doctoral programs | X | X | | | |
| Collect and disseminate information of available, within the university, Doctoral programs | X | | | | |

| | | | | | |
|---|---|---|---|---|---|
| Collect opinions of related stakeholders for the improvement of PhD education and of the abilities of PhD graduates | X | | X | X | X |
| Encourage departments to enrol as many PhD candidates as they can adequately support | X | | | | |
| Internationalise Doctoral education through mobility of Doctoral candidates, joint and co-tutored Doctoral programs | X | X | | | X |
| Improve funding possibilities for international doctoral programs | X | | | X | X |
| Foster recognition of mobility of researchers as an added value in career development | X | | | X | X |
| Recognize PhD candidates as early stage researchers | X | | X | X | X |
| Develop attractive research career perspectives for early stage researchers, including opportunities outside academia and industry | X | | X | X | X |
| Require that all academic staff is involved in Doctoral supervision | X | X | | | X |
| Encourage the improvement of the contact between PhD candidates and faculty | X | X | X | | |
| Encourage and reward good advisors | X | X | | | |
| Encourage the development of transferable skills | X | X | X | | |
| Encourage bigger involvement of industry in financing | X | | | X | |
| The so-called "professional Doctorates", must meet the same core standards as traditional ones in order to ensure the same level of quality. The research conducted should preferably be produced completely or partly in an academic department | X | X | | X | X |
| Alternatively, "professional Doctorates" should be very clearly differentiated from the research ones with the introduction of the appropriate legal framework, including a different title. | X | X | | X | X |

## 4.4 Working Environment for an Effective PhD

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**Key words**: Doctoral Education, Engineering, Education, Research, Bologna Process, working environment

### Introduction

The structure of a PhD program varies from department to department. Today, there is a need for collaboration within and across fields, and the ability to integrate knowledge in new ways. With a multi-disciplinary perspective, creating an effective working environment may play a supporting role for PhD education in Europe. It is expected that this report will help addressing the needs of PhD candidates, programs, and society. The document will include the following chapters:

### Importance of the working environment on PhDs

PhD education can be thought of as a series of requirements and milestones. The formal requirements and informal expectations allow PhD candidates to develop the knowledge, skills, and habits to be successful in their field.

### Creation of working environment for effective PhD

The creation of working environment for effective PhD is dependent upon various quality parameters, such as relationships between student and advisor (apprenticeship), student and faculty, faculty and faculty, departmental culture, research laboratory, etc.

During PhD education, much of the important teaching and learning takes place in a one-to-one relationship between student and his/her advisor. The single advisory approach is often coupled with tradition of faculty autonomy. There may be various strategies in PhD education such as

- Students learn by reading good research and observing a faculty making research;
- Students are thrown into their research topic, and the “good ones” find their way with minimum guidance;
- A program consisting of a set of examinations and barriers.

## Conclusions

Creating a working environment that has the features described in this report may challenge and support the development of PhD students. Creating such an environment requires the commitment of leaders and faculty members. By this approach, it is believed that PhD programs in which more PhD candidates arrive and develop to their full potential can be created, and the departments may become more competitive for PhD candidates and new faculty.

## 4.5 Facilitating multidisciplinary projects in international teams[29]

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**Key words:** teamwork, project based learning, international teams.

### Introduction

Modern engineering education should be focused, among others, on some generic competencies. An engineer today must be able to cope with a broad scope of disciplines: economics, management, communication, languages... Some of these competencies like teamwork, interpersonal skills, ability to work in international team with students of different disciplines, nationalities and study levels are of special importance. Many employers stress that to assure the live long employability graduates in engineering need to be able to learn by doing, to be able to solve problems without the experience and ground knowledge in the narrow discipline, but based on the ability to learn new. That is why many engineering schools implement in their curricula Problem Based Learning in the form of projects. Especially the interdisciplinary projects, which are solved in international teams, develop the skills expected by the globalised world.

The following, aims at coordinate experience exchange and working out materials enabling the propagation of good practice in the organisation of the didactic process in which all the above-mentioned skills and competencies are shaped. Many higher education institutions organise international teams of engineering students who carry out interdisciplinary projects. The experience gained so far and the opinions of students and employers allow us to draw a positive conclusion.

The task is also to work out the examples of good practices of creating and managing international teams of students who, on the basis of common tasks and projects, will be able to acquire unique skills and broad knowledge stemming from various disciplines, not necessarily from engineering. In addition, the methods of evaluating work in teams should be worked out. Another element to be taken into account while developing the skills of the supervisors, are psychological aspects of work in international students' teams.

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## Teaching teamwork

No one needs convincing these days that students should be taught teamwork. An ability to work in teams on complex projects is probably now one of the most desirable characteristics among higher education graduates. Today's unified Europe makes this ability especially important as a result of the differentiation of cultures, languages and lifestyles of people working alongside each other.
The carrying out of projects in teams has been permanently introduced into university curricula, not only in technical disciplines but also in science, social studies and the humanities. No effort should be spared in ensuring that the implemented curricula are based upon knowledge, experience and an understanding of the matter in hand. Particular care should be paid not only to the way in which classes are conducted but also to the later evaluation of participating students in order that it shall not become a straightforward transference of a traditional teaching method or evaluation, usually done by an individual teacher.

## Target groups

Consequently, it would seem necessary to gather the experience and the principles of conducting classes based on a group project. These principles that should encompass all parties involved in the process.

- The first group comprises the organizers of classes. At this stage, it is essential to define the aims we wish to achieve, the resources we care to use and which are available to us, and thereafter the ways we wish to carry out the classes.
- The second group consists of academic teachers (although not only) directly involved in the carrying out of a given project. Due to the specificity of such classes, a clear supervision must be defined to oversee their process, as well as an explicit evaluation of results. The students themselves should be made aware of this before classes commence.
- The third and the most important group are the students themselves - as participants and people responsible for the project.

## Outcomes

The outcomes contain the materials to help to design and run multidisciplinary projects in international teams (MPIT):

1. Manual of good practice in organisation of MPIT- Guide for Providers
2. Guide for courses and project design and supervision - Teachers' Guide.

3. Students Guide.
4. Seminar propagating the organisation of teaching based on interdisciplinary projects performed in international groups

1. Some of the institutions have gathered the experience in organisation of teaching for exchange students by projects. As this is becoming more and more popular and new institutions intend to implement the students exchange based on the interdisciplinary projects offered for students from different institutions and countries the guide to help them or even to initiate this process has been prepared. The organizational model of the project-based semester of studies for international students has to be shaped to the local conditions and the tradition of the university which provides it, but lot of elements and crucial points are common. The main goal of this guide is to provide basic explanation of the process and procedures that operate within MPIT. The issues that have been considered as important and strongly influencing the success have been described.

2. The aim of this guide is to assist tutors in the proper facilitation and support of student groups while they carry out their tasks in order to achieve learning outcomes. Admittedly, this task is not an easy task when we take into consideration the fact that the groups will consist of students from different nationalities, therefore having a different cultural and educational background, and often in various academic disciplines. Such a group has to be guided 'along the way'. This guidance begins at the stage of a team's formation, when decisions are made about its composition, when a group leader is chosen and when tasks are allocated, on up to the stage of an assessment of work quality and the workload of individual team members.

3. The Student Guide is to show mechanisms and principles which are to be followed while participating in a problem-based project conducted by a group of international and intercultural team of students. Having read the guide, every student should know according to which scheme to act and how to find his/her place among the team members from various cultures and educational backgrounds.

A target group consists of students participating in different kinds of projects conducted within international student groups, despite the project nature. The main mission of the guide is to facilitate maximum learning and participating for every student in the group.

## 4.6 Stimulating Student Research in the First Cycle[30]

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**Key words**: Engineering, Education, Research, Bologna Process, Students, First Cycle

### Introduction

As shown by Research Directorate-General's "Key Figures 2005"[31], the EU still has proportionately much fewer researchers than the United States and Japan. If the European Union is to achieve its ambitious goal of becoming the world's "most competitive and dynamic knowledge-based economy"[32], actions must be taken to address this disparity.

As the need for researchers grows, finding new ways of enhancing the attractiveness of research to graduate students should be given high priority in the agenda of the EU, in order to cope with the issues mentioned above.

Our work has started with the belief that research activity included at the undergraduate level not only encourages students to continue later with PhD studies, but also provides them with technical, communication, group and research skills valuable for their education as tomorrow's engineers. Providing students with the possibility to conduct research already at undergraduate level is an interesting option that also contributes to their overall motivation.

Our role has been to examine the ways in which research activity can be included in the first cycle in combination with regular studies.

### Organisation and structure of output

The main target audience for our study is the large base of European higher education institutions dealing with research and the interaction between education and research, willing to dig deeper into the topic of undergraduate research. In particular, universities interested in running an undergraduate research programme.

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31 ftp://ftp.cordis.europa.eu/pub/indicators/docs/2004_1857_en_web.pdf

32 http://ue.eu.int/ueDocs/cms_Data/docs/pressData/en/ec/00100-r1.en0.htm

The target groups addressed by our proposed recommendations are identified to be: Higher Education Institutions (HEI) management; HEI professors, researchers and other departmental staff; higher education state departments of EU countries; industry and research institutes' management.
During the life cycle of the study, the input from the following parties has been gathered:

- from students, in BEST Events on Education
- from BEST members, through a survey
- from TREE members, through a survey
- from academics, through a literature review (Internet only) and TREE events

Unfortunately, no input from industry has been obtained, nor any input from out of Europe sources has been gathered (Internet-based literature excluded).
We provide the reader with a final document containing two main outcomes:

- A state-of-the-art report of research activities in the first cycle in European HEIs, based on:
  - ☐ A Survey among TREE members
  - ☐ A Survey among BEST members
- Guidelines for implementation of undergraduate research programmes in EU HEIs, based on findings collected at the following venues:
  - ☐ BEST Symposium in Ljubljana
  - ☐ BEST Academics and Companies Forum in Brussels
  - ☐ TREE meetings

The major findings can be summarized as follows.

## Characteristics of undergraduate research

The main advantages of undergraduate research (UR) activities as perceived by students are the hands-on research experience, the research oriented thinking and training, the gained skills (like creativity and team working) and the exploration of an interesting scientific field. Professors, universities and companies will have the opportunity to work with young people with fresh ideas and possibly high potential, and thus keep up to date more easily with the advancements of technology, as well as make contacts with their possible future employees and PhD students.
The main drawbacks of UR are dealing mostly with the financial nature of the research activities. In order to have more people carrying out research, more research projects are needed and thus more resources. This may lead to a stronger influence of the industry in the research activities of the universities. Furthermore, the undergraduate students usually need a longer training period before actually starting conducting research, compared to their postgraduate and more experienced colleagues. Lastly, since the

students are an inexpensive working force, there exists a danger of their exaggerated exploitation: this should be prevented.

## State-of-art in Europe

The current state of the art of UR in Europe shows that no nation-wide frameworks for UR exist in almost all European countries, with the notable exception of Hungary. Again, with notable exceptions, the only UR activity in most countries is the BSc thesis. The general picture is that UR is optional, poorly organized and underfunded, unless industry is actively involved.

## Guidelines for implementation of UR programmes

Concerning the guidelines for implementation of UR programmes, we denote the importance of "introduction to research" courses in the 1st cycle (educating in scientific principles and soft skills), as a way to stimulate students in thinking about a research career and complement their education with research skills valuable in other fields other than research. In addition, the professor initiating UR activity is central in the process, for guidance and mentoring. The role of research team and collaborators also underlined, so that the young students learn the values of teamwork and communication. Cooperation between universities and industry is critical: a good cooperation and productive research project is beneficial for everybody. Further, the need for financial resources would be covered partly by state, partly by universities, partly by industry and partly by inter-European research agencies. Finally, accreditation and recognition of UR work increases student motivation and therefore is an important element to make UR programmes successful.

## Further research

The proposed follow-up of this research study is a web site to share good practices about UR in Europe. The implementation will be discussed by BEST and TREE.

CHAPTER 5

# Quality and Accreditation of Engineering Education in the framework of the "Bologna process"

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## 5.0 Introduction

The final 6 Volumes produced in 2003 by the E4 Thematic Network (the predecessor of the TREE Thematic Network) included information on the status of implementation of the Bologna Process in Engineering Education and a review of the relevant accreditation and recognition practices in 23 countries of the perspective European Higher Education Area (EHEA).

In the years since then, the Bologna Process has made great progress: further indications have been developed and are being implemented in several countries, new countries have joined the process, "Quality Assurance" has risen to top priority....

In particular, in the first of the two Ministerial Meetings held during the TREE lifetime (Bergen 2005) two fundamental documents have been approved: the "Standards and Guidelines for Quality Assurance in Higher Education" prepared by the European Association for Quality Assurance in Higher Education (ENQA), and "A Framework for Qualifications of the European Higher Education Area", prepared by the Bologna Working Group on Qualifications Frameworks (these two documents will be referred in the following as S&G and EQF). The later Ministerial Meeting (London 2007) has strengthened the request to develop QA systems of Higher Education throughout the future European Higher Education Area (EHEA).

Bologna Process, its impact of engineering education, QA, recognition of qualifications and accreditation have been dealt by several working groups (SIGs) within TREE, namely A1, A2, A3, A4, A5 and A8: the results of their work are collected into the five Sections of Chapter 5, that are summarized in the following. The arrangement of the Sections and Subsections does not follow rigidly those of the SIGs.



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## 5.1 National systems of engineering education, QA and accreditation.

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The main report of SIG A5 'Quality and Accreditation of Engineering Education in the framework of the "Bologna process"' consists of an introductory short Sub-section 5.1.00 and a series of descriptions (Sub-sections 5.1.01 to 5.1.31) of the national systems of engineering education, with particular emphasis on quality assurance and accreditation, in 31 countries out of the 46 participants in the Bologna Process and prospective members of the European Higher Education Area (EHEA), in alphabetical order from Austria through Montenegro (the last country joining the Bologna process in 2007) to United Kingdom. Each "national" Sub-section is written (and signed) by a different author: this leads to some differences in style and content from one Sub-section to another, but - hopefully - to descriptions more lively than the "official" ones that can be found in websites.

Because of the rapid evolution of the situations, the Authors have been asked several times to update their contribution: the published texts have been written between 2002 and 2007.

Indeed, looking through the national Subsections 5.1.01-31 it appears evident that, notwithstanding the envisaged "convergence" between the national educational systems, the existing great differences do not appear to be reducing, let alone being eliminated. Even more marked are the differences between recognition and accreditation procedures of engineering degrees, which depend not only on the education system, but also on how the engineering profession is organized. However, while a few years ago formal accreditation of engineering degrees was pursued in a handful of European countries and rejected in others, in these last few years, the need of "accrediting" degrees (in particular, newly established degrees and degrees of new-born Universities) has rapidly spread throughout Europe. This was one of the motivations behind the support, recalled in the Introduction, given by the Education Ministers to the development of Quality Assurance systems.

As well known, the European Union has established a legal framework for the mutual recognition of professional qualifications, first with the 1989 "General Directive" 89/48/EEC and the specific directives for some professions (medical professions, architects, and lawyers), then with the unified Directive published in September 2005 as "Directive 2005/36/EC of the European Parliament and of the Council on the Recognition of Professional Qualifications" and still in the process of implementation.

These Directives, however, regard professional qualifications, while a true trans-national accreditation system of higher education degrees on the European scale nor a Europe-wide agreement for trans-national recognition of national accreditations exist: these questions, and the proposed European Accreditation system of Engineering degrees elaborated by the EUR-ACE project and at present being implemented by ENAEE is the object of the second product of SIG A5 "The EUR-ACE quality label: a European system for accreditation of Engineering Education".

The work of SIG A1 was complementary to SIG A5: its report describes the implementation of the Bologna

Process into the engineering education systems of seven countries: these are a very significant examples of the difficulties that the Bologna process encounters in its implementation; it is fair to say that most countries of the envisaged European Higher Education Area face different, but analogous, difficulties.

## The EUR-ACE quality label: a European system for accreditation of EE

### 5.2.0 Introduction: why "accreditation"?

It is fair to start by underlining that the quality of European engineering programmes is in general quite high on a global standard, thanks also to the frequent contacts and exchanges between Engineering Faculties, facilitated by permanent International European Associations like SEFI and CESAER, and lately by EC-supported Thematic Networks (Higher Engineering Education for Europe H3E; 1997-99; Enhancing European Engineering Education E4; 2000-04; Teaching and Research in Engineering in Europe TREE; 2004-2007). However, the national EE systems are very different from each other, and the variety of educational situations and of degrees awarded makes trans-national recognition of academic and professional qualifications rather difficult: as already noted, the situation has not been significantly modified by the Bologna Process.[33]
Accreditation of engineering educational programmes can be a powerful tool to reduce these difficulties, and at the same time to improve both academic quality and relevance for the job market. However, not only great differences in accreditation practices persist within European engineering, but as far as "accreditation" and recognition with professional implications no shared project, let alone an accreditation system recognized on the continental scale, apparently exists: a proposal for filling this gap, developed by the EUR-ACE project, with which TREE has strictly collaborated, is described in detail in Section 5.2 of the CD and summarized here.

### 5.2.1 What is "accreditation"? What is its status in Europe?

Indeed, the word "accreditation", used in the United States since the '30s, did not find its way into European specialized literature and official documents up to very recent years, but then has rapidly become a catch word. The engineering community, on the whole, favours "programme accreditation" (intended by EUR-ACE as "the process used to ensure the suitability of a programme as entry route to the engineering profession" vs. the "Institutional accreditation" preferred in some Academic circles; moreover, this definition underlines that "accreditation" cannot be a process closed within academic circles, but need the participation of other stakeholders.

33 Cf. also Section 5.5

The present situation of European Engineering in regard to accreditation has been described in several papers and reports, besides the already quoted E4 Output Volumes). Formal accreditation procedures are in place in several European countries but, quoting European Commission (DG EaC) documents, “most evaluation and accreditation is [still] carried out on a national or regional basis” although “it is expected that these local exercises will become more comparable and more European through the use of “an agreed set of standards, procedures and guidelines” and the involvement of foreign experts....” DG EaC went on by stating: “In a limited number of cases there is scope for transnational evaluation and accreditation. For instance in highly internationalised fields of study like business and engineering or in cases where universities or sponsors (public or private) seek to obtain a label for reasons of branding or consumer protection. ...”

In the first decade of the 21st Century, accreditation of engineering programmes is widespread throughout the world, but historically Europe has been in the forefront.

Within Continental Europe, formal accreditation started in France: a law dating back to 1934 established the Commission des Titres d’ Ingénieur (CTI), in which not only academia but also employers and social stakeholders are represented on an equal basis. Only graduates from an accredited programme can use the title of “ingénieur diplômé”, which makes accreditation (“habilitation”) practically compulsory. The “habilitation” lasts a maximum of six years; at present, about 700 engineering programmes are accredited in the French Schools. Each year, CTI awards about 100 “habilitations” in France, and a score in other countries.

In the UK a similar role is played since the 19th Century by the Professional Engineering Institutions, which accredit the different engineering disciplines. Each Professional Institution has been endowed with a Royal Charter, and in 1981 the overarching Engineering Council was established, also by a Royal Charter, to advance the education and training of engineers for the public benefit, and to coordinate the accreditation process: it can be said that in practice the business of accrediting individual degrees is sub-contracted by the Engineering Council, which awards the professional title, to the discipline-specific Institutions (Institution of Civil Engineers, Institution of Mechanical Engineers, Institution of Engineering and Technology, etc.).

Thus, although neither in France nor in Great Britain there is a formal obligation to be part of some register in order to practice the engineering profession, in both countries there is some “regulation” that makes “accreditation” of engineering programmes (in the above defined sense) de-facto practically compulsory.

The situation in Germany is rather different: up to a few years ago, all Higher Education programmes had to conform to strict (State or Federal) rules, which made accreditation practically superfluous. In the 1990s new programmes leading to the “Bachelor” and “Master” degrees were introduced, and formal accreditation has been prescribed for these programmes.

As already pointed out, no specifically European system of accreditation of engineering education exists, while several international agreements are active (the Washington Accord, the Engineering Mobility Forum, etc.) These are spontaneous “bottom-up” agreements for mutual recognition of degrees and/or qualifications; some bilateral or multilateral such agreements exist sporadically also in Europe, and some (e.g. the

Washington Accord) involve European countries. However, it is fair to state that, notwithstanding the prestige of the National systems and of some Academic titles, in a global job market the lack of an accreditation system recognized on the continental scale puts the European engineer in a objectively weak position.

### 5.2.2 Historical background for a system of accreditation of Engineering programmes in Europe.

The relevance of this problem has been felt for quite sometime. Already in 1994, the European Commission set up a Task Force tasked with investigating possible synergies between recognition of qualifications for academic and professional purposes and issued a Commission Recommendation based on the report of this Task Force.

More recently, after three "European Workshops for Accreditation of Engineering Programmes" (EWAEPs) in which Working Group 2 of the European Thematic Network H3E invited higher engineering institutions providing engineering programmes and professional bodies active in Accreditation and Quality Assurance, a few academic and professional organisations set up in September 2000 the "European Standing Observatory for the Engineering Profession and Education" (ESOEPE).

The stage was thus set for taking up the suggestion coming from the European Commission (DG Education and Culture) that in March 2004 issued a "Call for Proposals for Europe-wide Participation Projects contributing to the Realisation of the European Higher Education Area (Bologna Process)", in which it was stated that "the Commission supports the setting up and testing phase of transnational evaluation and accreditation... The Commission would welcome ... proposals from subject specific professional organisations developing European Cooperation in Accreditation in fields like medicine or engineering."

It was thus quite natural to answer with a project proposal, namely the EUR-ACE (EURopean ACredited Engineer) project, that was submitted in April, approved in August, started in September 2004, and completed by 31 March 2006.

### 5.2.3 The work and proposals of the EUR-ACE project.

The EUR-ACE project first compared existing Standards for accreditation of engineering programmes, finding striking similarities behind different façades, then elaborated (in several successive versions, collaborated by tests in "trial accreditations") "Framework Standards", intended for use throughout Europe (and possibly beyond). Like most of the more recent Accreditation Standards, these are outcome-based: i.e. the learning outcomes to be reached are stated, but it is not indicated how they should be achieved.

Indeed, a comparison of the EUR-ACE Standards and other recent Accreditation Standards throughout the world, shows rather little difference in the contents: they are all outcome-based, and all lists of the programme outcomes are very similar to the EUR-ACE list:

- knowledge and Understanding;
- engineering Analysis;
- engineering Design;
- investigations;
- engineering Practice;
- transferable Skills.

A specific peculiarity of the EUR-ACE Framework Standards is the provision for accreditation at the “First Cycle” (FC) and “Second Cycle” (SC) level, consistent with the “Bologna process” approach. Thus, while other Standards specify only one set of outcomes to be met, for each outcome the EUR-ACE Standards differentiate between the requirements for FC and SC graduates. For example, the requirements for “Knowledge and Understanding” are first defined in general terms:

“The underpinning knowledge and understanding of science, mathematics and engineering fundamentals are essential to satisfying the other programme outcomes. Graduates should demonstrate their knowledge and understanding of their engineering specialisation, and also of the wider context of engineering.”

and it is then specified that:

“First Cycle graduates should have:

- knowledge and understanding of the scientific and mathematical principles underlying their branch of engineering;
- a systematic understanding of the key aspects and concepts of their branch of engineering;
- coherent knowledge of their branch of engineering including some at the forefront of the branch;
- awareness of the wider multidisciplinary context of engineering.

Second Cycle graduates should have:

- an in-depth knowledge and understanding of the principles of their branch of engineering;
- a critical awareness of the forefront of their branch.”

The EUR-ACE Standards are complemented by “Guidelines” and “Procedures for Programme Assessment and Programme Accreditation” (that include the assessment, among other requirements, of the human resources and facilities available for the programme) and finally a “Template for Publication of Accredited Programmes”.

The EUR-ACE Standards are defined (not by chance) “Framework Standards”: in fact they intend not to substitute 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) which will add a European dimension to existing (and future) national accreditation procedures.

Note that, in addition to the distinction between FC and SC degrees, in a few European countries engineering programmes are also differentiated according to "profiles", in some countries the accreditation distinguishes between engineering branches (disciplines), and in some others there is no differentiation at all in the accreditation.

Therefore, in order to be as flexible and comprehensive as possible, and not to exclude any "compatible" accreditation system, the EUR-ACE Framework Standards do not distinguish between different profiles, but only between First and Second Cycle Degrees, as defined in the European Qualification Framework.

Moreover, "the Standards [are] applicable also to the accreditation of programmes leading directly to a degree equivalent to a Second Cycle Degree (conventionally termed 'Integrated Programmes')". Indeed, "integrated programmes" are an important part of European engineering education: not only in the "old" Continental Schools, but also in U.K., Ireland and other countries.

Summing up, "the EUR-ACE Framework Standards will apply indiscriminately to all different types or profiles of engineering study programmes, and these programmes will be judged based on whether they provide graduates with the academic qualifications necessary to enter the engineering profession." Consequently, they must be interpreted (and if necessary completed) to reflect the specific demands of different branches, cycles and profiles, while HEIs retain 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.

### 5.2.4 The EUR-ACE accreditation system and its implementation

The most significant and novel contribution of the EUR-ACE proposals, essential for the correct application of the Framework Standards, is the operational system, which was described thus in the relevant EUR-ACE document:

"EUR-ACE advocates a bottom-up approach which involves the active participation of present and future national accreditation agencies and which should embrace a multilateral mutual recognition agreement based on agreed Standards and procedures. No supra-national Accreditation Board should be formed: accreditation should always be awarded by a national (or regional) agency which may already be in existence or may be created in the future." In other words, a multi-lateral bottom-up agreement would add a common European label to the accreditation certificates of the National (or Regional) Agencies, either existing or to be created: this "decentralized" approach appears a novel approach in the world-wide panorama of systems for accreditation of engineering programmes.

In this decentralized system for international accreditation, the rich experiences accumulated in decades by national bodies like the French "Commission des Titres d' Ingénieur" and the British Engineering

Institutions will not be wasted, but on the contrary exploited to create a consistent accreditation system of engineering education at the continental scale.

While developing the EUR-ACE proposals, the need for a permanent organisation to coordinate and supervise and the system became evident: such a structure, promoted by the participating national agencies should "verify the consistency between the standards, rules and practices in force in each Agency and the EUR-ACE Framework Standards; if this requirement is satisfied, [it] will authorize the Agency to add the EUR-ACE (FC or SC) label to its accreditations".

With this necessity in mind, ESOEPE decided to transform from a "Standing Observatory" into ENAEE, the "European Network for Accreditation of Engineering Education", formally founded as an international no-profit association in February 2006 by 14 associations concerned with engineering education throughout Europe (two more organisations have joined ENAEE later). Thus, when EUR-ACE was concluded by a public event on 31 March 2006, ENAEE was also presented.

Since then, ENAEE has recognized that six Accreditation Agencies in six different countries (namely, Engineering Council - UK; EngineersIreland; OE, Portugal; RAEE, Russia; CTI, France; ASIIN, Germany) fulfil already the requirements of the EUR-ACE Framework Standards, and has consequently authorized them to award the EUR-ACE label. These six countries, covering a variety of educational, political and social realities throughout Europe, will constitute the initial core of the EUR-ACE system: it is expected that the first EUR-ACE labels will be granted within the current year 2007.

In the meantime, the basis will also be set for appropriate procedures able to enlarge, in due time, the EUR-ACE system beyond the initial core of six agencies and countries. Three possible alternatives are at present envisaged:

1. Include other Agencies in the system, as soon as they fulfil the Framework Standards and associated requirements: this can be soon the case of a couple of organisations that are already members of ENAEE.
2. In countries without any accreditation system, create a new Engineering Accreditation Agency. In the meantime, programmes may be accredited by an Agency already active in the system.
3. In countries with established "general" accreditation agencies, they could require the fulfilment of specific Standards (in our case, the EUR-ACE Framework Standards) for their accreditation when this implies (or preludes to) a professional recognition. In this case, they could be authorized to add the EUR-ACE label. Agreements in this direction are already being elaborated; contacts have also been taken with the European Consortium on Accreditation (ECA).

## 5.3 The Quality Assurance Framework: development of a communication tool for QA of Engineering Education.

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### 5.3.1 - Introduction

Work on this theme (essentially developed by SIG A4) has moved along the lines already set with projects E4 and H3E, and passed from the stage of the survey (outcome of E4) to a full stage of proposals (an embryo was, in effect, already exposed as the outcome of H3E) concerning the essential requirements for Quality Assurance of Degree Courses. A survey element has remained, as the weight of ongoing national quality assurance / evaluation / accreditation experiences (agencies) needs to be taken into consideration.

The outcome of the previous E4 project can be regarded as exhaustive and sufficiently adjourned as far as national schemes for evaluation were concerned; this Report takes into consideration a sufficient spectrum of evaluation / accreditation processes and reports in the respective nations that have been used when drafting the final report.

However, the following further developments have been taken into consideration:

- Standards and Guidelines for Quality Assurance in the European Higher Education Area, ENQA, European Association for Quality Assurance in Higher Education, 2005, Helsinki
- RECOMMENDATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 15 February 2006 on further European cooperation in quality assurance in higher education (2006/143/EC)
- proposal for a RECOMMENDATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on the establishment of the European Qualifications Framework for lifelong learning (presented by the Commission) {SEC(2006) 1093}, {SEC(2006) 1094}

Three main needs were emphasized:

- the institution and its degree programmes must be able to choose the features of their quality management system independently, as this Q.A. Framework must be adapted to their size, academic aims, history and local context. The same is true of the information which will be needed to highlight quality factors and underpin control and improvement. The institution owns its quality management system, and it must be able to be evaluated/accredited on the basis of this Q.A. Framework.
- quality management must not consist only of inspections, audits and controls. Rather, it must inform the degree programme's day-to-day operations, becoming an open window on the institution.
- the degree programme must provide the outside world with a basic set of uniformly organized information that enables stakeholders to make informed judgments, helps orient prospective students, and facilitates second-party and third-party evaluation/accreditation.

Meeting all three of these needs calls for an approach based on permanent monitoring: the programme must be asked to produce and maintain a set of appropriate information, collected in an "information protocol" developed around a scheme here called **Q.A. Framework matrix** and presented at the end of this Chapter.
The resulting information protocol has been titled the "**Q.A. Framework**": it contains all the qualitative and quantitative parameters needed to arrive at an informed judgment about the degree programme's aims, methods and the learning environment provided to the student.
The **Q.A. Framework** is thus the foundation for all future evaluation/accreditation processes. It must satisfy minimum requirements for content and form so that degree programmes of the same or similar type offered by different institutions can be readily compared.
The proposed **Q.A. Framework** presented below marshals the essential information that provides the basis for regarding a programme as "assessable for accreditation purposes".

## 5.3.2 - The Tool: Quality Assurance Framework
### 5.3.2.1 – Boundary conditions

Individual SIG A4 member institutions currently adhere to national and / or professional body processes when designing engineering programmes. It is acknowledged that there is diversity in the processes to which institutions must adhere. This had to be taken into consideration by the SIG A4 members at their own institutions.
For instance, Irish programmes adhere to HETAC processes and may adhere to "Engineers Ireland" accreditation criteria.
In Turkey, procedures and rules set by the Higher Education Council and education assessment criteria, ABET and local ABET-like processes to which individual universities choose to submit on voluntary basis.
In Estonia, Higher Education Standards are adopted by the Government; moreover there is a Quality Agreement of the Rectors' Conference for cross evaluations and mutual recognitions. These procedures are effective in evaluation and accreditation; moreover there are governmental criteria to which a new programme design must be submitted.
In Italy there are general rules, by law or decree, with which programmes must comply; at the moment these are not organised around an explicit Quality Assurance set of criteria. However, there are a number of local Regional accreditations and Quality Assurance processes which exist as pre-conditions for granting funds.
Without examining here in detail all possible cases, it is already evident that there is a diverse range of schemes in operation that SIG A4 members had to take into account. By virtue of the fact that the members of SIG A4 have different national requirements for accreditation, the work of this group has been enriched and strengthened by their contribution.

### 5.3.2.2 – Core Requisites

Besides taking into account basic Quality Assurance requirements and European guidelines, the QA Framework has been wrapped around learning outcomes and/or academic competencies, which are now the most interesting development under way at the international level. These have to be defined by content and level[34], and have proved to be, even in the present work by SIG A4, the most challenging task when populating the tables. It is therefore not surprising that this part of the problem has been solved by the authors in different manners.
During the design of the Q.A. Framework, this line of thought has been deployed into the following set of hierarchical core requisites:

- the programme must be clearly designed around External Requirements and Target Competencies which are in agreement with the needs of the employers and the labour market; such relations should be present already at the design phase, and not only (as it often happens) at the award stage or the final project.
- the programme must be clearly implemented with up-to-date learning outcomes, which are in agreement (content, amount, level) with the target competencies.
- the programme must expose the students to an appropriate learning environment, with appropriate and state of the art equipment.
- the programme appropriately certifies that the learning outcomes have been reached and that the exams have a certifying value.

### 5.3.2.3 – Attributes of the Tool

The **Q.A. Framework** is equally valid for any level of award, or their combination, with the exception of Doctorate and Master of Research Programmes.
The SIG A4 has developed a tool fully compatible with ENQA requirements and, in general, the European trends toward internal Quality Assurance of Programmes.
The Q.A. Framework is

- designed so as to be effective in allowing an appropriate evaluation of the programme by third parties,
- a communication protocol, which should allow efficient insight into the requisites around which the programme is designed and of the means through which it is delivered,
- intended to be a design tool posing the right questions to be answered when a programme is designed,
- a communication prospectus which describes an engineering programme to external stakeholders,
- an "outcome oriented" tool, even if it allows to accommodate the appropriate process elements.

34 In this Section 5.3, like in the European Qualification Framework, the terms "level" and "cycle" are used as synonyms.

The information contained in the **Q.A. Framework** can be "assessed" (which involves checking and scoring) or "evaluated" (which involves drawing one's own conclusions) by external stakeholders.

The **Q.A. Framework** is designed to be maintained on an ongoing basis rather than as a periodic reporting structure. For this reason it is recommended that the ongoing maintenance could be controlled and delivered by an internal Faculty; in fact, the SIG A4 recognises that the expertise for the programme delivery, review and reporting resides internally.

A specific attribute of this **Q.A. Framework** is that it is modular in design, allowing for information to be easily accessed. The information is not presented in a sequential manner, rather information is contained in individual blocks where stakeholders can obtain specific information.

Special care was taken, during the framework development, for the fact that accreditation and evaluation are very time consuming processes, and may easily generate fatigue and rejection.

The information generated forms the basis of any internal review and the basis of assessment by external accreditation / evaluation panels.

## 5.3.2.4 – Features and advantages of the developed Q.A. Framework

On completion of the Framework and of the associated Tables by each SIG A4 member, the group is in agreement that the implementation of the **Q.A. Framework** has the following advantages and features.

The populated tables of the **Q.A. Framework** give a clear and concise picture of the educational programme on offer.

Prior to the implementation of this Framework there is difficulty in comparing different programmes as a result of different criteria to be followed. The concise standard format of information, concerning the common core of almost all criteria, can now be used in comparing different educational programmes.

It is envisaged that current national procedures will not be superseded by the **Q.A. Framework**, rather that this Framework will overcome the difficulty in comparing programmes which are described using different formats.

The **Q.A. Framework** captures the critical information which is required by stakeholders such as employers, the labour market, students, educational policy makers and educational establishments. It collects and collates all the details which are strictly necessary.

In the absence of any currently prescribed model, this Framework can be adopted as a programme design tool as a checklist for its evaluation and as a guideline for the implementation of internal Quality Assurance.

The **Q.A. Framework** is structured in a modular manner, making it possible to be effectively used in a web medium, therefore allowing access by the public at large, making it an instrument for transparency and control.

In the release of this Framework and associated Tables the SIG A4 anticipates that the format is flexible enough to be adapted to the individual institutional needs. However, it is recommended, to facilitate comparability, that the general format and the appearance of the tables should be maintained.

### 5.3.2.5 – Recommendations

While this **Q.A. Framework** is necessarily a public document, it can be flanked by a periodic "Self-evaluation Report" prepared exclusively for parties inside and external to the institution who are involved in any form of evaluation and accreditation. This "Report" would describe quality factors and the actions involved in control, highlighting the degree programme's strengths and weaknesses, corrective measures, review activities and follow-up, and their effects over time.

However, such self evaluation reports can, in the future, be effectively substituted by the collection of (presumably annual) reviews, where systematic observations and governing actions are given the appropriate evidence, thus proving that the Q.A. systems are effectively in operation. Support processes can be addressed in the tables purposely designed, and are essential in highlighting the quality of the organization in the planning and delivery of educational programmes.

The **Q.A. Framework** is thus the foundation for all future evaluation/accreditation processes. It must satisfy minimum requirements for content and form so that degree programmes of the same or similar type offered by different institutions can be readily compared.

This is the initial release of the **Q.A. Framework** in an international context, and the SIG A4 recommends that the design and implementation be reviewed at a later stage, after more extensive testing and feedback. At that stage issues like ongoing maintenance and the update of the information should be addressed.

### 5.3.3 – List of populated sets of Tables[35] (see CD)

| | |
|---|---|
| Gabriela ATANASIU | Programme "Civil Engineering" - First Cycle (I level) Degree - "Gh. Asachi" Technical University of Iasi, Romania |
| Liam COSTELLOE | Programme "Mechanical Engineering", Bachelor of Engineering (Hons) - First Cycle (I level) Degree - Institute of Technology Tallaght, Ireland |
| Bruno DI MAIO | Programme "Electronic Engineering" - First Cycle (I level) Degree - University of Palermo, Italy |
| Maria EBEL | Programme Technical Physics » - First Cycle (I level) Degree - Vienna University of Technology, Austria |
| Muzio GOLA: | Programme "Aerospace Engineering" - First Cycle (I level) Degree - Politecnico di Torino, Italy |
| Regis LALLEMENT | comparison between the matrix and a French document for the CTI |
| Carlo NOÉ | Programme "Industrial Management" - First Cycle (I level) Degree - Università Cattaneo-LIUC, Italy |
| Selahattin KURU | Programme "Electrical and Electronics Engineering" - First Cycle (I level) Degree - Boôaziçi University, Istanbul, Turkey |

35 The Tables are credited to each individual author and developed under her/his responsibility, even if repeatedly discussed in SIG A4.

| | | | | | | |
|---|---|---|---|---|---|---|
| **I level (design) evidence** | **Main / reference Roles & target Competencies**<br>List of Scholarly or Professional Roles for which the Programme is specifically designed to prepare graduates; broad declaration of Competencies<br>**Table A2 - External requirements**<br>required to fill role or to exercise functions in role. | | **Subject areas & Learning outcomes**<br>Particular choice of Subject Areas in accordance with stated competencies<br>Learning Outcomes: **Table A3: - Intended learning outcomes and associated course work**<br>Knowledge, understanding and skills the student is expected to gain, and which are needed to develop professional competencies. | | ***The Q.A. Framework matrix*** | |
| **II level (implementation) evidence** | **Interactions with external stakeholders**<br>1 - Academic body or person representing the institution.<br>2 - External stakeholders.<br>**Table A1 - Interactions with external stakeholders** | **External requirements**<br>1 - Expected characteristics of students at enrolment, entry qualifications:<br>**Table B1a: selective admissions**<br>**Table B1b: for orientation**<br>2 - Perspectives and opportunities for graduates at local or national or international level (benchmarking, sector studies). | **Teaching, learning and assessment**<br>1 - Overall structure of Programme, deployment of Subject Areas in Course Modules.<br>**Table A3: Intended learning outcomes and associated course work**<br>**Table B2: Curricular content**<br>2 – ***Single Module*** descriptions: contents, teaching materials and methods, student assessment methods. | **Resources and services**<br>1 - Faculty qualifications.<br>**Table B2: Curricular content**<br>2 – Technical and administrative support.<br>3 - Infrastructures (classrooms, labs, libraries, facilities, equipment, etc.).<br>**Table C1: Locations**<br>4 - Student guidance and support.<br>***Guide to services***<br>***(Table D2 available)*** | **Monitoring, analysis**<br>1 - Student enrolment and progression data (internal effectiveness).<br>**Table D1: Student enrolment and progression data**<br>2 - Student, graduate, (employer) satisfaction. (Student opinion surveys)<br>3 - Time to work.<br>(Placement surveys)<br>**Table D2: other data** | **Review**<br>Periodic assessment of Programme adequacy and effectiveness<br>**Table D3: Analysis, monitoring and review** |
| **III level Quality Assurance mechanisms** | **Organisation of interactions**<br>Who, when, how & documents on record. | **Determination of professional roles**<br>Who, when, how & documents on record. | **Course implementation**<br>Who, when, how & documents on record. | **Resource and infrastructure control**<br>Who, when, how & documents on record. | **Data collection**<br>Who, when, how, for data collection and elaboration | |

## 5.4 The use of ECTS in engineering: results of two surveys

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### 5.4.1. ECTS 2004 – 2007: an overview

Another important contribution to the transparency and exchangeability of results aimed at by the Bologna Process is the European Credit Transfer System (ECTS), started in the late '80s. One of the tasks assumed by SIG A2 was to collect available information on ECTS with particular reference to Engineering Education, to follow relevant developments during the life-span of TREE, and to conduct a trial survey.
The most significant aspects and findings of these activities are summarized here; they will be presented in more detail in the full report of SIG A2.

#### 5.4.1.1 ECTS in the official documents of the Conferences of Ministers of Education

Explicit reference to ECTS was made in the Bologna Declaration of June 19, 1999, which asked for the "*establishment of a system of credits – such as in the ECTS system – as a proper means of promoting the most wide spread student mobility*".
In the Communiqués of both Prague (May 19, 2001) and Berlin (September 19, 2003) conferences the emphasis was put also on the accumulation function of ECTS, in addition to the transferability function.
There was no mention on ECTS in the Bergen Communiqué (May 20, 2005), which could lead to the conclusion that the implementation of ECTS reached a stage at which there was no need for further "top-down" stimulus.
In reality it was not quite so, as put into evidence by in the London Communiqué (May 18, 2007) when ECTS is mentioned twice, on the context of "*degree structure*" (… "*efforts should concentrate in future on removing barriers to access and progression between cycles and on proper implementation of ECTS based on learning outcomes and student workload*") and of "recognition" (…"*there has been progress in the implementation of the Lisbon Recognition Convention (LRC), ECTS and diploma supplements"…)*

#### 5.4.1.2 ECTS and the European Commission

European Credit Transfer System (ECTS) was created following a pilot project run by the European Commission between 1988-1995 to promote student mobility and the recognition of periods of study abroad.

Several documents were issued under the auspices of EC in order to help the implementation of ECTS in higher education institutions across EUROPE.
To date, the most useful and comprehensive of these documents is the *ECTS Users' Guide* published on 17 August 2003 by the DG for Education and Culture.

### 5.4.1.3 ECTS and Tuning

"*Tuning Educational Structures in Europe"* in short TUNING, is a Project supported by the European Commission in the framework of the SOCRATES Programmes.
One of the three lines undertaken in the Phase 1 of the TUNING Project (2000-2002) was devoted to ECTS and called "*New Perspectives on ECTS as an Accumulation and Transfer System*". The Final Report on Phase 1 contains three valuable materials prepared by TUNING Management Committee.
In the Phase 2 of the Project (2002 – 2005), further consideration was due to ECTS, resulting in a approach for determining student workload in Higher Education programmes.

### 5.4.1.4 ECTS and EUA

Reports produced by European University Association – EUA in preparation to the Conferences of Minister of Education, known as "Trends" reports, based on big surveys across HEIs in Europe, give up-to-date information on the use of ECTS.
The last of such reports, "T*rends V: Universities shaping the European Higher Education Area*", issued in 2007, prior to the London Conference, showed, for instance, that three quarters of institutions responding to the Trends V questionnaire reported using ECTS for credit transfer in all Bachelor and Master programmes, compared to 68% in 2003.

### 5.4.1.5 ECTS and ESIB

ESIB, the National Unions of Students in Europe, prepares also reports for the Ministerial Summits, named "*Bologna with Student Eyes*". The last report of the kind, published in 2007, is rather critical when addressing the ECTS matter: "*The European Credit Transfer and Accumulation System (ECTS) is formally in place in the vast majority of Bologna signatory countries. However, its key feature are not properly implemented and used yet. No country uses ECTS for accumulation and transfer, with a full implementation of the learning outcomes approach and ECTS credits being linked to properly measured student workload*".

### 5.4.1.6 ECTS and EUCEET

EUCEET (European Civil Engineering Education and Training) is a Thematic Network initiated in 1997 by the Technical University of Civil Engineering Bucharest, which so far received grants from the European Commission for four projects: EUCEET I (1998 – 2001), EUCEET I Dissemination (2001-2002), EUCEET II (2002-2005) and EUCEET III (2006-2009).

Under the Theme C of the EUCEET II Project ("*Promoting the European dimension in civil engineering education*") was developed the Specific Project 8 "*Synergies between TN EUCEET and other activities under the SOCRATES Erasmus Programme*". One of the topics tackled by SP.8 was ECTS.

A survey was conducted within SP. 8 among academic partners in EUCEET. The outcome was fairly good, with 33 answers coming from 20 countries.

One of the questions was: "Do you follow the rule that 1 ECTS credit = 30 working hours?" Interesting enough, only 3% of the respondents said YES.

### 5.4.2. SIG A2 survey: higher education institutions

The Special Interest Group A2 undertook a survey on the use of ECTS in higher education institutions partners in TREE.

A questionnaire was prepared, comprising 5 groups of questions:

- general information on the institutions
- information on the respondent
- information on the study programme selected for the questionnaire
- additional information on the study programme
- information on the use of ECTS for the study programme.

On March 17, 2006, SIG A2 sent the Questionnaire to all academic members of TREE Thematic Network. 33 Higher Education Institutions from 24 countries answered the questionnaire, namely: TU Vienna, UACEG Sofia, University of Rousse, University of Lugano, University of Cyprus, Czech Technical University in Prague, Engineering College of Copenhagen, E.T.S.I. Informática y de Telecomunicación Granada, EVTEK University of Applied Sciences, FH Regensburg, TU Dresden, University of Hannover, Bauhaus-University Weimar, Aristotle University of Thessaloniki, Budapest Polytechnic, University of Pécs, Institute Technology Tallaght Dublin, Università Cattaneo – LIUC, Università di Palermo, Riga Technical University, University of Malta, Vestfold University College, Politechnika Opolska, Minho University, TUCE Bucharest, Tomsk Polytechnic University, Uppsala University, University of Zilina, Middle East Technical University, Faculty of Engineering, Ege University, Turkish Naval Academy, Dogus University, University of Birmingham.

The study programmes to which the answers referred pertained to the following engineering fields: Civil and Environmental Engineering (11), Electrical Engineering (10), Mechanical Engineering (4), Computer Engineering and Informatics (4), Industrial Engineering (2), Physics Engineering (1), Chemical Engineering (1).

Among the 33 study programmes, 22 were first cycle degree programmes of 3-4 years, 5 were second cycle degree (Master) programmes of 1.5-2 years and 6 were integrated programmes of 4.5-5 years.

In only 3 out of the total of 33 institutions, ECTS was not used (University of Birmingham, Uppsala University, E.T.S.I. Informática y de Telecomunicación Granada).

In the vast majority of the institutions (28), the 2-semester academic year is used, with exams at the end of each semester.

To the question: "*When credits were allocated to various subjects for the study programme in your institution, was 1 ECTS credit based on 25-30 working hours?*", were received 23 YES and 4 NOT (3 institutions from those using ECTS, gave no response).

To the question: "*Is the grading system A to F recommended in the "ECTS users' guide" correlated with the grading system in your institution?"*, were received 16 YES and 10 NOT.

To the question: "*Have been undertaken in your institutions actions in order to link the credits to the learning outcomes and levels of study?*", were received 12 YES and 16 NOT.

The survey conducted among higher education institutions partner in TREE on the use of ECTS can be considered as a real success. In first place, by the amount of answers received: 33, representing 1/3 of the total number of the TREE academic partners.

The survey confirmed that ECTS is well implemented in institutions offering study programmes in engineering. Even if the few cases when ECTS as such is not used, a mechanism of equivalence was put in place in order to facilitate the mobility of students and the recognition of study periods abroad.

A problem, revealed also by the EUCEET survey, is the high diversity of the grading systems. In many cases, the grading system used in the institution is not correlated to the grading system recommended in the ECTS users' guide, which obviously would cause difficulties at the sending institutions when trying to make the recognition of the study period abroad.

### 5.4.3. SIG A2 survey among students

On 8th January 2007, a "SIG A2 Questionnaire for students on the use of the European credit Transfer System (ECTS) in higher education institutions partners in the Thematic Network Project is TREE" was disseminated among all academic members of TREE.

Answers were received from 30 Erasmus students, coming from 6 countries: Romania (10), Slovakia (6), Turkey (6), Finland (4), Hungary (3), Bulgaria (1); destinations for their mobilities were universities in Italy (5), France (4), Germany (3), Spain (2), Sweden (3), Ireland (2), Finland (2), United Kingdom (2), Czech Republic (1), Netherlands (1), Portugal (1); in 4 cases, the destination was not available. Of these 30 mobilities, 5 took place in the academic year 2003 – 2004, 15 in 2005 – 2006 and 10 in 2006 – 2007.

Practically, the entire spectrum of study programmes in engineering currently offered in Europe can be recognized in the selection made by the students who answered the questionnaire:

- Bachelor (first cycle) programmes: 9
- Master (second cycle) programmes: 9
- 5-year (integrated) programmes: 8
- Advanced studies (following the integrated programmes): 3
- Doctoral programme: 1

In 25 cases, the objective of the study period was to take courses offered by the host institutions either for only one semester (16 cases) or for the entire academic year (9 cases). In 4 other cases the objective was the preparation of a final project and in one case activity related to the doctoral thesis.

To the question: "*Was the respondent involved in the preparation of learning agreement between the sending institutions and the host institution?*" answers were: 28 for YES, 2 for NOT.

In almost all cases, information which helped the respondent in preparing the draft of the learning agreement was obtained by accessing the WEB site of the host institution. In addition, half of the respondents declared they read the ECTS Guide of the host institution provided by the International Office of the sending institution.

For 10 respondents, needed information was also obtained by speaking with Erasmus students at their institution who undertook previously a similar study programme at the same host institution.

In a rather high proportion (12 out of 30), the learning agreement was modified after the arrival of the respondent at the host institution. The reasons behind the change in the learning agreement were equally shared between "*the course unit(s) not offered in the respective study period*" and "*prerequisite for the access to the course unit which were not met by the respondent*".

As for the recognition of the study period abroad, this was done "*on a global base*" (18 respondents) or "*by considering each course unit*" (12 respondents).

To the question: "*Following the recognition of the study period abroad, had the respondent to undertake additional activities at the house institution, in order to compensate for missing course units, in total or in part (chapters, projects, etc)?*", 26 answers were NOT and 4 were YES. However, none of the 4 respondents took the pain to estimate in terms of ECTS credits the additional activities.

In 27 cases the host institution helped the respondent in finding accommodation facilities. In most cases, respondents were lodged in student dormitories or in student apartments.

At the end of the questionnaire, respondents were asked to make an evaluation of the impact made by the study period abroad on higher academic development, using a ranking scale of 1 to 4 (1 – little; 2 – moderate; 3 – great; 4 – very great).

The answers were: 4 – moderate; 7 – great; 19 – very great.

Although of a very limited extent, the survey among students produced quite interesting results.

In first place, one should mention the active involvement of the students in the preparation of the learning agreement. It is true that in 40% of the cases analysed the agreement had to be modified once the student arrived at the host institution. Far from showing a weakness of the system, such changes reflect the responsibility with which all three partners (host and sending institutions and the student) tackled the important task of building a study programme at the required level.

The recognition of the study period abroad is a key factor for the enhancement of student mobilities under Erasmus. It is worth to note that in 60% of the cases this was done on a global base. This result can be viewed as a direct consequence of the efforts made in recent years for the harmonization of study programmes across Europe. But, even in the case of a "punctual" recognition (when each course unit is scrutinized in turn), the output was altogether favourable, since in only 4 out of 30 cases additional activities were required for the completion of the prescribed credits.

As expected, 90% of the host universities helped incoming students to solve the problem of accommodation. This is one more feature of what could be named "Erasmus culture", in which academic and social problems are intricately related.

Almost 90% of the respondents to the SIG A2 questionnaire appreciated as "great" or "very great" the impact of the study period abroad on their academic development. This is an appropriate, although somewhat optimistic, conclusion of the survey.

## 5.5 Demand and offer of Engineers in Europe: some data

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### 5.5.0 Introduction and Summary of Section 5.5

The separateness between academia and the productive world may lead to mismatch between the demand and the offer of the engineers' work force. The final Section of Chapter 5 (Section 5.5) is dedicated to the results of a specific survey on this question. The survey was carried on in Italy and in some other European countries, according to the *Bologna declaration* programmatic intention of generating "a new enhanced European cooperation" especially focused on higher education and employability.

The recent deep changes in the educational and vocational systems as well as in the international macroeconomic contexts bring about the need of enhancing the engineering curricula according to the labour market demand.

Volumes and statistical analysis are not enough to understand the issue. Just as an example, in 2003 about 290.000 European students got an engineering degree[36]. The questions are: how can the local productive structure condition the inflows of engineers into the labour market; what kinds of competencies make a German engineer different from a Polish engineer; what kinds of competencies have in common a Spanish *ingeniero tecnico* and a French *ingénieur diplômé*; what the expectations about young engineers of a German or an Italian SME or a multinational company with local sites, just like for example Airbus or Siemens.

Accordingly, Section 5.5 contains:

- a quantitative comparison between the inflow of engineers in the Italian, German and French labour markets
- a qualitative analysis of the engineers' competencies and profiles required by ICT companies in Italy
- a short abstract of a qualitative analysis among students from different European countries on competencies developed in their technical universities

In order to achieve the aims of the study, the activities focused on two main research works.

The first one, related to the quantitative inquiry, answers the following questions:

- To what extent are engineers needed by the labour market?
- In which sectors and of which purposes are they required?

Therefore, the survey focused on volumes of engineers recruited by companies, types of engineering disciplines and specialities chosen by the market, and companies' trends according to their sizes, business sectors, market behaviours and trends.

36 Eurostat, 2003: people with and engineering / engineering trades degree belonging to the "wider Europe" countries (EU25)

The second main activity, related to the qualitative inquiries, leaded to identify the engineering core competencies developed by different European universities (according to the ISCED 97 levels 5-6) and to analyze the market expectations related to engineers' competencies.
At this first stage, tools for the whole survey were built. These tools (that is a unique reference grid) can be used for both the analysis of the university "offering" (competencies developed, courses, etc), and the analysis of companies "demand" (competencies required, where these competencies are applied, etc) as well as for the analysis of students perceptions about competencies developed in their universities.
After that, the "competence grid" was tested on eight Italian large companies, with the support of Assolombarda, the major Companies Association in Lombardy, in order to understand which competencies they require for "ICT engineers" (that is electronic, computer and informatics engineers) during their first employment year.
The reference people interviewed were, for companies, responsible for HR development and for the target business areas, as well as professors and departments' directors for universities.
Moreover, also 20 students from European countries were interviewed.
According to relationships already settled, countries involved at the beginning were Italy, France, Germany, Portugal, Turkey, and Bulgaria. In order to go on this work inside a permanent engineering observatory, the future partnership will include Industrial Associations, technical universities, multinational as well as local companies.

### 5.5.1 First research area: the quantitative survey

Concerning the first main research work about quantitative analysis, it is possible to summarize the main results achieved as follows:

- The analysis of surveys on inflows[37] of engineers, provided by Conseil National des Ingénieurs et de Scientifiques de France (CNISF), Comité d'études sur les formations des ingénieurs (F), Institut für Arbeitsmarkt- und Berufsforschung (DE), and Centro Studi del Consiglio Nazionale degli Ingegneri (I), cannot leave out of consideration what the term "engineer" means. There are deep differences among the EU members states about the meaning of "engineer" and if the Bologna Declaration has initiated a reform, it is actually still not implemented by all European Countries; moreover, the period of transition of the early adopters makes the situation more complex.[38] So, even though at a local level it is possible

37 We used the term "inflows" as a synonym of *recruitment/hiring* of engineers entering into the labour market and recruitment of engineers changing their job

38 For a thorough discussion on these questions, cf. Section 5.2 *(Editor)*

to find detailed data describing the engineers' conditions of work from several points of view, when the expected level of detail increases and the scope of the analysis becomes wider, then data could lose significance; even the collection and the analysis of data become more complex and inaccurate because several and diverse organizations have to be interviewed in order to gather information, each of them using different valuation methods.

- After these preliminary remarks, the research focused on analysis of inflows of the following kinds of "engineers":
  - *Ingénieurs diplômés* for France;
  - *Ingenieure*[39] holding a University or *Facchochschule* degree for Germany;
  - *Ingegneri* holding a "Laurea Quinquennale" or "Diploma di Laurea triennale" degree (both degrees were awarded before the Bologna Declaration) and a "Laurea" or "Laurea Magistrale" degree (awarded after the Bologna Declaration) for Italy.

Data were organised according to three categories: *destination of engineers* by *industry size class,* type of degree held by engineers and industry *activity field* (following NACE classification).

- At an aggregate level, data showed relevant differences among the three Countries analysed. Referring to the period 2001-2003, the mean values of inflows in France and Germany were from two to three times higher than the Italian inflows. Besides the different valuation methods used (as we already said), the higher values of French and German inflows could be also referred to historical and cultural reasons (the scientific degrees and technical occupation have a different "reputation" in the three countries), as well as to the local labour markets peculiarities (for instance, differences in turnover rates).
- The analysis of inflows by industry size class showed the relevant impact of the domestic productive structures. Concerning France, it is evident that the *Ingénieurs diplômés* are a preferred target for companies having more than 500 employees. About the 50% of inflows is a matter of *grandes entreprises*, whereas the companies with less than 20 employees recruit only the 10% of total number of engineers.

  The main reasons can be traced to both macroeconomic factors (the number of large enterprises on the total number of companies is relevant in France), and educational aspects, as well as to the *Ingénieurs diplômés*' reputation itself, in fact engineers are usually thought as managerial profiles rather than as technician by the labour market.

  The Italian situation is quite different. Even though also in Italy large enterprises are the preferred "destination" for the *Ingegneri*, in this case we have to consider companies with more than 250 workers (smaller than the French ones) in order to reach the 50% of the inflows. The big impact of the "PMI"[40] is evidently strong, considering that the 15% of recruitment is made by *microimprese* (companies with less than 9 employees).

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39 For Germany, in some cases data analysed include also the inflows of Architects.

40 *Piccole e Medie Imprese*, the Italian Small and Medium Enterprises, companies with less than 250 employees. They represent more than the 90% of the Italian companies.

The German situation seems closer to the Italian situation rather than to the French one. In the German case, however, the intake by societies smaller than 10 employees appears residual, between 7 and 12% av. (depending on whether we consider the inflows of *Architects and Construction Engineers* or not).

- The engineering specialty (type of degree) analysis showed how engineers coming from the traditional industrial engineering field represent a third part of the amount of the inflows (no matter which country is considered). The situation appeared to be more variegated if we consider other macro specialties. The ICT engineers represent the remaining quota of the hired engineers in Italy (where only the 20% av. is made of *Construction/Civil/Environmental Engineers* and *Others Engineers*); otherwise, France and Germany show similar intakes for that specialization type, between 20 and 30%. Finally, if in France the *Construction/Civil/Environmental Engineers'* intake represents the 15% av., Germany seems to be the nation with the highest number of hired engineers not included in the traditional types among the considered countries.
- The quantity research focused, at last, on the hiring data segmentation based on company's activity field. This dimension of analysis makes it possible to underline how, in the three countries, only five business sectors (*Manufacture of electrical and optical equipment*, *Manufacture of machinery transport equipment*, *Construction*, *Advanced business services* and *Architectural and engineering activities and related technical consultancy*) determine an intake between 40 and 50% of the grand total.
  If we also consider the *Telecommunications and Computer and related activities* field we reach the 65% of the hiring in France and the 75% in Italy, while in Germany the fields of *Manufacture and recycling of basic metals and fabricated metal products*, *Manufacture of coke, refined petroleum products, nuclear fuel, chemicals and chemical products* and *Trade* are characterized by an intake higher than the ICT fields.

### 5.5.2 Second research area: the qualitative surveys

With respect to the second research work, the main evidences emerged from the qualitative survey inside Italian companies with the support of Assolombarda, can be summarized as follows:

- The survey showed that telecommunication and IT companies were quite satisfied of technical skills acquired by students with an engineering degree; on the contrary, they indicated soft skills as poor and patchy. In particular, *communication skills* are quite absent and *team work capacities* are often very weak in young graduated people. The main crucial competencies required by companies are in the areas of *management* and *self management*, *internationalisation* and *networking* as it is shown in Table 1.

**Table 1. Most crucial competencies needed by companies interviewed**

| Area | Competence | Detail |
|---|---|---|
| Management | CUSTOMER RELATIONSHIPS | To be able to use client management techniques |
| | PROJECT MANAGEMENT | To know methodologies of time management, methodologies and techniques for cost/quality/time improvement<br>To be able to apply relational skills, leadership, conflict management and team building competencies. |
| Networking . Internationalisation | INTERNATIONAL RELATIOSHIPS | To know open source world<br>To be able to work in international processes, to manage activities in international contexts |
| Self Management | FLEXIBILITY | To be able to operate in different projects, to be able to adapt yourself to different contexts |

In Table 2 companies' answers to the questions: *a) To what extent is University responsible for the acquisition of competencies? b) Which methods are really suitable to improve learning and competencies development?* are reported.

About the first questions, the bubbles indicate the companies' perceptions: e.g., the full black bubbles point out a university full responsibility in the opinion of companies interviewed.

It is interesting to underline that the companies interviewed give university a full responsibility for both methodological and technological competencies as well as for communication skills. On the contrary, "creativity", "ownership", "flexibility", "integration" are considered "natural" attitudes that can be perhaps developed at an early stage.

On the other hand, if we analyse technical universities curricula in the UK we can notice that they give a strong importance to the so called "soft competencies". They programmes strongly take into account the so called "employability profiles" and even emphasize behavioural and managerial skills instead of the technical ones (cf. Student Employability Profile, Engineering Subject centre, May 2005).

Actually, in the UK there is a long tradition of cooperation between universities and companies and for a long time they have adopted a common language based on "operational" descriptions of competencies and "learning outcomes" (cf. www.dfes.gov.uk/ )

**Table 2. Companies' answers**

| Area | Competence | University's responsibility for learning | Learning methods |
|---|---|---|---|
| **ICT** | Methodologies | ● | Classical (lectures, seminars) |
| | SW technologies | ● | Classical (lectures, seminars); more importance allowed to laboratory and practical activities; involvment of companies during degree thesis |
| | HW technologies | ◖ | Classical (lectures, seminars) |
| | Project and applications | ◖ | Classical (lectures, seminars); team works |
| | System performances | ◉ | Classical (lectures, seminars); involvement of companies during degree thesis |
| **Management** | Customer relationships | ◖ | Classical (lectures, seminars); more importance to oral exams (mainly during the last year of bachelor and master courses; lectures with the involvement of business experts; ad hoc exams) |
| | Project management | ◖ | Classical (lectures, seminars); team work; business game; improvement of management courses |
| | Economy | ◉ | Classical (lectures, seminars); improvement of management courses |
| | Processes and systems | ◉ | Classical (lectures, seminars); lessons about standardized processes and terminologies; business game |
| **Innovation** | Integration | ⊙ | Classical (lectures, seminars) |
| | Technological transfert | ◉ | Classical (lectures, seminars) |
| | Creativity, lateral thinking | ○? | |
| **Networking** | Network creation | ⊙ | International programs (Erasmus) |
| | Network management | ◖ | International programs (Erasmus) team work |
| | International relationships | ◉ | International programs (Erasmus) |
| **Self Management** | Communication | ● | Classical (lectures, seminars); ad hoc courses |
| | Responsibility | ○? | |
| | Problem setting - solving | ◖ | Classical (lectures, seminars); case studies; partnerships with companies |
| | Flexibility | ⊙ | |

Low responsability ←→ High responsability

○ ⊙ ◖ ◉ ●

About learning methods, companies interviewed are aware that beside classical and traditional classroom lessons other strategies and methods could be used to improve learning and competencies development; the methods largely mentioned are team work, business games, case studies, stages, international experiences. Moreover, companies consider oral examinations very crucial to develop communication and relational skills even useful to manage clients in the future work activities. However, it is quite curious that with respect to competencies related to “innovation”, they were not able to give recommendations really useful to foster and improve them. Accordingly, the reference companies consider “innovation” as something related to the Research and Development area instead of considering it as a cross-dimension involving many organisational functions.

Finally, the qualitative survey addressed to about twenty students (both Bachelor and Master degrees) coming from different European countries (Austria, Belgium, Slovenia, Lithuania, Pollen, Holland, Macedonia, Greece, Portugal, Romania, Spain, the UK, Turkey) enlightened the following main questions:

- traditional engineering degrees (e.g. chemical, electrical, metallurgical and material, mechanics, computer science) pay not so much attention to economy and management while they focus on innovation and problem solving
- sometimes students have the perception that ICT core competencies are not very well developed at university
- most universities adopt project work approaches as learning methods
- the participation to international initiatives helps students to develop competencies related to “self management” and economy, not so much considered in the universities programs
- in general, international experiences give a great contribution to the enhancement of soft, behavioural skills

## 5.6 An inquiry about real needs of industry in international formation

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This final Section of Chapter 5 contains the outcome of SIG A3, namely an essay on the needs and requests of enterprises on international formation of engineers.
Full references to the quoted documents can be found in the CD.

### 5.6.1. Introduction and project topics description

The expansion in technology and materials development has been so rapid that for the first time in our history we have made obsolete many of the rules and much of the infrastructure that serves society's needs today. The effect of globalization has driven through tremendous changes within the industry worldwide. The above results with technology advances and workplace changes that can lead to exciting and rewarding careers and require to be flexible and committed to continuing professional development. The key to survival is establishing a framework for life-long learning worldwide. In the face of business globalization the engineers must sharp his capability to communicate both in the written and oral modes and must work in teams to tackle issues and resolve problems.

The engineering education falls behind with research and technology progress, as well as economy market development. The phenomenon of the total knowledge growth is accompanied with easy information distribution with free or limited access via world electronic network. To support process technology in 2000s' the higher engineering education institutions must be ready to offer the student's knowledge and skills expected by manufacture in the age of globalisation, especially at: microelectronics, biotechnology, low-waste production, improved process control, recycling and reuse of process waste streams, transportation.

The Lisbon UE Declaration foresees, that till year 2010 European economy will stand up the most competitive on world. It bets that two third on science expenses it has to come from enterprises founds. This wakes the definite discontent of enterprises with attention on fact that the expenses of Europe on science do not cross 2% GDP (near 2,7 % the expenses in USA). In Europe, even when it gives already on science money, often later we are not able to use effects of researchers' results in practice. The elaboration of effective and efficient principles of co-operation industry with science is the urgent necessity and challenge for European the engineers education system. The most important challenge is to establish well running and profitable engineering education environment in Europe.

This essay reflects knowledge and position of dozens named and un-named academics, engineers and managers from Europe, America and Asia expressed during professional discussions and debates, as well as the state of knowledge of authors of selected 72 publishes references detailed essay on the needs and requests of enterprises on international formation of engineers. Also the presented report includes conclusions of professional discussions with specialists both from industry and technology engineering institutions during conferences, workshops and seminars had place in Europe and others countries world-wide. The above subject is also in target of several documents of European Commission and US National Academy of Engineering, as well as professional institutions like: FEANI, IEEE, IFAC, ISPE and others.

The reflections in the topics named inquiry about real needs of industry in international formation in aspect of Technology Engineering Education are rather difficult to recognize, because the today changes are so rapidly and the future is more unknown today that in the past.

### 5.6.2. Industry needs

Many countries need to modify their higher education model in order to participate fully in global knowledge and technology-led economic growth. The EU's push towards a knowledge-based society at the beginning of the 21st century (*The Lisbon Strategy*) was justified by the need to remain competitive since the technological revolution was born in the United States and chiefly benefited the US economy.

The industry has over the last decade undergone a significant change: are operating in a global market, as a part of the supply chain and distributors, as well as many of them into the digital business. They all comprise an integrated international co-operative network to provide manufactured goods and support services for a world market just in time, at low prices and with quality surpassing customers' expectations.

The European known industry players have been confirmed that in order to remain competitive, firms in the engineering industry must respond by becoming world class. World-class businesses continually innovate and improve performance. A critical issue for the engineering sector is the exploitation of technological advances in terms of product development and production processes. Quality products and services require competitiveness of industry that depends on adaptable and competent workforces especially engineering personnel. The practice of engineering has and is changing significantly. Consequently the educational institutions will have to continually adapt and develop training and qualifications in the different branches of engineering and related disciplines, so as to respond to the future needs of the engineering industry. A key issue for the engineering industry is *learning to change*. Companies must be flexible, be keenly aware of customer needs, changing technology and market development and must continuously improve.

Today one of the globalization output is a new professions sourcing in global value and practice globalization to maximize value and not just minimize cost of professional activity via: new practices of multidisciplinary decision - making, new methodologies and tools, new management practices and processes, new ways to manage collective progress, hybrid skills and new shared tools, engineering interacting with consumers in virtual purchase context. There is an increasing need to communicate across disciplines in order to have effective system-level designs.

Engineering challenges must be ready to answer the manufacturing vision in 21st century:

- fundamental industrial process will still be around and will not be much different,
- products and services will be increasingly and in multiple configurations of alliances,
- networks of flexible entrepreneurial sites will replace large, more rigid central sites,
- products that are built - to - order will create pressures to reduce scale and locate sales and services near manufacturing sites,
- industry will produce more highly customized, high value products,
- new developments in biotechnology and nano-technology will create whole new industries and industrial alliances based on interactive in 3D (simulation-based),
- visualization of complex structures integrating behavioural, organisational people issues with other analysis,
- intelligent communication systems,
- sensors for process controls in closed-loop systems,
- sustainability, new technologies for handling manufacturing process waste, lighter/ smaller equipment.

The world has been and now more than everywhere engineers can find inspiration, knowledge, employability and opportunities. With the beginning of the 21st century, society has become more aware of its rapidly expanding stockpile of information, knowledge and technology. In fact, there is so much information that no one person can hope to learn all of it. The new technologies require new knowledge of the surrounding world and skills that have not been considered before. During any person’s working life, he or she generally has a few careers and several employers.

Needs and requests of enterprises on international formation of engineers have been discussed by details from different businesses, perspectives and points in several documents: EU 2003; EU 2006; EUG 2007;

GEE, 2006; Grabowski & Szpytko, 2005; NAE, 2004; RAE, 2006; Szpytko, 2000; Szpytko & Lis, 2006; Szpytko & Lis, 2007 ; Szpytko & Winkler, 2000; Szpytko, 2004; Thieme, 2007; WEF, 2006.

### 5.6.3. Final remarks

Today the world is at stage where new discoveries and inventions must be undertaken in order for new wealth to be created, which will support human life and needs. In many industries the whole world have been consistently talking about innovation to be the next paradigm for global competitiveness and survival (BHEF, 2001; CC, 2004; Doody, 2001; Friedman, 2006; Santoro & Betts, 2002; US DC, 2006). Innovation means the process and the outcomes of this process through which new ideas respond to societal or economic demand and generate new products, services, or business models that are successfully introduced in an existing market or that are able to create new markets.
Inquiry about real needs of industry in international formation is difficult to recognize preciously. The presented report cannot answer clearly for the future business needs, because the changes are rapidly and the future is more unknown today that in the past. Still is possible to ask (Santarini, 2007): What skill sets will US/ EU engineers need to cope with the rapidly changing world, how many engineers will there be, and where will they be located? What is the university's role in thinking about what engineering careers are going to look like in the future. What are our responsibilities in providing our students with the opportunities to have careers that are going to not only prepare them for the day they graduate but probably more importantly for the 40 years after that?

The past history shows that the underlying foundation of innovation must largely come from the field of engineering. It is the fact that most of what the engineering profession undertakes is for the benefit of other professions and society. The above results with stronger join cooperation and meaningful partnerships the engineering profession with various professions. Moreover due to the advent of information and communication technologies, the transfer of information and sharing of expertise from one part of the world to another is becoming increasingly possible and effortless.

It exists urgent needs to increase effectiveness of practical results utilization of scientific investigations. This is possible as result of stronger industry including to the education process and realization of scientific investigations dedicated into market needs. The engineer fulfilled and will played still in future the stimulus functions of civilization development and shaping of man prosperity. Engineers are ones, that will be creating and building new facilities and devices for people's enjoyment and comfort.

To increase humane life, the development of new markets, new manufacturing processes and new products became a pressing issue. Today innovation achievements are possible on an economic redevelopment of the manufacturing base, with support society, legislative, industrial, business and universities. Mutually beneficial relationship between higher engineering education and industry must be based on university - industry interactions. The above achievements in: increasing productivity, providing opportunities for training and conceptualization of experiences, implementing exchange programmes for both lectures in industry and industrial staff/ engineers in universities for updating their knowledge and skills (Viswanathan, 2007).

The impact of globalization on the economy and culture of the Europe, United States and Asia will be immense. Business is driving the world's economy towards multinational corporations who will shift jobs and investment based on productivity and the bottom line. The today situation in many European countries: less number of students is interesting with engineering technology education, because: the study is rather difficult and time consuming, the reward perspectives after diploma are rather limited and unknown, and the motivation of study is rather low. From the second hand the education expenses in engineering technology are rather high and the governments are rather reducing founds instead decreasing (because the expenses are growing), as well as business have limited interests and motivation to supply engineering education sector with finance resources. Today we are observing small supply of home - grown engineers, facing an explosion of technical mental horsepower overseas. One of the possible scenarios of playing only the economic advantage will be closing expensive higher engineering institutions, which will results with import all the engineering we need in the future.

The higher engineering institutions have come out ahead in defining its role as a catalyst for innovation and change. Engineering are vital actors in the processes of knowledge acquisition, creation, diffusion, transfer and commercialization. It is possible to conclude that good business needs good engineering and good engineering needs good business.

## 5.7 IGIP system of accreditation for programs in Engineering Pedagogy

*by K. Hernaut*
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The pedagogical and didactical abilities of engineering educators (i.e. teaching personnel in engineering programs) has a decisive influence on the quality of engineering education. IGIP - the International Society for Engineering Pedagogy - puts a special focus on this aspect of engineering education process and recommends that every person involved in engineering education be properly trained and qualified in engineering pedagogy.

The qualification profile of an engineering educator should be based on two pillars:

- Engineering qualification in a recognised and accredited engineering education followed by relevant professional experience,
- Qualification in engineering pedagogy acquired in the course of a comprehensive educational program for engineering educators.

The Engineering Pedagogy Program should normally be an independent second cycle course of studies. But alternatively it can also be an integral part of a second cycle engineering degree program. In this case the university should introduce a separate certificate in order to attest the engineering graduate an additional engineering pedagogy qualification.

In order to guarantee that graduates of the Engineering Pedagogical Programs are well prepared to perform the teaching in engineering subjects IGIP has established an accreditation system for programs in Engineering Pedagogy and a professional register for International Engineering Educators (ING-PAED IGIP) open to persons who have completed such accredited program and gained some professional experience in teaching engineering subjects.

The goals of IGIP accreditation are:

- to assure that graduates of an accredited Engineering Pedagogical Program are well prepared to perform the teaching in engineering subjects and meet the criteria for IGIP registration as an International Engineering Educator, ING-PAED IGIP.
- to promote the quality assurance, quality improvement and advancement of the engineering pedagogy programs.
- to create public awareness of the high quality of the programs for engineering educators.

The IGIP accreditation criteria include:

- organisation of the program,
- entrance requirements for first year students,
- skills/abilities of the graduates,
- engineering pedagogical curriculum,
- lecturers and professors,
- institutional resources,
- quality control and feedback.

For each criterion IGIP has developed a set of standards which an Engineering Pedagogy Program must meet in order to be accredited.

The Criterion (C) sets up the competencies which graduates of an Engineering Pedagogy Program have to achieve in the areas such as:

- pedagogical, social, psychological and ethical skills
- didactical skills
- evaluative skills
- organisational / management skills
- self-awareness and developmental skills
- communicative and peer group skills.

The accreditation Criterion (d) defines the scope of core content which must be covered by Curriculum in an Engineering Pedagogy Program. The minimum extent of 20 ECTS is required. The areas to be covered are:

- theoretical and Practical Engineering Pedagogy
- laboratory Methodology
- psychology and Sociology
- ethics and Intercultural competencies
- oral Communication Skills, Scientific Writing
- working with Projects
- media, E-Learning, Computer Aided Technologies.

For additional information and the complete accreditation standards please consult the report by SIG C4 on the CD version of the TREE outcomes and the IGIP website *http://www.igip.org/.*

CHAPTER 6

# Sustainability of Engineering Competencies through Continuing Education ■

*by Markku Markkula*
Helsinki University of Technology
TREE Line D Promoter

*With the contribution of:*
*Markku Markkula, Flemming Fink, Erik de Graaff, Seija Hämäläinen, Tapio Koskinen, Patricio Montesinos, Wim van Petegem, Hannu Peltola, Henk Zandvoort*

## 6.1. Introduction

The purpose of this chapter is to provide the reader with raw material, concepts of thinking and partly also complete thinking maps by means of which it is possible to shape activities on the individual, communal and societal levels so as to allow the essential traits of the knowledge society to develop in the right direction. What is distinctive of this development is the determination demonstrated in the interwoven way that the empowerment of individuals, teams and communities develop through effective networking for the benefit of society as a whole. Sustainability is the key word guiding the thinking process throughout this chapter.

This chapter describes the major outcomes of line D as part of the thematic network of TREE "Teaching and Research in Engineering Education". This document includes only a small part of the outcomes of the SIGs. Full reports are available in the TREE CD-rom and through the web.

Sustainability in this context means the need and methods through which engineers keep up their competencies while taking into account the impacts of ethics, code of conduct etc. The overall target of this report is to review the European and global initiatives focusing on the impacts of technological development on teaching and learning, as well as on the new methodologies in technology-enhanced learning and continuing education in order to develop concepts and tools for universities for managing effectively the on-going educational change.

The three perspectives covered by Line D and the different SIGs (special interest groups) are described in Figure 1. The SIGs worked with the following chairpersons:

**D1: Managing continuing engineering education (CEE) effectively**
*(Markku Markkula, SEFI WG CEE chair, Helsinki University of Technology)*



Claudio Borri, Francesco Maffioli, (edited by), *Re-engineering engineering education in Europe,*
ISBN 978-88-8453- 675-4 (print) ISBN 978-88-8453- 676-1 (online) © *2007 Firenze University Press*

**D2: New ICT-based forms of continuing professional development (CPD)**

*(Wim van Petegem, SEFI Administrative Council member, Catholic University Leuven)*

**D3: Changing work-culture, foresight & innovation**

*(Tapio Koskinen, SEFI WG CEE secr, Helsinki University of Technology)*

**D4: Virtual University Collaboration**

*(Hannu Peltola, Finnish Virtual University)*

**D5: EFQM concept for managing university change**

*(Patricio Montesinos, SEFI WG CEE co-chair, Universidad Politechnica de Valencia)*

**D6: Ethical issues in EE**

*(Henk Zandvoort, SEFI WG on Ethics chair, Delft Technical University)*

**D7: Adult education model for European universities**

*(Seija Hämäläinen, Helsinki University of Technology)*

**D8: Work-Based Learning**

*(Flemming Fink, SEFI Administrative Council member, Aalborg University)*

**D9: Active Learning**

*(Erik de Graaf, SEFI vice president, SEFI WG on Curriculum Development chair, Delft Technical University)*

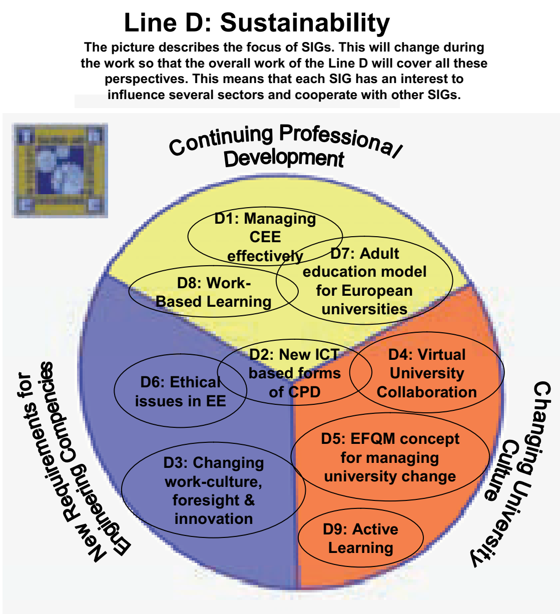


**Figure 1**

The following reading results from the work accomplished within the above-mentioned SIGs and the reports written by the SIG chairpersons. Line Promoter Markku Markkula is the editor of this chapter. He is also, responsible for outlining the entirety, selecting the passages and compiling the texts.
However, the results of SIG D4 and SIG D9 are more extensively covered by Ch. 3.

## 6.2. Sustainability – a cornerstone in Knowledge Society
### 6.2.1 Foresight and road mapping

Anticipating changes and preparing systematically for them are prerequisites for the sustainable build-up of society. Everyone can detect changes taking place even on a larger scale. Four driving forces of change, affecting society as a whole, have been identified[41]. All the driving forces presented are "plural", complex buzzwords in the political debate, and yet their meaning can be circumscribed and their influence on education and training can be examined. They are globalization, demographics i.e. aging society, ICT revolution and the shift in values.

In today's global and technological world, learning has become increasingly important to all people and all communities; it is the best way to cope and manage in a competitive and ever-changing environment. The development of learning is no longer the exclusive domain of education professionals, but a whole host of experts from different fields are needed to organise as well as to support, produce and supervise learning[42].

The increasing significance of learning is closely associated with the concept of sustainability. Society must focus its resources on creating the desired future in a more and more determined way. Persistence should be accentuated. The only way of reaching the targeted direction in the activities of decision makers and ordinary citizens is by increasing the value of foresight activities. The issue is not just predicting the future but much more the mental change towards inventing the future. An example will best illustrate the contents of this desired change.
FinnSight 2015 - Science and Technology in Finland in the 2010s, was a joint foresight project of the Academy of Finland and TEKES, the Finnish Funding Agency for Technology and Innovation. The project was carried out in 2005-2006. The foresight project examined the change factors that have an impact on Finnish business and industry and on Finnish society, identified future challenges to innovation and research activity, and analysed such areas of expertise which will foster the well-being in society and the

41 Leonie, MENON Network, 2005

42 FinnSight 2015, TEKES, Finland 2006

competitiveness of business and industry by means of scientific research and innovation activities. The results of this study are very relevant not only to Finland but the rest of the world, as well. The focus areas of competence development were identified as follows:

- the neurological, cognitive, motivational and social basis of learning
- human technologies that support learning
- technology-based working and operating environments, management of mobile and distributed work
- practices of lifelong learning, the education system and informal learning
- civic skills and competencies, life control and social innovations.

Information technology and information networks have made learning and knowledge independent of the constraints of time and place. Information is created and distributed globally online via social software. With respect to organisational learning, the main focus needs to be on knowledge creation theories and the preconditions for a learning organisation. Technology impacts both individual and community learning by providing tools and support for the creation and distribution of knowledge.

For individual learning to turn into community learning and collective learning, it is necessary to have an environment where the search and retrieval of new knowledge, learning and the distribution of competencies are consciously steered in the right direction by a manager or "teacher" and where human interaction is supported by culture. The various fields of learning research should be integrated and the experts working in these fields brought together.

The Prolearn Network operating as one of the Networks of Excellence within the EU 6$^{th}$ Framework Programme has linked the foresight studies focusing on both science and working life developments to professional learning. The road mapping process aims to provide different stakeholders with the information about the current state and vision/foresight/desired future. Once this is achieved the stakeholders will be in a position to determine the action plan to make the desired future to happen. The process includes the following stages (Figure 2):

- Vision: tacit idea representing the desired future state
- Expressed future state: instantiation of the vision in a formal and systematic way
- Gap analysis: between the current state of the art and desired future state (critical capabilities needed to implement one or more vision statements)
- Actions: a portfolio of short-, mid- and long-term actions and recommendations, based on the gap analysis

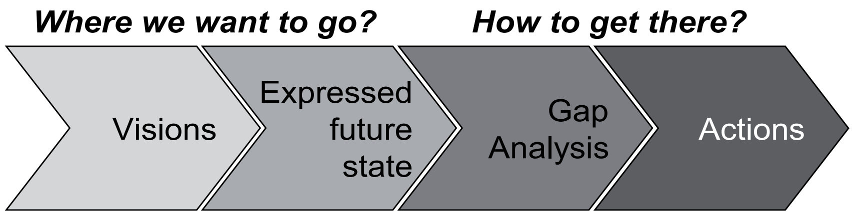


**Figure 2. Roadmapping stages**

Foresight plays an important role also in CEE. SIG D3 (chaired by Tapio Koskinen) has identified two main areas for foresight useful especially for CEE development:

- Understanding the new competency needs arising from the changes in working life and business environment will enable CEE providers to develop new programmes that better match the needs of the industry.
- Understanding the changes in learning systems and working life will enable CEE providers to develop new services that better support learning at work.

SIG D3 has studied these two areas through analysing two scenarios addressing different challenges of CEE at work:

1. Learning as a means to support and enhance work performance.
   - To support human performance improvements and to provide links between business processes, competencies and learning processes
   - To use ICT-enhanced learning to design high quality work-based learning activities so that learning and working becomes interlocked
2. Promoting innovation, creativity, and entrepreneurship at work.
   - Learning supporting radical change in an organisation and improving the ability to change
   - To support innovation in an organisation by enhancing knowledge sharing and collaboration
   - To develop specific competencies related to thinking out of the box, creativity, asking the right questions, leadership.

The first scenario focuses on performance support and the linkages between learning and business process management. It is more about learning supporting the continuous improvement, while the second scenario focuses on learning that supports the build-up of competencies needed for managing disruptive changes. Together the two scenarios represent the main challenges for learning at work today. The results of SIG D3 are partly written here and partly included in the CD-rom inside the report of SIG D1.

### 6.2.2 Benchmarking Knowledge Societies

The ongoing change means transition from industrial to knowledge society, and in that change education is increasing its role from an ancillary service to a leading force of economic and social development. Traditionally the three main aims of education were to build disciplined individuals, competent workers and respectful citizens. This way was perfectly suitable to the classic industrial society which reserved responsibility, creativity and political initiative to smoothly enlarging elites. What sort of individuals, workers and citizens are needed in the knowledge society? Several answers can be given to this question, but a large consensus exists, not only among educationalists, on the fact that autonomous individuals, entrepreneurial and creative workers, responsive and socially active citizens are preferable to the "versions" considered more popular in the industrial society. Innovation and creativity are now valued as keys to successful economic development, the real "wealth of nations" of the 21st century.

There is not a unique standard Knowledge Society model. However, based on several evaluation studies the following factors[43] seem to be fundamental for the knowledge-based economy:

- Creativity and innovativeness are the driving forces,
- Effective networking is a way of life in creating a shared knowledge reality among both individuals and organisations,
- Increasing intellectual capital is the most important value base of work organisations,
- Knowledge management and encouraging systematic lifelong learning are bases for building a concept of a learning organisation,
- The future of economic success is more and more built on the national innovation system with special emphasis on a well-targeted regional innovation policy,
- Increasing the investments in research and development play a crucial role in the governmental policy.

Gaining the desired change is not easy. It is important to realize that change in the educational system cannot be achieved by concentrating solely on e-learning. The desired breakthrough can only be generated via a combined effect of many parallel actions, one strengthening the other. We need to implement a broad spectrum of activities, which in brief can be defined as the key success factors needed in development and change. These activities have to be defined and planned by taking into account several perspectives, yet they need to be focused.

One could mention many of these success factors but it is wise to make choices and to concentrate on the essential. Consequently, the Finnish top 10 list[44] looks like this:

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43 Markku Markkula, Learning in Organizations – Inventing Desired Futures in a Global Society, The 1st SoL Global Forum, Lifelong Learning Institute Dipoli, Espoo Finland, 11-14 June 2003,

44 Markku Markkula, Creating Favourable Conditions for Knowledge Society through Knowledge Management, eGovernance and eLearning, FIG Budapest Hungary, 27-29 April 2006

- Open access & Welfare Society & ICT,
- Motivation and enthusiasm towards lifelong learning and innovativeness,
- Research and development & multidisciplinarity,
- Enrolment to higher education,
- e-governance and e-learning,
- Global competitiveness,
- Efficient knowledge management at the individual and organisational level,
- Continuing education linked with work,
- Quality and productivity,
- Innovative learning and working environments.

These factors and operating areas are closely interwoven. They have created positive growth potential by means of which societal operations as an entirety are built on a sustainable foundation. Each country and community must recognize from its own points of departure the corresponding success factors that help reach the targeted results and that can be backed up with consensus that is strong enough and built on values and attitudes.

### 6.2.3 Ethics and social responsibility in engineering education

The results of the SIG D6 (chaired by Henk Zandvoort) are of special importance for the ongoing lifelong development of every engineer's competencies. The results deal with issues such as knowledge needed in decision making, critical reflecting and other skills in analyzing different aspects within the work processes, as well as attitudes and values in ethical and socially responsible conduct and decision making. These issues need to play an active role in teaching and learning, to a certain extent, during the initial education – all are of special importance in professional development all throughout the engineer's career.

All these issues are covered by the SIG D6 and they are presented in an interesting way in the TREE CD-rom. The members of the SIG have written their personal short statement "theses", argumented their theses, and finally written some guidelines for implementation.

The major target in formulating the theses, which are fully included in the TREE CD-rom, was to describe the requirements that should be imposed on engineering education in order to equip the future engineers with adequate ethical and socially responsible conduct and decision making.

All theses were developed against the background of a broad definition of ethics, and this has rendered them critically relevant for achieving sustainability of engineering competencies as defined in this chapter. Ethics as understood by the SIG D6 members deals with developing a balanced personal value base and in-depth understanding of the criteria on which the goals of one's life and work are based, but also with understanding the impacts upon others of one's decisions and actions following these decisions. The impacts of the work of engineers are always dependent upon and influenced by the wider organisational, social, legal, and political context in which they work. This means that ethical competency of engineers should include a broad type of understanding of and critical reflection on this wider context. This is stated by one of the theses as follows: "Engineers need to understand the context in which engineering practice takes place and the importance of engineers seeking to shape that context so that a sustainable engineering practice is possible. This involves understanding the wider social issues inherent in the design, choice, adoption and use of technology and the procedures for collective decision making including the role of law. Engineers need to understand how interests are generated and advanced to shape the public policy. This requires an understanding of power structures deriving from the study of sociology." Other theses have started from a similar perspective, while adding other requirements regarding the knowledge, skills, and attitudes that engineers need to possess in order to take up their part in the knowledge society characterized in 2.2 above, in such a way that there is a credible perspective of realizing positive growth potential for all world inhabitants.

The issues that were dealt with in the SIG D6 are closely related to professional development and knowledge management – and thus to the core of sustainability of competencies. The relationship is close especially with the values of effective knowledge management which, according to the organizational development concept Knowledge Management Dynamo, are openness and trust as basic values, and collaboration and sharing as operational values (see the outcomes of SIG D1).

As was seen above, one of the theses stressed the need for competent engineers to have an understanding of power structures deriving from the study of sociology. Other theses have presented arguments for the need to incorporate in engineering education deeper elements such as:

- knowledge of and critical reflection upon the procedures for collective decision making, the foundation and functioning of law, the functioning of hierarchical organizations, the theory of decision making under uncertainty, and game theory;
- knowledge of and reflection upon corporate social responsibility (CSR);
- analyzing the interests behind the codes of conduct;
- volition aspects in technology, i.e. ethos, attitude, pathos, will, underlying emotion;
- reflection on possible strategies to solve the global problems of our times (including sustainability);
- non-western philosophies, cultural values and norms.

All theses presenters agree that future engineers need to gain awareness about the societal impacts of their work, and need to be equipped with knowledge, skills and/or attitudes to render them capable for a socially responsible and ethical role in the global knowledge society characterized in 2.2. The deeper thought on elements described above leads to emphasizing the importance of technology assessment broadly conceived, i.e. including a critical assessment of the context in which engineering practice takes place and which will determine the ultimate impact of the work of engineers upon society. The results of such assessments should not be used by the engineering educators and the engineering profession only, but be actively used in society in general.
Teaching ethics is a challenge, as one of the theses stated "Students have an inherent conception of social responsibility before they begin formal education. This conception evolves and changes throughout the education programme and needs to be nurtured along the way." In European universities the way ethics is taught varies from specific courses on ethics and from ethics being an integral part of several technical courses, to not having any ethics taught to the students. The theses and their arguments include many ideas worth implementation such as devoting a part of graduation thesis on societal impacts, and defending the thesis along with its ethical elements in front of the thesis committee.

## 6.3. Universities facing new challenges
### 6.3.1 Globalization and ICT changing work culture

The development of new work and business cultures, along with more effective information transmission methods and the development of ICT-driven work methods has become a fundamental development trend.[45] The development of ICT has facilitated the effective networking of activities physically far apart. As a consequence of internationalization, different actors in the production of goods, services and information are increasingly focused on core competence and processes. Activities are constructed as value chains and value networks, and many support and other activities are outsourced.

The change in work culture facilitates new business structures and methods. The digitisation of information and the many-sided use of information networks and linked appliances enable change towards new communality and a networked, global working culture. Knowledge management is a fundamental part of every work community and of the activity of every information specialist. The success of individuals and the work community is based on the long-term increase of expertise, where the management of information, methods and processes is crucial. Creativity and fundamental knowledge acquire new importance. Business models and value networks have changed rapidly. Successful activity on global markets requires products and services to be tailored for different target groups. Communication networks

45 Efficiency and vitality in future Finland, Information Society Council, 2006

are crucial marketing and trade channels. Business becomes electronic business, new online shops come into being, and the need for new logistical solutions grows. Alongside mass production the demand for individualised products and services will drive decentralised and small-scale production, which will increasingly often be integrated into the global processes of mass production.

The following megatrends, which are focused on education and especially on competence development, are based on studies conducted within TKK Dipoli[46]:

1. Companies and communities operate more and more in global markets. An increasing part of their activities involves global value networks.
2. Labour markets become world-wide; knowledge work, in particular, becomes multidimensional and network-based.
3. Bologna process, Lisbon strategy, eEurope, EU i2010… in other words, EU-level policies have an increasing impact.
4. Complex systems become the basis of top products and production. Reaching the international top requires even greater investments than before. Quality is available, but its price is considerably higher.
5. Among different engineering and business tasks the ones with immensely growing demand are those focusing on innovation. Exploitation of technology and innovation becomes more and more important for success.
6. Differences grow. The global field has numerous sectors where the top level can be reached. Achieving results requires perseverance. It is based on quality, specialisation, innovations and ability to genuinely work and learn together.
7. Society emphasises the ageing citizens' motivation for working and learning.
8. The use of mobile information network, global digitalising media, leisure industry, simulators, open information sources, etc. gain ground in teaching and learning.
9. ICT increases information flow, but also enables high quality profitable knowledge management.
10. Motivation is a crucial prerequisite for learning. Active learning is much more than traditional participation in education. Active learning is strongly based on critical and constructive reflection. Learners dream of new experiences. The learner wants to get returns for the time and hard work invested in participating in CEE.

Globalization and ICT have changed the business processes very rapidly. The important role of e-learning in professional development can be understood by reviewing the on-going changes in work culture. The key success factors for working life are the knowledge capital of work communities, influenced by the systematic professional development, and self-renewal capacity of communities and individuals, and

46 Markku Markkula, A Lifelong Learning University, 26th EUCEN Symposium, Aveiro Portugal, 6-8 November 2003

also dynamic management of processes. Additionally, it must be ensured that in the workplace the best possible knowledge of communication technology is used efficiently and economically, and in such a way that the prerequisites for high productivity are met in all the central areas.

The change in work culture (Figure 3) facilitates new business structures and methods. The digitisation of information and the many-sided use of information networks and linked appliances enable change towards a new communality and a networked, global working culture. Knowledge management is a fundamental part of every work community. The success of individuals and the work community is based on effective knowledge management and long-term increase in professional expertise.

## Changes in Working Life and Productivity

Substantial improvements can be achieved with the help of mental processes and ICT. The aim of radically improving productivity can be met especially with the joint influence of the factors portrayed in the table.

| ***Issue*** | ***Present state*** | ***Target state*** |
|---|---|---|
| *Knowledge* | *General knowledge in common use* | *Goal-oriented competence development* |
| *Nature of work* | *Being at work* | *Goal-oriented working seen as a process* |
| *Work culture* | *Acting too much alone* | *Goal-oriented working and learning together* |
| *Information management* | *Information obtained for specific needs case by case* | *Actors' systematic command of knowledge management* |
| *Knowledge creation* | *Based on researcher's interests* | *Use of multidisciplinary developer networks* |
| *Structural thinking* | *Focus on own staff* | *Focus on own core processes and relational capital* |

*Source: Markku Markkula, TKK Dipoli 2005.*

**Figure 3: Changes in working life from present to target state.**[47]

The entity formed by the success factors is of crucial importance. To improve competitiveness and productivity the work culture should be chosen[48] as priority target for development. In this the focus areas are:

47 Markku Markkula, Document prepared for the Information Society Council, 2006

48 Towards a Networked Finland, The Information Society Council of Finland, Report, 2005

- Work community's culture of working together.
- Efficient utilisation of ICT and know-how that influences productivity.
- Work processes and process methods.
- Innovativeness, self-renewal and anticipation capacity of organisations and their management.

The desired work culture change can be carried out due to the remarkable development of in the last years. At the same time it is possible to instil the systematic utilisation of new software, device and network development into the practices of work communities.

### 6.3.2 Changing university culture towards knowledge universities

The knowledge society requires "knowledge universities" with a new institutional attitude. This development, however, is not easy in the classical, social or academic higher education institutions (HEIs). New roles, relations and value chains are needed and they must be defined and assumed in the next few years. The challenge translates into an enormous workload– the work only HEIs themselves can conduct and develop successfully.

The World Class Universities (WCUs) concept is a hot issue among the academic community. A new dimension in the classification process offered by the ranking concept could be the third mission. It is commonly accepted that a World Class organisation is "considered the best developing its main activities". Which are the main university activities that can be classified in order to determine "who are the best"? At least three fields should be pointed out: teaching, research and all the activities that are "beyond teaching and research". Humboldt defined in the XIX century the University as an entity that could develop "intellectual erudition" – that is research and "personal development through learning", i.e. from the academic point of view, teaching. Both activities have been considered essential and substantial to university's "main reason to exist", i.e. the university's missions. It is also a commonly acknowledged fact that the actual rankings try to measure this first and the second mission (teaching and research) development in WCU.

Henry Etzkowitz defined these two main activities as the "university's first and second missions"[49]. In addition the Universities are able to develop "3rd mission" activities, which cannot be considered neither teaching nor research. Independently of the predominant character of teaching and researching, most WCUs have undertaken other tasks that, although related, are separate in terms of context and results. These actions are included in a set that have different definitions like Etzkowitz's third mission, outreach or "Mode Two" Universities (Gibbons, 2000) or Universities third stream, as defined by the Russell Group. All these habitual terms do not have the

49 Etzkowitz, 2000

same meaning and coincide only in the aggregation of the activities that are extra to the teaching and learning. Does it affect the University World Class consideration to have third mission activities? How can these activities be classified? Which functions are addressed under the outreach approach? Is it possible to define a world class “rankings on third mission development”? Which kind of Units are used for developing the 3rd mission functions? How are these units organised in WCU? Which indicators are used to measure their level of “binding” functions? Which role do the Science Parks have in developing the 3rd mission framework?

Newspapers and journals all over the world try to orientate their customers every year with a titanic effort classifying parameters related to the first mission development. And related to the second mission, it is also commonly accepted (and of course contested and debated by those universities that are not present) that the well known “Shanghai Ranking” is a “second mission (research) ranking”. It is measured and classified according to classical parameters as representing excellence in the scientific production. These rankings represent the efforts to measure and classify the HE systems in the world to achieve World Class references and activities. Special attention will be given to the management models of the units that develop 3rd mission activities, their functions and the indicators used to measure their activities and the implications of rank under this perspective. There are several variables and indicators that could be applied to define a new approach that serves not only governments but also the industry in understanding which benchmarks are common in the WCU considerations.

Examples of activities of third mission represent an enormous diversity. They comprise several degrees of funding and of human resources. Continuing education and professional development courses, workshops and seminars are the most common projects that denote the intention of extending the service of universities to the public sector. Technology Transfer Units, Science Parks, Employment Bureaus and Entrepreneur Programmes for Student “start ups”, Internationalization of the University are part of these sets of activities. It is a natural evolution of the teaching role with the enlargement of the target population and diversification of curricula to establish non-traditional relations with the industry and the national and international institutions via this media. It is embedded in the idea of lifelong learning and regional development and it should also integrate some developments of the research outputs. Other activities of the third mission have social, cultural and political motivations. With a social initial background there are projects, for example, that are pointed at economic development, integration of minorities, acquisition of basic skills, environmental questions and healthcare services. The tasks of the third mission with cultural origins include, for instance, dissemination of research results, concerts, exhibitions, seminars, radio and TV stations, literary and cinema fora and international exchanges.

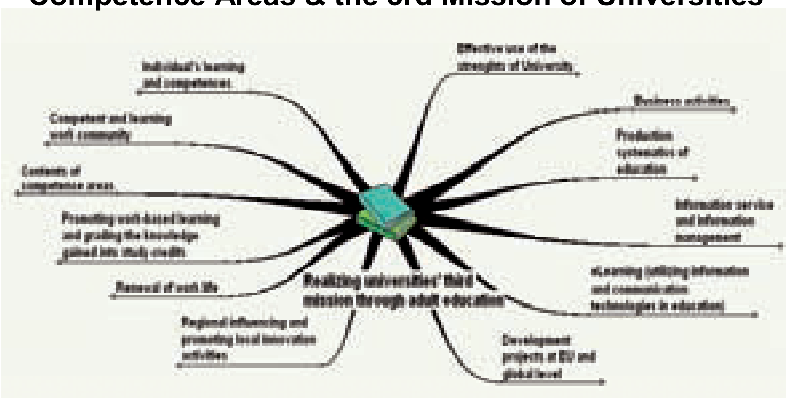
Several universities have taken an active role in their region. The outcome of SIG D5 (chaired by Patricio Montesinos) describes the need for modelling a new concept, the Regional System for Intellectual Capital management. Especially the universities of technology can, and they should, actively take responsibility for being an instrument for the regional innovation policy. Innovation and Knowledge management can be considered as two faces of the "same coin", two alternatives to solve the same problem, the need of the industry to develop strategic cooperation with universities in order to be able to respond to the challenges of the global economy. And those regional systems, the intellectual capital ones, can be considered as the regional elements of a national concept, the knowledge society. This is the environment where the "knowledge universities" must operate. At least six attitudes have been previously identified. The institutional attitude based on the majority attitude of its members can be "academic", "classical", "social", "oriented to projects", "entrepreneurial", and/or "innovative". The Knowledge University is a complex concept. It is an attitude towards an active innovation policy which is based on a permanent well-functioning coordination inside the university focusing on the four basic products of the HEI:

- R+D+I (research, development and innovation),
- Continuing Professional Development (CPD or continuing education),
- Entrepreneurial attention (spin-off programmes and/or entrepreneurial support services) and
- Employment services (from undergraduate stage to working life practices).

The real challenge to universities is that the coordination of different activities is not enough. Professional leadership using the best methods of business and innovation management is an essential success factor of modern universities.

The following figure 4 gives an overview of the different competence areas which are needed to cover in operating as a CE provider when taking care of the third mission of universities.[50]

**Competence Areas & the 3rd Mission of Universities**




Each of these 12 competence areas includes as an average 4 x 3 more detailed competence areas. This means that in the detailed Mind Map we have defined approximately 150 competence areas which need to be covered in organizing effective CEE in answering the challenges of the 3rd mission of universities.

**Figure 4: Competence areas needed to cover the broad spectrum of the third mission activities**

50 Markku Markkula, Document for UCEF University Continuing Education Network Finland, 2005

### 6.3.3 Broad-scale responsibilities

Lifelong learning is a guiding principle in sustainability for both individuals and communities. Furthermore, it is a guiding value base for society, and universities as part of society, as well as for education policy planning and implementation. Learning is seen as a continuum covering the individual's entire life span. All forms of learning and all learning environments enabling learning are included.

Universities have developed different forms of CE to meet the challenges of society and especially the needs of the engineering profession and other knowledge workers. As means to reach the desired development level, courses and programmes are, however, not effective enough. Universities need experienced brokers of societal development and change agents who operate at the forefront of international development of learning innovations. This means that traditional continuing education centres in many countries have developed their working processes to be built more than before on the business basis. Thus they no longer act only as providers of short courses and supporters of continuing professional development.

The first step in assuming broader responsibilities has often been to become a developer and an organiser of university degree education, when operating with students working on a part-time basis or with adults in general.

This broader responsibility is based on defining the role of the CE provider as a unit to support effectively the distribution of university-level knowledge and know-how and as a developer of effective methods of knowledge dissemination. ICT is often the driver of change. In many cases CE centres in universities are active developers of e-learning, network-based working methods and the virtual university concept within the entire university system.

As part of their third mission, universities need to be organisers of innovation policy activities in society in general and especially in the regions where the university operates. Effectiveness in these activities necessitates high-level professional competence. Traditional administrative help is not enough. Instead, the support needed is most often organised through CE centres or other units specialising in innovation management, including IPR and other contract services. In the future universities are likely to become experts in developing workplace learning and acknowledgers of learning-by-doing and other forms of recognized learning performance.

These activity areas are so broad and demanding that the leadership and management processes of the university and its continuing education have to be planned using the best business theories and experiences. A simplified frame of strategic thinking is described in Figure 5.[51]

51 TKK Dipoli, Strategy Process, 2007

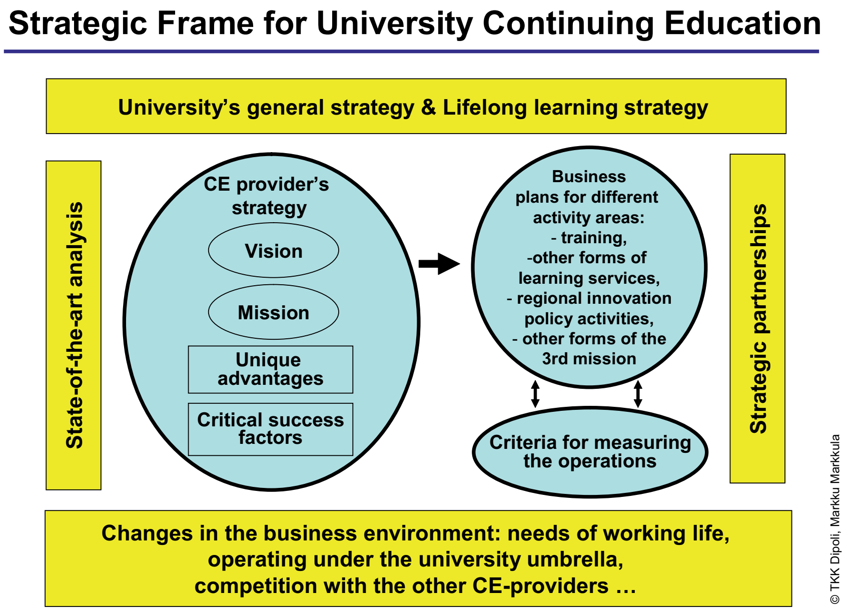



**Figure 5: Strategic frame for university continuing education**

As and example of the new responsibilities the universities are working on, TREE has through the work of SIG D4 (chaired by Hannu Peltola) tackled the latest European development in the area of e-learning focusing especially on virtual university development. The summary of the case studies, as a result of the work, is included in the CD-rom. The results show, among others, that the desired change means long-term commitment to the collaboration of universities. The outcomes are, however, reached only by means of the paradigm shift of working habits on a grassroot level, i.e. professors and other lecturers need to change their whole teaching process. The focus should no longer be on lecturing, but instead on preparing interactive learning material together with other knowledge experts within the subject area, and on sharing experiences and developing their teaching methods to facilitate effective learning. The most critical success factors are the commitment to joint forces through teaming up based on sharing and trust, and effective support services including concepts for IPR contracts, platforms and software for joint ICT-based document production, and well as structured knowledge sharing databanks. The experiences from different countries show that the developments and, as a result of that, the differences between universities are enormous.

## 6.4. Effective continuing education management
### 6.4.1 Managing change through learning

The necessity of lifelong learning is not merely a matter of political will. It involves more aspects than the will to enhance the civilisation of all the citizens. It is also a question of changes in the working life and the challenges business enterprises have faced in the 1990s. The entire industrialised world continues to live in an extremely rapid pace of change. Parallel to the persistently high unemployment rate, many areas of the European industry are suffering from a tremendous shortage of skilled employees. Primarily, the problem lies elsewhere than in inappropriate basic education. The skills and knowledge of those employees who have been engaged in working life for a long time are not sufficient for more demanding tasks. On the other hand, the basic education of children and young people does not sufficiently encourage them to find out how they should learn to learn.

Linking work and learning closely together along with the changes in the educational system from teacher-centred instruction to active learning seem to be the solutions. We need to recognise the entire educational system. The basic education and ordinary work experiences are no longer enough. The need for a paradigm shift in competence development was clearly seen in the 1990s. The following trends have increased the need for lifelong learning, in-service training and systematic adult education[52]:

1. The ever increasing amount and speed of knowledge forces all individuals to develop their abilities in both acquiring and managing information and knowledge.
2. International co-operation in the information field and global information systems together with user-friendly personal information systems give people a better chance to use their human resources for more productive activities.
3. In the “shrinking” world, it is more difficult for businesses to find growing markets for their products in emerging areas. Consequently, they have to specialise in products which meet the real needs of their customers and which are often more complicated than before.
4. Due to the growing complexity of product development, profitability necessitates teams that are more and more versatile and can change their composition flexibly. Small units in charge of several concurrent projects are needed.
5. As for individual work tasks, they seem to develop in two directions. Firstly, the specialised new tasks require the ability to solve difficult field-specific problems. And secondly, individuals must be able to accomplish tasks requiring “soft” skills in order to secure their employability.
6. As regards organisations, the work processes are becoming more demanding. Sharing the knowledge needed in these processes is a key to success. Mutual understanding is needed between

52 Markku Markkula, Document prepared for EUA European University Association, 2001

the top management and the employees. The managers must allow people to take responsibility for their jobs and to enjoy the work they are doing. Mutual trust, encouragement and effective communication are key factors on the way to success.

It is primarily the working life that has to face these six challenges. There is a most urgent need for a system of professional development activities, which would be part of everyone's working task and a way of taking responsibility for their own employability. Naturally, it is not possible to ensure long-term results until positive learning attitudes become so prevailing in society that lifelong learning is a principle guiding all action.

To be able to define in detail the role and responsibilities of universities with respect to these challenges it is important to link the needed analyses to reviewing the changing requirements of the engineering profession. According the studies carried out by the Finnish Association of Graduate Engineers TEK[53], the following fundamental abilities and skills need to be highlighted:

- Self-knowledge: Know your role in the big picture and develop it. The first step for efficient team work and partnerships.
- Ability to love: Being passionate about whatever you work on.
- Ability to trust: The only way to foster knowledge is by sharing it.
- Ability to empathy: Depending on the actions taken, globalization increases polarization or increases global well-being.
- Being unprejudiced: Having a degree doesn't guarantee anything. A 12-year old might be more skilled than you are.
- Creativeness: Look for solutions out of the box.
- Multidisciplinarity: Seek structural holes. Ability to combine technological and social excellence.
- Multicultural: English is no longer a foreign language.
- Networking and team work: Seldom is one individual able to accomplish world-class innovations.
- Communication skills: In a multidisciplinary, multicultural global village this is a must.
- Entrepreneurship: As a mind set and profession.
- Systematic learning skills: Ability to see learning situations everywhere. Ability to build on the existing knowledge and skills.

An element to be added to this list is, as a result of the report of SIG D6, ethics including ability for critical reflecting.

53 Kati Korhonen-Yrjänheikki TEK, Anticipating changes in the environment, labour market and society, SEFI CEE Working Group seminar, Tallinn Estonia, 17 December 2004

On the overall level this listing is feasible for anyone pondering on the challenges posed by working life and engineering education and developing measures to help meet the challenges. The application of this list is naturally not only restricted to university education, but instead serves as a kind of platform for all learning, i.e. the entire education system, including on-the-job learning and other forms of continuing education.

Universities can play a key role in meeting the CE needs in knowledge society by understanding more deeply than before the starting processes of new visionary knowledge and knowledge creation. This means that they should develop efficient implementation concepts of adult education, and methods to manage these concepts. Another important cornerstone for their role is that CE should concentrate on universities' international knowledge flows, and by the help of this, develop working life practices.

When the target is to increase the engineering competencies and through that the quality and productivity of the work, the university top management, as well as the continuing education providers, have to understand the paradigm shift, which is a consequence of working life development and can in brief be characterized by the following three features[54]:

1. A company or any organisation is no longer a fixed system like it used to be.
2. The focus of all knowledge-intensive work is on value. In practice the focus is on new knowledge-focused processes which are on a constant change. Processes are collaborative with cross-boundary interaction and thus the need for creating a shared knowledge reality is of special importance. Processes are based on strong mental networks with a shared purpose and thus strategic partnerships are a cornerstone for success.
3. Networks are more and more operating virtually with shared knowledge management methods.

This all means especially dramatic changes in work culture and performance measures throughout the working life. This all gives universities special advantages to develop and manage top-quality CE products and services. The advantages of universities are that they operate close to the latest research results, and with the experts of knowledge management.

### 6.4.2 Strategic development of university CE

The following list is based on the analyses of the latest business life development and is applied to the strategic development of university continuing education:

54 Markku Markkula, Strategic Planning, SEFI CEE Working Group seminar, Uppsala Sweden, 10 – 12 December 2003

1. Recent industrial development forces universities to understand their role in lifelong learning in a new way: Individuals, communities and societies will develop successfully only with the help of a joint profound system of professional development. Universities should move into lifelong development of the engineering profession in general, and inside that focus and plan their activities towards specially defined customer segments, as well as tailor-made learning processes for companies and other work organisations.
2. Strategy-level core questions for universities in organising CE are: What is the added value you produce that others do not, or even better, cannot produce? How do you develop your work processes in implementing your strategy?
3. The process of producing added value permeates everything: University CE centres should choose a strong added value that suits their university, produce this added value, adopt this added value as the core of all their actions, and as the core of their image.
4. Understanding the operational logic of value chains: CE should change their basic strategy from the use of good lecturers and subcontractors into facilitating learning and professional development through genuine partnerships.
5. CE production system is based on different kinds of high-level training products, not just traditional courses which are mainly based on lecturing. Focus should be more on customer-oriented marketing. It replaces product-based marketing.

The Figure 6 forms a strategic starting point in deciding where to focus the change activities needed in developing CE.[55]

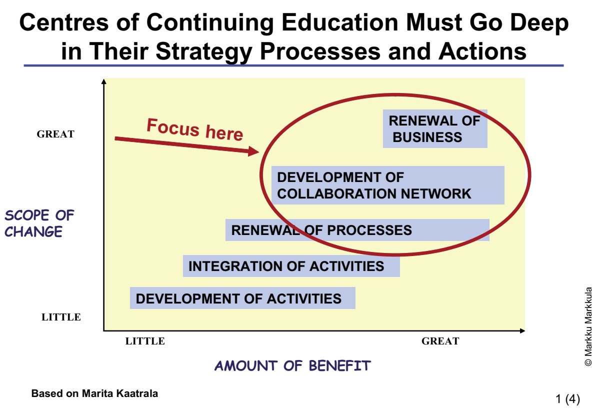



**Figure 6: Focus options for the strategy processes of CE Centres**

55 TKK Dipoli Strategy Process, 2005

Focusing on the unique advantages the universities have, the role of their continuing education must be enhanced in view of performing especially the following basic tasks:[56]

1. To develop and maintain mechanisms for the dissemination, transfer and internalisation of university-generated knowledge, and to develop and maintain knowledge management methods so as to enable the generation and use of new knowledge in all working life sectors.
2. To develop and maintain professional development systematics based on collaboration between various education and training providers, so as to enable the provision of high-quality modular training for the various occupational groups in all sectors.
3. To process the knowledge people produce in their own universities and knowledge-generating institutions into a form suitable for practical professional use as teaching material, in a way that enables the various instructors and teaching support personnel to use it economically in their own work.

### 6.4.3 Work-Based Learning and Facilitated Work-Based Learning

Work-Based Learning is an approach which focuses upon the practical utility of learning and is therefore directly relevant to learners and their work environment. A WBL approach to learning acknowledges that learning can take place in a variety of situations and settings, and is not restricted to settings developed through the classroom or lecture theatre. All WBL programmes utilise a range of tools to aid and enhance learning - including lecture sessions, workshops, tutorials, learning sets, and online guided learning activities. This 'blended' learning approach enables WBL programmes to be tailored to student needs and preferences, whilst still operating within an academic framework. WBL is a practical and successful way of creating University-level learning that is directly related to the workplace[57].

Universities must learn to be able to meet the organisation and the learner on their ground. Universities must be able to understand the role of the learning process in the industrial productive process, the role of new knowledge, the sharing and implementation of new knowledge in the learning organisation. This also means that Work-Based Learning cannot be planned and prepared in advance. Universities and university faculty must be flexible and ready for ad hoc programmes. A major role for faculty is to facilitate the learning process rather than lecturing. This will also be a new task for faculty from most universities with traditional course-based programmes.

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56 Parliamentary Adult Education Committee, Finland, Report, 2002

57 Margaret Gibbons, Leeds University Business School http://lubswww.leeds.ac.uk/wbl/index.php?id=77

Work-Based Learning begins with the learners and their workplaces, and end with the university – in contrast to more conventional university courses, which begin with the university and its conceptions of what is legitimate knowledge, before moving to the workplace and the learner[58].

Work-Based Learning programmes will normally be individualized programmes based on the learner's individual needs, interests and prior knowledge. Unlike more conventional university programmes, WBL programmes will follow a more customized approach. This also means that they cannot be planned well in advance, and not solely by the faculty. The learner and his/her organisation must be involved in the planning. The programme must accept that the learner is involved in a work situation where learning will only be part of the job.

The first step in defining the WBL learning programme is to identify the goal and the learning objectives for the individual learner. By definition a WBL programme will always be based on a planned learning outcome[59]. As the programme is going to be assessed by an educational institution, the terminology to be used is defined by this institution in terms of assessment criteria. The learner, the company and the university must now agree on how to reach those learning outcomes, which work tasks the learner must go though etc.

In WBL programmes the learner is expected to learn from his workplace. The workplace is expected to hold the knowledge and support the learner in the process to learn and obtain a Degree. WBL is thus characterized by focus on the learner, and his personal and professional development is also supported by the workplace.

Facilitated Work-Based Learning, on the other hand, focuses on bringing new knowledge to the workplace and bring this new knowledge into application in the organisation. The learner will obtain new knowledge and bring it to the organisation, facilitated by the university partner.

Consequently, the aim of the FWBL methodology is:

1. To facilitate knowledge transfer to the busy employee in the industry without necessarily having to reserve time for participation in traditional taught courses.

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58 David Boud and Nicky Solomon (Eds.): "Work-based Learning – A New Higher Education?" SRHE and Open University Press, 2001, ISBN 0 335 20580

59 Scottish Centre for Work Based Learning, Glasgow Caledonian University http://www.learningservices.gcal.ac.uk/scwbl/about.html

2. To integrate new knowledge directly and for immediate practical use to the employee in his/her job function.
3. To plan a learning process matching the competence development strategy of the enterprise.
4. To tailor-make the learning process to the individual employee.
5. To schedule the learning process to match the specific project in the enterprise.
6. To use the experiences from the on-campus problem-based and project-organised learning model.

Cooperation between faculty and workplace supervisors is very important and should be mentioned in the learning contract. Focus on quality is a crucial point: Will all university teachers be able to do this, and do we have quality of service of education methods adequate for this? Faculty must also be able to accredit and acknowledge learning taking place at the workplace. Will this learning be accepted at the same level as traditional academic knowledge, will the learners learn the right things, and can we grant a Degree on that background? These questions are still important for many academics who fear that the level in general will be lower in (F)WBL programmes. More of the WBL and FWBL is described in the outcome report of SIG D8 (chaired by Flemming Fink) in the TREE CD-rom.

### 6.4.4 Successful ICT-based CE

Integrating ICT into continuing professional development broadens the opportunities for innovative, more flexible forms of learning, thus enabling the education to a larger target audience.

Lifelong learning courses or programmes that make use of ICT to support the learning process have distinguishing features as compared to more traditional courses. Course developers should be aware of these distinctive characteristics and make the right choices in the creative process.
Derived from the experiences learned through several defined and analyzed good practice examples, and bearing in mind organisational, technological and pedagogical critical success factors when implementing ICT in CPD, the following ten guidelines aimed at course developers experimenting with ICT were identified:

1. When selecting the appropriate mix of technologies for the course, make sure to test and evaluate their different types. Experience shows that technologies that work in one course format are not always the best option for another course. It all depends on your course content and course participants and is hence very context dependent.
2. ICT-based training offers a great opportunity to form inter-institutional partnerships. Be aware, however, that the quality of the offered training depends greatly on the strength and motivation

of the partnership as a whole. Therefore, make sure to select the members of your partnership carefully and invest enough time in the maintenance and sustainability of the partnership in order to achieve satisfying results.

3. Don't forget to evaluate your course. Course evaluation is an important factor, as it helps you to assess the success and impact of the tools used and teaching methods applied.
4. The use of ICT inherently contains risks. Try to foresee technical problems when using ICT in your course by providing back-up material.
5. Lifelong learning training is often a unique opportunity for establishing networks of professionals among the teachers and participants. ICT tools create new opportunities for networking after the training has ended. If this is one of your aims, don't forget to incorporate (virtual) follow-up activities.
6. Not only virtual follow-up activities, but virtual preparatory activities as well might add value to your CPD course.
7. In theory, completely ICT-based courses can contain all the elements needed in order to give successful training. Practice, however, has taught that the human factor cannot be ignored and that a lot of initiatives opt for a blended activity in which virtual and face-to-face elements are combined.
8. ICT-based course developers should always keep in mind the target group. Especially the factor of existing background knowledge of the participants will have a distinctive impact on the pedagogical approach.
9. As the ICT-sector evolves at a rapid pace, there is a necessity for continuously updating your course.
10. Try to attract the right focus group to your CPD course, by stressing the advantages of the use of ICT, such as flexibility.

The outcomes of this topic which was analysed by the SIG D2 (chaired by Wim van Petegem) can be found from the TREE CD-rom.

### 6.4.5 EFQM Quality Management in continuing education

The European Model of Excellence, better known by the abbreviation EFQM which corresponds to the foundation which developed it (the European Foundation of Quality Management), is a practical tool which helps organisations to determine at what point they find themselves on their way towards excellence. The EFQM model is described in Figure 7.

The self-assessment process offers the organisations the opportunity to know about themselves profoundly, to learn more about the organisation's progress and to compare and share information and experiences with others. There is no enhancement without knowledge.

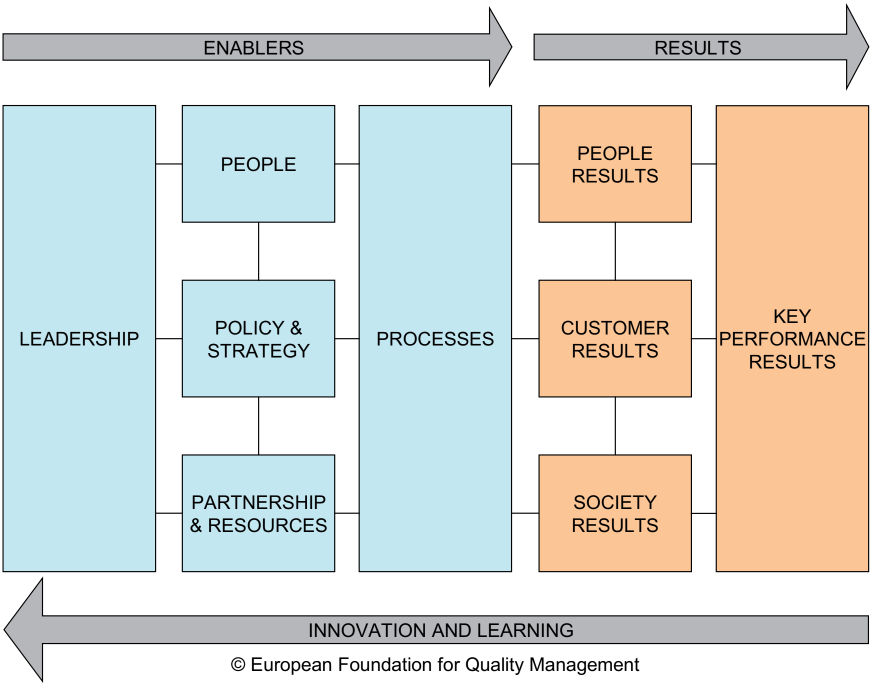


**Figure 7: EFQM model**

The EFQM model centres its attention on nine criteria which are considered fundamental to the pursuit of excellence in an institution. These criteria are divided up between five Enablers and four Results. The 'Enabler' criteria analyse what an organisation does, how it carries out its key activities. The 'Results' criteria cover what an organisation achieves. Each of the nine fields is subdivided into a certain number of sub criteria. The International Association for Continuing Engineering Education IACEE and several of its member universities have implemented and further developed the EFQM model. The DAETE project[60], partly funded through EU/US Atlantis programme, is using the following definitions of the enablers.

60 DAETE – Development of Accreditation in Engineering Training and Education, project in the EU/US Atlantis programme

*Leadership*

Excellent Leaders develop and facilitate the achievement of the mission and vision. They develop organizational values and systems required for sustainable success and implement these via their actions and behaviours. During periods of change they retain a constancy of purpose. Where required, such leaders are able to change direction of the organization and inspire others to follow.

*Policy and Strategy*

Excellent organizations implement their mission and vision by developing a stakeholder focused strategy that takes account of the market and sector in which it operates. Policies, plans, objectives and processes are developed and deployed to deliver strategy.

*People*

Excellent organizations manage, develop and release the full potential of their people at an individual, team-based and organizational level. They promote fairness and equality and involve and empower their people. They care for, communicate, reward and recognise, in a way that motivates staff and builds commitment to using their skills and knowledge for the benefit of the organization.

*Partnerships and Resources*

Excellent organizations plan to manage external partnerships, suppliers and internal resources in order to support policy and strategy and the effective operation of processes. During planning and whilst managing partnerships and resources, they balance the current and future needs of the organization, the community, and the environment.

*Processes*

Excellent organizations design, manage and improve processes in order to fully satisfy, and generate increasing value for, customers and other stakeholders.

The self-assessment matrix is an adaptation of the five enabler criteria to the university continuing education organisation and processes. Each sub-criteria is divided into as an average to five levels of development with the following meaning:[61]

Level 1: Quality depends on individual initiatives and is not globally programmed in the centre. No policy, only ad-hoc reactions. No measurements.

Level 2: Starting the attention for processes: The responsibility for the actions is no longer individual and became joint responsibility inside the centre. There is some short-term planning.

61 Patricio Montesinos, UPV

Level 3: Quality Assessment: There are rules, procedures or policies settled down and well known for everybody. There is medium-term planning. Processes are defined.

Level 4: Systematic evaluation and improvement of processes: The main aim is to constantly anticipate the needs of the beneficiaries and avoid complaints. There is a real client orientation. There is a medium-term policy with clear objectives and results of measurements.

Level 5: External orientation of the excellence: There is knowledge exchange not only inside the centre but with other external contacts (professionals and competitors) as well. External people are concerned in the establishment of the processes. Entrance into partnerships. Comparisons with other centres.

One of the outcomes of the SIG 5 (chaired by Patricio Montesinos) is the EFQM model applied to CE. This is in more detail described in the TREE CD-rom.

## 6.5. Towards sustainability of competencies by using the European Qualifications Framework

The EU Commission has already for several years declared that education and training are critical factors for achieving the Lisbon strategy objectives of raising economic growth, competitiveness and social inclusion. However, adult education has not gained the recognition it deserves in terms of visibility, policy prioritisation and resources, notwithstanding the political emphasis placed on lifelong learning in recent years.

The EU Commission adopted in September 2006 a proposal on the establishment of the European Qualifications Framework for lifelong learning (EQF). The EQF will provide a common language to describe qualifications which will help Member States, employers and individuals compare qualifications across the EU's diverse education and training systems.
The core element of the Framework is a set of eight reference levels describing what a learner knows, understands and is able to do - their 'learning outcomes' - regardless of the system where a particular qualification was acquired. The EQF reference levels therefore shift the focus away from the traditional approach, which emphasizes learning inputs (length of a learning experience, type of institution). Shifting the focus to learning outcomes:[62]

- supports a better match between the needs of the labour market (for knowledge, skills and competencies) and education and training provisions;

62 EU, European Qualifications Framework, MEMO/06/318, 05/09/2006

- facilitates the validation of non-formal and informal learning;
- facilitates the transfer and application of qualifications across different countries and education and training systems.

The ongoing development work will enable individuals and employers to use the EQF as a reference tool to compare the qualification levels of different countries and different education and training systems, for example vocational training and higher education. The EQF will function as a type of translation device to make relationships between qualifications and different systems clearer.

The importance of lifelong learning is clearly seen and stated by the EU and national governments. The development means systematic reform processes, mainly due to the changing profile and needs of learners. The cornerstone of the ongoing development is a growing trend to recognise learning which has taken place in less formalised environments, creating new challenges concerned with how learning is assessed and validated and by whom. This development increases the need for improved learner support mechanisms, including the provision of information about learning opportunities, and guidance and counselling to assist learners to make suitable choices. National Frameworks all facilitate and encourage increased lifelong learning. Important elements of these Frameworks are credit accumulation and transfer. The change is towards an approach based on learning outcomes and the recognition of non-formal and informal learning. International benchmarking shows that these are the elements necessary for encouraging lifelong learning. In most European countries a lot of effort is needed to create common procedures to validate informal and non-formal learning outcomes. In engineering the focus of new procedures is especially in linking work and learning closer together.

The EQF makes it possible to create an adult education system motivating individuals to determinedly and continuously develop their professional competencies. What is decisive is the principle that no attempts are made to fit adult learning and the evaluation of learning outcomes into the traditional education system designed for adolescents. If and when Europeans decide to genuinely enhance the competitiveness of working life, innovative solutions must be found on the basis of the needs dictated by working life and on the terms suitable for those engaged in working life.

From the viewpoint of the individual, this calls for agility on the part of the system. It must be possible to connect learning to one's own professional aspirations and development of work processes and to extend learning over several years, at times by acquiring plenty of credits and at other times by allocating only little time to studying. Efficient learning requires also a methodical and individually designed study and learning plan.

The measures taken by a company or other such an employer are, on their part, decisive also when securing the prerequisites of the targeted degree-oriented studies. Most often, the company pays for the course fees induced by continuing education and enables the effective integration of work and studies; in other words, it must be possible to adjust work tasks so as to support studies and in work tasks challenges and problems should be examined persistently beyond the interests of the succeeding quarter or even years. It is quite often that a company allows for part of the working hours to be spent on reading and drawing reports.

Universities are to create such a degree system meeting the needs of the working life and those engaged in working life that operates with agility in each situation at hand and facilitates the adjustment of study attainments individually. The SIG D8 Work-Based Learning report depicts important principles and practices. As the learning objectives are not identical with those in degree education targeted to adolescents, also the objectives set for the degree differ. Still, no less is required of degree quality. The essential aspect is that learning objectives are defined by taking into consideration the individual's work experience and work tasks. Part of the studies can serve work objectives directly and contribute to the work itself, as long as learning is evaluated e.g. by means of a learning report serving as a credit requirement. The main emphasis in learning contents is not so much on scientific theories as on their application. Theories, however, cannot be forgotten, but instead one should learn to search for them through the diverse information sources, and above all, one should learn to use them as arguments for application.

Those with extensive experience from working life do not often require a degree certificate in order to prove their formal competence in relation to a certain task. On the contrary, their tasks challenge them to update and upgrade their own expertise as well as make is necessary to provide evidence to their current and new employers indicating that they master the most recent knowledge in their field and are active in enhancing their competencies. Individual course credits do not sufficiently serve this purpose. The value of university-provided continuing education certificates is growing along with the competence needs of the working life. But the certificates must verify the level and scope of the studies in terms of ECTS credits and/or student learning hours. Typical examples of studies connected closely to working life are the MBA degree and different Professional Development studies.

The learning requirements set on the various levels of studies require the definition of uniform principles to be used and relied on throughout all the universities. The CLUSTER-network[63], a consortium of several top-level European universities, has started the work to define what certificate, diploma and master's level

63 CLUSTER - Consortium Linking Universities of Science and Technology for Education and Research, www.cluster.org

education systems mean in the continuing education framework and which are the requirement criteria for courses and programmes in each of these levels.

In general the definitions made for traditional university studies can be applied also to continuing education. Among the outcomes of SIG 7 (chaired by Seija Hämäläinen) are the guidelines for the adult education concept, targeted especially to those who already have a university degree but which, however, is outdated.

Their professional competence necessitates the attainment of even several university-level degrees during their business careers. However, it is not appropriate to make the degrees identical with those of adolescent years, when the essential skill involved acquiring mathematical-scientific ability to think. Especially in engineering fields where the technological information renews extremely fast and where the work tasks require the acquisition of the latest university-level knowledge, new types of degrees leaning on on-the-job learning are needed, and it is natural to base the definition of their level requirements on the EQF standards.

CHAPTER 7

# The Glossary of Terms and the Guide of Engineering Schools in Europe ■

*by Gunter Heitmann*
Leader of Special Interest Group A6 of TREE

## 7.0 Tools: The Glossary of Terms and the Guide of Engineering Schools in Europe

One main aim of TREE was the provision of tools to contribute to the improvement of engineering education in Europe and to facilitate transparency, recognition and mobility. Two genuine tools and outcomes of TREE are the "Glossary of terms in Higher Education" (SIG A6) with particular emphasis on engineering education and the "Guide to Engineering Schools in Europe" (SIG A7) with a focus on the respective Higher Education Institutions (HEI) and their programmes in the various branches and specialities of engineering.

## 7.1 The Glossary

A widely accepted and broadly used glossary promoting a common language and understanding in the respective areas of Higher Education in Europe is a tool for a wide variety of target groups and potential users, comprising the members of TREE and the respective Thematic Networks, the Higher Education Institutions, European and national bodies, associations and professional organizations as well as students and teaching staff. Already in the frame of the Thematic Network E4, the predecessor of TREE, a glossary of English terms was developed and published, enlarged by a few descriptions of national engineering education systems and the awarded degrees and titles in the original language. As the Bologna Process at that time (2002 to 2004) had just started in the majority of involved signatory countries it turned out to be quite difficult to provide the most recent state of the art concerning old and new degrees and titles. Also with regard to shared English definitions of terms used within the Bologna Process documents and activities, the work was at the beginning. An official Bologna Process Glossary in English did not exist. Meanwhile various activities have been undertaken from different authorities on the European and on national level to arrive at shared definitions, explanations and a common language. The most prominent examples are the Eurydice glossaries, the glossaries of the ENIC-NARIC networks, the one of UNESCO-CEPES and, last but not least, CEDEFOP. A kind of "Bologna Process Glossary" - even if still not of an official and commonly agreed status - is available at the Bologna Process web-sites. Focused



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definitions of terms have been also provided in the context of different Conventions, the Bologna Process Communiques, Bologna seminar papers and EU Directives as well as various EU Thematic Networks like e.g. the "Tuning"- project.

However, the most recent Trend Report of the Bologna Process (Trend V), submitted to the London Bologna-Follow-up Conference in 2007, stressed the fact that a broad dissemination and shared understanding of terms is not yet achieved and that "the "Bologna" terminology is applied locally in a manner which may not be immediately understood from outside the particular system. Implementation of what appears to be a single European process is thus altered by the variety of national contexts in which the reform is taking place. An additional cause of this problem is no doubt that the "Bologna language" that is spreading across Europe is developed within an overly restricted circle of "European specialists", with not enough attention being paid to the process of dissemination of ideas. As one of the purposes of common terminology is to increase understanding and transparency, this is a serious issue in looking how systems and institutions relate to each other, and one which has perhaps been underestimated" (EUA Trend V Report, 2007, p. 22).

In addition, ENQA, the European Association of Quality Assurance in Higher Education, has stressed the problem of using English as the primary common language. "Many of the difficulties in communicating ideas, processes and procedures about quality assurance amongst ENQA members result from both the number of languages used by them and, in particular, the consequences of English having been adopted as the common international language for the purpose. Many terms used in quality assurance do not easily translate from English into other European languages and vice versa. The use of English as the 'mediating' language between others can also give rise to misunderstanding and even a misplaced sense of effective communication.

There have frequently been calls for the development of authoritative and comprehensive 'glossaries' of concepts, words and terms used in quality assurance in Europe, but these have invariably proved to be of limited value because of the difficulty in agreeing the meanings of the concepts and words themselves in English. The consequent lack of a shared linguistic understanding is one of the major stumbling blocks to the full development of the European Higher Education Area, at least in terms of shared values for quality assurance" (see: ENQA Workshop on the Language of European Quality Assurance, 29-30 June 2006).

The workshop commenced by ENQA in 2006 has tried "to help participants to gain a confident understanding of the range of meanings of relevant English words and phrases used in quality assurance and to relate them more firmly to the corresponding words and phrases in their own languages and also to place these words and phrases in their theoretical and operational contexts".

Aware of the outlined difficulties the TREE Special Interest Group on the Glossary of Terms has tried to arrive at definitions of terms in English which hopefully can be shared by native speakers and the respective international community dealing with higher education issues, in particular the members and contributors of the related Thematic Networks themselves. Wherever possible, the TREE - Glossary refers to definitions of terms as agreed on in relevant European contexts and projects or as offered by world wide recognized dictionaries. A list of references with the appropriate links is attached as an Annex to the Glossary as well as a list of relevant acronyms. Only in cases where agreed definitions have not been available or where different meanings can be connected with certain terms, the TREE - Glossary proposes its own definitions focused on meanings agreed on and used by the various Special Interest Groups of TREE and by projects like "Tuning" and EUR-ACE. However, the TREE - Glossary reflects the "state of the art" in 2007 only and needs to be continuously up-dated and enhanced. An unsolved problem are consistent and comparable glossaries in languages other than English. Many countries have started to develop glossaries of terms related to the Bologna Process in their own languages. Also the official translations of Directives and documents of the European Union contribute to the development of a common understanding and use of terms. Hopefully the TREE – Glossary, with a particular focus on engineering higher education, will facilitate this process.

## 7.2 The Guide

Transparency is one of the prerequisites for mutual recognition in the European Higher Education Area (EHEA) and for the promotion of mobility of students, graduates and staff as well as for the promotion of enhanced collaboration of the Higher Education Institutions. The Bologna Process, aiming at common reference structures for the EHEA, a convergence of the various national higher education systems and - in due course - a strengthening of diversity, has for the time being created a sometimes confusing variety of new study programmes and degrees alongside with still offered or only by and by closed traditional programmes. Students interested in going abroad, HEI facing the need to recognize modules, programmes and degrees from foreign countries and persons interested in collaboration with colleagues from other HEI, are looking for reliable and most up to date information.

Information about study programmes is primarily available on national level and offered either in printed form or published in the Internet, the latter being more an more common. Most institutions give more information in the net than one can get printed, increasingly not only in the home language but also in other languages, preferable in English. On this institutional level there exist in the European Union (EU) many thousand different home pages in the web which inform applicants about the various study programmes, including on engineering. Users who are interested in a special engineering study programme have on this level only a very small chance to find an adequate engineering school of their interest. Therefore in most countries of the EU, governmental and also non-governmental organisations have edited national study guides to state driven and in some cases also private institutions, which offer study programmes at a university level. For example in Germany you may find at least 25 different study guides which lead applicants to all or to a part of engineering schools and only a few of those study guides lead an applicant to all engineering schools in Germany. It is therefore in the interest of engineering schools in Europe that there will be an internet portal that leads applicants to potentially all engineering schools in Europe. Attempts have been initiated to arrive at a European platform in the frame of EURYDICE and recently with the new platform "PLOTEUS". However, it is still difficult, or at least time consuming, to go for a focused search: you are often guided to information sources of different content and quality and not comparable to each other.

The project "Guide of Engineering Schools in Europe" aims at providing in an easy way objective information of applicant students or other interested users on engineering schools everywhere in the European Union and in affiliated states. The basic idea is to build up a guide which guides the applicant to all relevant study programmes of his or her interest. The proposed and implemented result is a guide of engineering schools which uses existing information sources and gives applicants information how to use relevant special guides to engineering study programmes in Europe. In short form, the main outcome can be described as a Guide To Guides (GTG). One main advantage of such a GTG will therefore be that it is always up to date, at least as much as the guides supported by the national or institutional providers are.

This GTG is realized through a software programme which uses PHP and a data base with data management system embedded in an html-programme. As a result, a website is offered where one can interactively find a suitable Engineering School which fulfils special wishes, e.g. for studying in a particular European Engineering School or even a special engineering study programme. The GTG may also be copied to a CD-ROM with the three interactive Internet pages. To use the data base you have to have an Internet access.

The basis for building up as well the GTG as selecting adequate guides is the Catalogue of Questions and Criteria (CQC). The catalogue has nine different main fields of possible interests and questions concerning the choice of an engineering study programme. From different study guides, from discussions with applicants and with student advisers the following main categories and levels of interest have been deduced:

| | | |
|---|---|---|
| Subject of study | Type of study | Type of degree |
| Type of university | Language of study | Place of study |
| Social/cultural criteria | Scholarships/grants | Costs |

Beside these questions and criteria on the main level, there are two subsequent levels with more differentiated questions and criteria. This part of the CQC may easily be changed depending on experiences with the GTG. At the current level of realisation it has the following structure, including the main level:

Level of interests

| First/Main level | Second level | Third level |
|---|---|---|
| I1: Subject of study | I11: Electrical/Electronical/Energy Engineering | |
| | I12: Mechanical/Industrial Engineering | |
| | I13: Civil Engineering/Architecture/Regional Planning | |
| | I14: Computer/Automation/Information | |
| | I15: Environmental Engineering | |
| | I16: Materials/Metallurgy Engineering | |
| | I17: Chemical Engineering | |
| | I18: Agricultural/Biotechnical Engineering | |
| | I19: Geological/Surveying/Marine Engineering | |
| I2: Type of study | I21: Undergraduate | |
| | I22: Graduate | |
| | I23: PhD/doctorate | |
| | I2x: kind of courses | |
| | | I211: fulltime |
| | | I212: parttime |
| | | I213: distant learning |
| | | I214: summer course |
| | | I215: research related |
| | | I216: practical oriented |
| | | I227: project studies |
| | PhD only | I231: fulltime |
| | | I232: parttime |
| I3: Type of degree | I31: Bachelor | |
| | I32: Master | |
| | I33: PhD | |
| | I34: Any other | |

| | | |
|---|---|---|
| I4: Type of school | I41: Technical University | |
| | I42: University college/University of applied sciences | |
| | I43: University | |
| | I44: College | |
| | I45: Any other | |
| | I4x: status | I451: state driven |
| | | I452: private |
| | | I453: confessional |
| I5: Language of study | I51: Language of the state | |
| | I52: English | |
| I6: Place of study | I6i: “State-i” | I6ij:”city-j” |
| I7: Social/cultural criteria | I71: Student life | |
| | I72: Cultural life | |
| | I73: Sports | |
| | I7x: on campus | I711:student organisation |
| I8: Scholarships/grants | I81: Exchange programmes | |
| | I82: Scholarship programmes | |
| I9: Costs | I91: Total fees | |
| | I92: Living costs | |
| | I9x: housing | I921: dormitories |
| | | I922: renting rates |

If a user opens the GTG he or she will find a short description how to proceed. In the next steps the GTG shows the study guides which give answers to the questions and criteria of interest given to the programme: After checking the data base, up to 15 links are shown to the user. If there is no study guide available that fulfils these interests one can go back, change any selected topic and check again. This feature offers a great variety to check the guides.

The most important part of the project is the List of Relevant Guides (LRG) which, from each country, contains the Internet address of at least one study guide that leads interested users to all existing engineering schools in this country. If there is more than one Internet address which fulfils these criteria then the one which offers the best available information is selected. If there is not a single Internet address which leads to all engineering study programmes of a country, then the Internet addresses of all necessary study guides are included and shown at the top of the list of links containing all links existing for the special country. This is an important feature of the TREE GTG in comparison to search machines which usually offer more than 20, mostly even more than a hundred different web addresses to the applicant who has to decide which one should be used first. The GTG offers the links that are necessary to find all - for the applicant relevant - engineering schools in a country at the top of the list of links. But on the other hand if the feature “Place of study: city” is used only the guides for this special city are shown. The list of the study guides which are used in the GTG is based on the assessment undertaken by the respective TREE Special Interest Group and by selected national correspondents. Therefore, in some cases, it may not be exhaustive, but it is open for additional links from any interested institution. Therefore the LRG is updated automatically if institutional links are added.

It is most important for the usefulness and relevance of the GTG that the study guide of each country or institution is regularly revised by a national or institutional responsible authority. In order to become a sustainable tool the TREE Guide to Engineering Schools in Europe has to be continuously up-dated and embedded into the current activities of respective national or European organizations dealing with engineering Education, e.g. the European Society for Engineering Education (SEFI).
For the time being links to the Glossary as well as to the Guide of Guides will be provided via the home page of TREE: http://www3.unifi.it/tree/

Comments and questions may be addressed to the respective SIG leaders:
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## 7.3 The TUNING questionnaire

In line with the TUNING[64] project strategies and recommendations, TREE Thematic Network decided to distribute among its partners Institutions a questionnaire on series of competencies specific to the Engineering field.
The questionnaire was elaborated with reference the first and the second cycle levels of education, according to the Bologna declaration.

64 For additional information see *http://www.unideusto.org/tuning/*

A full report presenting the analysis of the answers to the questionnaire is available in the CD Rom.

This analysis of the questionnaire should be considered as transversal activity with respect to the actions of the Network and has been realised by TREE headquarters with the great contribution of Omer Hantal (President of BEST, Board of European Students of Technology).

CHAPTER 8

# Future challenges

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## 8.1 Ten key challenges

Across Europe, higher education systems have generally been relatively homogeneous although within this homogeneity there have been, and still are, considerable national differences. European universities have, until recently, been closely controlled by the state (at national and/or regional level). This control has concerned such things as the duration of studies, the titles awarded, the appointment of teaching and administrative staff (both of which have the status of civil servants in most states), the admission of students, and, in some countries, curricular structure, course content and final examinations. The general tendency in recent years towards the decentralisation of higher education and the granting of greater autonomy to universities has been paralleled by a requirement for external quality assurance procedures. Systems to serve this purpose have come into being at the national level in France (the *CNE*), in the Netherlands (the *VSNU* for the universities and the *HBO-RAAD* for the *Hogescholen*), in Sweden (the Quality Audit and Enhancement Unit of the National Agency for Higher Education) and in Spain through the *Consejo de Universidades*, and at regional level in Germany (for example, the evaluation agency in Lower Saxony).

A generation ago, three broad models for European universities tended to be distinguished. These were:

- the Humboldtian academic model (after Wilhelm von Humboldt's foundation of the University of Berlin in 1809) of a research university which was characterised by the entrenched rights of professors and students to freedom of study and teaching, and in which independent research and study was intended to provide the guiding principle of the student's university programme (Germany, the Netherlands and to some extent Sweden);



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• the Anglo-Saxon model with strong emphasis on the personal development of the student;
• the Napoleonic model (France and Spain) which was characterised by a heavily centralised approach.

National systems of higher education have moved somewhat from these origins, the main diversification in the last twenty or thirty years being in the development, alongside traditional academic studies, of more professionally oriented programmes at institutions such as *Fachhochschulen* (Germany), *Hogescholen* (the Netherlands), *Instituts Universitaires de Technologie* (France), *Technologika Ekpaideftika Idrimata* (Greece) and *Escuelas Universitarias* (Spain).

Universities are in fact confronted with changing framework conditions and new social demand. The self-understanding of universities is in discussion and the institutional fabric of university structures is under pressure to change and to adapt. As the educational university was changing to the Humboldtian model in the 19th and 20th century, the Humboldtian model of the university itself is currently challenged by a new entrepreneurial model. Especially in Europe, the Lisbon targets to make Europe the most competitive knowledge-based economy of the world, the creation of a common European Research Area and an European Higher Education Area as envisaged in the Bologna declaration call universities to enhance their ability to develop new activities in addition to well established educational programmes. Especially the development and improvement of university-business linkages and of university-labour market linkages are in demand.

In this framework TREE, evolution of a previos Thematic Network called E4, has tried to focus on some of the challenges the Engineering Education is facing. This has been done mainly through small targeted working groups (Special Interest Groups, or SIGs for short), each one with a specific topic.

It appears evident that many of these issues remain unsolved and hence we point out 10 key challenges, developed in the following paragraphs, that have been the leitmotif behind the activities of TREE, and are likely to remain valid also in the future because of the continuos rapid evolution of EE in Europe.

### 8.1.1 EE in Europe and Globalisation

Global perspective will be a critical skill for the engineer of the 21st century. As a consequence colleges of engineering must ensure that our educational environment offers a variety of challenging and rewarding international experiences.

The differences, as far as the strategies of cooperation between Europe and the Americas, show that there is a urgent need of echoed structures aimed at enhancing their cooperation. The European model could be considered as a best practice in order to develop a transatlantic cooperation based on the tuning instruments worked out at the European level. The existing examples of successful study programs open to American students are often limited to an international mobility experience, which has no real impact on the cooperation between the involved countries.

It is important to remember that industrial partners have much to add to this dialog. They are not just potential sources of funding but also sources of ideas and solutions. They have faced many of the challenges now confronting the academic world as universities seek to embrace a global perspective. While in the Americas the permeability of the education system towards industry is rather remarkable, it must be pointed out that in Europe impermeability is to a certain extent the norm and sometimes the industrial involvement in the education system is limited to a sponsorship.
Moreover, it appears pertinent to recall once more the recent European efforts towards the creation of a Pan-European Quality Label in the engineering and technology field as an additional element of cooperation with the more mature American system, which has counted on the ABET system for many years. Collaboration on this topic appears a *conditio sine qua non* for a true success of the European accreditation system and TREE Thematic Network has played a major role towards this objective.

### 8.1.2 Entrepreneurship

Management education for engineering people who work in the private sector has become of a crucial importance. Specifically, adult education to foster people who can identify new business opportunity and who can create value by challenging new endeavours is decisive.
Moreover, it has been observed that many of the industrial models involve some of the elements of the academic models but extend them through some form of industrial experience.
It appears therefore that higher education has a key role to play in the developing of enterprise and entrepreneurship skills of engineering graduates.
Even if the links between Engineering Education and entrepreurship have not been taken explicitely into account by TREE, it appears pertinent to mention that these issues are very much related to the studies of Line A and in particular to the quality assurance and accreditation matters. Moreover entrepreneurship constitutes one of the key topics for a further investigation, in case of a follower of TREE.
It must be noted that significance of accreditation and the procedures for achieving it vary greatly from one European country to the other.
Three typical examples follow:

- In Great Britain and Ireland, accreditation standards and procedures are the responsibility of professional institutions like the Engineering Council UK ($EC^{UK}$), which was established in 1981 to advance the education and training of engineers and technologists and to promote the science and practice of engineering for the public benefit. Higher Education Institutes (HEIs) are only involved through the assessment of education programs, although sometimes they have to adapt the curricula in order that their programs be accredited.

- In Germany, ASIIN is the German Accreditation Agency specialized in accrediting degree programs in the field of engineering. It was formed in 2002 as a non-profit association and officially accredited by the German Accreditation Council.
- In France, since as early as 1934, a "habilitation" is granted to engineering programs and higher educations by the "Commission des Titres d'Ingénieur" (CTI), in which the academic world, the profession and the employers are represented on a parity basis.

Such differences lead to confusion in the mutual recognition of academic and professional qualifications: consequently, difficulties still remain in the mobility and trans-national acceptance of engineers (and other professionals), notwithstanding that since 1989 a European Directive should guarantee them, at least within the EU.

To solve the aforementioned difficulties, it is necessary to reach a European-wide consensus on standards required for engineering educational programs and on establishing a system for accrediting programs, higher education institutions and graduates when such standards are achieved. This is the main goal of the EUR-ACE Implementation Project (Accreditation of European Engineering Programs and Graduates). This initiative is strongly supported by TREE TN and appears to be the result of a solid cooperation which traces its origins back to the E4 Thematic Network. This aspect is further developed below (see 8.1.9).

### 8.1.3 The need for a strong ethical formation

European universities must face the crisis of the Humboldtian model, and find new organisational solutions. TREE TN proceeded from two starting observations. The first is the one according to which we are in a "cultural shift" that makes culture the element on which performance, both technologically and cognitively, depends. The development of societies now depends on the culture shared by human beings more than on their economy or technology. The second observation is that culture itself and its ethical underpinning should be open for consideration. The development of society now depends on culture and on its adaptive capacity.

Ethical issues in Engineering Education is the title of one of TREE SIG's.

The formation of students in relation to ethical issues plays a crucial part in their preparation for a career in engineering practice. Therefore, a sustainable programme in engineering education should include aspects like: professional ethics, awareness of the consequences of technology, concern about environmental protection, humanitarian problems, etc. Although the importance of such issues has been recognised widely since quite a time, the identification of effective ways of introducing such aspects in the curricula still needs much attention.

Participants in this SIG have been staff members with responsibility for teaching ethics as linked to engineering practice. The evolution of EE under the pressure of globalisation continues to increase the importance of the challenging task of introducing effective ethical formation for engineering students.

### 8.1.4 The challenge of attracting the best young minds

Are careers in scientific research still attractive to the most talented young European? This is a critical question since it is widely held that innovation in science depends less on the many "worker bees" in the enterprise than on a decent sprinkling of the very best minds. In one sense such careers surely remain attractive because breathtaking advances in fields such as neuroscience, genomics, and computer science are intellectually exciting. But there are also less attractive aspects that top students must consider in making choices about advanced education and careers. Training and apprenticeship times in science have become very long: ten years or more counting the postdoctoral appointment that has become often a must for most attractive career positions. Compensation for graduate students and postdoctoral appointees is very modest for professionals who are often in their thirties. Probably most important, prospects for autonomous research positions in Academia and elsewhere that most would-be scientists aspire to at the end of this long road are uncertain and increasingly slim.

Why should society and policymakers worry about this? In most fields we depend on market signals and mechanisms to guide people to educational and career tracks. If our best and brightest choose to become lawyers and investment bankers rather than scientists and engineers, why not say, "So be it"? A "laissez-faire" approach will not work in this case because public policy largely determines the demand for scientists and engineers with advanced degrees. Most PhD-trained scientists are employed in research or teaching, and the most of the support in both areas comes from government. From a policy perspective, it is critical to recognize that the research and teaching most scientists do has an important public good element, meaning that society as a whole benefits in ways not fully valued in market signals such as compensation levels. Government's role is to ensure through policy that the value of the public good is recognized. If policies serve to make scientific research careers inadequately attractive to the best young minds, this will surely work to society's detriment in an age when scientific and technological advances are basic to key values such as economic growth, environmental protection, public health, and national security. In short, we cannot leave these decisions to the market without recognizing that we, the citizenry, are a large part of the market.

Moreover, we would like to draw the attention on another important aspect behind that of attracting engineering students. Recent studies in fact demonstrate that according to the statistics it is expected that in the future the demand of Engineers will be bigger than the offer that European HEI can provide.

### 8.1.5 Implement effectively the Bologna three-tier system

On May 17, 2007 education ministers from 46 states convened in London to advance the ongoing project of a European higher-education area. Among the principle goals of the conferences was for member states to discuss the progress of the Bologna Process. One of the principal objectives of that the EU education ministers agreed upon in 1999, in Bologna,(the conference that gave birth to the Bologna Process) was to institute international structure of Bachelor’s and Master’s degrees throughout the European Union by the year 2010. Institutional autonomy, academic freedom, student-centered education, equal opportunities, international mobility and employability constituted the central themes of the London conference. Matters concerning international graduation requirements also ranked high on the London Conference Agenda.

While a number of the European states have already succeeded in making the widespread changes to the education system, which include the conversion to a three-tiered (Bachelor, Master and PhD) degree structure these changes have posed challenges to other countries. Nonetheless, significant progress has been registered on the Bologna Process overall. For instance, the Trends V study by the European University Association reports that now more than 80% (up 50% from what was registered in 2003) of EU universities are implementing the three-tier system. In addition more than 70% of universities are using the European Credit-Transfer System (ECTS).

Despite numerous challenges and cultural resistance to the Bologna Process, some European countries have registered significant progress in adopting the educational reforms.

Most Member States have introduced a two-cycle degree system. A few professional studies, such as medicine, are usually kept as one-cycle programme. Since their previous meeting in Berlin, Ministers considered it necessary to go beyond the previous focus on two main cycles of higher education to include the doctoral level as the third cycle in the Bologna Process and to promote closer links between higher education and research. National legislations should open up for this development. In Armenia, “candidate of science” would be the relevant third cycle degree. Member states are now being encouraged to elaborate a national framework of qualifications for their higher education systems. At the same time, work has been started to develop an overarching framework of qualifications for the European Higher Education Area. Within such frameworks, degrees shall have different defined outcomes. First and second cycle degrees shall have different orientations and profiles to accommodate individual, academic and labour market needs.

As far as the specic aspects related to research are concerned we would like to underline that TREE as been very focused on them, especially through Line B ("Education and Research Line"). The outcomes produced by the SIGs of Line B are of great interest even if we are perfectly aware that further studies and activities are necessary to go deeper in developing such issues.

### 8.1.6 Improve the pedagogical abilities of teachers

Engineering teachers need to be offered and take advantage of opportunities to begin developing their pedagogical reasoning ability as part of their education.

The report from SIG C4 of TREE Thematic Network (Promotion of Pedagogical Abilities of Engineering Lecturers - A (limited) Survey on the State of the Art and Examples of Good Practice) is specifically focused on these matters.

The report stresses the fact that required qualification of academics in higher education used to be mainly research oriented. The excellence is measured by the number of scientific publications, the pedagogical abilities are usually less important.

This attitude seems to change now. Learning has become in the focus of higher education; as a consequence of the Bologna declaration. The work load of the students is mirrored in the credit points for a module in the respective curriculum. But learning needs the coaching of the teachers and there is a world wide move to improve the teaching abilities, described as didactic and pedagogical competencies.

A specific goal of the Bologna declaration is to promote mobility amongst engineering students in Europe. As a consequence, universities will have to engage in an international competition to attract students. This results in a growing interest for improvement and innovation in engineering education. All over Europe 'Centres of Expertise on Learning and Teaching' are being established or, in case of older existing institutes are re-installed. The position of a centre of this kind within the university organisation varies as well as its tasks and responsibilities. Some establishments are divided into a research group and a teacher-training and consultant division.

Excellence in teaching is of interest to all involved: university to sharpen its profile, students to save time and efforts and teachers to be rewarded with happy clients.

Changes are slow, but it is interesting to note, that teaching competencies are beginning to be incorporated.

### 8.1.7 Exploit the learning potential of research activity at all levels

Recent research has changed our understanding of how people learn. These findings are based on well-established learning theories that can potentially help faculty teach more effectively. Unfortunately, most science faculty have little or no exposure to research on learning or its application to teaching.

Research is essential in institutions that claim to educate academic engineers. Active participation in "on the edge" research guarantees that the teaching staff is up to date. Involvement of students in research guarantees that they develop the necessary attitudes towards creating new knowledge, new technologies, innovation, solving problems that have not been solved before. University education is largely an education through research: teaching is carried out by those who create new knowledge and are in close and continuous contact and interacting with their peers throughout the world.

By involving engineering students, from the undergraduate level on, in research work one does not only develop their creativity and engineering attitude but also their communication and presentation skills and their ability to work in a multidisciplinary team.

Financial resources should be made available to allow all engineering students to take part in research work. It is recommended that national research funding agencies and the E.U. make it compulsory to reserve part of any research budget for the participation of students in the research projects.

Academic teachers should be encouraged to modify their courses to include "self study" or research components. Through the preparation of a guide for research based teaching and the organization of seminars they should be trained in  methods of involving (undergraduate) students in research projects. The E.U. could facilitate this process for example by providing financial resources for the organization of summer courses  to teach young university lecturers how to teach young students using their research experience, exciting their curiosity. In the long range, one should strive at a systematic modification of the curricula to include more project based teaching and research activities.

One of the most direct ways for allowing the (doctoral) students to reach the edge of current research (science development) and to help them in their doctoral research is the introduction of specialised courses at doctoral level (research schools, graduate schools, doctoral schools). Because of the high level op specialisation and the relative low number of interested doctoral students these highly specialised courses should preferably be organised at a European level. The EU could contribute in providing more funding for mobility of young researchers.

It has been demonstrated that research and practical implementation efforts can guarantee sustained improvement in learning techniques. education Institutes would benefit from the study of learning and teaching of basic cognitive skills as well as the underpinnings and elements of effective learning environments..

This can be surely compared to experimental learning, which can be described as a process for drawing learning from experience.

Although most engineering faculty members know little or nothing about this research or its theoretical basis, it can be used to improve classroom teaching engineering teachers and scientists who study learning need to work together to conduct research on engineering education.
This is surely among the conclusions of the SIG B1 of TREE (Synergies between research and education activities) but it is clear that the matter, of great interest for the engineering education community, would benefit from further investigations.

### 8.1.8 Forming good autonomous adult learners: the most important challenge

Part of being an effective instructor involves understanding how adults learn best. Compared to children and teens, adults have special needs and requirements as learners. Despite the apparent truth, adult learning is a relatively new area of study and adult learners are characterised mainly by the following peculiarities:

- Adults are *autonomous* and *self-directed.* They need to be free to direct themselves. Their teachers must actively involve adult participants in the learning process and serve as facilitators for them. Specifically, they must get participants' perspectives about what topics to cover and let them work on projects that reflect their interests. They should allow the participants to assume responsibility for presentations and group leadership. They have to be sure to act as facilitators, guiding participants to their own knowledge rather than supplying them with facts. Finally, they must show participants how the class will help them reach their goals (e.g., via a personal goals sheet).
- Adults have accumulated a foundation of *life experiences* and *knowledge* that may include work-related activities, family responsibilities, and previous education. They need to connect learning to this knowledge/experience base. To help them do so, they should draw out participants' experience and knowledge which is relevant to the topic. They must relate theories and concepts to the participants and recognize the value of experience in learning.
- Adults are *goal-oriented*. Upon enrolling in a course, they usually know what goal they want to attain. They, therefore, appreciate an educational program that is organized and has clearly defined elements. Instructors must show participants how this class will help them attain their goals. This classification of goals and course objectives must be done early in the course.
- Adults are *relevancy-oriented*. They must see a reason for learning something. Learning has to be applicable to their work or other responsibilities to be of value to them. Therefore, instructors must identify objectives for adult participants before the course begins. This means, also, that theories

and concepts must be related to a setting familiar to participants. This need can be fulfilled by letting participants choose projects that reflect their own interests.

- Adults are *practical*, focusing on the aspects of a lesson most useful to them in their work. They may not be interested in knowledge for its own sake. Instructors must tell participants explicitly how the lesson will be useful to them on the job.

This can be applied in all fields and has been taken into account mainly by Special Interest group D7 (Adult education model for European universities) and D1 (Managing continuing engineering education (CEE) effectively) of TREE, with specific reference to engineering. The full reports of these two working groups are to found in the CD accompanying this volume.
It appears that the formation of good adult learners is one of the main goals of the European Higher Education Area, which has been stressed many times within the Bologna follow up group and also recently at the occasion of the Ministries of Education meeting in London.

It appears pertinent to mention here that, besides the above mentioned aspects, which have been trated extensively by Line D SIGs, an innovative way of enhancing and improving continuing eduction could be the result of a focus on the undergraduate level. From this perspective the formation of good adult learners could begin even at the pre-university level. This aspect should be however specifically investigated as it was not approached by TREE.

### 8.1.9 A well recognised European accreditation system of engineering programmes

Since a few years, “accreditation” has become a key word in European Higher Education circles. Most countries have or are developing accreditation procedures, but these remain strongly different from one country to another: thus, the need for a coherent European system is strongly felt, in particular for fields with strong professional impact like Engineering, also because of the variety of educational programmes and of degrees awarded.

Moreover, the need for an accreditation system of engineering education on the European scale is becoming more and more significant, since many systems of this type do exist or are being established in other geo-political areas.

The previous Thematic Networks H3E and E4 were very active in putting the bases for such developments: H3E organized a series of “European Workshops on Accreditation of Engineering Programmes” (EWAEPs) that lead to the creation in 2000 of a trans-national observatory on these matters (ESOEPE); Activity 2 of E4 devoted one of its final documents to a survey of the accreditation procedures and practices in 23 European countries.

A most recent development is the EC-supported project "EUR-ACE: Accreditation of European Engineering Programmes and Graduates", coordinated by the leader of SIG A5, that has been concluded on 31 March 2006.

Another significant and concrete result of EUR-ACE has been the transformation of the quoted "observatory" ESOEPE into a non-profit Association denoted "European Network for Accreditation of Engineering Education (ENAEE)" that will be essential in the actual establishment of the accreditation system proposed by EUR-ACE.

It must be noted that SIG A5 has worked in close cooperation and synergy with EUR-ACE, each project favouring the success of the other. It is intended to do the same with any follow-up of the EUR-ACE project, aimed in particular to the implementation of the EUR-ACE proposals.

Moreover, SIG A5 took care of completing and updating the above quoted E4-A2 document into a document tentatively called: "Accreditation and Recognition in European Engineering: a review".

You can find in the attached CD the full report by SIG A5 ("Accreditation of EE in Europe") which can be taken as a point of departure for further investigations.

### 8.1.10 Improve and augment high quality LLL opportunities

Lifelong Learning is as essential for Professional Engineers as their initial training and certification. Continued professional development is an urgent imperative to ensure public safety, a sustainable environment, a competitive national economy, a respected profession, a profitable employer and a fulfilling career. The primary responsibility for this resides with the individual engineer, actively supported by all stakeholders.

The processes for maintaining continued competency vary markedly among practitioners, depending both on their employment status and the engineering functions that they fulfil. A paper[65], prepared by the Canadian Academy of Engineering, presents lifelong learning guidelines for employees, employers, educational institutions and professional and technical engineering societies. In addition, best practices of leading organizations and their engineering staff are described to illustrate the broad range of lifelong learning approaches. Learning on the job is highlighted as one of the most important routes to maximizing professional competency.

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65 "Lifelong Learning for professional engineers" a report of the Canadian academy of engineering prepared by a task force chaired by Dr. Clem Bowman, FCAE (October 1997) ISBN: 0-9682770-1-2.

## 8.2 A global challenge

The development of the European Higher Education Area has received another impulse forward from the meeting of the Ministers of Education in London last May 2007 where some the goals scheduled for 2010 have been taken into account in the light of the developments occurred over the last two years and priorities for next meeting of the 2009 have been set. It appeared that the above mentioned developments have brought Europe a significant step closer to the realisation of the European Higher Education Area (EHEA).

Among these goals, the generalisation of a two-tier system, the adoption of the Diploma Supplement and of ECTS. The high priority given to the so-called Bologna Process has many motivations: enhancing mobility of work forces across Europe, attracting good students from the whole world, improving the situation of the EU as far as (technological) innovation capabilities, favouring European Industry's performance in a rapidly evolving global economy. EE is asked, quite naturally, to play a central role in this scenario.

It is well known that academic institutions are characterised by a much slower capacity of adaptation than, say, Industry. Yet they have to face a period of rapid evolution, because of the reasons mentioned above, to which one has to add the enlargement of the EU and the consequent increase in complexity of all challenges, those in higher education being no exception. The path leading to a satisfactory, if not perfect, development of the EHEA is therefore full of obstacles, and no other domain than EE needs more that these obstacles be removed as fast as possible. To mention only some of them, we find: language and cultural barriers to internationalisation, differences in educational systems, differences in the way doctoral studies are organised, diverse degree of development in the use of ICTs, different importance given to accreditation issues.

But which could be the lines of development of such a future ?

We have identified two sets of criteria/challenges. The first set, A, lists aspects functional to the improvement of fitting-for-purpose of EE institutions. In other words challenges that, if dealt with, can play a key role in making European engineering schools better. The second set, B, is looking not inside EE institutions, but outside them, i.e. to the many ways EE institutions must interface with industry, society, and the whole world. No claim about the exhaustiveness of such sets is made, but the authors of this chapter believe that they constitute a good starting point for the effort to let EE in Europe to evolve in the right direction.

**Set A**

- Augment the productivity of learning (e.g using ICTs, stimulating pedagogical formation)
- Be concerned about the formation of good adult learners also during the first two levels
- Exploit the potential of research and project oriented learning
- Enhance the sustainability of EE institutions (e.g. by developing CEE)
- Fight tendencies to isolation
- Introduce the ethical formation for engineering students
- Take advantage of QA practices and accreditation opportunities

**Set B**

- Attract best students from secondary school education to engineering
- Value highly the employability of graduates
- Try to counteract the shortage of engineers in Europe, foreseen for the near future
- Stimulate innovative minds, as asked by the Lisbon Agenda
- Be open to the world (attracting more students from outside EU especially at doctoral level)
- Contribute to the capacity of European industry to compete successfully in the global economy (e.g. with joint applied research projects with industry)

In declaring our intention to continue to contribute to the enhancement of EE in Europe, we finally would like to observe that EE is mature as a true research field, and that perhaps the time has arrived to form a dedicated group of experts in EE to pursue such research activity further in the interest of the rapid development of the European Higher Education Area and of the European Research Area.

## 8.3 What's next ?

At the present moment (September 2007) it is still not known which will be the future of TREE Thematic Network (which period of eligibility as far as the European Community grant is concerned ends on September 30th 2007) .

Additional support (through the "Accompanying Measures" action of the LLL Programme) has been granted in order to guarantee the project results with a wide dissemination and of course this volume is to be considered as the major instrument for such an action.

It is presumed that the Management Committee will contribute to the the steering committee for a possible new "working Group" (a network? An excellence centre? A consultancy body?) which will bring ahead (and further develop) the issues approached not only by TREE but also by the previous Thematic Networks

E4 (Enhancing Engineering Education in Europe) and H3E (Higher Engineering Education for Europe). It is hoped that reppresentatives, from Industry will also accept to be included in such committe.
The aims, the partners, the procedures, the framework of reference and the actors are still to be defined but it is sure that this steering committee has a real strong background and solid competencies to face the challenging task to propose a fruitful future for TREE.

*by Elisa Guberti*
Facoltà di Ingegneria, Univ. di Firenze
Project Manager of TREE

## 1. TREE Thematic Network - Management Committee

C. Borri (School of Engineering, University of Florence, IT) - *President and Legal Representative*
F. Maffioli (Politecnico di Milano, IT) - *Co-ordinator*
E. Guberti (School of Engineering, University of Florence, IT) - *Project Manager*

G. Augusti (Univ. di Roma La Sapienza, IT) - *Line A Promoter*
A. Avdelas (Aristotle Univ. of Thessaloniki) - *Line B Promoter*
K. Hawwash (Univ. of Birmingham) - *Line C Promoter*
M. Markkula (Helsinki Univ. of Technology) - *Line D Promoter*

F. Come (SEFI)
N. Wojewoda (BEST)
J. Berlamont (CESAER)

## 2. International Advisory Board

F. G. Baron, member of the International Advisory Board
G. Haug, member of the International Advisory Board
K. Hernaut, member of the International Advisory Board
P. Uronen, member of the International Advisory Board

## 3. Industry Advisory Group

W. Adam, EIIL
S. D. Price, EIIL
M.G. Zappa, EuroCadres
J. Grady, Hewlett Packard
M. Rimini Doering, Bosch
K. Hernant, Siemens
F. Maffioli, TREE Coordinator
T. Hundebol, Secretary



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## 4. TREE Thematic Network - Special Interest Group Leaders

A1) Klaus Bednarz, Technical University Berlin
*Increasing the quality of the majority – a key challenge*
A2) Iacint Manoliu, Technical University of Civil Engineering of Bucharest
*From ECTS to a complete qualification profiling in EE*
A3) Janusz Szpytko, AGH University of Science and Technology, Cracow
*Inquiry about real needs of industries in international formation*
A4) Muzio Gola, Politecnico di Torino
*Tools for Quality Assurance and Assessment of EE*
A5) Giuliano Augusti, Università di Roma "la Sapienza"
*Accreditation of EE in Europe*
A6) Günter Heitmann, Technical University Berlin
*Updating of the Glossary in EE*
A7) Helmut Schmidt, SEFI
*Guide of Engineering Schools in Europe*
A8) Clementina Marinoni, Fondazione Politecnico di Milano
*Engineering demand and offer in Europe*

B1) Jean Berlamont, KU Leuven
*Synergies between research and education activities*
B2) Aris Avdelas, Aristotle University of Thessaloniki
*Status of doctoral (PhD) studies in Europe*
B3) Bohdan Macukow, Warsaw University of Technology
*Facilitating international projects in team*
*B4) Radu Chisleag, Technical University Bucharest*
*Engineering students in European research programmes - This SIG has been closed and only partially merged with SIG B6.*
B5) Selahattin Kuru, ISIK University.
*Problem based and project oriented learning*
B6) Nicolò Wojewoda, BEST
*Stimulating undergraduate research*
B7) Marie Demlova, CTU Prague
*Mathematics education for engineers in the changing world*

C1) Rüdiger Höffer, Ruhr University Bochum

*Promoting Higher Engineering Education in Europe*

*C2) Radu Chisleag, Technical University Bucharest*

*Directory of courses of study for foreigners - This SIG has been closed and only partially merged with SIG A7.*

C3) László Szentirmai, University of Miskolc

*Identification of tools for enhancing Tempus projects in EE*

C4) Gunther Kurz, University of Esslingen

*Promotion of pedagogical abilities of engineering teachers*

C5)Urbano Dominguez, Universidad de Valladolid

*Status of double degrees in EE in Europe*

C6) Kamel Hawwash, University of Birmingham

*Widening participation in EE for under-represented groups*

C7)Joanna Daudt, Technical University Delft

*Attracting and retaining female students*

C8) Ömer Hantal, BEST

*The role of extra-curricular activities*

D1) Markku Markkula, Helsinki University of Technology

*Managing continuing engineering education (CEE) effectively*

D2) Wim van Petegem, KU Leuven

*Examples of good practice in open and distant learning (ODL)*

D3) Tapio Koskinen, Helsinki University of Technology

*Changing work-culture, foresight and innovation*

D4) Hannu Peltola, Finnish Virtual University

*Virtual university collaboration*

D5) Patricio Montesinos, Universidad Politecnica de Valencia

*EFQM concept for managing university change*

D6) Henk Zandvoort, Technical University Delft

*Ethical issues in EE*

D7) Seija Hämäläinen, Helsinki University of Technology

*Adult education model for European universities*

D8) Flemming Fink, Aalborg University

*Work-based learning*

D9) Erik de Graaff, Technical University Delft

*Active learning*

## 5. List of TREE Main events

2004

| What | When | Where |
|---|---|---|
| First Strategic Meeting | 28-29.10.04 | Leuven, BE |
| Line C SIG Leaders meeting | 28.10.04 | Leuven, BE |
| First Management Committee Meeting | 29.10.04 | Leuven, BE |

2005

| What | When | Where |
|---|---|---|
| Special Interest Group C1 Meeting | 17.01.05 | Berlin, DE |
| First Plenary Meeting | 11-14.02.05 | Rome, IT |
| Round Table on "Teaching And Research in Engineering in Europe - From Bologna to Bergen" | 14.02.05 | Rome, IT |
| Second Management Committee Meeting | 12.02.05 | Rome, IT |
| Special Interest Group C7 Meeting | 11-14.02.05 | Rome, IT |
| Special Interest Group B6 meeting | 01.05.05 | Ljubljana, SI |
| Special Interest Group C8 meeting | 27-31.07.05 | Rome, IT |
| TREE Session within SEFI Annual Conference | 09.09.05 | Ankara, TR |
| International Conference on Engineering Education | 25-29.07.05 | Gliwice, PL |
| Special Interest Group A4 Meeting | 29.09-01.10.05 | Istanbul, TR |
| Third Management Committee Meeting | 08.10.05 | Brussels, BE |
| Line D Meeting | 05.11.05 | Dublin, IE |

2006

| What | When | Where |
|---|---|---|
| Special Interest Group D8 Meeting | 23.01.06 | Aalborg, DK |
| TN co-ordinators meeting | 13.02.06 | Brussels, BE |
| Fourth Management Committee Meeting | 16 and 18.02.06 | Loveno di Menaggio, IT |
| Scientific Committee Meeting | 16-19.02.06 | Loveno di Menaggio, IT |
| SIG D1, D3 and D5 Meeting | 19.04.06 | Vienna, AT |
| Special Interest Group C5 Meeting | 26.05.06 | Valladolid, ES |
| TREE Session within SEFI Annual Conference | 30.06.06 | Uppsala, SE |
| Special Interest Group A2 Meeting | 01.07.06 | Uppsala, SE |
| Special Interest Group D6 meeting | 01.07.06 | Uppsala, SE |
| Line D SIG Chairs Meeting | 03-06.07.06 | Espoo, FI |
| First Industry Advisory Group Meeting | 24.07.06 | Brussels, BE |
| Techno TN Forum 2006 | 04-05.09.06 | Brussels, BE |
| Fifth Management Committee Meeting | 06.09.06 | Brussels, BE |
| Special Interest Group A4 Meeting | 07.10.06 | Berlin,DE |
| Line A meeting | 09.10.06 | Berlin, DE |
| Line D meeting | 01-04.11.06 | Trondheim, NO |
| Line B meeting | 03-04.11.06 | Brussels, BE |
| First Editorial Board Meeting | 09.11.06 | Birmingham, UK |
| Sixth Management Committee Meeting | 10.11.06 | Birmingham, UK |
| Second Industry Advisory Group Meeting | 01.12.06 | Brussels, BE |

2007

| What | When | Where |
|---|---|---|
| Line C meeting | 09-10.01.07 | Berlin, DE |
| Second Editorial Board Meeting | 05.02.07 | Milano, IT |
| TREE Session within BEST Academics & Companies Forum | 06.03.07 | Brussels, BE |
| Line D SIG Chairs Meeting | 18.03.07 | Leureen, BE |
| Second Scientific Committee Meeting | 19-20.03.07 | Katholieke University Leuven |
| Third Editorial Board Meeting | 20.03.07 | Leuven, BE |
| Seventh Management Committee Meeting | 21.03.07 | Katholieke University Leuven |
| Fourth Editorial Board Meeting | 06.05.07 | Brussels, BE |
| Special Interest Group A4 Meeting | 25-26.05.07 | Dublin, IE |
| TREE Session within 7th ALE international Workshop | 04-06.06.07 | Toulouse, FR |
| TREE Session within SEFI Annual Conference | 03.07.07 | Miskolc, HU |
| Eight Management Committee and Editorial Board Meeting | 03.07.07 | Miskolc, HU |
| Ninth Management Committee and Editorial Board Meeting | 14-15.09.07 | Rome, IT |

## 6. List of TREE Partners

### Key

| | |
|---|---|
| (green) | Contracting Institution |
| (yellow) | Silent partner |
| (orange) | Co-ordinator |

| Nr. | Contact Person | | Institution/Association | |
|---|---|---|---|---|
| | Surname | Name | | |
| 0 | Borri | Claudio | Università di Firenze - Facoltà di Ingegneria | IT |
| 1 | Zemann | Andreas | Technical University Wien | AT |
| 2 | Veretennicoff | Irina | Vrije Universiteit Brussel | BE |
| 3 | Van Keer | Chris | Kaho Sint-Lieven | BE |
| 4 | Bognolo | Guido | European Institute for Industrial Leadership (EIIL) AISBL | BE |
| 5 | De Zutter | Daniel | Ghent University | BE |
| 6 | Come | Françoise | SEFI – Société Europ. pour la Formation des Ing. | BE |
| 7 | Van Petegem | Wim | EuroPACE | BE |
| 8 | Berlamont | Jean | Catholic University Leuven | BE |
| 9 | Coninx | Lieve | CESAER | BE |
| 10 | Zappa | Giordano | EUOCADRES | BE |
| 11 | Ivanov | Rosen | University of Rousse | BG |
| 12 | Bonev | Zdravko | UACEG – Univ. of Architecture, Civil Eng. and Geodesy | BG |
| 13 | Lazov | Lyubomir | Technical University Gabrovo | BG |

| | | | | |
|---|---|---|---|---|
| 14 | Papanastasiou | Panos | University of Cyprus | CY |
| 15 | Kuraz | Vaclav | CTU in Prague | CZ |
| 16 | Hoffer | Rudiger | Ruhr-Universitaet Bochum | DE |
| 17 | Wasser | Iring | ASIIN | DE |
| 18 | Bomke | Wilhelm | Fachhochschule Regensburg | DE |
| 19 | Heinzel | Winfried | Technische Universität Darmstadt | DE |
| 20 | Harder | Raimo | Bauhaus-Universitaet Weimar | DE |
| 21 | Kurz | Gunther | University of Applied Sciences Esslingen | DE |
| 22 | March | Frank | Technische Universitaet Ilmenau | DE |
| 23 | Peil | Udo | Technical University Braunschweig | DE |
| 24 | Thurian | Patrick | Technical University Berlin | DE |
| 25 | Wagner | Ulrich | University of Hannover | DE |
| 26 | Gnuechtel | Stefan | Technische Universitaet Dresden | DE |
| 27 | Hansen | Hans | Vitus Bering Denmark | DK |
| 28 | Kristensen | Hans-Jorgen | Odense University College of Engineering | DK |
| 29 | Fink | Flemming K. | Aalborg University - Fac. of Eng. and Science | DK |
| 30 | Krogh | Flemming | Copenhagen University College of Engineering | DK |
| 31 | Kaps | Tiit | Tallinn Technical University | EE |
| 32 | Dominguez | Urbano | University of Valladolid | ES |
| 33 | Garcia | Marinela | Universidad Politecnica de Madrid | ES |
| 34 | Heller del Riego | Christine | Universidad Pontificia Comillas de Madrid | ES |
| 35 | Martinez | Helena | Technical University of Catalunya | ES |
| 36 | Huete | Juan F. | Technical University of Granada | ES |
| 37 | Montesinos | Patricio | Universidad Politecnica de Valencia | ES |
| 38 | Markkula | Markku | Helsinki University of Technology | FI |
| 39 | Lahdeniemi | Matti | Satakunta Polytechnic | FI |
| 40 | Lindfors | Juha | Helsinki Polytechnic | FI |
| 41 | Karhu | Markku | EVTEK - Institute of Technology | FI |
| 42 | Morel | André | ESTP - Ecole Spéciale des Travaux Publics | FR |
| 43 | Lallement | Regis | BNEI - Bureau Nat. des Elèves Ingénieurs | FR |
| 44 | Tailly | François | CTI – Commission des Titres d'Ingénieurs | FR |
| 45 | Cammarota | Marie Ange | ENPC – Ecole Nationale des Ponts et Chaussées | FR |
| 46 | Futin | Michel | Ecole Centrale de Lyon | FR |
| 47 | Wojewoda | Nicolò | BEST | FR |
| 48 | Matsatsinis | Nikolaos | Technical University of Crete | GR |
| 49 | Avdelas | Aris | Aristotle University of Thessaloniki | GR |
| 50 | Patko' | Gyula | University of Miskolc | HU |
| 51 | Markus | Bela | University of West Hungary | HU |
| 52 | Toth | Agnes | Budapest Polytechnic – Banki Mechanical Engineering Faculty | HU |

| | | | | |
|---|---|---|---|---|
| 53 | Asvanyi | Jozsef | University of Pecs | HU |
| 54 | Murphy | Mike | Dublin Institute of Technology | IE |
| 55 | Costelloe | Liam | Institute Technology Tallaght | IE |
| 56 | Brynjolfsson | Sigurdur | University of Iceland | IS |
| 57 | Maffioli | Francesco | Politecnico di Milano | IT |
| 58 | Gola | Muzio | Politecnico di Torino | IT |
| 59 | Massardo | Aristide | Università di Genova | IT |
| 60 | Noè | Carlo | LIUC – Università Cattaneo | IT |
| 61 | Di Maio | Bruno | Università di Palermo | IT |
| 62 | Augusti | Giuliano | Università di Roma “La Sapienza” | IT |
| 63 | Zunino | Elena | APE-Associazione Professionisti Europei Laureati | IT |
| 64 | Dumciuviene | Daiva | Kaunas University of Technology | LT |
| 65 | Valiulis | Algirdas | Vilnius Gediminas Technical University | LT |
| 66 | Ribickis | Leonids | Riga Technical University | LV |
| 67 | Grech | Maurice | University of Malta | MT |
| 68 | Egberts | Marie-José | Avans Hogeschool | NL |
| 69 | Groot Kormelink<br>Daudt | Joost<br>Joanna | Delft Technical University | NL |
| 70[1] | Ravnsborg | Sissel | Sor-Trondelag University College | NO |
| 71 | Malvig | Kjell | Norwegian University of Science and Technology | NO |
| 72 | Arne | Oddvin | Vestfold University College | NO |
| 73 | Hryniewicz | Tadeusz | Politechnika Koszalinska | PL |
| 74 | Szpytko | Janusz | AGH University of Science and Technology | PL |
| 75 | Soryusz-Wolski | Tomasz | Technical University of Lodz | PL |
| 76 | Fijak | Janusz | Politechnika Opolska | PL |
| 77 | Pawlowska | Malgorzata | Wroclaw University of Technology | PL |
| 78 | Szewczyk | Pawel | Silesian University of Technology | PL |
| 79 | Macukow | Bohdan | Warsaw University of Technology | PL |
| 80 | Durlik | Ireneusz | Czestochowa Technical University | PL |
| 81 | Cortez Vieira | Maria Margarida | Universidade do Algarve | PT |
| 82 | Ferrari | Antonio | Universidade de Aveiro | PT |
| 83 | Vasconcelos | Rosa | Universidade do Minho | PT |
| 84 | Soeiro | Alfredo | Universidade do Porto | PT |
| 85 | Atanasiu | Gabriela M. | “Gh. Asachi” Technical University of Iasi | RO |
| 86 | Topan | Dumitru | University of Craiova | RO |
| 87 | Manoliu | Iacint | Technical University of Civil Engineering Bucharest | RO |
| 88 | Chisleag | Radu | University “Politehnica” | RO |
| 89 | Andersson | Per | Uppsala University | SE |
| 90 | Miklavcic | Marianne | Linkoping Institute of Technology | SE |
| 91 | Hanson | Mats | KTH-Royal Institute of Technology | SE |

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|---|---|---|---|---|
| 92 | Westerstrom | Anita | Lulea University of Technology | SE |
| 93 | Tittus | Michael | University College of Boras | SE |
| 94 | Zarnic | Roko | University of Ljubljana | SI |
| 95 | Pokorny | Michal | University of Zilina | SK |
| 96 | Aygun | Huseyin | Turkish Naval Academy - Deniz Harp Okulu | TR |
| 97 | Anagun | A. Sermet | Osmangazi University | TR |
| 98 | Cem Göknar | Izzet | DOGUS University | TR |
| 99 | Hakan Gür | Cemil | Middle East Technical University | TR |
| 100 | Atalay | Suheyda | Ege University | TR |
| 101 | Kuru | Selahattin | Isik University | TR |
| 102 | Begg | John | Institution of Incorporated Engineers | UK |
| 103 | Whitehouse | Carol | Learning and Teaching Support Network Engineering | UK |
| 104 | Birch | J. M. | Engineering Council | UK |
| 105 | Martland | M. F. | EPC - Engineering Professors' Council | UK |
| 106 | Mitchell | Irving | European Access Network (EAN) | UK |
| 107 | Gibbs | Sylvia | University of Huddersfield | UK |
| 108 | Baker | Chris J. | University of Birmingham | UK |
| 109 | Uhomoibhi | James | University of Ulster | UK |

## Silent Partners

| | | | | |
|---|---|---|---|---|
| s.p.1 | Flückiger | Federico | IGIP - Intern. Gesellschaft für Ingenieurpaedagogik | CH |
| s.p.2 | Fromentin | Antoine | EPFL - Swiss Federal Institute of Tech. Lausanne | CH |
| s.p.3 | Cantoni | Lorenzo | University of Lugano | CH |
| s.p.4 | Flückiger | Federico | SUPSI - Univ. of Applied Sciences of South. Switz. | CH |
| s.p.5 | Boev | Oleg V. | Tomsk Polytechnic University | RU |
| s.p.6 | Kuznetsova | Vera | Kazan State University of Architecture and Engineering | RU |
| s.p.7 | Zelenin | Gennadiy | UEPA - Ukrainian Engineering Pedagogic Academy | UA |
| s.p.8 | Rashkevych | Yuriy | Lviv Polytechnic National University | UA |

# 7. Reports from the International Advisory Board of TREE

## 7.1 First report by the International Advisory Board to the TREE President and the Coordinator - December 2005

The present report has been prepared jointly by the members of the International Advisory Board (IAB) at the invitation of the Management Committee. It is based on our experience with TREE since our appointment, in particular on our participation in TREE meetings/events since the autumn of 2004.

*1. The International Advisory Board in TREE*

Composition

The International Advisory Board consists of three members:

*Gerard Baron, France*
*Dr. Kruno Hernaut, Germany*
*Professor Paavo Uronen, Finland.*

The IAB is of opinion that its optimal size is 3 members. This allows the IAB to function effectively as a small group able to discuss its opinions before delivering them to the Network.

It is important that IAB members serve *ad personam* and do not in any way represent their organisation. It is equally important that the appointment process and the choice of IAB members be decided by the appropriate TREE Network and not by current IAB members.

Role

In accordance with our appointment letter and with discussions in the Management Committee, we see our role as that of external, independent persons providing expert views and advice and drawing the attention of the TREE leadership to relevant present and forthcoming issues. Such views and advice are formally made to the President and Coordinator rather than to the full Management Committee. IAB members are observers and cannot carry any executive or fiscal responsibility. It should also be clear that while we may on occasion participate in discussions at TREE information events or meetings, we may not represent the thematic network in any formal or legal way.

Conditions for efficient/useful functioning

We wish first to emphasise that it has been a very positive initiative of TREE's leadership to create an international advisory body (IAB) to ensure that its decisions and activities are based on the broadest possible knowledge of the field and background trends. This has been confirmed by our experience hitherto, which indicates that the IAB can provide useful information and viewpoints, serve as a link between the various internal networks and relay TREE activities to the external world.

We see the following as the key conditions for the relevance and efficiency of the IAB:

- IAB members should normally participate in a small number of meetings each year, usually of the management committee (2 to 4, not necessarily the same for all IAB members) but cannot and should not get involved in the many meetings of TREE groups;
- IAB members must have an opportunity to meet between themselves on occasions and should avail themselves of this possibility;
- The quality of the work of the IAB is dependent on good information on TREE activities and issues; the current practice of sending to the IAB an invitation to all main meetings (thus seeking our involvement, however with no obligation to attend) and all minutes/documents is commended and encouraged;
- IAB members should speak openly, including commenting on deficiencies and problem areas, as indeed we have been able to do;
- Finally IAB costs must remain modest in the overall TREE budget.

*2. IAB observations on progress in the work of TREE*

<u>Structure/organisation</u>

TREE can be seen as a kind of follow-up project of E4 - Enhancing Engineering Education in Europe. Since E4 was focussed on more fundamental analysis of the main aspects of Engineering Education in Europe the focus of TREE is rather on how to implement the E4 recommendations on a broader scale taking into account the European dimension and global impact. This gives to TREE a larger number of specific topics to be covered, different in orientation, size and resources needed to achieve the satisfactory outcome. The structure and the organisation of the project must reflect these requirements.

Given the complexity and ambitions of the Project, its basic structure/organisation into some 30 Special Interest Groups (SIGs), grouped in 4 Lines, each promoted by one distinguished coordinator, is logical and gives the necessary flexibility to cover all major issues. There is however a danger that large number of SIG activities may be too diverse and suffer from the difficulty of assuring the overall quality towards the operational objectives of TREE. This entails a reasonable coordination effort which may cause some difficulties in managing the whole project. The objectives/tasks/activities of SIGs seem not to be always clearly defined and in some cases it is as yet unclear haw they shall be able to achieve the positive result. There is therefore a risk that some activities might fail.

We realise that this is the first year of the Project and some (maybe most) of the above issues were probably unavoidable. Yet we wish to draw the attention of the leadership on the need to focus activities in the future, directing them to the core aims of the project, which we suggest should be made more prominent and explained - if necessary repeatedly - in more operational terms.

Time and progress management

In the first strategic meeting in Oct. 2004 all the SIG leaders have committed to draw the outlines of their project concerning objectives/outcomes, content, resources needed and time schedule including milestones, following the common pattern set up by the management. In the first plenary meeting in Feb. 2005 the SIGs presented their projects and committed to start working.

Since then some SIGs seem to be well in schedule others are doing not so well having difficulties in project management and motivation. However more transparency on the actual project status of each SIG is needed on Management Committee level and if necessary hard decisions have to be taken.

*3. IAB Recommendations/suggestions*

- The IAB firmly acknowledges TREE as an important project for the future of engineering education and research in Europe in frame of Bologna Process and global trends and the IAB role within it.
- We see the need for an explicit common focus/direction, the continuation of efforts towards internal efficiency and the building of a team spirit within and between the SIGs as the main factors of success in the future stages of the project.
- We recommend that the leadership should emphasise more strongly the basic aims of TREE and both in the areas of project coordination and information efforts.
- We encourage the leadership to continue seeking contact with, and make TREE visible to other interested parties, not only in Europe but also in other parts of the world (in particular North America and Asia both regions with increasing interest in what happens in Europe in particular in Bologna Process).
- We recommend that special attention should be paid to the industrial input to the project.

This report goes to the President and the Coordinator for their consideration. We suggest that they may wish to share our observations with the Management Committee and/or include (some of) them into the Report to the EU Commission. We are ready to comment on the use of this report and to answer questions arising from it.

*Gerard Baron*
*Dr. Kruno Hernaut*
*Professor Paavo Uronen*

23 December 2005

## 7.2 Second report by the International Advisory Board to the TREE President and the Coordinator - September 2007

The present report has been prepared at the invitation of the Management Committee. It is based on the IAB's experience with TREE and in particular on the participation of IAB members in TREE meetings/events in 2006/2007.

*1. The International Advisory Board in TREE*

Current composition

The International Advisory Board consists of four members:

Mr. Gerard Baron, France
Dr. Guy Haug, Belgium (since 2006)
Dr. Kruno Hernaut, Germany
Professor Paavo Uronen, Finland.

Further to a proposal from the Management Committee the IAB agreed to enlarge its membership by Dr. Guy Haug, an additional outstanding expert on higher education policy in an international setting with experience in European engineering education.

We stress again the importance of IAB members serving *ad personam* and not in any way to represent their organisations..

Role

The role of the IAB was conceived as that of external, independent persons providing expert views and advice and in particularly drawing the attention of the TREE leadership and Management Committee to relevant present and forthcoming issues. Therefore, IAB members act as observers without any executive or fiscal responsibility. IAB members attended all Management Committee meetings and intervened in discussions whenever they felt it appropriate.

The conditions for the relevance and efficiency of the IAB were listed in the previous report and, for case of reference, are repeated in an annex to this report.

*2. IAB observations on progress in the work of TREE*

General

The IAB is pleased to report that its participation has been facilitated by the TREE organisation and its freedom and independence have been fully respected. IAB opinions have been sought extensively and its responses have evidently been useful to the Project and rewarding for IAB members.

Structure/organisation

In the previous report the IAB expressed its concern that the activities carried out through a large number of Special Interest Groups (SIGs) may suffer from the difficulty of ensuring the overall quality of TREE with regard to its operational objectives. Given the complexity, diversity and ambitions of the Project the IAB observed that the basic structure (32 SIGs pooled in 4 Lines) was still logical and covered all major issues. Nevertheless, the line promoters already reported some difficulties in coordinating the SIGs: progress towards the common operational objectives has not been homogeneous and some SIGs did not perform as well as necessary.

Responding to the IAB's repeated suggestion to focus activities towards the core aims of the project, the leadership and members of the core SIGs have commendably undertaken huge efforts to bring the project to a successful end. The IAB is pleased with this outcome, which took more than 30 meetings of the Bureau, the Management Committee, the SIGs and the Working Groups.

On the organisational side we have observed that the program organisation was supported by an excellent and efficient staff and that the financial arrangements have been well administered. We pay a special tribute to Professors Maffioli and Borri who have continued to invest an immense amount of time and effort to ensure progress across the board.

*3. IAB Recommendations / Suggestions*

During the progress of the project the IAB observed that TREE activities have been quite many and diverse. Consequently, the wide range of outcomes makes dissemination a greater challenge: the key question is how the different documents produced can be published and distributed in such a way that different audiences can easily find the information of interest to each.

Based on this, the IAB strongly recommended that special attention should be paid to the structure and content of the final publication, in order to meet the need of, and make it attractive to the various target groups.

The Management Committee responded positively to this recommendation and approved a common publishing structure which would serve as a template for all SIGs and Lines. The final publication will include both a printed volume providing a substantial overview of the TREE outcomes and a DVD containing the complete documentation together with an intuitive navigation thread through the complex matter aimed at meeting the specific expectations of the various audiences.

For the dissemination of all valuable outcomes of the TREE project, the management team applied for an additional dissemination year. This has been fully endorsed and strongly encouraged by the IAB.

During this extra year TREE will organise a number of conferences regionally spread all over Europe and focused on one Project Line each, in order to best reach the audience particularly interested in the topics of each of the Project's Lines. A final conference is also planned in order to present the whole TREE outcomes to European key organisations and decision makers, especially those from industry.

The IAB recommends that special attention should be paid to the selection of venues for the individual Line conferences, in order to reach the best possible regional audiences across Europe. However, in order to reach all interested key participants, the final TREE event should be located centrally in the European Union, preferably in Brussels.

The IAB also encourages the TREE management to consider steps towards establishing more strongly the quality seal that is being developed, both institutionally (by seeking access to ENQA membership) and in society with a view to increasing the knowledge and acceptance of the seal both in the community of universities and in industry.

In summary the IAB confidently acknowledges TREE as an important project for the future of engineering education in Europe and for the Bologna Process aiming at the creation of a efficient European Higher Education Area. Most conceptual and structural outcomes have been achieved, but the overall success of the project still hinges on the dissemination and acceptance of these outcomes. The IAB strongly recommends:

- an extended dissemination period for the project, in order to ensure that the work carried out within TREE can indeed achieve all expected outcomes and the proposed quality label can indeed be established and widely accepted;

- a carefully planned successor project building on what has been learnt and filling in what is still missing with regard to the objectives of the Bologna Process: the members of the IAB feel that subsequent decisions should place considerable weight on major new pan-European developments and needs in engineering education - such as the third cycle, life long learning, mutual recognition of qualifications and stronger participation of industry - the significance and importance of which may have actually increased since TREE began its work.

This report goes to the President and the Coordinator for their consideration. We suggest that they may wish to share our observations with the Management Committee and/or include (some of) them into the final report to the European Commission and the final TREE documentation. We are ready to comment on the use of this report and to answer questions arising from it.

*Mr. Gerard Baron*
*Dr. Guy Haug*
*Dr. Kruno Hernaut*
*Professor Paavo Uronen*

1 September 2007

## Annex

Conditions for efficiency of the IAB:

- IAB members serve *ad personam* and do not represent any organisation.
- IAB members should normally participate in a small number of meetings each year, usually of the management committee (2 to 4, not necessarily the same for all IAB members) but cannot and should not get involved in the many meetings of TREE groups;
- IAB members must have an opportunity to meet between themselves on occasions and should avail themselves of this possibility;
- The quality of the work of the IAB is dependent on good information on TREE activities and issues; the current practice of sending to the IAB an invitation to all main meetings (thus seeking our involvement, however with no obligation to attend) and all minutes/documents is commended and encouraged;
- IAB members should speak openly, including commenting on deficiencies and problem areas, as indeed we have been able to do;
- Finally IAB costs must remain modest in the overall TREE budget.

## 8. E4 (partial) Archives

### 1. Preamble

This section motivates the addition of three contributions of E4 ("Enhancing EE in Europe"), the TN which is the immediate predecessor of TREE, as Archives in the CD-Rom. It would have in fact been redundant to include the whole of the six volumes produced at the end of E4 life, since many of the chapters/sections either are now obsolete or have been updated by some of the results of TREE. The three retained parts are: the document produced by the TUNING synergy group on engineering, vol. C on the implementation details of curricula according to the Bologna Process, and vol. F about the effective use of new techniques of teaching and learning, in particular ICTs. The characteristics of each one of these parts are briefly summarised below.

### 2. TUNING Synergy Group on EE

The TUNING project has had many successive phases, in each one selecting a handful of areas for studying the evolution of ECTS across Europe in connection with the Bologna Process. At a certain point in time the European Commission stimulated the birth of "synergy groups" in order to augment the number of areas covered. E4 formed one of these synergy groups, bringing together experts from E4 itself, from the TN EUCEET, and from TUNING. The document which resulted from this effort was a photograph of the situation some years ago, but it is believed to be still of interest and hence reported in full as one of the appendixes of the CD.

### 3. Curriculum development and the Bologna Process

During the life of E4 one of the major task has been to propose detailed curricula for the different branches of engineering taking into account the 3+2 structure of the Bologna Process. One of the important characteristics of this effort was the shift from a teaching-centred to a learning-centred view, avoiding to propose syllabi, but rather proposing list of competencies/skills that the student must acquire attending university. Only the first and second level of education have been considered. We believe that this document still provides a valid guide, hence the decision to include it in the CD.

### 4. ICTs role in innovating learning in engineering

Some aspects of the importance of Information and Communication Technologies (ICT) in EE have been behind the work also of some SIGs of TREE, but volume F of E4 presents a more complete picture of the many areas in which ICTs have become indispensable. This has suggested its inclusion in the CD, disregarding the fact that some findings are not up-to-date.