Engineering Skills Education: The Bachelor in Engineering Programme of the "Vrije Universiteit Brussel" as a Case Study

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Abstract

The Bologna process has triggered an important change in the course outline towards a sustainable, transparent and quality driven European education system. In Belgium, engineering education had to be completely revised. The transformation of the former system-, leading to the degree of academic engineer after 5 years of study, into the typical Bologna 3+2 structure leading to the academic degrees of respectively Bachelor in Engineering and Master in Engineering has created opportunities to completely reconsider and restructure the Engineering education at the Vrije Universiteit Brussel. One of the main objectives of the new programme was to explicitly meet all the requirements with respect to the education output contained in the "Dublin descriptors" and that of present-day society at large. In this paper we report on our experience in this transformation. To this end, we use the outcomes of the consultation with alumni, our self assessments and assessments by an international panel appointed by the VLIR-VLOA (Flemish – Dutch inspection commissions) that took place in 2004 and 2007.

Keywords: Institutional and organisational change, new learning methods, curriculum development, creativity, new engineering competencies

1. INTRODUCTION

1.1 Mission of the VUB

The mission of the "Vrije Universiteit Brussel", the second largest university of Brussels, comprises the development, transfer and application of high-ranked education and research to contribute to the progress of humanity (Constitution of the VUB; Art. 1 and 3). This implies that the VUB is continuously aiming at anticipating on what is happening in the world in order to provide it with human resources educated to contribute to its economic growth and the development of a knowledge based society. Hereto, international academic and professional contacts are indispensable. As one of the leading universities of the capital of Europe and member of the UNICA (network of the UNIversities of the CApitals of Europe) [1] and T.I.M.E. network (Top Industrial Managers for Europe) [2], the VUB aims to create and provide an international atmosphere on the campuses by ensuring high density exchange of students in the education programmes and by attracting foreign researchers and guest lecturers.

1.2 Impact of the Bologna declaration on the education of academic engineering in Belgium and at the VUB

The Bologna declaration has triggered an important change in Europe in the way of organising academic engineering education towards a sustainable future. In Belgium, as has been the case in many other European countries, engineering education had to be completely reconsidered and revised.

The former engineering education system in Belgium, even after the enforcement of federalisation in the eighties of the communities[1], was based on the system provided by the French "'Écoles polytechniques" (Academic

[1] The federalisation of Belgium accounts 4 reforms of the state: the first reform of 1970, the second reform of 1980, the third reform of 1988-89 and the latest one of 1993. The reform of 1988-89 transferred the authority for education entirely towards the communities. Hence, for the VUB, the Flemish community is qualified for the organisation of education.

Polytechnic institutes/schools – not to be confused with the present Polytechnics in the UK) [3], [4]. The Polytechnic School (École Polytechnique) of the "Université Libre de Bruxelles" (ULB [11], Free University of Brussels[2]) was founded in 1873 and was entitled to offer the legal diploma of "Ingénieur civil des Mines[3]" (Mining Engineer) and "Ingénieur civil des Constructions" (Civil Engineering) after 5 years study. In 1890 the name was changed into "Faculté des Sciences Appliquées" ("Faculty of Applied Sciences") and the school became a Faculty of the University. In the course of the twentieth century, the list of academic legally recognised grades was enlarged: "Ingénieur civil Mécanicien et Électricien" (Mechanical and Electrical Engineer in 1929), "Ingénieur civil Chimistes" (Chemical Engineer in 1958) and "Ingénieur civil Métallurgiste" (Metallurgic Engineer in 1962). All degrees could be obtained after a minimum of 5 years of academic study. The Belgian academic engineering studies showed close similarities with the French system operational in the "Écoles polytechniques universitaires" (Polytechnic university schools) and the Dutch "Technical Universities" until 1986.

The transformation of the former system, leading after 5 years of study to the academic degree of engineer into the academic Bachelor in Engineering and Master in Engineering according to the Bologna agenda has been studied carefully at the VUB and has forced the authorities to completely reconsider the education system in order to satisfy the output required by the so-called "Dublin descriptors" [5]. The first reactions of the members of the Faculty of Engineering of the VUB active in the boards competent with educational matters were not very enthusiastic. Belgian engineers have an excellent (international) reputation and it was not clear what could be the benefits of a reform. Many feared that the consequence of the implementation of the Bologna declarations would be to level down the standard of the engineering degrees. But it was soon realised that the need of new structures was offering a unique opportunity to match the outcomes of the education to the new needs of present society and to attract new type of students. It was decided, therefore, to focus on those issues which would turn the reforms into benefits.

The transformation of the engineering education at the VUB has been based first on a critical analysis of the requirements of the new Bachelor-Master structure, as was imposed by law in the Flemish and French Communities. But it was based also on consultation with alumni using polling surveys, self assessments including S.W.O.T. analysis and assessments by the education authorities (VLIR-VLOA Flemish – Dutch inspection commissions) held in 2004 and 2007. In the coming chapters, the experience gained in the process of realising these drastic fundamental modifications of the Engineering curriculum of the VUB, will be shared.

2. RECONSIDERING THE ENGINEERING EDUCATION AT THE VUB

2.1 Adopting the Bachelor-Master structure in academic engineering education

Policy makers think often linearly in proposing new rules and regulations and are near future goal-oriented. The recommendations to replace the diverse academic education systems of the Member States of the European Union by a unified, transparent and transferable quality driven "Bologna scheme", has not, according to the authors of this paper been conducted properly, despite the excellent intentions. Decision makers went too far, too fast. The selection of the Anglo-Saxon Bachelor-Master education system as the model to be applied to all academic degrees in Europe was not sufficiently consolidated to verify whether university based "technical" studies, such as engineering and medicine, would or could provide after 180 ECTS Bachelors capable to be productive and competitive on the labour market.

Moreover, the urge to specialise more and to narrow the field of studies in the first cycle of higher education, (bachelor education) is an issue that should have been investigated in depth, be better documented and discussed in broader circles.

When radical changes are at stake, it is generally recommended to gain lessons from history, in order not to make the same mistakes twice. Restructuring of the educational system with increased deepening of the specialisation is not new, indeed. The appearance of broad literature and languages education in the *humaniora*

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[2] "Free" should be interpreted in 2 ways:

- Unbounded, i.e. independent from government regarding nomination of staff, management etc. but regulated for the set-up of the education; i.e. for the curricula, the quality and end terms of the programmes.
- Independent from any religion and influence of any kind of organised and structured church; i.e. in the spirit of free thinking, as declared by the founder Theodore Verhaegen in 1834.

[3] Civil Engineer, as a degree and title, should not be confused with 'construction engineer', but civil is opposed to the already existing polytechnic degree offered by the Royal Military Academy.

(*poesis, rethorica)* at the end of the fifteenth century forced – to use the actual trendy word – the top universities to narrow their fields of specialisation and to emphasis on disciplinary specialisms. This happened e.g. at the Collegium Trilingue of Louvain, in Belgium, or at the Collège de France [6]. Old universities having a rich tradition, but with fading and unsufficiently adapted curricula, e.g. Oxford and Cambridge in the U.K. or Paris, in France, were incited to revise their study offers drastically by the hyperspecialised *grandes écoles*, e.g. the "Écoles Polytechniques" [6]. Briefly, in the past one can observe back and forward evolution of reform of academic curricula and the field the users of the human resources, output products of the universities.

Therefore, what may seem as brilliant as the egg of Columbus in the Bologna process should still be regarded with a critical mind and not too much naivety! It is not sufficient to just reform something. In order to successfully reach the goals conceived by the reformers of the European academic education system, one should overlook the development of the European education system as a whole, from the bottom to the top. One should consider whether degradation of the level is sound and acceptable and try to look far ahead in the future (decades). At the same time the education system should be considered as a whole, internal cohesion should be taken into account and system analysis should point out if changes somewhere in the educational chain do not imply alternatives, which might weaken or even strongly erode the newly installed ones.

But Belgian Faculties of Engineering had no choice. The challenge was to transform the traditional Polytechnic School/Faculty of Applied Sciences structure, based on a general, broad 2 year first cycle broad education labelled "candidature", followed by a 3 year specialisation second cycle study called " licence" into a 3 years Bachelor in Engineering programme, with a degree in a well defined specialisation (civil engineering, electro-mechanical engineering, electrical engineering and chemical and materials engineering) and a 2 years Master in Engineering specialisation study, based on research and inputs from industry and the relevant disciplines. At first sight, the exercise seemed quite easy: use the same time frame of 5 years, but shift from 2+3 years in the old system to 3+2 years in the Bachelor/Master (BaMa) structure, as is simplified in figure 1.

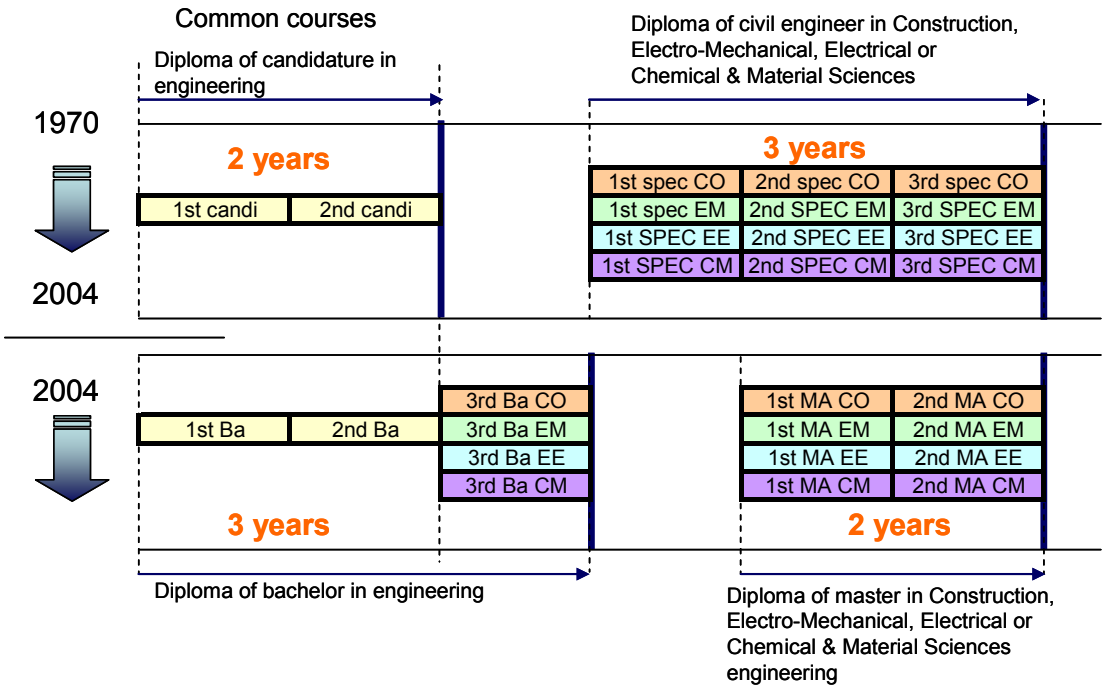

FIGURE 1: Organisation of engineering education at the VUB from 1970 to 2004 with the system leading to the legal degree of civil engineer in a specific specialisation field and the Bachelor-Master structure from 2004 onwards, (CO=construction, EM=electro-mechanical, EE=electrical, CM=chemistry and materials engineering)

However, such approach appeared not appropriate at all, because the Bologna declarations did alter the education system more drastically. The new programmes should be consistent with the ECTS (European Credit and Transfer and Accumulation System), where an average of 30 ECTS per semester should be scheduled, yielding 60 ECTS per study year, or 180 ECTS for the Bachelor degree in engineering and 120 for the Master. Next, the new programmes should fulfil the requirements incorporated in the Dublin descriptors, should match the aspirations of the field, i.e. the labour market and the industry, and should be attractive to youngsters having

finished their secondary school and looking for a career where technology is key. Also, the programmes should be such that they are accepted by the Flemish government, and hence therefore require negotiations in their set-up phase with the Department of Education of the Flemish government and with the two other Flemish universities, offering academic engineering degrees, i.e. the Ghent University (UGent) and the Catholic University of Louvain (KULeuven). Furthermore, the programmes should be worked out in order to ensure positive appreciations, from students, from alumni, but especially from the evaluation commissions installed by the government (VLIR-VLOA Flemish – Dutch inspection commissions), since those are indispensable to obtain accreditation for the offered degrees. The accreditation phase in Flanders hereto is scheduled between 2012 and 2014, and hence the programmes had to be defined between 2000 and 2004 and launched immediately after, in order to be tailored to obtain accreditation. An extra boundary condition in setting up the Bachelor-Master programmes has been to make the programmes compatible with the international exchange schemes for the students enrolled not only in the Master programmes (Erasmus, etc.), but also in the Bachelor programmes as e.g. is required within the double degrees of the T.I.M.E. network. [2].

The next chapters will focus especially *(i)* on the curriculum building of the Bachelor degrees in Engineering of the Engineering Faculty of the VUB with emphasis on the unique approach of the VUB in Flanders to offer a broad, general education with four semesters common to all engineering specialisation fields, *(ii)* on the integration of notions of ethics in finding sustainable and durable solutions for engineering problems and *(iii)* on the specific skills characteristic for the profession of engineers.

3. A BROAD EDUCATION IN THE BACHELOR DEGREE COMMON TO ALL ENGINEERING SPECIALITIES AT THE VUB

3.1 Objectives of the bachelor in engineering education programme of the VUB

The general objectives, aimed end qualification terms and the vision regarding the education of the current VUB program of Bachelor in Engineering are partly based on the previously operational two year candidature system, but have been fundamentally transformed for the current Bachelor-Master degrees. In particular, attention was paid to the introduction of the educational vision of the VUB authority, which focuses on competence acquisitions, and with the recommendations expressed by the VLIR-VLOA assessment commission of 2004. Compared to the objectives of the former Candidature – Civil Engineer (ir.) programs, those of the Bachelor-Master have been targeted more intensively towards the development of critical reflections regarding the acquired competences, towards skills and attitudes necessary to grow towards the profession of an academic engineer, towards research competences, management techniques and presentation and discussion skills.

The academic engineering education at the university aims at the formation of young persons to contribute efficiently to the design, realisation and support of sustainable projects with a scientific and/or technological content for the benefit of the fast evolving modern society. The bachelor education program, therefore, has the aspiration to train the students to become critical, conscious and engaged engineer scientists in a spirit of liberal examination from a non-dogmatic and pluralistic vision towards society and the chosen engineering specialisation field, with emphasis on the sustainability of the solutions, ethics and awareness of the implications to the environment.

This implies that a student should be able to follow an academic educational program that attempts to:

- Ensure a general, broad and in depth basic education, where emphasis is not put to overspecialisation;
- Provide a close relationship with and feedback from scientific research and the industrial field of the profession;
- Make the students acquire not only scientific perceptions, but also a broad scientific culture with accents on autonomy, creativity and inventiveness.

Moreover, the educational program encourages the development of attitudes that will enable future engineers to take responsibilities in a team and to reflect about the impact of their work. Social and language abilities, particularly for international literature investigations and autonomous assignments, therefore, should be encouraged. Likewise, one can state that an academically formed engineer:

- In addition to solving purely technological questions, should be able to delimit and formulate his tasks in order to submit these to a critical examination and the check the solutions for their sustainability and social relevance;
- Should apply oneself to a simultaneous horizontal broadening and vertical deepening of his discipline within a continuously changing society and industrial context, in a multi disciplinary and international environment. Life-long-learning has become an indispensable component in the life of an engineer.

An elaborated list of the aims and end terms of the bachelor in engineering programs of the VUB is available from the faculty website [7]. They can be summarised as follows:

- To ensure that students have acquired general and scientific competences which characterise academic education;
- To supply the common fundamental knowledge, skills, attitudes and ethical concerns, which are peculiar for the profession of an engineer;
- To enable future masters in engineering to choose their additional specialisation adequately by developing systematic knowledge of the kernel elements of the different disciplines of the profession of an engineer, including discussions about the most recent developments in these fields;
- To provide the specific foreground knowledge required to continue the studies in a specific master in engineering program in the home country and/or abroad;
- To present the basis for life-long-learning.

3.2 Adjustment of the objectives of the bachelor in engineering programme of the VUB to the competences and end terms defined by the Flemish decrees and the Dublin descriptors

The rules and requirements of the bachelor in engineering programme in Flanders are expressed in the *structural decree*, and more precisely in art. 58 §2/2 [8]. The general competences, independent from the chosen specialisation in engineering, which are therein described, can be summarised as follows:

- Acquisition of skills to gain, use and evaluate information:
  - Ability to logical, abstract and critical reasoning;
- Communication competences:
  - Ability to conduct open dialogues, discussions and negotiations;
  - Ability to write scientific reports;
  - Ability to report and hold presentations using the most modern ICT technologies;
  - As much as possible acquire knowledge of languages using self-study;
- Social competences:
  - Dispose of responsibility and ability to work in team;
  - Creativity and entrepreneurship;
  - Life-long learning;
  - Intellectual and/or physical mobility.

These competences, translated in the end terms for Bachelors in Engineering, are new to the VUB programme, originate from the Bologna declarations and are part of the Dublin descriptors [5]. Hence, in the curricula, defined in 2004, new lectures had to be integrated ensuring that such competences can be attained successfully. The content of these lectures are described more in detail in chapter 4.

3.3 International dimension in the objectives of the bachelor in engineering programmes of the VUB

The depicted objectives of the bachelor in engineering programmes of the VUB in §3.1 and the competences required by the Flemish decrees described in §3.2 do match the guidelines of the Thematic European Network E4 that has been active until 2004, and more precisely to §4.1 – 4.3 of the document "Guidelines for engineering core profiles 2010" [9], and the recommendations of the Thematic European Network TREE, of which the Faculty of Engineering of the VUB has been a partner [10].

The Faculty has taken important initiatives to strengthen considerably the international dimension of the education programme in 2005 and 2006: double degrees via the membership of VUB to T.I.M.E [2] and with the French speaking parent university of Brussels ULB [11], besides the classical Erasmus exchange programmes provided from the 85 bilateral agreements with European universities.

The basis of T.I.M.E. is to provide students in engineering with a double degree. For the third year of bachelor in engineering studies and the first year of the master programme, i.e. for 120 ECTS, the students go study abroad at a partner institution and obtain after a 5 year programme de degree of Master in Engineering from the VUB and from the partner university. This enforces the competences of the future engineers to work in a trans national and trans cultural environment.

At this moment, it is still too early to draw conclusions from this initiative, but the surprisingly high demand of students to participate in such an initiative underlines the interest of students in the international dimension of their education.

The international dimension in the objectives of the bachelor in engineering programmes of the VUB is essential for a 3+2 study year's structure. The problem which currently is at stake is the limited number of lectures in the

bachelor programme that can be offered in English according to Flemish decree. The benefit of accommodating the internationalisation aspects in the transformation phase from the former 2+3 years system to the current Bachelor-Master 3+2 years structure is the enhanced students' motivation for exchange programmes, mobility and double degree diplomas.

3.4 Implementation of the bachelor in engineering programme at the VUB

The bachelor programme is accessible to all students having finished their secondary school. At the end of the bachelor studies students should possess a broad basis of skills and knowledge for their continuation in an engineering master programme. The programme is structured such that milestones in the development of competences can be defined after each semester of the Bachelor education. They are summarised below [12]:

First semester:

In general the first semester starts on the last week of September and accounts 13 weeks. In the courses "Engineering skills" and "Informatics with programming project" the basic competences that every engineer should possess are instructed. These are:

- "Mathematical calculus": series, derivatives, integrals en elementary differential equations, which are regarded as the basic tools for courses in physics, chemistry and mechanics;
- "Measuring and experimenting": metrology, modelling and measurement errors;
- "Communication skills": written and oral professional reporting;
- "Computer competences": text processing, PowerPoint presentations, spreadsheets, queries on the internet, email communication, design of a website;
- "Programming": theoretical analysis of problems, structuring, algorithms, practical implementations.

In addition to these engineering skills, courses in basic and natural sciences are started. In the middle of the first semester the students are tested on the acquired engineering competences. For the units in basic and natural sciences both theoretical and exercises examinations are scheduled in January.

Second semester:

In the second semester the following competences are instructed:

- "Mathematical computer techniques": programming in Matlab;
- "Chemical experimenting"

The acquisition of theoretical and experimental knowledge is continued for the field of mathematical analysis, basic and natural sciences. Using the formats of seminars, invited lectures and practical assignments, the students also gain insight in issues regarding the environment in the profession of an engineer. The students are tested on the levels of knowledge, communication skills and logical reasoning.

Third semester:

The advancement of theoretical and experimental knowledge and insight in the basic education units, including technical drawing on a computer, is continued. Students are tested on knowledge and reasoning skills.

Fourth semester:

The students have the opportunity to validate to a large extent the acquired knowledge via a project. For each of the 4 engineering specialisations that are offered (construction engineering, electro-mechanical engineering, electronic and information technology engineering and chemical and material engineering), a technology project is organised in training workshops. Added values are: team work, planning and organisation, self-study, learning or improving of scientific English and communication. The technique enabling acquisition of knowledge from practical experiences is introduced, as the basis of life-long learning. The students learn to gain theoretical knowledge from a practical assignment. Students are judged on the combination of functioning in a team, the application of existing knowledge and the acquisition of new knowledge resulting from problem-oriented working, communication and reporting.

Fifth and sixth semester:

In the third year of the bachelor studies (semesters 5 and 6), the students choose a specialisation. The technology workshops in the fourth semester guide the students in an optimal way in that choice. The choice will enable the students to continue their studies in a master in engineering programme after having obtained the diploma of Bachelor in Engineering.

4. PROFILE OF THE BACHELOR IN ENGINEERING PROGRAMME AT THE VUB COMPARED TO SIMILAR PROGRAMMES ORGANISED IN BELGIUM

Taking into account the structure of the Flemish and Belgian industry, the Faculty of Engineering has opted for a solid but broad, and hence not too specialised education. The small-scale (the relative number of students) is regarded as beneficial and is part of the profiling versus the other Belgian universities offering academic engineering education.

In assessments in the past (2004 and 2007), the alumni was asked to compare their education with those of colleagues having studied outside the VUB. Most alumni have replied that the programmes are of equal quality (69%). A high number of alumni have stressed the better contacts that exist at the VUB between the teaching staff and the students (40%). The bachelor in engineering programmes of the VUB are also sensed to be more general, broader and not too extremely specialised, in accordance with the goals of the education (90%).

The academic bachelor in engineering creates a distinct profile for itself when compared to the professional bachelor programmes in industrial sciences offered at higher education institutes by the profundity of teaching of the subjects.

In preparing the transformation of the former civil engineering programme towards the Bologna Bachelor-Master programmes, the distinct education councils of the faculty of engineering[4] of the VUB have paid largely attention to the outline of an optimal model programme for the 4 specialisations in engineering. The vision to specialise early and deeper in the bachelor in engineering programmes of the other Flemish universities (Catholic university of Louvain, KULeuven, and the University of Ghent, UGent) has been investigated in depth in the education council boards of the faculty and were discussed with the alumni union of the engineers of the VUB. Alumni consider the broad education they have received as an absolute bonus for their career. Therefore, the faculty of engineering of the VUB decided to specialise only from the fifth semester onwards, instead of the third semester (KULeuven) of second semester (UGent). Interesting to note is that the French speaking parent university of the VUB, the ULB [11], and the "Faculté Polytechnique de Mons" (Polytechnic faculty of Mons in Wallonia) only spend 30 ECTS (1 semester) to specialisation in the third bachelor year. The other French speaking universities in Belgium are more inline with the approach of the VUB: the "Université Catholique de Louvain" (UCL) offers 107 ECTS on the total of 180 ECTS for the common part in the programme (nearly 4 semesters) and the "Université de Liège" (ULg), 105.

Finally, the possible advantages/drawbacks of the change in programme structure from 2+3 years of study in the former engineering education to 3+2 years leading to the degrees in the Bachelor and Master in Engineering has been largely discussed at the VUB in the boards competent for education matters and the faculty council meetings. Since the global study length for the model path student remains unaltered (5 years), at first sight the transformation in the programme seems to have no direct effects. However, this is not the case. Generic skills have been introduced in the Bachelor education, by transfer from courses from the specialised years (in the 3 last years of study in the old system) to the 4 first semesters in the Bachelor system, which are common to all engineering students. This has been, e.g. the case for the introductory course on economics. Elsewhere, new generic skills have been introduced in the Bachelor programme, since surveys conducted in the professional field has identified such skills, which are indispensable for becoming a professional, academically formed engineer: e.g. principles of innovation, protection of the environment, ethics and problem solving leading to durable solutions. What has been gained in generic skills, compared to the old system, has been widely appreciated by the students, by the industry, by research communities and by the evaluation commissions that have assessed the engineering education of the VUB recently in 2004 and 2007. Nevertheless, the study load for students in engineering has been decreased slightly by implementing the Bachelor-Master in engineering programmes, guaranteeing however full compatibility with the 180 ECTS for the degree of Bachelor in Engineering and 120 ECTS for the one of Master in Engineering, thereby ensuring approval of the 5 education councils competent for the Bachelor and Master in Engineering studies of the VUB. The load in mathematics has been decreased, e.g. in the disciplines of construction engineering, mechanical engineering and chemical and material science engineering, but remains unaltered for students in electrical engineering (by introducing an advanced mathematical course in the third bachelor year, while decreasing material sciences and theory of strength of materials courses to compensate for the extra load).

[4] The faculty education board are: ORBA (council board general bachelor in engineering programmes), ORBB (council for civil engineering education), ORCM (council chemistry and material sciences education), ORE (council for electrical engineering education), ORWE (council for electro-mechanical engineering education) and the faculty education commission FOWC.

5. INTEGRATION OF NOTIONS OF ETHICS IN THE BACHELOR OF ENGINEERING DEGREES AT THE VUB

The minimal requirements that are demanded to all bachelors in engineering concern a series of general competences and a polyvalent technical insight. Academic bachelors must have acquired broad knowledge of mathematics, physics and chemistry, which offer them a wide scientific basis. They learned basic notions of mechanics, material science, electricity, electronics and computer science, enabling them a solid foundation in, e.g., all constructing and processing techniques and in performances usage and maintenance of tools and instruments.

The bachelor should be able to measure, experiment, programme, communicate, report and make presentations on a professional level. This implies that he/she can perform analysis of the dimensions, of errors, etc. The bachelor should even so have gained additional knowledge in other domains, e.g. in economics, ethics and protection of the environment.

The course "Environmental Aspects of Engineering" has 3 main objectives:

- Large environmental problems of today and the relations and feedback with daily life:
  - Extinction of the natural resources;
  - Shrinkage of drinking water reserves;
  - Pollution of soils, air, water;
  - Green house effects;
  - Desertification;
  - Increase of the population;
  - Biodiversity;
  - The notion of sustainability.
- Political actions taken with respect to environmental problems and juridical implementations (worldwide down to locally);
  - International context: United nations conference on the human environment, Brundtland, Rio (agenda 21);
  - European context;
  - Federal and Flemish environment legislation and distribution of competences;
  - Overview of legislation for the quality of the air, waterways and reservoirs, soil policies;
  - Environmental licenses.
- Case studies of what an engineer can do to avoid environmental problems including ethical issues:
  - The role of an engineer in solving or preventing environmental problems: purification and decontamination, recycling, prudence when new developments are at stake, risk analysis.

6. CONCLUSIONS

In 2004 and 2007 the bachelor of engineering programmes of the VUB have been assessed by the VLIR-VLOA Flemish – Dutch inspection commission. Hereto, the faculty of engineering had to prepare self-assessment reports, which formed the basis for the in depth investigation of the assessment panels. The commission has a 4 ranking system (insufficient, sufficient, good and excellent) for the 6 chapters in the self-assessment report. The 2007 report concludes with the ranking table for the VUB, shown in table 1.

The faculty of engineering of the VUB, feels encouraged by the evaluation of the experts and rewarded in its efforts. This transformation to a trusty programme leading to the degree of civil engineer (ir.) in a certain discipline to the Bachelor-Master degrees as enforced by the Bologna declarations, has been conducted in such as way that loss in quality of education could be avoided.

Subject 1: Goals of the bachelor in engineering programs	
1.1 Level and orientation	**G**
1.2 Domain specific requirements	**G**
Subject 2: Content of the program	
2.1 Relations between aims and content	**S**
2.2 Professional demand and academic orientation	**G**
2.3 Coherence of the program	**E**
2.4 Duration and volume of the studies	**G**
2.5 Study time	**G**
2.6 Balance between specifications and content	**G**
2.7 Examination and assessment of students	**G**
2.8 Admission requirements	**G**
Subject 3: Personnel	
3.1 Quality of the personnel	**G**
3.2 Requirements for professional and academic orientation	**G**
3.3 Quantity of personnel	**G**
Subject 4: Facilities	
4.1 Material facilities	**G**
4.2 Study support	**E**
Subject 5: Internal quality control	
5.1 Results of evaluations	**G**
5.2 Measures for improvement	**G**
5.3 Involvement of alumni, co-workers, students, personnel in decision making	**G**
Subject 6: Results	
6.1 Achieved level	**G**
6.2 Efficiency of the education	**G**

TABLE 1: Ranking of the bachelor in engineering science of the VUB by the VLIR-VLOA Flemish – Dutch inspection commission in 2007. "S" = sufficient, "G" = good, "E" is excellent. No subject received the ranking insufficient.

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