Survey on educational material on sustainable constructions

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ABSTRACT:
Higher education of professionals in the construction and real estate sector is in the process of "Greening curricula". Pressures to educate environmentally literate workforce are increasing. Leading construction companies worldwide are becoming involved in green construction. "Green building, green project, green property, green procurement as well as green living and green citizenship" are concepts that are used in business like in voluntary organisations.

The literature survey shows that technical universities worldwide have incorporated modules, courses and programmes of sustainable construction. In general, new teaching methods and approaches are regarded as necessary due to the complexity of triple bottom-line issues of the sustainable construction. In addition to traditional lecturing and exercises, life-cycle and overall performance matters are taught by methods of team-work, problem-solving and learning-by-doing.

The material for this study was gathered from literature and virtual site visits of universities as well as a questionnaire among the participants of the COST C25. First remarks concerning all the material is that there are still few technical universities with a cross-cutting strategy about sustainability. Among the participants of the C25, 50% informed about systematic educational approach. This study is related to the initiative in the WG2 of C25 to establish a knowledge base to support development of educational material on sustainable constructions.

1 INTRODUCTION

Educational needs in the field of environmental, social and economic sustainability have grown parallel with increasing awareness about global threats to nature and climate. In 1972, The United Nations Conference in Stockholm regarded education in environmental matters as "essential in order to broaden the basis for an enlightened opinion and responsible conduct by individuals, enterprises and communities in protecting and improving the environment in its full human dimension". Nowadays, four international organisations of higher education are co-operating in the "Global Higher Education for Sustainability Partnership (GHESP)":

- Copernicus-Campus is a network responsible for the University Charter for Sustainable Development, known also as Copernicus Charter, signed by more than 300 university heads in European countries;
- University Leaders for a Sustainable Future ULSF serves as the Secretariat for the Tailores Declaration that is signed by more than 370 university presidents and chancellors in over 40 countries;
- International Association of Universities IAU provides a global Forum for cooperation among more than 650 member universities and institutions of higher education which have formally adopted the Kyoto Declaration on Sustainable Development
- UNESCO, which is also the parent organisation of IAU.

However, adoption of sustainability issues in educational and research programmes of technical universities has been slow. It can be described by an example of Delft University of Technology DUT, the Netherlands. Jansen, Mulder & Pessers (2005) tell the story: In the 1970'ies, debates were loud but achievements small. By 1990'ies, the number of new courses on environmental issues grew slowly and incidentally. First courses were concerning with urban design, energy and chemistry. During the last decade, development has been more systematic, and education is offered at all levels. DUT is an example of the universities, which have also signed a declaration aiming at improvement of sustainable education (Copernicus in 1996). Courtney Kibert (2000) illustrates a similar story about "the greening of the University of Florida" that began in 1990 with the signature of the Talloires Declaration and the promise to make environmental education and research a central goal in this institution.

In the starting phase of the sustainability education, most of the objectives were related to environmental issues. Gradually, the importance of economic and societal aspects has been better understood and taken care of in practice, too. Based on experiences of sustainable education in Delft University, Mulder argues that "an academic engineer should not be trained as a pure designer of technology but as a 'social' engineer" (2004). The future engineer will become the manager of the designers of sustainable technology and therefore must also be able to address social issues.

2 AIMS AND METHODS OF THE STUDY

This study is a part of the initiative in the COST Action C25 to create a knowledge base of educational material related to sustainable construction, with a focus to life-time structural engineering. Its main purpose was to gather preliminary information about:

- current teaching strategies, and possibly related reasoning
- examples of organization and planning
- educational material available, especially in the web.

The study has been conducted by a literature survey and collaborative analysis of its findings, as well as by a questionnaire among the participants of the COST Action C25 who are representing 26 countries. Replies to the survey were available from 16 universities in 14 countries (Table 1).

The main source of literature was obtained from virtual site visits in Internet, as institutes of higher education are well representing their organizations and activities there. The universities considered in this study are presented in Table 1.

Table 1: Sources of study material.

Universities		Reply to the C25 Survey		
included in the literature survey		Country	University	No
Universidad Politecnica de Catalunya (UPC), Barcelona		Czech R.	TU Prague	1
		Greece	Aristotle University of Thessaloniki	2
Delft University of Technology		Finland	TU Tampere	3
Cardiff		Italy	U of Naples Federico II/Architecture	4
Strathclyde		Italy	U of Genova	5
Chalmers, Gothenburg		Latvia	TU. of Riga	6
U.S. universities (Courtney Kibert 2000, Tinker&Burt 2004)		Lithuania	Kaunas U of Tech.	7
		Malta	U. of Malta/ Civ.Eng.	8
		Norway	U in Trondheim	9
Stanford		Poland	Rzeszow TU	10
Georgia Tech		Portugal	U. of Minho/ Civ.Eng.	11
		Romania	U. of Timisoara	12
		Serbia	U. of Belgrade/ Civ.Eng.	13
		Sweden	KTH, Stockholm	14
		Sweden	University of Gävle	15
		Turkey	U. Dokuz Eylul Izmir/ Architecture	16

Reports on education prepared in connection to Sustainable Building (SB) Conferences organized by International Initiative for Sustainable Environment iiSBE and CIB were also available for the study. The questions in the C25 Survey are presented in Table 2.

Table 2. Questions in the C25 Survey.

No	Question. The same questions were presented for two cycles (e.g. BSc and MSc)
1	Is a programme that focuses on sustainability available at your institution at the level of the first cycle? If yes, please give the name, scope of the program and possibly a link to a web address
2	Are there any courses available that focus on sustainability at any programme at your institution?
3	If the answer was yes to the previous question, please give the course title/s and provide more detail information about courses (e.g. number of hours in the classroom, type of projects, examination, literature, …).
4	If the answer was yes to the question 2, please refer to qualification of the teacher in charge of the course/courses (e.g. civil engineer/architect/other and academic degree lecturer/docent/professor).
5	If there are any courses available that just tackle sustainability issues in any way, please write about it in a similar way as above.
6	What kind of education material is used in courses mentioned in 2 – 5? Who are the authors of the basic literature and whether this material is in a public domain?

3 FINDINGS FROM THE LITERATURE SURVEY

3.1 Needs of sustainable education

The Copernicus-Campus (2006) network is promoting two important processes by stating: “To meet the challenges of a sustainable society, universities should be pro-active in realization of the Bologna reforms in order to face globalization and to serve the learners of the future”.

The construction and real estate sector is starting to turn sustainable or green. This process will require many companies to modify their working methods and practices. Construction educators can help this process by providing curricula that address sustainable or green issues. This means that each academic engineer should be trained and taught to understand economic and social aspects, and be skilled in interdisciplinary thinking and problem solving. Collaborative working and life-long learning methods should also be skills of new engineers.

There is both a moral and financial responsibility to educate future professionals in sustainable issues. Several papers and course brochures argue with similar views. like e.g. Horvath (1999), Dawe et al. (2005) and Tinker (2003). Leading construction companies are becoming involved in sustainable or green construction, and they are seeking for properly knowledgeable graduates. The certification of buildings is becoming obligatory or necessary on many markets. Owners and developers, especially on the public sector, are more often demanding life-cycle information about constructions. This evolution will result to a situation that all construction professional will be involved to some extent in sustainable issues. Horvath (1999) summarized the objectives of “environmentally-conscious construction education” as follows:

- to provide every civil engineering student with a notion that environmental issues are increasingly important in construction, in addition to the engineering and economic aspects, and that construction activities have large environmental impacts
- to teach students in construction engineering and management the practical methods and tools to lower the environmental footprint of construction design and management
- to organize continuing education courses for construction engineering and management practitioners to inform them about the latest developments in environmentally-conscious construction.

Sustainable education has also seen as a means to appeal more students to construction sector. In 2007, the Stanford University made a proposal to all U.S. civil and environmental engineering departments that the theme of “Engineering for Sustainability” is a new focal point that reunites the disciplines as well as increases the visibility, attractiveness, and relevance of our curriculum to today’s pressing problems (Luthy et al 2007). Similar remarks have been published, too that sustainable education could assist to appeal new students to engineering and especially civil engineering departments.

3.2 Strategies

It has been concluded in several papers and surveys concerning sustainability in higher education that new innovative approaches in teaching and learning are needed. A sustainable institution should impart a basic understanding of
(a) the complex environmental, social, and economic issues
(b) the nature of the political, organizational and individual responses needed.

Integration of the education of sustainable construction to the current programs requires both resources and skills of collaboration. It is almost a rule that several departments of one university or from various universities creates programmes together. It is also very common that stakeholder networks are created for consultation and contribution in planning and realization of research and education.

According to Hovard (1999), the objectives of sustainable education can be achieved by:
- including environmental modules in existing courses
- developing new courses that focus on environmentally-conscious construction
- encouraging and advising undergraduate and graduate research projects.

Teaching Objectives in Georgia Tech are formulated - from the instructor's perspective - as follows (Vaneblas et al 2002)
- Familiarize students with the concept of sustainability as it applies to the built environment, and its ramifications for design, decision making, and construction practice
- Introduce students to a general approach for solving problems, and show how it can be applied to real world problems
- Acquaint students with the principal theories, materials, and construction techniques used to create environmentally conscious buildings or retrofit existing buildings to be more sustainable

A research has been conducted in the U.K. concerning sustainability in higher education. It revealed three prevailing orientations in the teaching of sustainable development(Dawe et al, 2005)::
- Educators as role models and learners. This orientation places an emphasis on how the tutor can act as a role model for students in order to offer a credible and authoritative perspective on the realities of putting sustainability principles into practice.
- Experiential learning by reconnecting to real-life situations. This orientation focuses n real and practical life issues and actual experiences as learning situations.
- Holistic thinking. Many of the skills and knowledge for sustainable development are associated with complex, multi-layered and interconnected systems. This approach encompasses a more open-ended exploration of interdependency and transdisciplinary connections between subjects as well as including approaches to developing and honing critical thinking.

Courney Kibert (2000) argues that many institutions have begun implementing environmental literacy programs but few studies have been published indicating what methods of environmental education have been effective in creating changes in specific components of environmental literacy. However, several universities and centres argue that they are continuously collecting feedback from their selected strategies and methods, and in this way they are searching the best solutions.

Centres of sustainable development have been created in several European universities like for example Copernicus in Utrect University and Construction Knowledge Wales linked to Cardiff University. A part of their activities is usually related to the higher education. Example of the University of Gothenburg, Sweden is similar: it was one of the first universities to sign the Copernicus Charter for sustainable development in 1993. Together with the Chalmers University of Technology, it holds nowadays a centre for environment and sustainability that mainly runs research projects and contributes to doctoral studies. Some of the university centres are providing special programmes for certification purposes (e.g. Berkeley Extension).

Individual courses in sustainable construction are not the only technique to include environmental education into the construction curriculum. Sustainable ideas can be incorporated into existing classes throughout the program. Materials and methods courses can be supplemented with environmental products and techniques included in each respective CSI category. Alternate

energy systems, efficient HVAC and water conservation techniques can be included in mechanical and electrical courses. Efficient material usage can be taught in estimating courses and environmental jobsite techniques can be covered in construction administration or project engineering courses.

A widely known example of arranging sustainable education is University of Catalunia, Barcelona, UPC (Ferrer-Balas *et al.*, 2002 – *in Mulder*). It approved its first environment plan in order to introduce environmental commitments within the university. The plan covered six major areas of university life: undergraduate education, postgraduate education, research, university life, awareness raising and coordination. The main and most ambitious objective in the area of education was the curriculum greening of all the subjects offered at UPC. To start working on this, the first step was to prepare a collection of manuals (one for each school or faculty) to assist students (and lecturers) as an introduction to the study of environmental impact in final theses. The second step was to involve the schools in order to produce a *school curriculum greening plan* (SCGP) for each school. These SCGPs had three main phases:

- to establish the profile of environmental knowledge that a student needs to learn
- to design the optimal 'green' curriculum
- to establish an action plan at school level.

Apart from the lecturers of each school, the process for producing these SCGPs also involved professional associations and former students of the schools. They helped to establish a curriculum greening team (and responsibilities) in almost every school that produced an SCGP. Once the main schools at UPC had produced the SCGP, the next step was to work with the 'horizontal structure' of departments, in order to produce a *department greening plan* (DGP) for each one. Unlike the SCPGs, the DGPs covered not only curriculum greening, but also research and department life. The idea was to work with a structure closer to the reality of the lecturer, who, ultimately, is the key actor in the curriculum greening process.

3.3 Teaching approaches

Based on the literature, the sustainability education consists usually both of basic courses on sustainability issues and cross-cutting approaches integrated in the professional courses. This strategy is logical to the general view that the core competence of engineers has to be based on technologies and skills and attitudes needed for sustainability are complementing. However, there are opinions that sustainability shall be regarded as a core competence of engineers.

The situation in Delft university of Technology represent the picture of several universities as follows (Jansen et al 2006, Mulder 2004):

(i) An elementary course, 'Technology in sustainable development', for all students. The elementary course consists of two elements: a general and theoretical component of 40 study hours covering the most relevant concepts, models and practical exercises and a department specific component of 40 study hours connecting sustainable development to the specific discipline.

(ii) Intertwining of sustainable development in all regular disciplinary courses, in a way that corresponded to the nature of each specific course. Adequate intertwining of sustainable development in disciplinary courses depends on the nature of the course. A design course demands a different approach from a fundamental natural science course. In order to '*learn by doing*', one or two pilot projects per department will be set up to gain experience in how models and methods to intertwine sustainable development in different categories of courses can be used.

In Delft like in many other universities, it is also possible to specialize in "sustainable engineering". This may take place in all levels of higher education (first or second cycle, licenciate or doctoral level or in post-doctoral level). In Delft, the requirements for students following this path would be graduate work that is clearly sustainability oriented, following a selection of three to five sustainability oriented courses. The selection would have to cover some 400 study hours plus a thorough sustainability analysis of the subject of the thesis.

Approaches and experiences of Georgia Tech are presented in many papers and at the website. The curriculum development is presented in Figure 1.

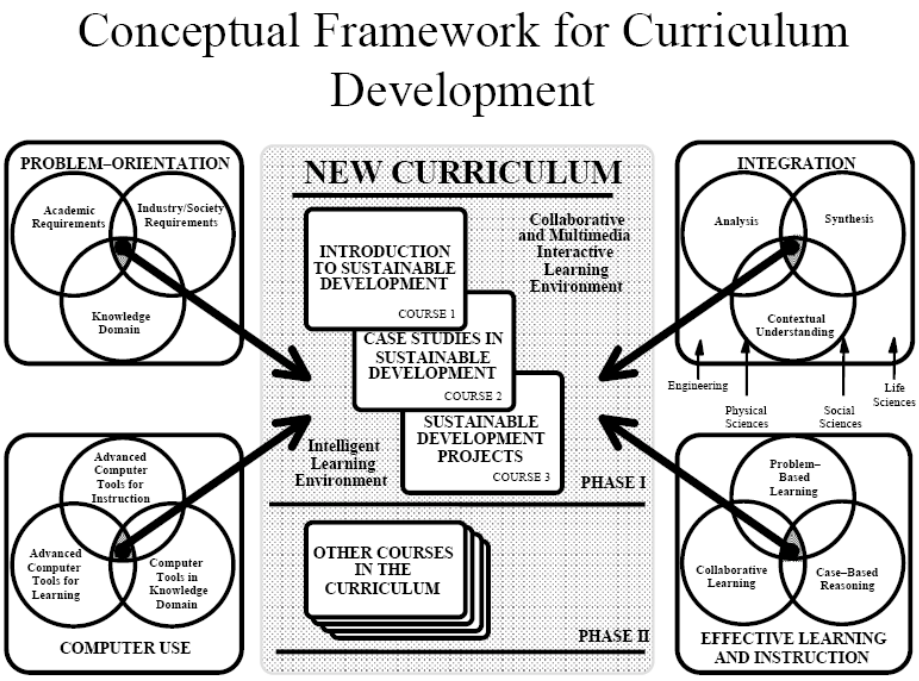

Figure 1. Curriculum development in Georgia Tech (Vanegas et al 2002)

In the Colorado State University there are three environmental courses: Sustainable Design and Construction, Appropriate Technology for Sustainable Living and Sustainable Technology in Built Environments. The first course mentioned is unique in that it is an interdisciplinary course in which students travel to the Virgin Islands and live and learn in an eco-camp for two weeks.

Texas A&M University has recently added two environmentally-related courses to the graduate curriculum. These include Earth Construction and Sustainable Construction. The first course investigates various methods of earth construction and includes hands-on experience in several earth methods. The Sustainable Construction course has even included a trip to the International Green Building Conference.

4 PRELIMINARY RESULTS OF C25 SURVEY

4.1 Summary of the answers

So far, the answers were got from 14 countries. Most likely, the research material will cover more countries and more universities in the near future. The summaries of the answers are presented in Tables 3 and 4.

In general, the answers were carefully answered, and programmes and courses were well described.

Table 3. Summary of the answers to the C25 Survey concerning the first cycle (e.g.BSc). Notations: - means that there is no information given, + means that information was given.

	Pro-gramme	Course	Information	Teachers	Issues in-corporated	Material/ web
1	no	no		-	yes	-
2	no	no	-	-	yes	+
3	no	yes	BIO-5000 Sustainable Devel-opment	teacher	yes	teacher
4	no	yes	+	+	no	+
5	no	no	-	-	yes	teacher
6	no	no	-	-	yes	+
7	no	no	-	-	yes	-
8						
9	-	-	-	-	-	-
10	no	yes	Low Energy Buildings	+	no	+
11	no	no	-	-	no	-
12	no	no	-	-	yes	-
13	no	yes	Elements of ecological engi-neering, Solid waste manage-ment, Water supply, Integrated water resource management			
14	no	yes	+	+	-	+
15	yes	yes	+	+	-	+
16	no	no	-	-	no	-

Table 4. Summary of the answers to the C25 Survey concerning the second cycle (e.g. MSc). Notations: - means that there is no information given, + means that information was given.

	Pro-gramme	Course	Information	Teachers	Issues incor-porated	Material/ web
1	yes	related	Buildings and Environment	+	no	+/+
2	yes	related	Environmental Protection & Sus-tainable Development (post)	-	no	-/+
3	no	no	-	-	yes	+
4	-	-	-	-	-	-
5	no	no	-	-	yes	teacher
6	no	no	-	-	yes	+
7	yes	yes	+	+	yes	+/+
8						
9	yes	yes	P: Urban Ecological Planning	-	-	-
10	yes	yes	P: Sustainable construction	+	yes	+
11			P: Sustainable Construction and Rehabilitation	+	yes	+
12	no	no	-	-	yes	-
13	yes	related	Educate! – Postgraduate course in Water Resources and Environ-mental Management, e-learning/	+	-	+/+
14	yes		EESI Environmental Engineering and Sustainable Infrastructure	-	-	-
15	-	-	-	-	-	-
16	no	no	-	-	no	-

4.2 Remarks about the answer

A few European technical universities has organised programmes or courses clearly dedicated to sustainability approaches or according to a cross-cutting strategy. Less programmes are given in the first cycle than in the second one, the same holds with the number of courses. Durability issues are included in some design courses. In the programmes dealing with sustainable construction, integrated approaches and collaborative learning methods can be find at least as a goals – the same mindset that can be found at several websites from universities outside Europe.

An interesting e-learning programme was presented by Snezana Marinkovic from Belgrade:

> "This programme is a joint venture with universities in Athens, Bucharest and Ljubljana. It is an e-learning type of program. First thematic area covers scientific background and it includes subjects such as Hydraulics and Hydrology, Ecology, Chemistry and Microbiology, and Data Analysis Tools. Second thematic area: Water Supply and Distribution Management. Overall, the module is expected to involve students in approximately 150 hours of learning, including 12 2.5-hour lectures; 50 hours assignments; 70 hours private study.
> One assessed coursework assignment (4,000 equivalent words including graphs and tables). Problem sheets and computer based problem solving. Examination paper (60%), Course work (40%) 3-hour examination, closed note and closed book.

Petr Hajek from the Czech Technical University in Prague describes the Master Programme Buildings and Environment in the following way:

> Program is focused on conceptual solution of building energy and environmental systems and building structure - heating, ventilation, air-conditioning, power distribution, control together with knowledge about building physics - thermal, lighting, acoustics in framework to create buildings with quality indoor environment and minimized impact to environment aimed to contribute to sustainable buildings. Theoretical courses from applied mathematics and physics give the base for applied science and practical courses divided into two specializations - building services and building structures. Training is completed in education of research and practical projects, using team-working method. Students will get knowledge about environmental and energy performance of buildings, which gives them opportunity to have integrated approach to solve problems.

5 CONCLUDING NOTES

The literature survey and questionnaire among the participants of the COST C25 are very preliminary, and aimed at a general view on the education in sustainable construction. The study has been very promising.

The "lessons learnt" listed by Mulder (2004) are in agreement with the first results of the C25 survey:

- Including environmental and sustainability aspects in engineering education is possible, although this requires considerable effort and produces slow results
- Generally speaking, faculties are interested in and agree with the objectives of introducing sustainability in the curricula, but do not know 'how to do it'.
- Sustainability should be an integral element of the designing process and of the development and implications of technology.
- Teaching a basic course on sustainable development alone is not enough to educate sustainable engineers.
- Teaching staff is generally hired and promoted based on research qualifications; engineering schools tend to hire specialized teaching staff instead of broad-minded problem solvers.
- To realize a cultural change in engineering education both top down and bottom up approaches are needed. Personal initiatives are thereby inevitable, but structural agree-

ments are essential to put the theme on a more permanent base on the agenda of a university.
- International exchange of experiences is needed not just to prevent failure, but also for moral support.

The preliminary survey has shown that the initiative of COST C25 to establish a knowledge base for educational material is important, and the participants are invited to work for it.

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