International Conference on Engineering Education in Sustainable Development
EESD2004
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Integrating sustainable thinking into the engineering course Built Environment according to the CIRRUS approach

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Key words: civil engineering, sustainable building, sustainable development,

Abstract. *The paper describes how the CIRRUS project, a pilot for a novel approach to introduce sustainable development in engineering education, has been implemented into the studies of the School of the Built Environment and Management. That concerns the implementation of sustainability in the curriculum of the School, regarding to content and form, as well as to a way of thinking by students and teachers.*

1. INTRODUCTION

Sustainable development should not just be a side issue in an engineering course, which it often still is, taking the form of a non-obligatory course or a specialization in the last year. The CIRRUS project that has run at Avans University of Professional Education for the last four years has shown that integrating sustainability as an essential element, in thinking and doing, throughout all parts and courses of the curriculum is possible and quite rewarding. Not just technology but also cultural, social and economic aspects are part of it. Much attention is paid to the development of interdisciplinary and system oriented thinking for problem evaluation and design methods [1, 2].

Essential components for integration as we intend, are:

1. an introductory course at an early moment to illustrate the concept and to give a general framework;
2. integration of sustainability in all courses, projects and other activities in the 'normal and existing' curriculum where sustainability is relevant with subjects such as materials' use, energy, design approaches, economics, business operation methods etc;

3. much attention to attitude, lateral thinking, interdisciplinary ability aimed at sustainability throughout all activities in the course;
4. explicit assessment of students on the competency "Sustainable Design" in which design has to be considered at different levels: from spatial development and architectural design to construction technology and product design;

The goal must be: students will still become experts in their respective fields, but with basic knowledge, understanding and a 'frame of mind' necessary to have the competences and attitude for 'sustainable thinking and doing' in their future jobs. That is not achieved by focusing on extensive knowledge of specific (so-called sustainable) technology, but by knowing the conditions that are to be met when designing, developing and operating processes and products when caring for people, the planet and economic development, now and in the future [4].

Sustainable development is already a long-time focus in building and spatial planning. So at the start of the CIRRUS project the courses for Civil and Architectural Engineering, Spatial and Urban Planning and Management for Building got easily involved. The courses are now part of the School for Built Environment and Management. Also because of that this still novel and ambitious approach has proven to be particularly successful in these studies. It functions in this respect as a model for other studies too.

2. WHY SUSTAINABLE PLANNING AND BUILDING

Sustainable development can be defined in many ways, but no matter how: also the School of the Built Environment and Management has to accept that it matters in every aspect of its area of interest. From the sixties onwards we have been working hard to combat the visible pollution, resulting in the false belief that the problem appeared to have been largely solved. Now the urgency for a sustainable approach is becoming more and more clear (global warming etc). Our last remaining gas field below the Wadden Sea has to be opened up. The land is sinking faster than the rivers can supply sand and gravel. Added to this more material is used for building and construction and the water level is rising. Also the marl (raw building material from Limburg) is getting depleted in a painfully visible way with hills collapsing. The struggle for space between living, working, recreation, infrastructure, energy supply, mining of raw materials, agricultural sector and nature is the focus of the public opinion, but they are all related also to building and space. Because of the geographical location of Holland the production of sustainable energy is possible, but not in an optimal way to satisfy the big demand. Wind and sun are too unreliable sources, tides and height differences necessary for hydropower are too small to meet our demands.
To prepare the students for their future, development of new techniques is required: Hi, Low and No-tech approaches.

3. FOCUS AND ISSUES IN OUR SCHOOL

Three issues get specific attention and form the 'frame' for attaining really sustainable designs:

1. a system approach in the design of buildings, constructional works and surroundings, instead of the often applied 'modular' approach (which means adding 'green' elements to an in essence still conventional design);
2. taking into account the influence of surroundings and the interaction with spatial planning;
3. keeping track of the decisions 'from first vision till final completion' during the design and the building process to prevent the ambitions and requirements concerning sustainability from 'fading away'.

The students learn to go from the planning of an entire town or district till the details of an object and are thus made aware of the interactions that exist between the various levels of planning and building. That is essential for attaining a really sustainable design.

However, students are supposed to specialize (i.e. Urban Design, Architecture, Building Technology, Civil Engineering or Construction Technology) and therefore they have to cooperate with other fields of interest, engaged in built environment. Only in this way a multidisciplinary approach is possible and necessary. This situation can be attained when students work together in a multidisciplinary project setting. In this setting students learn to take into account different interests and they discover the mutual interest of the sustainability chain.

4. INTEGRATION IN THE CURRICULUM

The curriculum is set up in such way that from the start the students encounter the challenges and requirements of sustainable development. Already in the introductory week students visit building sites and housing areas and are asked to give their vision on how sustainable elements could be incorporated.

A general treatment of the relevant issues including an introductory part are taught in the first year. In the subsequent years sustainability is an issue in the project-wise study method in different forms during all phases of the course. For instance already during the introduction in 'week 0' students do a project involving a visit to a housing area, including discussion with the people living there and the representatives of the municipality. They have to make a proposal for a more sustainable design and discover in that way how their 'customers' look at their future products and what they think sustainable development could imply. Comparable approaches and projects are done regularly during the 4 years of the course.

Furthermore specific issues specific issues of 'sustainable building' and 'sustainable development' are taught. The subject of the Bachelor Thesis is free. However many students take sustainable development as a key element and even as the main subject already.

4.1 Translating it in the "T-model" of the CIRRUS approach

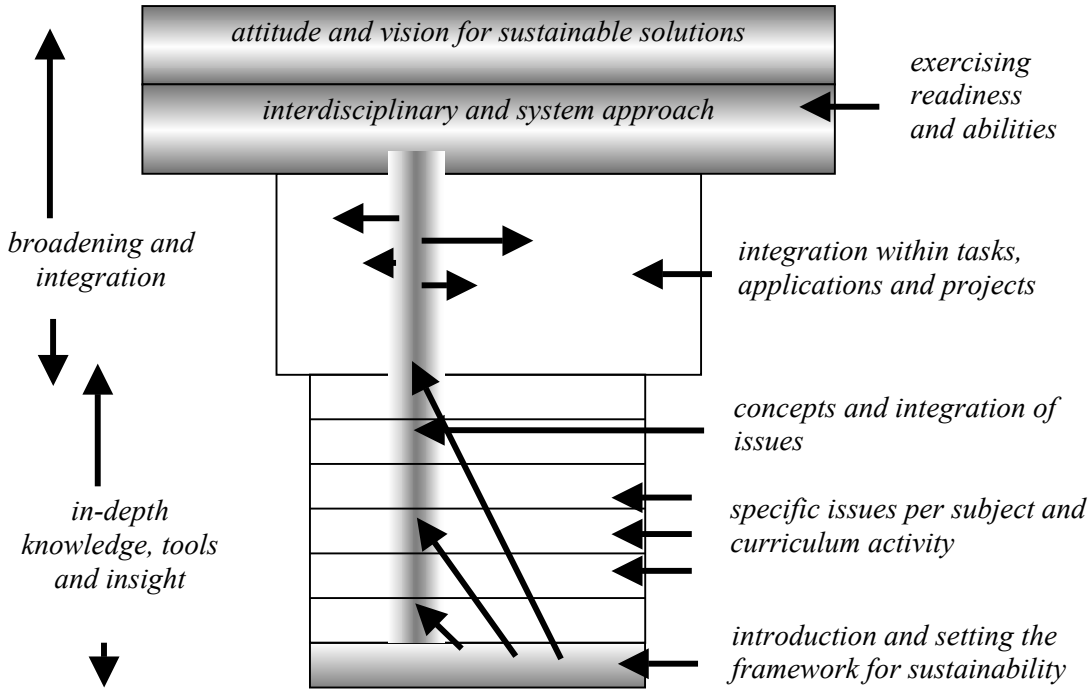

Figure 1. The basis for the CIRRUS approach

This T-model consists of a horizontal bar on top of a vertical one. The first bar represents the entrance year, with built in a basic module developed by the CIRRUS project (www.projectcirrus.net) through all phases. The first phase contains the real foundation with concepts such as Life Cycle Analysis, Chain Thinking and Ethics. In phase 2, 3 and 4 sustainability is integrated in the large modules, all of which have a multi-disciplinary setup. The vertical bar represents the Core, Apprenticeship and Final Thesis phases, with only small deepening and inspiring modules, where possible linked to large modules.

4.2 Integration in the first year

The new curriculum that we implemented is competency based. A competency we define as a combination of knowledge, skills and attitude, necessary to perform as a specialist in one of the fields of interest of Built Environment. We distinguish three groups of competencies ranging from general to specific:

1. *university* competencies, linked to University level;
2. *general engineering* competencies;
3. *professional* competencies, linked to professions related to Built Environment.

The general engineering competencies already contain some elements to direct the modules on sustainability. This creates the possibility to introduce a basic module in a multi-disciplinary way in the entire School of the Built Environment and Management.

Right from the start students are educated to gain skills in sustainable solutions. In this way the teachers (who are even more constricted in their views) are also forced to go beyond their specialism. The course covers all Built Environment aspects, from town planning and architecture to construction management. In the week prior to the first week of the study program an excursion is arranged to two sustainable housing projects. Thus during the introduction emphasis is put on sustainability, illustrated by realistic problems.

4.3 Actual integration in the subjects and modules starting from the second year

The remaining part (second year and further) of the curriculum has been developed as an integral program, keeping the overall view. During education development we planned a so called chess-board of modules, based on a defined set of competencies as mentioned in the previous part. Each student, opting for one of the fields of interest, meets a number of obligatory modules, necessary to train and test the basic competencies for his field of interest. Further the student can choose free modules, depending on his individual interest.

The modules are setup multi-disciplinary: students with different fields of interest meet and work together at realistic tasks, representing their own interest and meeting others [5]. The modules are based on so-called "aspects". Each module holds the aspects “technology”, "business operations" and "society", which can be seen as a translation of the terms Making, Managing and Translating into the direction of People, Planet, Profit. It is not the purpose to pay equal attention to all three aspects, but 0% for one aspect is not allowed. For example, it is allowed that the structural engineer spends 80% to 90% on technological issues, but in our Bachelor's model he must, for instance, be aware of the ethics of constructing (build another World Trade Center?) and the origin of steel or concrete as a material. What does the use of those materials mean in the framework of sustainability, what are the alternatives, how to design constructions so that later-on they can either be re-used, or be demolished and recycled in a sustainable way. So not only a focus on constructing as single issue.

4.4 Example of the setup of a module

A03 DEVELOPING A BUILDING ON A SPECIFIC LOCATION

Subject: Which concept for the new building of Avans University? Ecotech, high-tech or a minimum of installations?

Context: *Building* with an interface to surrounding *area.*

Starting point: Upon request of a principal a team (multidisciplinary composition) must do a feasibility study for a new building (for instance for the planned buildings of Avans University in Tilburg). The location can be fixed, but advice on it can be requested.

Characteristic activities related to the aspects:

Society: Determination strategy, exploring desires and interests of parties involved, determination of suitable housing concepts, determination of desired quality level, determination of ambition level with respect to sustainable construction.

Technology: Formulation of terms of reference, analysis suitability location, carrying out a feasibility study, listing of alternatives with possible building and installation concepts (sketch plan), formulation of selection criteria.

Business: Formulation of a project plan, determination of budget, estimate of risks, contracting construction team, testing the plan against laws and regulations.

Results: technical/financial feasibility investigation, terms of reference for preliminary design, outlines at conceptual level, indication of risks

Variables and limiting conditions: building must not be too small, but also not too big, for example between 5.000 and 10.000 m^2 floor surface; attention for sustainability, healthy environment inside, quality-aspects; knowledge required of construction and installation concepts

Dilemmas:
- to invest or not to invest in quality and/or sustainability
- which concepts are feasible in relation to budget and risks
- which housing concepts in relation to organization of the user, flexibility etc;

Remarks:
- working on the basis of index numbers,
- a good knowledge of the fundamentals of the own subject area is required.
- multi-disciplinary project: precisely consultations and attunement with other stakeholders is of great importance
- in later phase of the course, for instance K4, A1 of A2

Knowledge areas:
performance requirements, building and installation concepts, choice aspects at locations (also attunement with installation concepts), risks analysis, law and regulations, financing possibilities, sustainable construction, fitting in with development plan

	ABM Competency-set		**level**		
	University competencies		**1**	**2**	**3**
1-2	growth to professionalism			x	
3-4	working in project teams			x	
5-8	communication (internal)			x	
	Engineering competencies				
9	communication (external)			›	
10	detecting developments			›	
11	developing concepts				›
12	safe, sustainable, quality conscious				›
13	analyzing/investigating			›	
14	modeling/schematizing				›
15	controlling/reflecting				
16	innovating			›	›
17	be in charge			›	
18	managing processes			›	
19	managing costs/quality				›
20	dealing with regulations			›	

	Professional competencies		level		
			1	2	3
1	Start memorandum, stakeholders demands				›
2	Feasibility study / terms of reference				›
3	Project definition / terms of reference				›
4	Formulation and assessment of alternatives				x
5	Deal with advisers results				
6	Preparing schedule of requirements				
7	Formulating a project plan		x		
8	Maintaining and adjusting project plan				
9	Consultations and adjusting project plan		x		
10	Preparation (plan of) implementation				
11	Surveying plan of implementation				
12	Evaluation and feedback of project data				
13	Assessment and management of buildings		x		
14	Business operations and market approach				
15	Acquisition and development		x		

plan **Attitude**: - inquisitive, open minded, cooperative							

5. SPECIFIC SUBJECTS

The main problem in introducing Sustainable Development is to induce awareness of the need for it with the entire lecturing staff. To achieve this goal we organized (supported by CIRRUS) a teacher training of two days. Many lecturers considered this a loose of time; time that could have been better spent on teaching. Often the specialists in sustainability forget (also at a congress like this one) that the normal staff is not at all enthusiastic about this topics and find the everyday work more important.

Sustainability is put on top of the existing curriculum at which causes an enormous time pressure the same time that budgets are being cut. Many of the staff do not consider sustainability as part of chain thinking. Many of them are too narrow-minded to get involved. On the other hand, it must be slowly incorporated, like we did in the past with the insulation of buildings.

Since the sixties and seventies of the past century many groups have been active, which are still associated with the Flower Power movement, resulting in image problems for anybody involved in sustainability. The School of the Built Environment has to put sustainability as an innovative part of all their course.

6. RESULTS AND SOME LESSONS LEARNED

The approach has proven to be quite successful. Important is that companies and municipalities are interested to cooperate in such projects and offer placements and final projects for bachelor students.

Often the students are leading in the subject of sustainability, because they can choose the topic for their bachelor theses. In this way they act as catalysts for the lecturers. Their enthusiasm is proven by the fact that they often also participate in prize contests for graduates and obtain high scores.

Several students have won awards for their bachelor theses last years, six in the last three years, where sustainable development and innovation are principal criteria in the award procedure.

- Vitae Award, 2001 1st prize, 2002 2nd prize, 2003 2nd prize.
- NIRIA prize for study scriptions 2001, 3rd prize.
- Prize Steel constructions 2002 de 1st prize.
- SBR/ISSO innovation award 2002 de 1st prize.

The study is well represented also in the own University ‘CIRRUS award’ for theses that show promising visions of sustainability.

The CIRRUS project itself has won the “Egg of Columbus” for the introduction of Sustainable Technology in the tertiary educational system in The Netherlands. The accompanying sum of money has been put aside for the organization of a yearly prize contest

"The CIRRUS Award" for the most sustainable final bachelor thesis. During ten years there is € 2500,= for the winner and € 500 for the two runner-ups each.

7. FURTHER DEVELOPMENT

The mentioned curriculum just passed its third successful propaedeutics. Last years we implemented sustainability in our existing curriculum. At this moment we are about to start with the new developed bachelor after propaedeutic courses, in which sustainability is fully integrated.

It is important to realize that a shift towards a sustainable society is possible, only if sustainable development is incorporated as a serious issue into the curricula of all higher education institutes. This makes education as a key-agent for changes. It is important to develop education that gratifies these high commands, that takes into account the desires of future generations [3].

Sustainable development has to be a challenge for all our activities. By signing charters we committed ourselves to integrate the principles of sustainable development into education, research and operational management.

The Dutch Committee for Sustainable Development and Higher Education (CDHO) took the initiative to develop an auditing instrument called AISHE [6] (Auditing Instrument for Sustainability in Higher Education). With this instrument, the integration of sustainable development as a theme in higher education curricula can be measured and improved.

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[6] Information on the AISHI method can be found on www.dho.nl/index.php?mid=130