
A Minor Programme on Sustainability for the Engineering Curriculum at the University of Chile

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Abstract

The present paper presents a Minor Programme proposal on sustainability in the current engineering degree programmes at the University of Chile. Students in the Civil Engineering curriculum at the University of Chile can take any minor, as long as they comply with the course requirements. The Minor on sustainability is conceived as part of the undergraduate electives included in the curriculum of the School of Engineering, and it is expected to enter into the curricula on spring 2014. The paper discusses different alternatives to introduce sustainability-related topics in the curricula, the design process of the Minor and its organisation. The Minor has the following structure: one introductory course, three elective courses which can be selected from a given list and a final workshop. The paper describes the design process, support, and dissemination of the Minor and the main challenges found along the road.

Keywords

Education • Engineering • Sustainable development • Curriculum

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1 Introduction

In December 2002, the United Nations General Assembly proclaimed the UN Decade of Education for Sustainable Development, emphasizing that education is an indispensable element for achieving sustainable development (DESD-United Nations 2005–2014). Universities play a significant role in promoting the concept of sustainability in different avenues, such as new educational programs, research, cooperation with other entities and the use of demonstration projects. In fact, education for sustainable development has been on the agenda of many engineering faculties since 1990s (Segalas et al. 2010).

Much progress has been made over the last decade in developing ways to introduce the concepts and issues surrounding sustainable development to engineering students and to challenge them to think about sustainability-related problems in different ways (Fenner 2013). However, while education for sustainability literature shows there have been calls for embedding sustainable development content throughout engineering curricula (Allen et al. 2010), there has been little of strategic and systemic integration (Byrne et al. 2013).

One approach to introducing sustainability concepts to engineering education is incorporating sustainability-related topics directly in the curricula. Such mechanism has been implemented by many universities; see for example the case of the University of Nottingham Engineering Faculty. In another approach, the engineering undergraduate curriculum can incorporate a professional specialisation, for example the Energy, Sustainability and the Environment specialisation at the University of Cambridge. A third case worth-mentioning is to create a whole new academic unit dedicated to sustainability-related topics, for instance, the Department of Civil and Environmental Engineering at the Massachusetts Institute of Technology.

In regards specifically to Minors in Engineering Schools, a wide range of such programmes can be found worldwide. To mention a couple: Minor in Sustainability Engineering at the Binghamton University—the State University of New York—and also a Minor in Sustainable Engineering at the Columbia University in the City of New York.

The issue of sustainability in higher education from the learning and institutionalisation processes point of view has been revised in (Wals 2013). A major reflection in this work is the classification of “bolt-on” and “built-in” approaches. The first one consists of adding new courses and modules that have elements of Education for Sustainable Development (ESD), whereas the second one corresponds to integrating sustainability in existing studies and research programmes as well as in staff development. As the “bolt-on” responses seem to be becoming extinct, in the proposed Minor presented in this paper the “built-in” approach is selected. Therefore, this Minor programme is formed by using the current Minor structure of the Engineering Programme and its courses are mostly already available in the curricula.

International evidence has shown (Wals 2013) that most of the universities that engage in sustainability are universities that have a focus on education, rather than on research. In the case of the University of Chile, its main focus is on research, and

experience has shown that it has been an important challenge to open space for the introduction of sustainability at the Engineering School.

The main purpose of the paper is to present a field experience in assembling a Minor on sustainability in a research-oriented Engineering School, which is discussed in light of the international analysis and scholar evidence. Regarding the participatory approach, a wide consultation and collaborative practice have been viewed as important to achieve consensual agreement to harmonise collective views.

The remainder of this paper is organized as follows. In Sect. 2 a description of the engineering curricula at University of Chile’s Engineering School is presented. In Sect. 3 the main aspects of the design process are described. Section 4 focuses on the Minor’s structure proposal. Finally, Sect. 5 summarizes the main conclusions of this work.

2 Engineering Curricula Description

The engineering studies at University of Chile last 6 years. The main specialisations comprise mechanical, industrial, computer science, civil construction, electrical, chemical, mining, and biotechnology engineering. The first 2 years are set as a core programme in mathematics, physics and computer science. In Chile the secondary school education varies greatly in terms of contents and quality, so these 2 years serve as leverage for the students as well.

This two-year programme is denominated Common Plan, and the courses are described in Fig. 1.

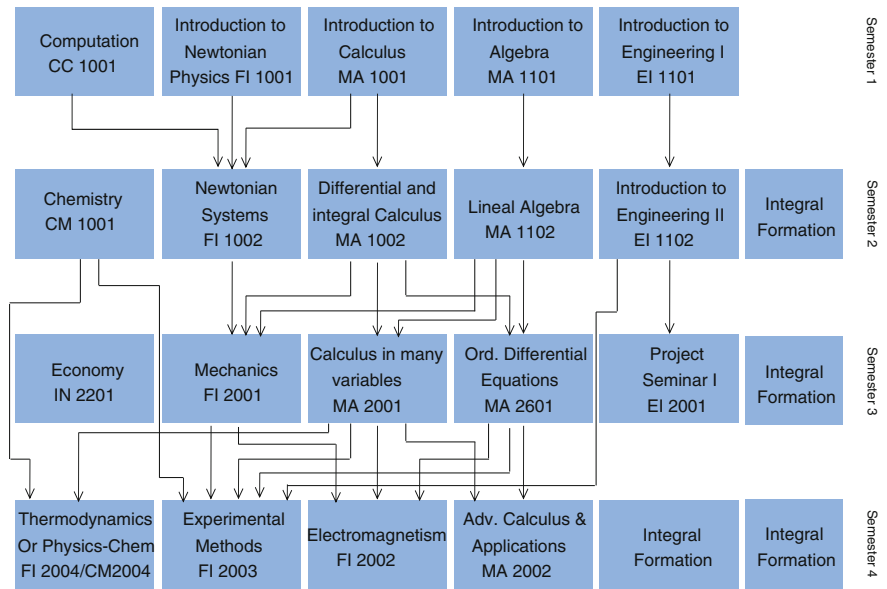


Fig. 1 Common plan



Fig. 2 The third and fourth year of the bachelor programme

In Fig. 1, each row represents a semester, and the academic year has two semesters. Lines with arrows indicate courses requirements. For instance, the course FI 2002 Electromagnetism has three requirements: FI 2001 Mechanics, MA 2001 Calculus in Many Variables and MA 2601 Ordinary Differential Equations. Every course has the same time dedication of 10 h per week, which consist of 4 h of teaching, 3 h of assistant-guided classes and 3 h of personal work. Additionally, there are Integral Formation courses for English and humanities. Students must take four of these courses, and the total dedication in this case is 5 h per week.

In third year students choose their field of specialisation and most of the courses they take are given by a specific Department (called Department Courses). The two following years, starting in semester 5, will fulfil the requirements to acquire the Bachelor Degree. A general outline is presented in Fig. 2.

Similarly, in Fig. 2 each row represents a semester. Basic Formation courses are defined by each Department, and correspond to those considered to be significant for the understanding of the discipline. For example, the Electrical Engineering Department designates the following three courses: Probability and Statistics, Optimisation, and Project Evaluation.

Starting in the sixth semester, there is a sequence of five courses dedicated to Minors (Minor Courses in Fig. 2). Two of them take place in Semester 7 and the other two in Semester 8. In the engineering curriculum at University of Chile there are around 20 Minors available, and they can be completed by students as long as they comply with the Minor course requirements. The students also have the possibility not to engage in a Minor and alternatively, take those five courses according to their own election freely.

3 The Design Process Description

In the present chapter the design process of the Minor in Engineering for Sustainable Development is described.

The origin of the idea of a Minor on sustainability is a directive given by the Dean of the Engineering School to the head of the Office of Engineering for Sustainable Development. The Minor would be implemented by putting together a set of courses, which could be offered as a Minor in Engineering for Sustainable Development. This indication responds to a very sensitive need expressed by engineering students to incorporate sustainability concepts and contents into the curriculum of the Engineering School.

It consists of the first step towards introducing sustainability in the curricula, and it was seen as an opportunity to introduce the sustainability concepts in a way which posed less resistance and barriers to implementation. The incorporation of sustainability topics in the Common Plan of the Engineering School is being currently developed, through working sessions with the coordinators and professors of the following courses: Computation, Introduction to Engineering, Chemistry and Electromagnetism.

4 Stage 1: Setting the Task Force

A group of professors were invited by the Head of the Office of Engineering for Sustainable Development to an initial brainstorming session to commence designing the Minor. The participating professors teach sustainability-related courses in their own fields at the Faculty. The departments involved in this initiative are Industrial Engineering, Electrical Engineering, Civil Engineering, Chemical Engineering, Mathematical Engineering, Mining Engineering, and Geophysics.

The School of Engineering has a Teaching and Pedagogical Area. The main task of this office is to assist professors to enhance their pedagogical skills. In addition, it organises and manages the Minors at the Engineering School.

The Teaching and Pedagogical Area promotes a competence-based approach in the training of engineers, therefore they recommended the Minor in Engineering for Sustainable Development should integrate a similar methodology. The Area also suggested integrating students in the working sessions, in order to be able to embrace from the beginning of the design process the students' thoughts and recommendations. Accordingly, students involved in environmental student groups were invited to participate in the design sessions of the Minor.

As a result, the task force in charge of designing the Minor is led by the Head of the Office of Engineering for Sustainable Development and the whole team is composed of 10 Professors, 3 Professionals and 4 students.

5 Stage 2: The Design Process

Five monthly working sessions were organised by the Head of the Office of Engineering for Sustainable Development. These sessions would typically last 2 h and have a couple of objectives to be discussed and agreed.

The team went through a typical evolution of forming, norming and storming, and it eventually reached a state of settled relationships and expectations. It is worth mentioning that vertical authoritarian leadership styles were not commonly observed throughout the sessions, which contributed greatly to the depth of the discussions and to achieving consensus. This process has followed a social learning approach (Barth and Rieckmann 2012), which is a learning system in which people learn from and with each other and, as a result, become individually and collectively more competent.

As an organisational change is needed, the involvement of staff as an important stakeholder group in this stage is seen as crucial, and empowering these stakeholders is considered as a critical step to attain the organisational change (Barth and Rieckmann 2012).

The key outcomes of the working sessions are a list of competences students should have by the end of the Minor, the structure and courses of the Minor, and the responsible teams of the various tasks.

6 The Sustainability Minor Proposal

The competences students should have by the end of the Minor are the following:

- The student links sustainability to complex systems analyses, in its social, environmental and economic dimensions.
- The student assumes sustainability as a professional attribute related to critical thinking and responsibility.
- The student integrates complexity and sustainability educational tools in the practice of its own field of specialisation.
- The student discusses, promotes, and proposes sustainable solutions to its local environmental.

The previously described competences have determined the definition of the structure of the Minor—which has 45 credits. The structure of the Minor aims not only to introduce basic sustainability contents and topics, but also to permit students to specialise in their own fields of interest, and to experience the complexities linked to sustainability through a practical workshop.

In terms of methodological approaches (Littledyke et al. 2013) argue that wide consultation, consensual agreement and collaborative practice have been viewed as important to achieve collective views and coordinated action for education for sustainability. The overall structure of the Minor is shown in Fig. 3.

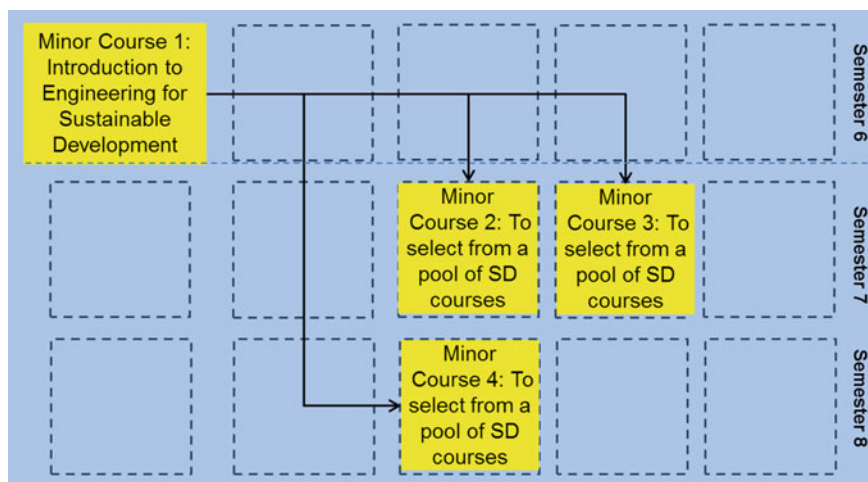


Fig. 3 Structure of the minor in engineering for sustainable development

Firstly, there is a mandatory introductory course to Engineering for Sustainable Development, which purpose is to introduce a common background in terms of engineering and sustainability to the students. There is a wide range of new forms of learning in ESD programmes (Wals 2013), including trans- and interdisciplinary learning, social learning, project-based learning, gaming, computer simulations, distance learning, backcasting, case-studies, policy-laboratoires, problem-based learning, bootstrapping, values education, ecological footprint analysis, experiential approaches, reflective journal writing. In our case, we have adopted interdisciplinary learning, project-based learning, values education, and the ecological footprint analysis.

Secondly, three elective courses must be chosen from a pool of approximately 15 courses offered by the various Engineering Departments within the Faculty. These elective courses comprise subjects such as climate systems, environmental engineering, environmental economics, sustainability in construction, innovation for sustainability, sustainability in mining, social project evaluation, and renewable energies. This initiative also led to the creation of two new elective courses in the undergraduate programme.

The Minor ends with a practical project where students propose a sustainability intervention to their surroundings (home, university, neighbourhood, etc.). The design of this workshop followed the ideas of (Segalas et al. 2010) in the sense that sustainability courses at technological universities should focus their content on the social and institutional aspects of sustainable development, and apply a constructive and community-oriented pedagogical approach.

The Minor in Engineering for Sustainable Development at the Engineering School of the University of Chile is scheduled to be launched in August 2014.

7 Conclusions

The Minor is assembled as a set of five courses, which have a combination of theoretical and practical applications. The possibility to choose the courses from a set of already existing courses (plus two new ones) provides the necessary flexibility to allow students from all the engineering specialities to enrol in this sustainability Minor.

The Minor is the first formal initiative in the engineering curriculum to incorporate sustainability-related concepts in all engineering careers at the University of Chile. As future work, the introduction of sustainable development topics in the Common Plan should be achieved, in order to have a strategic and more comprehensive approach to sustainability in the curricula.

An additional challenge is to give continuity to the Minor Task Force of professors, professionals and students in other initiatives to foster sustainability inside the university in additional fields, such as project demonstration (both inside and outside the campus), in incorporating sustainability contents and new courses in every Department, and in promoting multidisciplinary research within the Engineering School.

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