

THE INTRODUCTION OF SUSTAINABLE DEVELOPMENT INTO SCIENTIFIC EDUCATION

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Abstract

More and more universities are thinking about the application of the concept of sustainable development to the education of engineers. In France, this movement generally results from isolated initiatives taken by committed individuals. In an attempt to make up lost ground, a number of French schools which are preparing the way for the introduction of sustainable development into their teaching programmes have set up a working group to pool their experience and identify a number of principles and methods which should, in time, facilitate the spread of best practices among the members of the group and other educational establishments.

Index terms: sustainable development, learning effect, institutional project, citizen engineer

SUSTAINABLE DEVELOPMENT: A HINDRANCE OR AN OPPORTUNITY FOR THE ENGINEER?

The concept of sustainable development, which arose in the 1980s, advocates "development that responds to the needs of the present without compromising the ability of future generations to respond to theirs" [1]. The objective behind this definition is to reconcile economic, environmental and social considerations, as expressed in the diagram below.

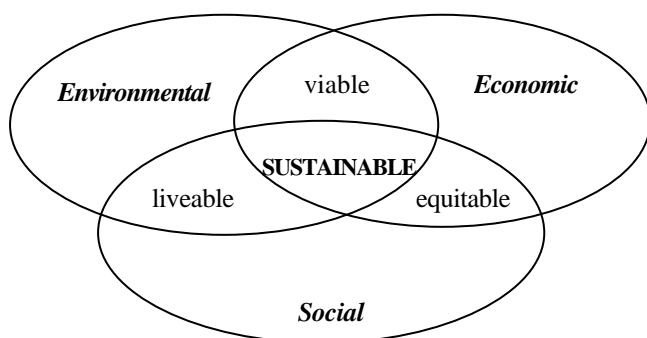


Figure 1: Diagrammatic representation of the concept of sustainable development

The elaboration of this concept, and its application, have for long been confined to the fields of research and politics; which has considerably hampered the integration of sustainable development into the world of business and other sectors of activity.

Over the last few years, however, more and more firms have begun to work with the concept, and have found that it is economically relevant to their future to integrate sustainable development into their strategy.

This implies, among other things:

- recognising that there cannot be long-term economic growth that is not ecologically and socially sound;
- accepting that the design of products, services and methods must not jeopardise the ability of future generations to satisfy their needs;
- creating an open dialogue with the different parties concerned (notably those representing local authorities), so as to determine expectations, potential problems and opportunities, and to come up with suitable solutions involving developmental synergies;
- motivating employees through incentives other than salary, especially by developing skills and favouring the upward movement of information about themes such as environmental policy and the organisation of work, health and safety;
- giving preference to anticipation through innovation, and voluntary commitment, rather than responses to imposed regulations;
- adhering to and propagating ethical principles, especially in the case of firms that work in developing countries, which could represent a positive aspect of globalisation.

Like the managerial innovations that preceded it (quality, the environment, just-in-time production, etc.), sustainable development is destined to become an inescapable dimension of the management of industrial systems. The issues involved in sustainable development feature more and more prominently in the strategies followed by industrial policy and business.

Throughout the world, firms of different sizes are moving in the direction of sustainable development. And it can now be seen that, far from being utopian, such actions constitute a positive reinforcement to these firms' relationships with their commercial and institutional partners.

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An ethically-accountable firm must have engineers who are themselves responsibly-minded and autonomous; and also, in more general terms, experts who see themselves as being citizens of their firm and their society, and responsible for outcomes and strategies in the technical and managerial dimensions of their professions [2].

The fact that engineering schools are not just centres of technical excellence, but also centres of excellence in economic and social development, means that it makes sense for them to include principles of sustainability in their teaching programmes.

THE CURRENT SITUATION IN ENGINEERING EDUCATION

For some years now, engineering curricula have been moving towards taking into consideration the "intra-mural" responsibility of the firm, involving questions of quality, hygiene, safety, or again relationships with other social actors. On the other hand, engineers are ill-prepared to take on "extra-mural" responsibility, i.e. in relation to key stakeholders in the wider society or the firm's geographical context.

The orientation of the engineer to the world outside the firm has not yet been incorporated into curricula, except, of course, for theories about market mechanisms. Teaching is essentially based on improving the firm's production methods, and is centred on conditions imposed by the market. There are new demands which, above and beyond strict technical considerations, have to do with skills related to the evaluation of limiting factors and opportunities within the firm's physical environment, conflict management and, broadly speaking, non-formalised aspects of societal life. What is needed now is a more social approach to engineering, and one which is more attentive to the needs of society. The aim is not to turn out generalist engineers, but to give people the ability to work with specialists in other disciplines and gain from contact with different modes of operation.

It is also important to note that firms have not so far shown much desire to recruit specialists in sustainable development, but rather specialised engineers who also happen to have received some training in sustainable development [3]. In career terms, specialisation in sustainable development therefore does not seem like a good idea.

OBSERVED OBSTACLES TO THE SPREAD OF EDUCATION IN SUSTAINABLE DEVELOPMENT

Many universities and engineering schools have begun looking at the question of introducing sustainable

development into their scientific teaching programmes, though so far relatively few concrete steps have been taken.

The precursors in this field face a number of difficulties with regard to the teaching methods that need to be built around the concept of sustainable development (the verification of knowledge acquisition, a corpus of theory, teaching aids, etc.) and, crucially, the commitment of directors and staff to the concept.

A certain number of obstacles have been identified [4], and these may partly explain the small number of practical measures so far adopted.

ACADEMIC AND CULTURAL OBSTACLES

The absence of a corpus of recognised knowledge and the "fuzzy" nature of the concept of sustainable development are often considered (wrongly, in some peoples' view) to be an impediment to progress.

It is undeniable that sustainable development is an evolving concept which can be defined only in very general terms. But a set of methods now exists – and some of them go back quite a long way – for dealing with the problems encountered in a perspective of sustainable development. Paradoxically, these methods (analysis of life cycles, quality approaches, value analysis, multicriteria analysis, conflict resolution, design methods, etc.) do not suffer from the wariness engendered by the concept of sustainable development, of which they are in fact empirical expressions. But there is an emerging requirement to respond to other needs: those of geographical locations, communities and individuals.

Firms are being confronted by new expectations on the part of society as a whole: production is evaluated not only in terms of cost, deadlines, quality and reactivity, but also, more and more, in terms of services provided, use value and eco-efficiency. And there is a strong probability that sustainability will become a factor in the allocation of public financial aid and loans, and even in the confidence of shareholders and consumers.

It is thus useful for a firm to have engineers who are trained to be responsive to questions of sustainable development. And it is conceivable that existing, scientifically-recognised methods could be used to promote the adoption of sustainable development in engineering practices. In fact, this concept does not represent a fundamental technological break with the past, but rather a change in behaviour.

Experiments carried out by a number of schools and universities on the content and methodologies that need to be brought into play show that a certain theoretical corpus is already available and applicable beyond what has already been tried out in the field of the environment. When it comes to an evolutionary concept such as sustainable development, a wait-and-see attitude stemming from a desire to found an exact science will not do; and indeed such an attitude would

entail a risk that the integration of the concept into the education of engineers might be postponed indefinitely.

INSTITUTIONAL OBSTACLES

Institutional obstacles to the introduction of this kind of teaching have frequently been observed in the pioneering institutions; and a reluctance to tamper with teaching programmes is the explanation most frequently given for the difficulty of bringing sustainable development into engineering education. As things stand, it is taught, at best, in optional courses that carry little weight in the overall marking system.

But at several points in their history, engineering schools have shown that no programme is sacrosanct when there is a real will to develop a new subject or an innovative approach. The introduction of economics, foreign languages and computing, or again the adoption of project-based methods, are just some examples of transformations that have taken place in engineering education; and they have all involved fundamental overhauls of programmes and working techniques. Yet these modules and methods are now taken for granted.

A teaching programme is an "artefact" which should be subject to permanent scrutiny, this being the only way in which it can adapt to evolutions in society. Adjusting it to societal evolution is in fact a prerequisite to its efficacy and viability.

For the moment, the introduction of sustainable development is an attempt to reply to the following question: "Given that teaching programmes are not flexible, how is sustainable development to be introduced into them?" But the obstacle looks much less insurmountable if tackled from another angle: "How can a programme be adapted in such a way as to introduce sustainable development into it?"

The debate about strategies for the more or less generalised integration of the concept into teaching programmes has made considerable progress, and ideas are not lacking. It is to be expected that, sooner or later, sustainable development will become a part of engineering education. But the "market – firm – teaching body" chain of influence does not yet seem to have conveyed this message forcefully enough, and it would thus appear that, if their graduates are to be competitive in the job market, engineering schools will need to pre-empt this coming state of affairs.

MISCONCEPTIONS ABOUT THE TERM "SUSTAINABLE DEVELOPMENT"

One of the difficulties about the spread of the concept of sustainable development in engineering education arises from the interpretation of the term. In many cases, it is

looked at solely from the environmental angle, and the social dimension is overlooked, notably when it comes to the firm's place and responsibility in its physical surroundings.

In the same way, while microeconomics has been relatively well integrated into engineering education, there are rarely basic courses in macroeconomics and mesoeconomics. And yet these disciplines are essential to the comprehension of the relationships between the different groups of economic agents, and their interdependence.

Sustainable development can exist only by taking into account three different types of factor: economic, social and environmental. It is therefore necessary to reinforce the social aspect of the concept so as to avoid its being identified simply as an extension of environment-related teaching.

THE AUTHORITIES' ROLE

Recent years have seen a number of experiments which have made an important methodological contribution. But these experiments generally take the form of one-off initiatives, and remain sporadic and isolated.

Such experiments are often spearheaded and carried through to completion by individuals, and the concept of sustainable development is still not usually presented as a major institutional objective. The academic authorities generally give it their implicit support; but they need to go further, and play an active leadership role, if staff and core competences are to be mobilised on behalf of sustainable development.

THE WORKING GROUP OF ENGINEERING SCHOOLS: OBJECTIVES, PRINCIPLES AND PROJECTS

A working group on "The Introduction of Sustainable Development into Scientific Education" was set up in 2001 on the initiative of the APDD. Its objective is to allow the French engineering schools which are taking the lead in this field to break out of their isolation by **exchanging, sharing and capitalising on the results of their individual experience.**

It currently comprises nine engineering schools and universities:

- Ecole Nationale des Ponts et Chaussées (ENPC);
- Ecole Nationale des Travaux Publics de l'Etat (ENTPE);
- Ecole Nationale Supérieure des Mines de Saint Etienne (ENM-SE);
- Ecole Supérieure d'Ingénieurs de Chambéry (ESIGEC);
- Groupe des Ecoles d'Ingénieurs de Marseille (ESIM);
- Institut National des Sciences Appliquées de Lyon (INSA);
- Université Technologique de Belfort Montbéliard;
- Université Technologique de Troyes;
- Université de Bordeaux 1;

and three associative structures from the university sector:

- Ecocampus;
- Cm3e (Centre Maîtrise de l'Energie – Environnement – Education);
- Association Universitaire de Grenoble.

The group is run by the Association pour les Pratiques du Développement Durable, which was set up by three engineering schools in 1997.

PRINCIPAL TEACHING METHODS

The working group embodies a certain number of principles which are accepted by all its members and comprise its fundamental ideas.

The members of the group share the view that sustainable development has to be introduced in the most generalised way in any given educational establishment, according to the following five parameters:

- educational methods;
- research;
- campus management;
- student participation in university life;
- equitable recruitment policies (for both staff and students).

To begin with, the members of the group agree that sustainable development should not become a discipline as such. The aim, rather, should be the **generalised introduction** of the concept across the whole range of teaching modules. It is not a question of creating sections that train engineers specialising in sustainable development (whose chances of succeeding in the job market would be relatively slim in view of firms' expectations [7]), but of working towards the introduction of the concept into the traditional education of, for example, chemical, mechanical and thermal engineers. This implies, of course, an adaptation of the concept to each of the different sections or specialisations.

The members of the working group recognise the need to win acceptance for a **project-based teaching methodology** that would anchor the concept of sustainable development in the real world, and would not allow it to turn into a merely rhetorical discipline but would instil a behavioural culture and reflexes. This method would be expensive, since it would be time-consuming for teachers, but costs could no doubt be held down by drawing on the new technologies of information and communication (NTIC).

The introduction of sustainable development in a diffuse way implies **training teachers** in the use of this concept. It also implies continuous monitoring of the progress that has been made, on account of the evolutionary nature of the concept. "Educating the educators" can be disconcerting and uncomfortable for teachers, but it is also indispensable to the adaptability and general quality of the methodology.

Finally, the members of the working group unanimously agree that the concept must be **put into practice on a campus-wide scale**. The educational process should be partly based on experimental learning and real-world problem-solving.

The value of example, as put forward by Ecocampus and the European Copernicus charter, is expressed by the injunction to "practise what you preach". Besides the learning effect of this principle (we retain 80% of what we *do*, as opposed to 10-20% of what we *hear* or *read*), all the experiments so far carried out have found a higher level of mobilisation among students and staff (both managers and teachers) when the concept is directly applied on the campus and makes use of local skills [6].

PROJECTS IN PROGRESS

The working group's first project was to carry out a **survey of members' experience**. A questionnaire was compiled jointly, taking into account pre-existing studies and questionnaires [7]. The form chosen for the survey was that of a relatively open-ended "activity report", so as to give the different establishments a chance to describe in detail their most interesting experiences.

Each member submitted an individual report, setting out the work that had already been done in the five key areas. The collected reports were then analysed in order to identify the avenues that remained to be explored, as well as the major learning effects, and to elaborate methodological approaches to the introduction of sustainable development into the curricula of educational establishments, especially those of universities. For the time being, the results of this survey are accessible only to the members of the working group.

The group's second project is to **collect and develop case studies**, putting into practice the ideas it espouses and using existing tools. These case studies will in due course be made available for consultation on a web site.

This project illustrates the group's belief that the way forward is to integrate sustainable development into traditional engineering curricula rather than to create specialised sustainable-development programmes for engineers.

Other projects for devising teaching methods are in the pipeline, and they should come to fruition in the next few years. Their success will no doubt depend on closer links being forged between the various members of the working group.

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