Engineering education and competences for sustainability education in Spain

Mónica Edwards[1], Diego Álvarez-Sánchez [2] & Luis M. Sánchez-Ruiz[3]

Abstract –**Education, and particularly engineering education, is a key tool to be used for facing today's challenges and for building a more sustainable world. Although sustainability education is already very much part of curricula in some fields of engineering education (as in the case of environmental engineering) but the question is concerning all other fields which are not directly connected to the concept of sustainability. In this work it presents an analysis on the treatment given to the competences for sustainability in a set of pilot projects developed in engineering education area with the collaboration of the National Agency for Quality Assessment and Accreditation (ANECA) and within the European Higher Education Area (EHEA) framework. The importance attributed to sustainability competences in the profiles and objectives of the different proposed degrees has been analyzed, The results show that, in general, the competences for sustainability education are poorly defined and included in these projects and there exist a great distance between which it is declared and what it occurs at level of the new curricular proposals.**

Index Terms - Engineering education, Bologna process, sustainability education, new degrees.

INTRODUCTION

After the Earth Summit in Rio in 1992 and the Agenda 21 implementation, education and capacity building have been increasingly recognized as critical to help shift societies towards sustainability [1]. Although one decade later, recognizing the urgent necessity of reinforcing this priority, the United Nations General Assembly adopted a resolution, establishing a Decade of Education for Sustainable Development (UNSD) from 2005 to 2014 [2]. UNESCO, in its Framework for a Draft International Implementation Scheme, states that "education for sustainable development has come to be seen as a process of learning how to make decisions that consider the long-term future of the economy, ecology and equity of all communities" and "this represents a new vision of education, a vision that helps people of all ages better understand the world in which they live, addressing the complexity and interconnectedness of problems such as poverty, wasteful consumption, environmental degradation, urban decay, population growth, health, conflict and the violation of human rights that threaten our future. The vision of education emphasizes a holistic, interdisciplinary approach to developing the knowledge and skills needed for a sustainable future as well as changes in values, behavior, and lifestyles" [1]. Higher education is essential if we are to achieve sustainable development and therefore social progress. It also serves to strengthen cultural identity, maintain social cohesion, reduce poverty and promote peace and understanding of the planetary crisis that we are facing [3]-[4].

Acknowledgement of the unique responsibility carried by the higher education sector is reflected in the many declarations of commitment to sustainability signed by hundreds of universities worldwide: the Talloires Declaration (1990), the Halifax Declaration (1991); the Swansea Declaration (1993), the Kyoto Declaration (1993), the CRE Copernicus Charter (1993), the Earth Charter (1994), the Student Declaration for a Sustainable Future (1995), the Beirut Declaration (1998), and the Lüneburg Declaration (2001). More recently, the Global Higher Education for Sustainability Partnership (GHESP) was launched at the UNESCO conference in Johannesburg [5].

Sustainability Education is already very much part of curricula in some fields of engineering education (particularly environmental engineering). But the question is: what happens with the students of all other engineering fields which are not directly connected with the concept of sustainability? Many engineering subjects, regardless of the disciplines, are taught in isolation with a minimal global awareness and exposure, and are usually taught on their own with no reference to the economic, environmental, political, cultural, technological, ethical and global aspects [6]-[7]-[8].

On the other hand and within the European Higher Education Area framework, the majority of universities are making important changes in their curricula and degree requirements. Recently, the Copernicus Campus has developed strategic guidelines for the incorporation of sustainable development into the European Higher Education Area to be presented for the conference of the European Ministers responsible for Higher Education in May 2007 in London, considering that "the universities must therefore commit themselves to an on-going process of informing, educating and mobilizing all the relevant parts of society concerning the consequences of ecological degradation, including its impact on global development and the conditions needed to ensure a sustainable and just world" [9].

In this context, this paper presents an analysis on the treatment given to the competences for sustainability education in a set of pilot projects developed in engineering education area with the collaboration of the National Agency for Quality Assessment and Accreditation (ANECA) in Spain. Importance attributed to competences for

[1] Mónica Edwards, School of Design Engineering Polytechnic University of Valencia, moed@doctor.upv.es
[2] Diego Álvarez-Sánchez , School of Applied Computer, Polytechnic University of Valencia, dalvarez@upvnet.upv.es
[3] Luis M. Sánchez-Ruiz, School of Design Engineering, Polytechnic University of Valencia, lmsr@mat.upv.es

sustainability education in the new curricular proposals is analyzed.

SUSTAINABILITY EDUCATION IN THE EUROPEAN HIGHER EDUCATION AREA FRAMEWORK

The social dimension can be considered as one of the links of the Bologna Process to the Lisbon Strategy. The famous statement of the European Council in 2000, which stressed the necessity to make Europe "the most competitive and the most dynamic knowledge-based economy in the world", has a second part, less often quoted, stating that Europe also needs "sustainable economic growth with more and better jobs and greater social cohesion" [10]. The 'Lisbon Strategy' rests on three pillars:

- An economic pillar preparing the ground for the transition to a competitive, dynamic, knowledge-based economy. Emphasis is placed on the need to adapt constantly to changes in the information society and to boost research and development.
- A social pillar designed to modernize the European social model by investing in human resources and combating social exclusion. The Member States are expected to invest in education and training, and to conduct an active policy for employment, making it easier to move to a knowledge economy.
- An environmental pillar draws attention to the fact that economic growth must be decoupled from the use of natural resources [10]-[11].

In the same direction, a conference held from 20-23 April 2005 in Graz (Austria) was sponsored by UNESCO as the lead agency for the UNS Decade [12]. The Graz Declaration asks Ministers to take appropriate action for incorporating the principle of sustainable development in the establishment of the European Higher Education Area. In the COPERNICUS-Guidelines for Sustainable Development in the European Higher Education Area, subtitled *How to incorporate the principles of sustainable development into the Bologna Process*, it affirms:

"Sustainable development as a principle and a practice brings added value to the content and process of higher education. Sustainable development can only be progressed – or indeed achieved – through a critical understanding of its complementary parts – such as how environmental, socio-political and economic factors influence our lives, the impact our choices and actions have on sustainable development – and a commitment to make a positive difference in our world.

Universities play a significant role in the development of graduates as active citizens and the strategic space they create for the cultivation of knowledge about global and sustainable development. There is the need to produce graduates educated with values which are transferable between local, regional and national contexts into the international or global arena" (p. 10) [12]

What is the situation in the engineering context? In the Barcelona Declaration it is affirmed that today's engineers must be able to:

• Understand how their work interacts with society and the environment, locally and globally, in order to identify potential challenges, risks and impacts.
• Understand the contribution of their work in different cultural, social and political contexts and take those differences into account.
• Work in multidisciplinary teams, in order to adapt current technology to the demands imposed by sustainable lifestyles, resource efficiency, pollution prevention and waste management.

- Apply a holistic and systemic approach to solving problems and the ability to move beyond the tradition of breaking reality down into disconnected parts.
- Participate actively in the discussion and definition of economic, social and technological policies, to help redirect society towards more sustainable development.
- Apply professional knowledge according to deontological principles and universal values and ethics.
- Listen closely to the demands of citizens and other stakeholders and let them have a say in the development of new technologies and infrastructures [13].

In the same document it is affirms that engineering education, with the support of the university community as well as the wider engineering and science community, must:

- Have an integrated approach to knowledge, attitudes, skills and values in teaching
- Incorporate disciplines of the social sciences and humanities
- Promote multidisciplinary teamwork.
- Stimulate creativity and critical thinking.
- Foster reflection and self-learning
- Strengthen systemic thinking and a holistic approach
- Train people who are motivated to participate and who are able to take responsible decisions.
- Raise awareness for the challenges posed by globalisation.

Significant efforts are being made in Europe and elsewhere to bring sustainability into engineering education. These efforts may be of a pedagogical nature by individual faculty, or may be policy decisions at a university or national level that enhance the implementation of sustainability into engineering education, At present and in spite of the progress which has been made in several European countries (and in the rest of the world), there are still enormous barriers in the reorientation of engineering education to sustainability [13]-[14]-[15]-[16].

OBJECTIVES

The main purpose of this paper is, in general, to explore in what extent the education for sustainability is considered in the formation of our future engineers within the convergence process towards the European Higher Education Area (EHEA) in Spain. It has made a critical analysis of the information provided from pilot projects developed in Spain -called *White Books*- for the adaptation of the future engineering degrees to European framework. These projects were elaborated in co-operation with the Spanish National Agency for the Quality Evaluation and Accreditation (ANECA). Specifically, we analyzed if competences related to sustainability education are included or not in a set of these "draft" curricular proposals.

SAMPLES AND METHODOLOGY

I. Sample

All the projects developed in engineering education in Spain with the ANECA collaboration were selected, in the following knowledge areas:

- Agricultural Engineering
- Civil Engineering
- Informatics Engineering
- Materials Engineering*
- Design Engineering
- Electrics Engineering
- Electronics and Automatic Engineering*
- Mechanical Engineering
- Industrial Organization Engineering*
- Chemical Engineering*
- Chemical Engineering
- Naval and Ocean Engineering
- Geomatics and Topography Engineering

These selected projects may be consulted in the web http://www.aneca.es/modal_eval/conver_docs_titulos.html.

II. Methodology

Although interesting and extensive studies on competences were considered, specially the results of CHEERS (Careers after Higher Education – A European Research Survey) [17], the ABET criteria [18] and the IEEE Technology Standards [19], the scope and methodology adopted in the great majority of the developed initiatives on competences in Spain have been taken from the project "Tuning Educational Structures in Europe" o, more briefly "Tuning Project" [20]. Tuning has established reference points for first and second cycle programmes for generic and subject-specific competences for diverse subject areas.

Competences and learning outcomes of a process of learning are formulated by the academic staff, on the basis of input of internal and external stakeholders (employers, graduated, etc.). Competences represent a dynamic combination of knowledge, understanding, skills, abilities and attitudes [20]-[21].

The Tuning taxonomy includes a list of 85 different skills and competences and, in general, a list or thirty competences were considered in the majority of the *White Books*. In all the analyzed documents only four competences related to sustainability education were found:

- Environmental sensibility (be aware of the social and environmental problems in the world)
- Ethical commitment
- Appreciation of multiculturality
- Knowledge of cultures and customes in other countries

It has made a qualitative and quantitative analysis related to the treatment given to the competences for sustainability education in each case (profiles, educative objectives and curricular contents).

RESULTS

Only in the *White Books* of Chemical and Agricultural Engineering there are included some aspects in profiles and academic objectives related to sustainability education (see, as example, the Agricultural Engineering Book, pp. 159-160).

In the proposal of Electronics and Automatics Engineering (p. 125) there were included the following competences:

- Environment and sustainability: To know the impact of the engineering solutions in a social context and demonstrate knowledge on sustainable development and its needs.

- Intercultural Competences. To work in international contexts respecting of cultural, linguistic, social and economic differences.

In except these examples and the *Informatics Engineering* case, the expressions 'sustainability' or 'sustainable development' are not present in the profiles and academic objectives of the *White Books* analyzed.

On the other hand, in the development process of each *White Book* a set of surveys were applied to graduates, employers and academics. In the following figure (Fig. 1) it presents the valuations given by academic samples (included in each White Book) to the four competences mentioned. It has been determined the average values for the different profiles and the different scales have been standardized.

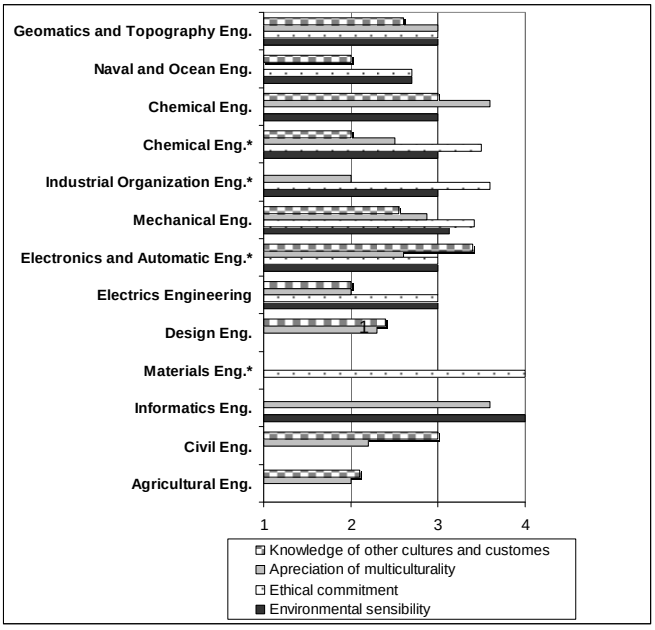

FIGURE 1
ACADEMICS' VALORATION OF COMPETENCES RELATED TO SUSTAINABILITY EDUCATION. IMPORTANCE LEVEL (4= MOST IMPORTANT TO 1= NOT IMPORTANT).
Note: *Proposals presented by Technical Schools of Engineering.

It has been observed that the word 'sustainability' appears mentioned (at least once) in 8 of 13 proposals (61%), but there is no mentioned in the listing of generic competences (and consequently, they are not valued). Two important competences related to labour mobility and for advancing in the consolidation of a multicultural Europe are 'knowledge of other cultures and customs' and 'recognition of the multiculturality'. They both are considered little or nothing important.

Only in the case of *White Books* of Chemical Engineering and Informatics Engineering the competences 'sensibility for environment' is described like very important (value 4). In the rest of proposals and, in general for the analyzed competences, it is observed that they are not considered very important (mainly considering that most of other competences have been valuated with the greater value of the scale). This absence of attention to the sustainability is reiterated in the directives and recommendations for the titles elaboration emitted recently by the Ministry of Culture and Education. This situation not only affects to the sustainability education approach but constitutes an obstacle to reach the Bologna objectives.

CONCLUSION

It seems there is no doubt that the inclusion of sustainability into the teaching curriculum is a key issue and there is an assumption that engineering should take a leading role in this sense. There is some evidence that sustainable development has already been incorporated in engineering education in a number of institutions around the world.

In Europe, while some institutions are making important changes in their curricula and degree requirements improving education for sustainability and civic engagement/social responsibility contents and setting important precedents for other higher education institutions, the majority of universities have no programs or requirements *for all students*.

The European convergence process offers a great opportunity to consolidate and replicate the existing good practice across the international higher education community. But at the present there exists a great distance between which it is declared and what it occurs with sustainability education at level of the new curricular proposals within the European Higher Education Area.

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