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INTRODUCING ETHICAL, SOCIAL AND ENVIRONMENTAL ISSUES IN ICT ENGINEERING DEGREES

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Abstract

This paper describes the experience of introducing ethical, social and environmental issues in undergraduate ICT engineering degrees at the Universidad Politécnica de Madrid. The experience before the Bologna Process was concentrated on developing elective courses related mainly on the field of the International Development Cooperation. The integration of those topics within the current ICT engineering curricula, adapted to the European Higher Education Area framework, has significantly improved. It reaches all of our students, as the programs include compulsory courses which focus on ethical and social issues, and these topics have to be considered when carrying out the Final Year Project. A holistic and comprehensive approach is being implemented, with a broad view of professional responsibility and sustainability. Appropriate contents, teaching methodologies and assessment methods have been aligned in order to make our students' training more effective. The result is an example of both bottom-up and top-down approach. It has been positively influenced by the European Higher Education Area framework and some external recommendations. However, the significant contribution regarding motivation, drive and previous experience of the teachers involved has been essential.

Keywords – Engineering education, Educational experiences, Generic competences, Social issues, Sustainability, Engineering ethics.

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1 INTRODUCTION

After the Ubuntu Declaration (International Association of Universities, 2002), an international commitment was established with the aim to review the programs and curricula of schools and universities, in order to better address the challenges and opportunities of sustainable development, with a focus on creating learning modules which will bring skills, knowledge, reflections, ethics and values together in a balanced way, and problem-based scientific research in tertiary education, both as a pedagogical approach and as a research function. Later, the Declaration of Barcelona (2004) also clearly supported the need for changing engineering education, incorporating disciplines of the social sciences and humanities, and fostering reflection, awareness and responsibility among other competences.

In the present globalized world, the impacts of the engineering profession are growing in importance, as society is becoming more aware of them, and both professionals and institutions have to assume the responsibility that their expertise and the impacts of their actions confer to them. With specific reference to information and communication technologies (hereafter ICT), changes are growing at an exponential rate and we agree with Moor (2005) when he argues that we need ethical approaches that are better informed concerning new technologies and their social consequences and that are more proactive in identifying and addressing ethical issues in relation to them.

It is increasingly common that ethical, social and environmental issues are included in academic engineering degree programs. A reference about how to introduce these topics into the academic programs is provided by several accrediting agencies such as ABET and EUR-ACE, or innovative initiatives as CDIO (Conceiving, Designing, Implementing & Operating). They include competences and learning outcomes directly related to ethical, social and environmental responsibility of engineering, and they support their integration into academic programs (Miñano, Fernández Aller & Anguera, 2015).

ABET includes in their professional competences “the understanding of professional and ethical responsibility”, and “the broad education necessary to understand the impact of engineering solutions in a global and societal context” (ABET, 2015).

The European Accreditation Agency EUR-ACE considered that graduates should be able, as a transferable skill, to “demonstrate awareness of the health, safety and legal issues and responsibilities of engineering practice, the impact of engineering solutions in a societal and environmental context, and commit to professional ethics, responsibilities and norms of engineering practice” (ENAEE, 2008). Apart from this awareness, its most recent framework standards includes as program outcomes the “ability to consult and apply codes of practice and safety regulations in their field of study”, the “ability to inform judgements that include reflection on relevant social and ethical issues” and the “ability to manage complex technical or professional activities or projects in their field of study, taking responsibility for decision making” (ENAEE, 2015).

Last, the CDIO Syllabus incorporates professional ethics and social responsibility as personal competences, and highlights the importance of knowing the societal and environmental context in order to guide any project and technological innovation to a sustainable development (CDIO, 2011).

In the context of the European Union, the framework for qualifications of the European Higher Education Area (hereafter EHEA) includes into the so-called 'Dublin Descriptors'' some relevant learning outcomes for education for ethical and social responsibility, and it is widely considered as an opportunity to introduce new educational elements for preparing students on those topics (EHEA, 2005; Rathje, Spitzer & Zandvoort, 2008; Zandvoort, Børsen, Deneke & Bird, 2013).

But there are some indications that the overall impact of these external demands has been limited and there is no evidence that the way in which universities currently prepare students in science and engineering for social responsibility is adequate or sufficient. There is some agreement about knowledge, skills and teaching methodologies to develop these competences but “some important and persistent barriers stand in the way of its sustained development. What is needed are both bottom-up teaching initiatives from individuals or groups of academic teachers, and top-down support to secure appropriate embedding in the university” (Zandvoort et al., 2013).

With this paper, we aim to share the experience of introducing topics of professional ethics, social and environmental responsibility to students of some ICT engineering degrees of the Universidad Politécnica de Madrid (hereafter UPM). To simplify the text, we are considering as “sustainability competences” the knowledge, skills and attitudes related to ethical, social and environmental issues of the engineering practice.

This experience is an example of both bottom-up and top-down approach, as it has been positively influenced by the EHEA framework and some external recommendations. However, it would not have been possible without the motivation, drive and effort of the teachers involved since in our university there is not a specific department devoted to social or humanities topics. It is a work still in progress and there are a lot of challenges to face. Section 1 explains our incipient experience before engineering degree programs were adapted to the EHEA framework. It was developed by elective courses concentrated on the field of the international cooperation for development. Section 2 addresses how we are introducing “sustainability competences”. First, it provides an outline of both the Spanish and the UPM context for developing these competences. The following subsections explain how these competences have been implemented in compulsory courses, elective activities and into Final Year Project (hereafter FYP). Finally, a reflection about this experience is presented, suggesting some proposals for future actions.

2 BACKGROUND: THE EXPERIENCE BEFORE THE EHEA FRAMEWORK

Back in year 2000, several teaching initiatives related to cooperation for development were initiated at the UPM. The first ones were elective courses called "Fundamentals of Development Cooperation", offered at the School of Agricultural Engineering and at the School of Telecommunications Engineering. Subsequently other subjects were offered at the Industrial Engineering School (“Introduction to International Development

Cooperation", "Development Cooperation Projects") and at the School of Telecommunications Engineering ("Telecommunication Engineering for Development Cooperation").

Inspired by these initiatives, a group of professors from the Campus Sur of the UPM started in 2004 to prepare a reflection on how to introduce the role and impact of ICT in society, into the curricula of telecommunications engineering degrees and computer science engineering degrees. Based in our experience in the field of the international development cooperation, the first proposal focused in the contributions of technology to human development, according to the United Nations' approach. The result was the offer of an elective subject called "ICT and Human Development" (Miñano et al., 2006).

This subject had three chapters. The first one introduced the concept of human development and the main indicators to measure it (UNDP), the global world situation were analyzed as well as the role of technology for promoting human development (UNDP, 2001). The second chapter provided some fundamentals of Science, Technology and Society, Engineering Ethics and Social Corporate Responsibility. The third one focused in International Cooperation for Development Strategies and the specificities of technological projects for human development.

We used active methodologies, enhancing personal and group reflection. We combined teacher explanations with debates, group dynamics, teamwork, external visitors, conferences attendance and round tables. The course included participation in planned activities such as a seminar about "ICT and Human Development" organized by the School of Telecommunications and System Engineering (4 sessions throughout the semester). Additionally, we promoted the incorporation of students to social development projects related to ICT, as well as short practical stays abroad. Some of our students oriented their FYP to a development cooperation project. In order to promote the plan, students joined a scholarship program, funded by the UPM, to support the execution of FYP in development projects (UPM & ISF, 2009).

The level of the student´s satisfaction was high, although it was not the most chosen subject. Some students' comments on the subject were: "this subject is different to the rest, it invites you to think and to share opinions with your mates"; "it helped me to know about professional ethics beyond the immediate revenue"; "I learnt different applications of ICT further than playing, chatting…", "it shows the human side of our studies".

The experience of the different elective subjects in several schools evolved into an UPM's own Expert Degree on "Development Cooperation" which was launched in 2008/09. This 40 ECTS degree was offered to undergraduate students as an initial training in development cooperation. Its purpose was to supplement students' training, so that the number and quality of professionals and researchers who focused their activity towards development cooperation would grow. Furthermore, it strengthened the overall education of the students through a better understanding of the interrelationship between technology, society and sustainable human development within the current global context. The Expert Degree program was designed by gathering the elective subjects mentioned above and some others such as "Corporate Social Responsibility", "Technology, Society and Human Development" or "Relations Skills and Team Management". Some of them were adapted to online format or b-learning format. The program included a set of mandatory courses (18 ECTS), some elective ones (12 ECTS) and a practical stay that students had to carry out integrated within a development project (Cervera, Mataix & Miñano, 2008).

The mandatory courses dealt about the fundamentals of development cooperation, technology-based development projects, relevant personal and systemic skills, Corporate Social Responsibility as well as ethical and social aspects of technology and human development. The range of elective subjects was very broad, according to the different specializations in the UPM: agricultural development, forestry development, land management, infrastructure, basic housing, information technology and communications, sustainable development or physical activity and sport.

When the new undergraduate degree programs adapted to the EHEA started at the UPM, the UPM's own expert degrees changed their regulation and the one about international development cooperation died off. However, other initiatives have given continuity to the experience of collaborative work between interdisciplinary groups, mainly dueto the motivation of teachers and students and "collective stubbornness" to introduce the concerns of sustainable human development, focusing on the human rights, in university activities. Among them, we highlight the Master in Technologies for Human Development (since 2010), now the Master in Strategies and Development Cooperation Policy (2014) and the Innovation and Technology for Development Centre created in 2012 (ITD, 2015).

From the educational point of view, all these activities have been an extraordinary "educational laboratory" which results have been integrated later in the curricula of the new engineering degrees at the UPM. Next

section explains in detail some initiatives that are currently being developed in the School of Telecommunications and System Engineering (hereafter ETSIST) and the School of Computer Systems Engineering (hereafter ETSISI), both at the Campus Sur of the UPM.

3 IMPLEMENTING SUSTAINABILITY COMPETENCES WITHIN THE EHEA FRAMEWORK

Spanish universities are integrated in the European Higher Education Area (EHEA), so they have included the Dublin Descriptors in every Bachelor and Masters degrees, so bachelor's students should "have the ability to gather and interpret relevant data (usually within their field of study) to inform judgments that include reflection on relevant social, scientific and ethical issues" (EHEA, 2005). In addition, each university determines a set of generic competences that must be included in every degree. Some universities have defined competences directly or indirectly related to professional ethics, social responsibility or sustainability. Some examples are: "responsible and ethical commitment" (Universidad de Valladolid), "act with responsibility and professional ethics" (Universidad de Extremadura) or "sustainability and social commitment" (Universitat Politècnica de Catalunya).

The Universidad Politécnica de Madrid (UPM) has included as a generic competence the "respect for the environment" in all of the offered degrees. Besides, the UPM Educational Model notes that "the training of engineers and architects must not only take account of scientific and technical knowledge, but also be in harmony with ethical values" and proposes -as a competence that must be developed- the "understanding of the profession and the social commitment to society and the environment, with the duty to respect their ethical code" (UPM, 2010).

As a result of an educational innovation project where teachers from different centers of the UPM were involved, a web site with teacher support resources about generic competences was developed (UPM, Innovación Educativa). Some guidelines for the competence "respect for the environment" are specified. Although it is oriented to environmental impacts, some references to ethical issues and social responsibility issues are included. Most of the methodological proposals focused on sustainability could be adapted to work ethical and social issues.

In spite of the fact that there is not a global plan for the implementation of the generic competence "respect for the environment" at the UPM degrees, there are some interesting experiences driven by both UPM Schools and some research groups. Some relevant examples are the teaching strategies of the School of Agricultural Engineering -oriented towards environmental sustainability-, the global strategies of the School of Industrial Engineering about Corporate Social Responsibility and sustainability, or the experiences of service learning at the School of Mining and Energy Engineering. Some research groups combine teaching and research practice in different areas such as sustainability, public health, social inclusion and international cooperation for development (Miñano et al., 2015).

In relation to specific degrees, the Spanish Council of Universities makes recommendations for each official degree about the competences that students should achieve during their university years. Each university and college incorporates these recommendations differently in compulsory subjects, elective specific subjects, and transversal inclusion into compulsory subjects or into the FYP. As an example, the recommendations for the degrees related to ICT engineering include competences such as "the capacity to understand and apply the ethical responsibility, legislation and professional deontology of computing engineering", the "ability to analyze and assess the social and environmental impact of technical solutions" and "ethical and professional responsibility attitudes, respect to the Human Rights and cultural diversity" (BOE, 2009a; BOE, 2009b).

In 2009, the ETSIST and the ETSISI started new degree programs designed according to the EHEA framework: Computer Engineering, Software engineering, Information Systems, Electronic and Communications Engineering, Telecommunications Systems, Engineering Sound and Image, and Telematics. Next subsections present how the UPM generic competence "respect for the environment" and the ones recommended by the Spanish Council of Universities have been implemented into these programs. To simplify the text, we are considering all those competences as "sustainability competences".

3.1 Compulsory subjects

All the new degree programs forementioned include compulsory subjects where “sustainability competences” must be developed. The subjects are different for the telecommunication engineering degrees and for the informatics degrees.

3.1.1 “Science, Technology and Society” in Telecommunication Engineering Degrees

Four different degrees are taught in the ETSIST: Electronics of Communications, Telecommunication Systems, Sound and Image, Telematics. All of their programs integrate a 3 ECTS compulsory course about Science, Technology and Society included in the 4th semester. The course’s learning outcomes include the students’ capacity to locate and analyze information critically and their abilities to relate scientific and technical aspects with the socio-economic environment, to the legal and political framework and with environmental and ethical issues.

The syllabus comprises three chapters. The first one takes the students through the history of science and technology. The second chapter analyzes the current technological society, reflecting on technological determinism and the role of ICT in society. The last one addresses issues about ethics and sustainability of the information society from a critical view of postmodernism.

“Science, Technology and Society” course applies different methodologies: teacher expositions, classroom debates, monographs, book reading and daily press review. Students in pairs must identify, select and bring to class news published in the media. These news must be related to technological issues with a relevant social, economic or environmental impact. In this way, students learn to compare how news are presented in different media and to analyze them critically.

3.1.2 “Social, Legal, Ethical and Professional Issues” in Informatics Engineering Degrees (2009 programs)

The programs of both Software Engineering and Computer Engineering of the UPM, developed in 2009 according to the EHEA, are based largely on the recommendations of the Association for Computing Machinery (ACM, 2013). One of them is the inclusion of ethical and social issues at the core of the curriculum, making very concrete proposals on compulsory and optional modules, and the introduction of compulsory topics in other subjects.

Following that recommendation, a compulsory subject, “Social, Legal, Ethical and Professional Issues” was included in the first year of both programs. While attending to this course, the students had to develop the generic competence “respect for the environment” and "critical thinking" -compulsory in the UPM- and the competences recommended by the Spanish Council of Universities for IT degrees explained before.

The course syllabus included different topics related to the professional performance of IT engineering and its relationship with society, being the legal issues -such as intellectual property and data protection- the core of the subject. Moreover, the students got familiarized with engineering professional values, professional codes of ethics, both social and environmental impacts of IT, the digital divide and the basic principles of Corporate Social Responsibility (Anguera de Sojo, Davara, Fernández & Miñano, 2012).

Throughout the course, active methodologies were used, fostering students participation with frequent debates in the classroom, case discussions, dilemmas, monographs, expert lectures or visits to research centers where their work has a significant social impact, such as the Digital Accessible Home or the CITSEM (Software Technology Center and Multimedia Systems for Sustainability).

Along these years we have checked the relevance of including ethical, social and professional issues in the curriculum, as there is a general lack of both knowledge and reflection on these issues. We have observed that the students accept well both this kind of contents and the use of different learning methodologies. The official questionnaires about the level of students' satisfaction with the teaching in the subjects show that the average for our “non-technical” subjects is higher than the global average for the “technical” subjects in the programs (Miñano et al., 2015).

In 2014 the UPM started a new degree in Information Systems and the programs of the Computer Engineering Degree and Software Engineering Degree were updated. The three degrees are developed in eight semesters and have a common core in the two first years. The former compulsory subject “Social, Legal, Ethical and

Professional Issues" is transformed into two new compulsory subjects of 3 ECTS: "Ethical and Social Issues" in the 2nd semester and "Legal and Professional Issues" in the 5th semester.

3.1.3 "Ethical and Social Issues" and "Legal and Professional Issues" in Informatics Engineering Degrees (2014 programs)

A relevant innovation of the new degrees is that all of them include as a generic competence the "social and environmental responsibility". This competence extends the former "respect for the environment" including a deeper approach to the ethical and social aspects of IT engineering. Specifically, it has been defined as the "knowledge, skills and attitudes needed to integrate into the profession, the social, environmental and ethical issues that affect IT engineering in a responsible and balanced way" (Miñano & Fernández Aller, 2015).

That competence should be developed at two levels:

- N1. knowledge of problematic issues, ethical principles and main regulations; and
- N2. skills for analyzing and integrating the professional responsibility criteria in specific engineering solutions.

The competence has been assigned to two compulsory subjects, "Ethical and Social Issues" and "Legal and Professional Issues", and it is also included in the competences to be developed and assessed in the FYP.

The subject "Ethical and Social Issues" deals with a wide variety of topics. We had as a main reference the ACM's Curriculum Guidelines, specifically the body of knowledge related to Social Issues and Professional Practice (ACM, 2013). The syllabus has four main chapters: social context, professional ethics, corporate social responsibility and current challenges and issues.

In the first chapter, we present a brief introduction to the main concepts of Science, Technology and Society, in order to the students to be aware of the role that technology plays in today's world and understand the interrelationships between society and technology development. Then, we focus on the main impacts of the IT on our society, promoting a reflection about how the IT contribute, or not, to a better society for all. To deepen into the contemporary challenges, at the end of the year, the students have to make a presentation of a monographic work about some of the most relevant issues related to the IT (chapter four in the syllabus). Last year the topics chosen were the digital divide, net neutrality, e-accessibility, privacy, intellectual property, security, cybercrimes and sustainability. In some of them, such as privacy, data protection and intellectual property, the Spanish regulation is introduced and explained.

Our goal is not only to focus on the negative impacts or problems, but also to highlight the potential of ICT to promote social welfare and sustainable human development. We encourage students to look for successful experiences in the fields of e-health, e-education, e-participation, e-inclusion, or experiences for bridging the digital divide.

In the chapter related to professional ethics, we analyze what the profession offers to society and the main ethical issues that arise in the professional practice of computing engineering (ownership of information, conflicts of interests or values, reporting, security, dual use, etc.) and the principles of professional ethics (ACMa). Besides, we present some deontological codes (ACMb; IEEE) and the students get familiarized with them working with professional ethics dilemmas; they can use them to analyze the situation and to argue about the decision that a good professional should make.

We have introduced a chapter related to Corporate Social Responsibility (hereafter CSR) that is not included in the recommendations of the ACM's Curriculum Guidelines. CSR is a result of the power and impact of corporations in today's globalized society in many different areas (labor, social, economic, environmental, technological or political) and entails the need to assume the consequences. By introducing these topics, we want to go beyond the individualistic approach (work place ethics or "micro-ethics") and give due attention to the meso (company, CSR) and macro-level (laws, political system), including topics such as social justice, equity, empowerment of people and environmental sustainability. From our teaching experience, we agree with other authors (Conlon, 2010; Didier & Derouet, 2013) that including CSR in the syllabus is a good and necessary strategy.

The subject "Legal and Professional Issues" includes the core of the subject of the previous degree program, focused on the legal aspects of IT engineering. The issues are mainly related to data protection, intellectual property rights, patents and trademarks, electronic commerce, digital signature, cyber security and crime. Also some professional issues such as regulations of professional activity and professional associations are explained.

As it is framed in the 5th semester of the program, it allows to deepen into some concepts that arose in the previous subject (“Ethical and Social Issues”), and to work on more specific issues with the use of laws and regulations, closer to the reality that the students will find as professionals.

In relation to the teaching methodologies, there is a general agreement on the effectiveness of the use of active learning practices linked to appropriate theoretical and empirical input (Bowden & Smythe, 2008; Conlon, 2010; Davis, 2006; Rathje et al., 2008; Zandvoort et al., 2013). Our course takes two hours of class per week. The teacher theoretical explanations are often combined with group discussions and debates. It is a propitious subject to present situations where legal issues collide with ethical principles, both professionally and personally. In many classes the students get online to search for information in order to analyze cases with controversial situations and make decisions in line with current regulations and consistent with the professional ethical principles. The have also to make reports about the CSR strategies of ICT companies.

The assessment is made taking into account different activities: analysis of practical cases (professional situations which involve social, legal and ethical dilemmas), online activities (discussion forums, debating on texts, test questionnaires) and monographs with oral presentations. In addition, the students have to pass two written tests with objective questions.

The experience of this first year is quite positive; the course has had a good level of acceptance by the students, who valued positively the inclusion of these topics in a technological degree (Miñano et al., 2015).

3.2 Elective courses and activities

At the Spanish universities, undergraduate degree’s students can get academic recognition in credits for participation in university cultural, sports, students’ representation, solidarity and cooperation activities, representing up to 6 credits of the total curriculum issued (BOE, 2007). Within this framework, we offered various training activities in order to allow the students to gain credits. On one hand, two courses included in the Expert Degree on Development Cooperation were offered. Courses were entitled “Technology, Society and Human Development" and "ICT and Development Cooperation". The first course provided an opportunity to reflect on the role that technology plays in human development, whereas the second one focused more on the opportunities offered by ICT in the field of international cooperation for development and to address some global challenges.

Within a project of educational innovation aimed at designing methodologies for developing skills related to social and environmental responsibility in ICT engineering, we designed the “Technology and Social Responsibility Path”. Along the academic years 2011-12 and 2012-13, the schools of the Campus Sur of the UPM organized a program of cultural events and activities related to ethical and social issues related to ICT. The program included conferences, round tables, seminars and movie forums on topics such as net neutrality, ICT and social entrepreneurship, technological acceleration, social networks and social movements. These events were open for the whole university community, but the students could obtain credits by attending the events and making some specific homework related to them.

However, it was very difficult to ensure students’ attendance, due to the overload of activities and continuous assessment tests. We tried to schedule events in coordination with particular courses, but to manage the timetables become too complicated. Therefore, it was decided not to continue with these activities, even though they were highly appreciated by the participants and they helped to revitalize the entire university community.

3.3 Final Year Project

As the Final Year project (FYP) is the closest academic activity to the future engineering projects on which the students will work, we agree with other authors (Bragós et al., 2010; Liebert, 2013; López, Sánchez, Vidal & Pegueroles, 2014) in the view that the FYP provides a great opportunity for practicing and evaluating professional skills such as sustainability or social responsibility.

The FYP is an academic activity included in most graduate engineering programs in Spain. Generic competences such as oral and written communication, creativity and planning are explicitly assessed when presenting the FYP, however the “sustainability competences” rarely are explicitly assessed. In our context, the FYP for telecommunications engineering includes the "ability to handle specifications, rules and regulations and

applying them in the development of the profession" as a competence to be developed. It is the only one indirectly related to social issues, but it does not explicitly appear in the evaluation criteria.

In the case of the informatics engineering, the tutor's assessment report for the FYP includes some questions on whether students have considered the social impact of the developed application and also whether that application contributes positively to the environment, including an analysis of the environmental impact of the product. But no further actions to support the achievement of these results were taken.

In the academic year 2014-15 we have begun to support the development of the SER competence in the FYP. Therefore, we are offering to students and teachers a methodology to develop these competences and tutorial support. The goal is to provide them with the knowledge and operational techniques that will help them to improve reflection on ethical, social and environmental aspects related to their FYP and their integration, when appropriate, in their work (Miñano et al., 2015).

Our proposal is based on different resources: the Value-Sensitive Design approach -methodology developed in human-computer interaction research (Cummings, 2006)-, some proposals from the Social Life Cycle Assessment (UNEP, 2009) and methodologies for ethical impact assessment of information technology (Brey, 2012; Wright, 2011). We distinguish four phases: identification of possible impacts, analysis and selection of the relevant issues, the technical or empirical phase and a final reflection.

In the first phase, all the possible ethical, social and environmental issues or impacts related to the project should be identified. As a previous step, we propose to define the scenario where the work will be developed. The students must consider:

- The technological sector the project is framed in (artificial intelligence, management software, mobile applications, security, intelligent systems...); depending on the sector there are specific ethical, social or environmental issues particularly relevant.
- Organizational aspects; if the project is part of a broader program, the role it plays in that program must be defined (basic research, development of a module or a specific product, application of a developed product, etc.).
- The whole life cycle of both the FYP and the broader program.
- The socio-economic, geographical and cultural context in which the different phases of the project life cycle are developed or may be developed in the future.
- The stakeholders who will be directly or indirectly affected by the implementation of the project in any of its phases, both positive and negatively.

Given this scenario, all possible impacts and ethical, social and environmental issues that may be related to the project will be identified. The goal is not to make an exhaustive list but make sure that major impacts will not go unnoticed.

We propose two methodologies. One is based on a checklist; given a list of categories of both environmental and social impacts, and a list of ethical principles and associated problems, the students will check which of them are related to their project. The list has been compiled taking into account various references from ethical assessment of technology (Brey, 2012), social responsibility management (GRI; ISOb; WBCSD) and environmental management (ISOa). The other approach involves reflecting about a series of questions related to both the main principles of professional ethics and the most common problems in engineering projects. We have adapted the questionnaire designed by Wright (2011).

In the second phase of the four previously mentioned, students have to select the most relevant issues to their project from the ones identified in the previous phase, and analyze them in depth. They are asked to accomplish the following tasks: making a detailed description of the impacts selected; identifying stakeholders and how they are affected; identifying regulations, laws, ethical codes related to them; and pondering on the possibilities of an assessment or quantitative evaluation of them.

The third phase is called technical or empirical. The impacts selected in the previous phase will be quantified and measured, using appropriate methodologies depending on the nature of the project. The results will be taken into account when analyzing different alternatives for the project development. When possible, the students will test the product, to study the interactions with potential users or affected groups, so as to contrast the expected impacts or to identify new ones. Since this phase depends so much on the nature of the project,

and bearing in mind that the academic context of the FYP rarely allows to implement it completely, we let this phase as optional.

The last phase is a final reflection. Starting on the next academic year 2015-16, all students will have to include in the FYP memory a reflection on the social and environmental impacts, as well as ethical or legal issues that could be related to the project. This reflection must include the identification, description and analysis of the most significant social, environmental, ethical or legal aspects of the project carried out, both positive and negative. Therefore, synthesize the results of both the first and second phases.

When appropriate, we propose to add the explanation of how they have taken into account these aspects when undertaking the project: restrictions imposed by regulations, laws or ethical codes; risk assessment and prevention; dialogue with stakeholders; analysis of alternatives for the project design, etc. Besides, we recommend making an assessment of the final outcome, highlighting how the risks and negative impacts have been minimized, how the positive impacts have been enhanced, as well as the overall coherence of the project with professional deontology.

Our proposal aims to take advantage of the possibilities offered by the FYP to develop the "sustainability competences" by guiding the identification and analysis of the ethical, social and environmental aspects of the project and encouraging, when possible, its effective integration into it.

4 CONCLUSIONS AND CHALLENGES

We have presented our experience in implementing "sustainability competences" in some ICT engineering degrees of the UPM: Computer Engineering, Software engineering, Information Systems, Electronic and Communications Engineering, Telecommunications Systems, Engineering Sound and Image, and Telematics. All these degrees are taught at the Campus Sur of the UPM. We are considering as "sustainability competences" the knowledge, skills and attitudes related to ethical, social and environmental issues of the engineering practice. When the undergraduate degrees were adapted to the EHEA, these competences have been included into their programs. Actually they have been integrated into mandatory subjects, elective activities and within the Final Year Project.

First of all, we would like to highlight that our current framework is the result of both a top-down and a bottom-up approach. We recognize the important role played by external demands -the Dublin Descriptors, the Spanish Council of Universities recommendations- to justify to the faculty the inclusion of the "sustainability competences" into the programs. In the particular case of informatics engineering degrees, we highlight the reference to the ACM Criteria and Guidelines on how to implement them. In order to reach the integration of social issues in engineering programs, we consider as capital the involvement of professionals associations. But, as our university has not specific department for social or humanities topics, the motivation, drive and effort of the teachers involved in the experience have played a significant role in the process.

Secondly, regarding the contents of the courses, we point out that we are developing a holistic and comprehensive approach, from different perspectives. We offer a broad view of professional responsibility and sustainability integrating ethical, social, legal and environmental issues. We show how these topics affect not only the individual level and the personal behavior (the micro level). As engineers develop their professional activities in enterprises and public institutions, we are reinforcing the role of the Corporate Social Responsibility (the meso level). Finally we aim our students to be aware about the global impacts of the engineering and, specifically the global impacts of ICT in our globalized world (the macro level).

As a final point, our framework for introducing "sustainability competences" has the advantage to reach all of our students, as it includes mandatory courses, in contrast to other engineering degree programs in Spanish universities. Moreover, the new programs for Informatics Engineering, updated in 2014, allow a better development of "sustainability competences" throughout the degree. In the former programs the ethical and social issues had a reduced presence, only in one subject in the first year. Nowadays, with the updated programs, these topics have improved their recognition with a specific subject. Legal and professional issues will be studied in the third year, enabling a deeper and more detailed analysis. Furthermore, some guidelines for introducing sustainability issues into the FYP are provided and they will contribute to complete an effective basic training for our students.

Our work is still in progress and there are a lot of challenges to face. One of them is improving our teaching methodologies. We are working on the design a "project based learning" methodology in our mandatory courses. Each project would be developed by a group of students and, given a particular ICT technology (mobile

applications, big data, cloud computing, social networks, radio frequency identification, videogames), they will have to:

- describe that particular technology;
- identify and describe the most relevant ethical, social and/or environmental issues related to that technology;
- identify current legal framework and legal challenges in relation with those issues (data protection; Intellectual property rights; criminal liability);
- analyze in detail the possible impacts which could affect diverse stakeholders in order to prevent risks or conflicts and to identify opportunities to enhance social benefits.

Working with this approach will provide students useful strategies to integrate sustainability criteria into their FYP and their future professional projects.

Another challenge is the assessment of "sustainability competences", especially when working in big groups while paying attention to all the students in a program (Colby & Sullivan, 2008; Fabregat, 2013). We are developing evaluation tools (dilemmas, cases, monographs, objective tests, etc.) and rubrics adapted to our context that allow us to make an assessment of the students' progress, to contrast the efficacy of our methodologies and simplify the evaluation's tasks.

We also aim to improve the coordination with the faculty in our Campus in two ways:

- increasing their participation in the subjects mentioned in section 2.1, so they can provide their particular point of view on social issues from their different fields of work;
- extending the implementation of "sustainability competences" into other subjects in a consistent and coordinated way.

It is feasible because some of the current subjects in the new programs include already topics related to these competences in their syllabuses, for instance, "Artificial Intelligence" and "Software Quality". Besides, there are other thematic areas that could introduce some contents, such as topics on CSR into the subjects related to business, or regulations and cases on privacy and data protection in courses on computer security or database administration, etc.

As the ethical, social or environmental issues are complex, it is a challenge to introduce them into the future engineers' training. Nevertheless looking backward, it can be appreciated that our current academic context has significantly improved in the last ten years and there are prospects that it can continue to progress in the future.

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