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SOCIAL SKILLS AND MORAL VALUES IN ENGINEERING EDUCATION

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***Abstract*:** All technical degrees in the Spanish Higher Educational System include a mandatory Final or Honours project. This is a technical activity which should lead the student to put into practice most of the skills acquired throughout the whole degree. Only technical skills are usually put into practice, although recent studies have proved that further capabilities, such as those included in the category of "social skills", will also be demanded by employers. Moreover, the introduction of the European Higher Educational System, strongly emphasizes the importance of this sort of capabilities. What we present in this work is a way to include both social skills and moral values in the Honours Project without any loss of its technical character. To do so we have launched a line of projects devoted to the development of technical aids to improve the welfare of disabled people. Collaboration agreements with nonprofit institutions and charities give us access to the needs of these communities and the opportunity to apply the results of the projects. A procedure to manage projects of this kind is also presented.

Keywords: Social responsibility, Social skills, Moral values.

Introduction

In the globalized world we are living, all economic, technological, social and cultural aspects affecting many different countries are strongly connected. From the economic point of view, this has led to an increasingly competitive world where the cost of products must be lowered to find a place for them in the markets. From the technological side, products are bound to be constantly evolving in order to outperform their competitors. Fortunately, this competitive

vision of the world is not always shared. In some contexts, social and moral values also have a role to play. Moreover, engineers are sometimes identified with environmentally damaging technologies, so they are being forced to become aware of the wider social context in which they are working. This is what has been called "The New Engineer", a professional who is socially and environmentally responsible (Beder, 1998), where social responsibility must be understood as a contribution to an equitable, sustainable and socially just, world. Some authors have written about this relationship between engineers and society (Conlon, 2008) and it is assumed that, at universities, we educate professionals for the future so their mentality and vision of the world will reflect the influence of their trainers. The literature highlights the importance of acquiring non-technical generic competencies in areas such as communication, project management, leadership and teamwork, rather than the acquisition of theoretical knowledge in a range of "socio-economic" subjects (Markes, 2006; Palmer, 2003). It is obvious that in a globalized context, engineers tend to use business considerations as appropriate criteria for engineering decisions and they do not perceive the fair distribution of the benefits of economic activity as their concern (Johnston, Gostelow & King, 2000). Therefore, querying students' conceptions about what an engineer must be is actually a relevant question (Capobianco et al., 2011). Educators are expected to intervene as knowledge producers, in order to promote a socially responsible use of this knowledge. The inclusion of sustainable development into the curricula is just one example of how to adapt engineering education in our ever-changing environment (Azapagic et al., 2005; Lathem et al., 2011). Let us put the spotlight on a European university. For instance, in Spain all engineering students must develop a technical project as a mandatory condition to obtain their diploma. In this framework, it can be stated that the objectives of the project must be such that the student is forced to put in practice all major skills acquired throughout the degree. In this work, we will show how student's technical capabilities can be trained while social skills and moral values are enhanced alongside. This compatibility is achieved by means of an adequate definition of the project's objectives. If we consider Computer Engineering we realize that projects usually consist of application programs. In this scenario it is quite feasible to think of an

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application program to facilitate access to the computer for a seriously disabled individual. Socially committed projects are as technically complex as any other but with a supportive purpose. However, choosing adequate contents for these projects is not an easy task. There must be a sufficient amount of commitment from the tutor and student to become familiar with the needs of disabled population. For this purpose, the collaboration with associations and charities is fundamental as they will take the role of our customers. The users of the product will be handicapped people but usually they are not able to express their needs and constraints.

Related work

According with the Spanish regulations, as stated in a Royal Decree (Ministerio de Educación y Ciencia, 2007), all university courses adapted to the European Higher Education System must train the students on the rights of disabled people, including the principles of fairness in their syllabus. However, these skills have to share their space in the syllabus with many other personal and professional ones. Therefore, they are usually difficult to spot among the rest when trying to check the compliance of the diploma with that Royal Decree.

The inclusion of these principles in courses not directly related to disability, such as engineering, has already received some attention from other colleagues. In this regard, Godino-Llorente et ali. (2012) describe a course on design for all named “DACIS” (Design for All in the Context of the Information Society), that is included in the syllabus of an engineering master program. This is certainly a good approach that fully complies with the Spanish regulations. Nevertheless, at the time the syllabus is being elaborated it is usually difficult to find a place for courses like this, especially in bachelor programs where we find no precedents of similar experiences.

Although the regulations affecting the disabled population and the design of engineering programs are different worldwide, other valuable examples can be found in literature. Since 1998 de U.S. National Science Foundation encourages the development of custom software and hardware devices for disabled people (Enderle, 1999). The program includes funding for engineering students to carry

out their projects. In this way, the IEEE program named as Engineering Projects in Community Service (EPICS, 2012) aims to involve high school students along with IEEE students groups to carry out "community service-related engineering projects".

Our experience takes a pinch of each approach. Our goal is include the skills required by the Spanish regulations in bachelor engineering programs. Since we do not have the opportunity to include specific course as in Godino-Llorente (2012) we make use of existing ones to embed these new skills in the already designed syllabus. To do so, we work with the students on their Final Project which is a mandatory part of every engineering diploma. What we obtain is, similarly to both mentioned before, software and hardware products designed to address the needs of disabled people. Unlike the former experiences, they are not being encouraged by well-intentioned external agents but by the University staff instead.

Honours project tradition

The Final or Honours project is a long lasting tradition among engineering degrees within the Spanish Higher Educational System. It has its origin in the legal capability of engineers to sign technical projects for the Spanish market. According to Spanish regulations, all technical projects have to be signed by a competent engineer or architect depending on the contents of the project. As long as the project demands any kind of knowledge formerly acquired by the student, it is consequently located at the end of the degree. Usually, the student obtains the corresponding diploma right after a public presentation of his Honours Project is performed. As it is a public event, it is attended by class mates, friends, relatives and, in our case, representatives of partner institutions. These projects are carried out in a number of different modalities. Nevertheless, two major categories can be considered:

- Collaborations with enterprises and institutions.
- Internally proposed projects.

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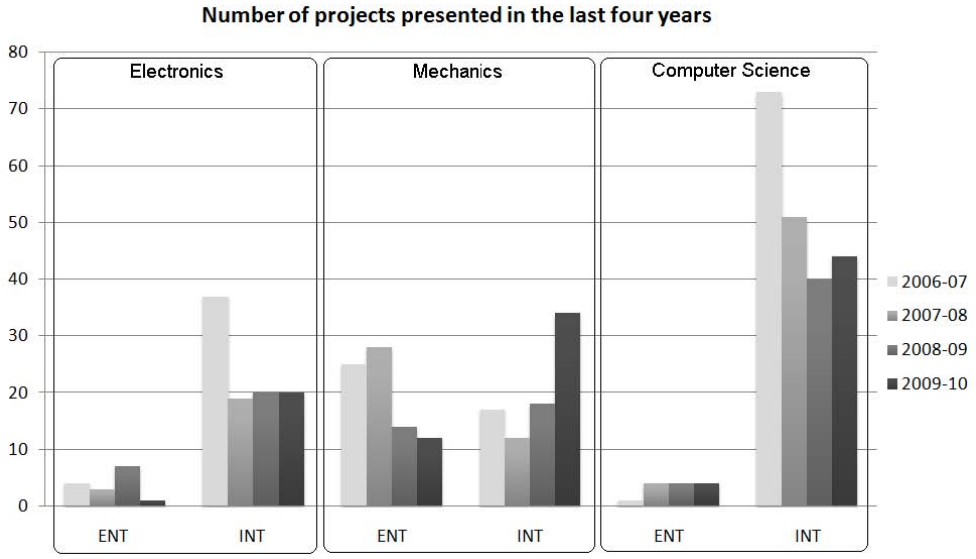
Figure 1. Evolution of the types of Honours Projects developed by the students (Mechanics, Electronics and Computer Science engineering degrees are considered). ENT stands for "Collaborations with enterprises", and INT stands for "Internally proposed".



Among all different degrees, we focus our attention on these ones: Mechanics, Electronics and Computer Science. We strongly believe that these are the areas of knowledge where technical aids for the disabled may be proposed. Figure 1 shows how projects have been distributed in these areas from academic year 2006-2007 to 2009-2010. Collaboration with enterprises is a major objective for our Institution and, according to the figures of this period, it will have to be enhanced. This is particularly obvious in both Electronics and Computer Science degrees. Even though the objective may eventually be accomplished there will always be internally proposed projects to accommodate supportive initiatives like ours. Furthermore, this sort of projects can also be developed in some cases in collaboration with enterprises and associations, thus fulfilling the goal of a professional training of the student as well. As a matter of fact, as we state in the conclusions section, it is a future trend to provide an entrepreneurial spirit to this activity.

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Description of the proposal

In this work we present a comprehensive procedure meant to set up and maintain a line of projects devoted to develop different technical aids for disabled people. In addition to the technical characteristics of the aids, a major objective of the projects is to introduce social skills and moral values into the student's curriculum. Most internally proposed projects are very easily managed. They just need to be proposed to the students by the tutors who patiently wait for applicants. Our socially committed projects require a slightly more complex procedure. This complexity has no relation with their supportive character but with the inclusion of more factors in the project. The main innovation of this process is the presence of a single type of client. In most cases, the subject of the aid to be developed is not a certain individual but a profile of disability. Nevertheless, individuals suffering from a certain disease are not usually our interlocutors, but the associations representing them. Close contact with associations and charities allows us to collect the main needs of their members and becomes the best possible benchmark for our proposals. All projects are tested by those who are expected to benefit from them before they are considered as finished.

The flowchart in Figure 2 describes the different stages of the procedure:

- Stage 1: without any student's participation, a meeting between the project's tutor and the association is convened. As a result a proposal for a project is generated. It corresponds to a real demand for a technical aid. In spite of its supportive purpose, the overall amount of work required by the project must not exceed the standards observed in the degree. This is so in order to avoid deterring students from enrolling in this type of projects.
- Stage 2: the proposal is offered to the students who have registered for the Honours Project course. Once a project has been assigned to the students, we then proceed to stage 3.

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- Stage 3: the students attend a meeting with the association in order to obtain the project's specifications, that is, what kind of technical aid is needed.
- The loop including stages 4 to 6 becomes the bulk of the work. Students develop preliminary versions of the technical solution to be tested by the customer, who suggests corrections and modifications. This process matches traditional software development life cycles such as those presented in (Dawson, 1999). It also takes into account modern methodologies for web application and graphical user interface design, such as those presented in (Pressman, 2010). Usually the association or charity involved in the project takes the role of the customer, suggesting modifications and eventually determining that the project is ready to be exploited. In order to facilitate this interactive process several meetings are held with the attendance of the customer, student and academic tutor. Once the project is fully validated we proceed to stage 7.

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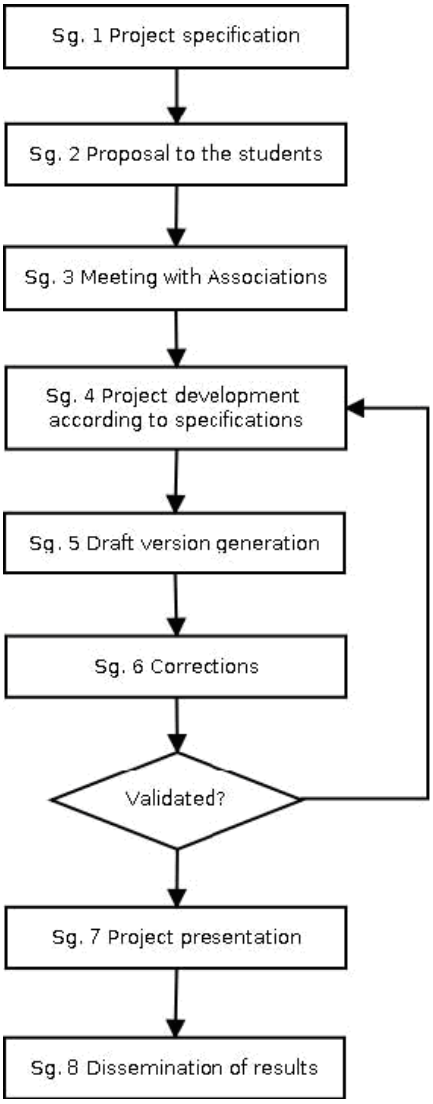
Figure 2. Flowchart diagram including all necessary stages to develop a socially committed project.



- Stage 7: all formal aspects of the project are arranged in order to present it to the tribunal who will mark the work. The tribunal is integrated by five lecturers belonging to different areas of knowledge. It will assess only the technical aspects of the work. Its assistive purpose is not taken into consideration.
- Stage 8: this final stage, not usual in other kinds of projects, intends to inform the society about the achievements of the project. Stage 8 includes a number of activities:
    - Reports to the media: TV, radio, press.

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- Participation in different kinds of contests.
- Papers and articles sent to conferences and magazines.
- Transmission of the new solution to other associations and charities by the partner association.

In case a commercial exploitation of the project is feasible, the University may award it with a fund intended to support the creation of a spin-off enterprise.

Results

Once we became aware of the social responsibility and sustainability principles that should guide the engineer's activity as mentioned at the beginning, we started an activity meant to introduce such principles in the student's training. This started back in 2000 with some scattered projects lacking from any common guideline. It was not until 2007 that this activity settled down; supportive projects have never stopped ever since. Table 1 shows the projects carried out by our students so far.

Although the scope of our group is wider, they can all be included in two categories associated with their respective types of disability:

- Projects intended to grant access to information technologies to patients affected by cerebral palsy.
- Projects meant to facilitate access to information to deaf people.

Cerebral palsy has been our first and, for the time being, main area of interest. It is also the most challenging type of disease to tackle due to the different types of damage suffered by each patient. Up to the realization of this article, seven projects have been successfully carried out. It is obvious that the figure does not reflect a massive activity. Nevertheless, the bottleneck is not actually on the interest of the students for this activity but on the number of tutors available. This sustained interest among the students in this kind of projects can be considered a sign of success. Furthermore, the projects have been awarded with several prizes, awards and scholarships as was shown in Table 1. These awards are particularly positive as a motivating factor for prospective students. As a

matter of fact, it is not common that Honours Projects receive an external award. Appearances on the media, very frequent in these cases, are also rare in other types of projects.

Table 1. List of titles and awards won by the commited projects. These titles and awards are originaly in Spanish, but here we provide a translation made for this paper.

Project title	Awards
Software tool to facilitate reading and adaptive learning to disabled adults	Castilla y León Accessibility Awards, 2007 edition (Consejería, 2007)
"WIIMO" (Software tool to facilitate access to computers to users with severe mobility impairments)	Fundación DFA (www.fundaciondfa.es)
"AUREA" (Augmented reality in educational environments)	Scholarship prototype. OTRI-OTC (www.ubu.es/es/otri)
"HADA" (Software package to help hearing impaired people)	Scholarship prototype. OTRI-OTC (www.ubu.es/es/otri)
"Rehabilit-AR" (Augmented reality for rehabilitation)	Scholarship prototype .OTRI-OTC (www.ubu.es/es/otri)
On screen interface	Scholarship prototype; "UBUemprende". OTRI-OTC (www.ubu.es/es/otri)
Wii console adaptation for use in social networks	Scholarship prototype. OTRI-OTC (www.ubu.es/es/otri)

Another extra feature we are able to provide to our students is the opportunity of participating in written articles, conferences, interviews and debates, all of which are very constructive for their personal and professional training. In order to obtain the necessary feedback from the students and then to assess their degree of contentment with this experience, we have issued the survey that is shown in Table 2.

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Table 2. Questions included in the satisfaction survey.

Question number	Question text
1	Initial interest for this type of project
2	Degree of satisfaction with the mark obtained
3	Overall degree of satisfaction with the project
4	Did your project stand on equal footing with the rest?
5	Were the contents of the project related to the rest of the degree?
6	Did you have enough time to carry out the project?
7	Did you have adequate tools at your disposal?
8	Is the evaluation procedure appropriate for this type of project?
9	Are the ethical and social objectives of the project achieved?

This survey has been filled by all students involved in the projects described in Table 1 right after their projects have been marked. In question 1, the student must assess the a priori motivation that led him to choose a supportive project. Once the project has been finished and the student obtains a certain mark, the student can assess his contentment (question 2) and the overall satisfaction with the project (question 3). As long as the project is quite different from other projects, we want to know if the student perceives any kind of discrimination on the marking system, the mark itself, resources available and even time (questions 4 to 8). Finally, question 9 tries to verify if the student feels that, in addition to the academic goals of the project, some ethical and social objectives have been addressed and accomplished. They are all scaled questions marked from 0 to 5, where 0 is associated with the lowest possible level of satisfaction and 5 with the highest. Figure 3 depicts the results obtained. All average scores are clearly above the neutral mark of 2.5. That means that students are highly satisfied. Among these positive results, question 5 gets the worst score. Seemingly, the students are not totally convinced that their projects have that much in common with the rest of their studies. Even though the score does not reflect high

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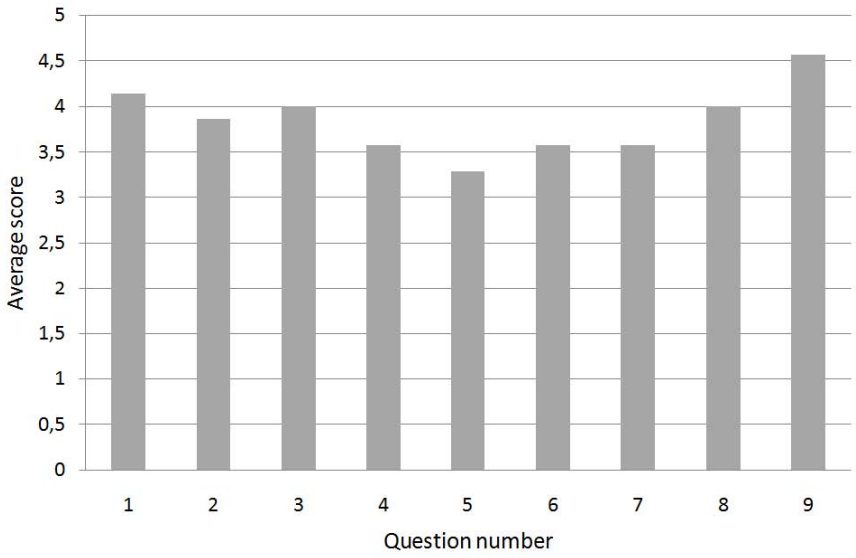
discontentment at all, it tends to indicate that the initiative have to be explained more carefully. On the other hand, the best score is obtained by question 9. This is an extremely encouraging result. It means that the social benefits of the projects have been well understood and valued by the students. Questions 2 and 3 suggest that the students have a good impression of the work they have carried out and the mark they have obtained for it.

Figure 3. Degree of satisfaction according to responses given by the students to the questions listed in Table 1.



Project WIIMO

Project WIIMO has become an icon of supportive applications managed as Honours Projects. Its development lasted for one year, finishing back in 2009. Its main goal was to allow any patient suffering from cerebral palsy to use a PC. To do so, we needed to be able to transform any movement from the human body into orders to move the mouse and to click on any desired place of the screen. The most challenging part of it, is tracking the patient's movements with enough precision. Fortunately, the vendor's hardware is capable of achieving such accuracy. In this particular case, we have used the remote control provided by Nintendo for its Wii (www.nintendo.com/wii) gaming product. This gaming technology to assist disabled people has been used as an alternative to custom-made devices. This is the case of the work developed by Standen, Camm,

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Battersby, Brown, & Harrison (2011). In our case, we take advantage of the fact that the device can detect an infrared light signal with admirable precision. The light is generated by a 2-D LED array specially designed for this project. The light is reflected by a sticker attached to the part of the body that the patient can control. Displacements of the sticker are directly converted into mouse movements. There's no way to press a button with a sticker though. In order to click on the screen there are several options:

- Stop on the same place for a configurable amount of time.
- Add a personalized hardware device to be controlled with another part of the body.
- Adapt a standard mouse to facilitate the clicking operation. The resulting product has been successfully tested with several patients severely affected by the disease. Before WIIMO they had to use heavy mechanical devices, thus resulting in a discouraging lack of precision and much higher fatigue. In spite of the fact that we only use the optical capabilities of the hardware, it is worth purchasing the whole device. Developing a customized device to replace it would be certainly be much more costly. For all those reasons the product has been largely praised by our partner associations. The impact of the project in society is also remarkable. Its capabilities have been widespread in the media and specialized forums, such as:
    - A number of citations in local press.
    - Up to 13 articles in newspapers nationwide.
    - Local TV and radio.
    - National radio prime time interviews.
    - Presentations in conferences on disability and innovation on education (Sanchez, 2010; 2011).

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Conclusions and future trends

In this work, we have proposed an innovative type of Honours Projects intended to enhance students' social skills and moral values without any loss of technical interest. This leads to a quite complex process involving the students, their advisers and external institutions and charities. We have presented a procedure to ensure an adequate handling of all these interactions. What has been achieved is a line of projects lasting in time and satisfactory in results for all parts involved. This activity can be improved by the addition of new types of supportive projects, providing solutions to other sorts of disabilities. Furthermore, we reckon that we should improve the way disabled people can access the solutions that are being developed for them. Not much more than prototypes have been delivered for the moment. Our goal is to promote the creation of spin-off companies intended to satisfy the increasing demand of our products. In order to facilitate this transition, our University has recently set up a program to provide training, advice and funding to help students become entrepreneurs.

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