ICT4Girls: from High School to University
An approach

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ABSTRACT: Technological advances are improving living conditions. Oddly, there continues to be a decrease in the number of ICT students. The decline in the number of female students is particularly noteworthy. One of the main reasons is that neither the model of professional profile promoted, nor the global approach of the mission is attractive or appealing. In this paper we present our ICT4Girls project with two goals: to collaborate with high schools in mentoring and encouraging students (mainly girls) to integrate their skills with their personal vocation and their future career; and to present computer science as a real tool for providing service to the society, promoting ICT careers and making women visible in the world of technology. The results and conclusions we present are based on three activities carried out in a pilot project.

Keywords: ICT, profession, society, visibility of women, social impact.

1. INTRODUCTION

For the last few years, technological degree programs have experienced a significant and continuous decline in the number of students enrolled-especially in the ICT (Information and Communications Technology) programs- in Catalonia as well as the rest of Europe and the United States (Rashid 2008). At the same time, companies are having difficulty filling positions that require a higher level of training and experience in computing. Among the causes of this decrease in technological vocations, essentially two reasons seem to stand out: the stereotype of the perceived professional profile is unattractive and the overall focus of the work environment that is promoted is not appealing to young people (Rashid 2008). These reasons mainly affect women, although they also have an influence on men, which leads to increasingly fewer high school students attracted to these degrees despite being qualified to study them. Very little is known about what an ICT professional actually does in their field, and how they cooperate with society. The closest and most familiar model, when one exists, is the overall negative one that cinema and television series offer: a timid person, almost always male, who exhibits antisocial behaviour and usually works on projects that are against the law. The new degree system and curriculum of the Bologna Process will give university degrees a mainly professional focus; in other words, directed at certain professional profiles. This means that the visibility of

professional models- what a given professional does and how they take part and relate to society- will be more decisive than ever for high school students to decide on a degree of study and help them determine a professional vocation in line with their skills and abilities, and also their interests. This is one of the specific goals of the UPC's "Strategic Plan" for the period between 2007 and 2010. The main objective of the Strategic Plan is to guarantee the principle of equal opportunities among all of the men and women in the university community. To achieve this, it is necessary to promote a culture in favour of equal opportunities among women and men. At the same time, the UPC is concerned about the increasingly fewer number of female students admitted to technological degree programs and therefore the frequent inability of achieving an adequate proportion of female investigators and professors in the different levels of civil service and education. For the last few years, the Department of Computer Architecture (DAC) at the Universitat Politècnica de Catalunya (UPC), with classes taught at the School of Telecommunications Engineering of Barcelona (ETSETB) and the Barcelona School of Informatics (FIB), has been studying and proposing possible plans of action to solve this problem. A group of male and female professors have seen the need to act from within their field, as professionals representing the ICT profile, and during the last few years have been evaluating and implementing diverse activities. According to the conclusions reached by studies carried out by different specialities and in diverse countries (Collis 1991; Educational Foundation Commission on Technology, Gender, and Teacher Education, 2000; Hyde 2005; Sanders 2005), the main action points in the field of computer engineering will be:

- To show the reality of working in engineering and technology, changing stereotypes if necessary.
- To highlight the most relevant skills related to technical jobs.

In this paper we present our ICT4Girls project, a collaborative project between high schools, the UPC University and businesses. There are two main goals: to collaborate with high schools in mentoring and encouraging students (mainly girls) to integrate their skills with their personal vocation and their future career; and to present computer science as a real tool at the service of society, promoting ICT careers (Sellen et al. 2009). In order to create a favourable social atmosphere, the project was carried out in diverse environments: in high schools and the university (involving both students and professors), and in the social sphere (involving families and businesses).

In the following sections, first we will present a pilot project with high school students in the university. In Section 3, we evaluate the project's results and propose the next steps to be taken. In Section 4, conclusions are presented and activities are introduced that are currently underway in line with the main objectives of the project. Lastly, in section five we acknowledge our appreciation all those who have participated in the project by giving their collaboration and support; and in section six the bibliography and references are provided.

2. Pilot Project: Year 2008-2009

The starting point for the ICT4Girls project is to encourage girls who have the skills and abilities to achieve a technology degree and who are drawn towards the profession to continue studying. Therefore, a key goal is carrying out activities with high school students and teachers; on one hand to ascertain their views on computer engineering, and on the other to encourage them and promote the necessary attitudes for pursuing a degree in higher education in this field. During the 2008-2009 school year, we carried out a pilot project at the UPC oriented towards 14 to16 year-old students from an *ESO* secondary school[i] in Barcelona. The group was comprised of 30 girls, all of which were taking a compulsory technology course in school. The main objective of this project was to show the high school girls the real possibilities offered by the computer engineering profession, through a real experience as university students and by drawing their attention to research projects in ICT environments that make a clear contribution to society (Buckley 2009; Haberman et al. 2009). The project was based on three activities with different independent objectives, designed with the idea that each could be carried out separately and independently of one another in any order and with different participants.

One of the main foundations of ICT4Girls is to provide visibility to women in the world of technology: it is important to involve women. Therefore, a secondary objective was to encourage female undergraduate computer engineering students to participate by guiding the activities. The university students who participated in ICT4Girls acted as guides, not only in the physical sense (leading a tour of the campus, the classrooms, the library and other areas of special interest) but also in an academic sense by orienting the high school girls and sharing their own personal experiences as students, discussing the classes they had taken and possible future career options, etc. The latter aspect was the most interesting for them, and what motivated them to participate. This objective will be discussed later in more detail. The main objective is to increase the number of students, especially women, that enroll in these degree programs and later join the profession, contributing with their talent and personal abilities. The three activities in question were:

- To visit a research team (BSC/Marenostrum Supercomputer) and visit FIB: guided by female university undergraduates.
- To attend a lecture adapted to high school level in a university classroom given by a university professor.
- To collaborate on a real project. (Daniels et al. 2002).

The focus was mainly on the more "social" side, showing the existing link between computer science and community service (Sellen et al. 2009).The project is about showing how computing as a profession is much more that simply programming, about highlighting the imaginative and creative aspects, and using the complex character of computing to solve problems and meet the needs of society (of people and their community). With this combination of activities, we not only aspired to increase the number of students entering ICT degree programs, but also

provide a positive and more open outlook on these types of professions that currently are practically unknown. We will take a closer look in more detail at each of the activities, designed and treated with the greatest care by studying the most adequate and attractive way to achieve the desired effect.

2.1. Visiting the Marenostrum Supercomputer

The first activity that we will explain consists of involving each student in the work environment of an investigator and a professional, experiencing their work day and interpersonal relationships with the rest of the department members and laboratory personnel firsthand. In this case, the group visited the installations of the Barcelona Supercomputing Center, taking advantage of the fact that a visit had already been arranged as part of the aforementioned compulsory technology course in their high school. During this visit, there was a discussion about the applications that are used and the multidisciplinary research groups that work towards solving problems (improving the environment, reducing air pollution, simulating the reaction of human organs to medicine for prevention and improvement in patients, etc.). The Director of the Center, an investigator of international prestige, introduced the students to the world of advanced computing, sharing examples of current problems with them (a simulation of the traffic in Barcelona and how it affects air pollution, virtual heart and other vital organ surgeries, etc.) and how the Center helps in interdisciplinary teams with other scientists, to find a better solution.

Figure 1. *Research group with the high school students and university undergraduate guide. Below, the visit to the Marenostrum Supercomputer that during years has been the first of its kind in Europe.*

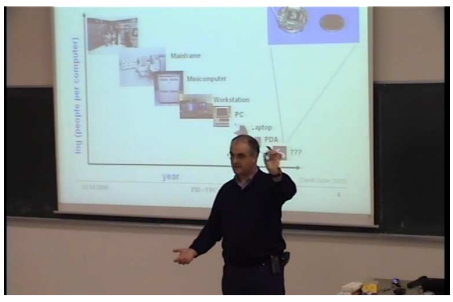
2.2. Class: University Level Topic Adapted to High School

The second activity was focused on getting to know the university campus and having a personal experience there. The female undergraduate university students gave the girls a tour of the campus, visiting the central library, the student cafeterias in different schools and other key student areas of campus. During this tour, the undergraduate student would share her own experiences, favourite places on campus, and personal advice. The tour ended with a university-style lecture in the classrooms of the Campus Nord. Adapting the level of the class to suit the high school audience allowed students to discover their capacity for becoming involved in the subject matter the degree requires, different

from what they would have learned from a talk or a conference. Professors from the Department of Computer Architecture were asked to give a university-style lecture adapted to the high school audience so that students could follow it without difficulty. In order to achieve this, the high school instructor who was teaching the compulsory technology class shared the syllabus with the topics that had been studied and the knowledge that the students had gained in this specific area so far, so that the university professor could design the class based on concepts that were known and familiar (at least those sounding familiar) to the girls. Also, in this case it was important to stress the more "social" aspects, showing the link that exists between computing and directly or indirectly serving others.

The gender of the university professors was not considered relevant, highlighting the professional reality that students will experience in this area, and more precisely the intellectual and creative wealth that the presence of both men and women in the professional field provides. The fact that the lectures were held in university classrooms provided an added value to the students' personal experience.

Teaching technology subject matter to a group of female students at this age proved to be very effective, given their self esteem in this area with respect to their male classmates (Collis 1991; Du et al. 2009). More specifically, it was a lecture that introduced students to sensor networks, how they are deployed in diverse areas, and what type of applications and services they permit. The lecture began with a link back to the previous visit with the research team, with references to current research topics such as the Wireless Sensor Network (WSN). The class began with several examples of real applications developed in both scientific and domestic settings, and ended with devices and computer programs that were a part of their own personal lives (video games, cellular phone applications, urban robots, etc.) It was a question of visualizing computing as a frequent tool in their daily lives, and that the people behind this technology are applying their creativity, intelligence and sensitivity in order to achieve a product that is relevant to people and their environment: they could be one of those people! (Hammel and Rich, 2007). Overall, what this activity hoped to achieve was to attract girls to university studies starting with a personal experience in the classrooms.



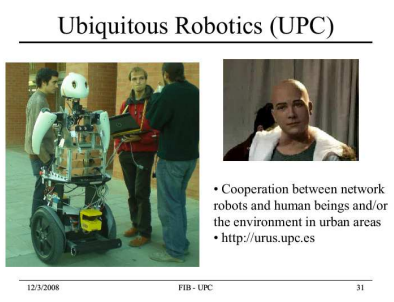


Figure 2. *University-style lecture, relating real-life projects to social improvements.*

2.3. University and High School Collaboration: "Listen around!"

The third activity fully involved the female undergraduate students and had a double-impact objective. On one hand, to generate a reasonable critical mass of female computer engineering students so they could get to know each other and create a "support group" in which they could share personal information and interests, parallel to their studies, and help them advance in their field. The barrier of "masculinization" in the areas of study of engineering, mainly in electronics and computers, impedes women from beginning their studies, finishing their degrees and starting a career in the field (Educational Foundation Commission on Technology, Gender, and Teacher Education, 2000; Du et al. 2009; Sanders 2005). On the other hand, it was about defining a real ICT project that high school and university students could participate in (Du et al. 2009).

Although students of both sexes could take part, a majority of girls, especially high school girls, was hoped for. During the pilot project, the participants were able to verify the social contributions that technology permits, and at the same time develop and propose new applications and services. The project also allowed them to practice and develop their multidisciplinary teamwork skills (students from diverse backgrounds, ages, cultures and academic training). This will enhance their capacity for choosing their future profession and give them a more realistic and attractive perception of the ICT field, while at the same time providing them with a greater awareness about viewing their future careers as a contribution to society.

An evaluation was made in order to choose the most appropriate platform, keeping in mind the current research projects being carried out in the department. Possibilities were also considered that focused more on the individual (giving support and service to the members of the university community) that could be developed in diverse groups, in part collectively and in part independently, in order to carry out research projects at the high school as well as final projects for the computer engineering degree, including more advanced research and development projects.

The proposed ICT project consisted of the development of a platform based on Wireless Sensor Networks (WSN). The objective was to involve diverse participants in the definition, evaluation, and expansion of the system: in this particular case university students from different course levels, high school students, and professionals from the computing sector.

Initially, for the female undergraduate student participants, the platform base was spread over the university campus (the UPC's Campus Nord) in order to gather information (Carcelle et al. 2009). In this case, the information gathered was temperature data. Using this data, diverse applications would be developed to improve and facilitate daily services for users in the university community. The applications to be developed on this platform would be of two types:

A. Those oriented towards improving service to users on campus (students, professors, administrative personnel, etc.) by offering a comfortable temperature in their workspace.

B. Those oriented towards monitoring and proposing improvements in the cost of energy (temperature, in our case, but which could also be electricity and water, etc.).

Access to the information would be gained through the campus WIFI network, or also directly through the UPC intranet. This way, communication is facilitated from different locations, and guaranteed to be used only by those pertaining to the aforementioned environment. In the future, communication via cellular phones was suggested as well as working with the spatial distribution of different settings (open spaces such as gardens or squares, and closed spaces like shopping malls, libraries or classrooms).

The first study that was developed consisted of gathering data on temperature in a specific classroom: using this data, average temperatures can be monitored in the classrooms when they are vacant and when they are occupied, allowing for improvements in energy use- in the policies and strategies of heating or cooling the rooms and the laboratories.

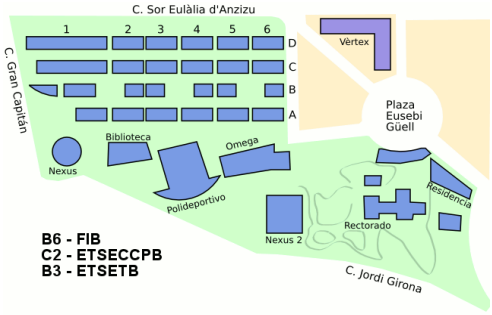


Figure 3. *Campus Nord map showing the location of the classrooms, in the South.*

Other objectives proposed were to:

- Confirm whether or not a classroom was in use.
- Determine which of the campus cafeterias had open tables.
- Ascertain if there was a free table in the library.
- Meet up with an acquaintance that was walking around the campus.
- Confirm whether or not an acquaintance was on campus or not.

This framework can be adapted to other settings, such as a bank, a large department store, a school, an apartment building, etc.

As a result of the previous activities (especially the university-style lecture in which the WSN and other diverse applications were introduced), ten high school students (around one-third of those attending) requested to do their Research Project in the fourth year of the *ESO* program[ii] on wireless sensor networks; three students were selected from the group.

Afterwards, one student from another high school also did her *Bachillerato* Research Project[iii] (a compulsory subject in the Spanish pre-university curriculum) on wireless sensor networks. The projects were:

- The *ESO* students developed a similar platform, with simpler electronic materials that they had already worked with in their technology classes. They carried out a similar study with the platform in the classrooms at their high school in order to evaluate the energy costs related to the adequate comfort level of the users and reach an optimal solution.
- The *Bachillerato* student carried out a study with the WSN platform in her own home, evaluating the comfort temperature in different situations: with air conditioning, fans, closing or opening the blinds…

As part of the project, all of the high school and university students held periodic meetings together. In addition to the team meetings, the university students mentored and guided the high school students, not only at a technical level but also on a problem-solving basis with suggestions for how to amplify the observation area, validate and interpret the data collected and present the final project document. All of the students have had initiation sessions to learn more about the platform and initial problem solving with the company that developed the product, DEXMA. These meetings held a special interest for all, as a unique opportunity for the different parties involved to exchange opinions: their different ages and levels of academic training offered different realities and experiences related to the product. Some of the ideas and solutions were shared via the ICT4Girls blog and the DEXMA forum.

The undergraduate university students provide the continuity of the research project. A presentation of their work was given at a workshop on sustainability at the UPC[iv]. Following the presentation, a group of civil architecture students asked them to collaborate on a proposal to improve the façade of the Gabriel Ferrater Library (the central campus library) affected by sun exposure, causing high temperatures in the interior (superior to those of comfort-level). This step has been highly positive in that it has allowed for greater interdisciplinary cooperation on projects (computer engineers together with civil architects).

3. EVALUATION

When evaluating the project, we must evaluate the two objectives that were initially proposed: on one hand, how we have achieved a social impact and on the other, if the number of female vocations in computer engineering has really been affected. Conclusions about this last point evidently cannot be reached in such a short period of time.

It is also important to think about the conclusions that different participants of the project have reached: the high school and university students (the potential and real students of computer engineering), the professors who were involved, and the society. Starting with society, where the project has had the most distant and widest impact, the result has been clearly positive. A number of Spanish and international publications have given visibility to the project itself, and in particular to the work of female computer engineers in the area of sustainability. Similarly, collaboration on interdisciplinary projects has begun between students from different degree programs as well as collaboration on financed projects between undergraduates and businesses. These results

show the importance of the perception that the people in these environments have of the work done by computer engineers and the type of creativity and sensibility that women engineers add to the field; on the one hand concerning the type of problems to be solved, and on the other, the actual solution to the problem. This positive perception is evident through the interest in collaboration on interdisciplinary projects and research groups that until now have had a low number of women participating; the acceptance of articles in conferences that specialize in technological research with a more social component (for example, in the area of sustainability); the invitation to speak in university forums and at ICT businesses about projects related to the interaction between people and technology. This dissemination of information is part of the objectives we seek of visibility, transparency and knowledge about ICTs and their role in the society.

The ICT4girls' blog has announced ideas, projects and engineering-related activities, and has proven to be an efficient tool that allows participants to express their opinions and experiences and exchange ideas while participating on-line. As for the students, we must differentiate between the potential future engineering students (the high school girls) and the computer engineering undergraduate students (the female university students).

With respect to the former, we must conclude that the experience has been highly positive: we were able to reveal the social role of a computer engineering professional to the students. These students themselves are the best representatives to spread the word, in concentric circles that are increasingly larger, about the role of computer engineers in the current and future society; and therefore, share this vision and knowledge with others, and at the same time change the stereotype that has existed until now.

With respect to the undergraduate students, they have pleasantly reinforced their professional vocation. In other words, we could say that their self- esteem has increased in their professional environment. The ideas they contributed with for social improvements were accepted by the society (represented by the audience of the sustainability workshop, the high school girls, and the university students from other degree programs), and they were able to implement them in collaboration with the DEXMA company. They have also formed a small group of women who have gotten to know each other and this first critical mass acts as a magnet for other girls to consider forming part of the degree program[v].

Finally, the university professors' and high school teachers' reactions were varied. The university professors have enthusiastically participated and collaborated on the project and were motivated to generously offer their time and experience. The high school teachers, on the other hand, are still a pending matter. Despite being receptive to the project, we were not able to involve them fully in the activity. An example is the fact that the experience has not been repeated for lack of support, problems posed at the organizational level (the school board, professors and parents association, etc.) We must strengthen our relationship and collaboration with them, and put ourselves in their shoes in order to solve the situation from their point of view; using the means and setting they are familiar with (Katehi et al. 2009).

4. CONCLUSIONS

We are positively influencing people's vision and behaviour regarding technology. We are promoting positive personal attitudes such as:

- Being conscious of threats to the environment and acquiring new, more respectful habits.
- Promoting interdisciplinary channels of dialogue between people: students, teachers, and professionals.

We are also promoting positive professional attitudes such as:

- Being excited about converting technology into a tool to serve people and the environment.
- Understanding the consequences of one's own work.
- Providing incentives for research into low-power high-tech.

We still have to work harder in the high schools to make the world of engineering more attractive, and portray it as an attainable possibility for the future.

"*A good tool is an invisible tool; you focus on the task, not the tool. Eyeglasses are a good tool – you look at the world, not the eyeglasses*" (Mark Weiser). So, we are developing tools which are powerful, adaptable, and indispensable in the students' learning process and subsequently in all aspects of their everyday lives. As a first step, computer engineering students are preparing their Master Thesis on the development of a group of example applications in Scratch as a support software for mathematics courses for high school students, based on a creative and attractive environment (Goode 2008), (Klawe et al. 2009). The students themselves use a methodology that allows them to increase the complexity or variety of the examples using the same Scratch language.

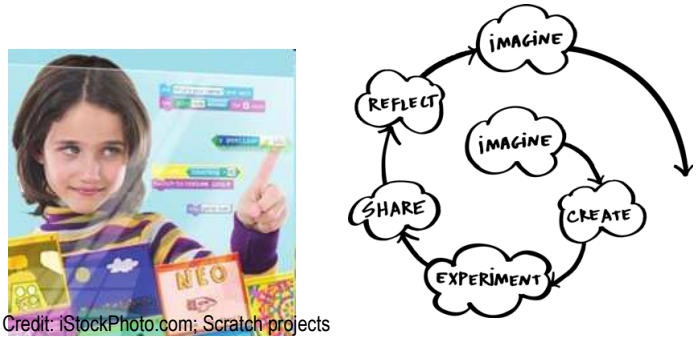


Figure 4. *Scratch project.*

The objective is for high school students to familiarize themselves with concepts and computer skills in non-traditional computer settings (in this case for mathematics) and to begin to use them as work and development tools (National Academy of Engineering 2004). In this way, students will improve their computational thinking skills and their view of computer engineering (Proposal for a recommendation of the European Parliament and of the Council on key competences for lifelong learning 2005).

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[i] In Spain, the secondary school system is divided into two different entities. The ESO (Educación Superior Obligatoria) is a four -year mandatory education program for students approximately 12-16 years of age . Following the ESO program are two years of Bachillerato (equivalent to the last two years of U.S. high school) for ages 17-18 (approximately) that prepares students for the university. For the purposes of this study, our secondary school participants aged 14-16 years of age have been referred to as "high school" students.

[ii] In the fourth year of the ESO program (see Footnote 1) students must complete a research project as part of the required curriculum. The fourth year of the ESO program corresponds roughly to the sophomore year of a U.S. high school student. This may vary in other countries.

[iii] During the two year Bachillerato program for students ages 17-18 (see Footnote 1) students must complete a research project as part of the required curriculum.

[iv] II Congrés UPC Sostenible 2015. La recerca en Sostenibilitat: estat actual i reptes de futur, 2009.

[v] This factor has proven to be very important among high school students when choosing a degree program, especially among women.