The final publication is available at

Additional Information

Telecochips: Promoting Telecommunications and Electronic Engineering among Young Students

Carmen Bachiller Martín and J. Alberto Conejero

Abstract—The study of Science, Technology, Engineering and Mathematics (STEM) has suffered a strong decrease during the last decade in Western Countries. The causes of this decrease are very diverse, but it seems necessary to take actions to improve the perception that the future students have about these studies and to approach technology to high school classrooms. *Telecochips* is a pool of activities designed for promoting the engagement of high school students for Telecommunications and Electronic Engineering in the UPV – Universitat Politècnica de València (Spain).

Index Terms—Information and Communication Technology, technological vocations, secondary and high school students, Telecommunications Engineering, scientific outreach activities.

I. INTRODUCTION

Since the last decade the study of Engineering, particularly that related to the Information and Communication Technology (ICT), has suffered a strong decrease in Europe and also in Spain. As a matter of fact, in 2010/11 we have noticed a reduction of about 30% in the number of students enrolled in the degrees of Telecommunications and Computer Science with Engineering respect to the academic year 2000/01, [1].

Although the number of ICT jobs decreased 10% in Europe during the period 2006/10, Europe is expected to require one million ICT professionals in a short future [2]. Moreover, it is a fact that a good development in ICT is crucial to face an economic crisis like the one that is ruining Spain, with one of the highest unemployment rates of the Organization for Economic Cooperation and Development (OECD), 25.2% in 2012 [3], and with the least skilled workers among 24 developed countries surveyed by the OECD, too [?].

Nevertheless, two main factors contribute to maintaining this situation, or even to worsening it, the setup of high school studies and the perception that students have regarding technological studies. On the one hand, after the compulsory secondary education in Spain, students must choose their Baccalaureate among three types: Arts, Humanities and Social Sciences, and Science and Technology [4], [5]. In some high schools the Science and Technology Baccalaureate is not fully completed due to a lack of material resources (a science laboratory is far more expensive than a conventional classroom). Moreover, subjects like Technology and Computing are optional and the programs of Mathematics and Physics are less extensive than in the 90's and 2000's, previous to the current educational reform performed by the previous Spanish Government. Despite a 35% increase in budget on education in Spain since 2003, the results on Mathematics in the PISA evaluations are similar, and they have just slightly improved in Science [6].

Additionally to this scenario students have a negative perception of technological studies: difficult and poorly paid. Although in Spain the number of technology companies is enough to absorb the graduates from the University (only 7.6% of

C. Bachiller belongs to Departamento de Comunicaciones, Universitat Politècnica de València, Valencia, E-46022, ESP, email: mabacmar@dcom.upv.es

J. Alberto Conejero belongs to Instituto Universitario de Matemática Pura y Aplicada, Universitat Politècnica de València, Valencia, E-46022, ESP, email: aconejero@upv.es

Telecommunications Engineers are unemployed and 1.4% are looking for their first job [8]) some of them decide to look for a job abroad in order to get better incomes. Finally, but not less important, society perceives that ICT professionals are nerds; the media show them as funny strange people without glamour: just make the comparison between *The Big Bang Theory* and *CSI* characters [9], [10], where both are supposedly scientists. It is even worse if compared with the image given by other professionals such as lawyers, doctors or brokers. Moreover, ICT studies are less attractive to girls: only 10% to 20% of ICT students are women, and those data are not increasing over time (see also [13], [14]).

Independently of the big numbers and how the development of a country is affected by a dramatic fall of its technology vocations, engineering colleges are suffering the decline of these vocations.

Engineering colleges have to compete in order to attract the students from the scientific and technological option of the Baccalaureate, and if it is possible to attract the students with the highest university access mark. The access mark of the last year and the number of applications by students are two important criteria used by public and private administrators for funding studies and institutions. This policy is harming ICT students in Spain, where the graduation rate of population who successfully complete secondary school is below the European average [15].

Nevertheless, regional, national and European institutions alike have tried to reverse this situation. A number of programs for promoting STEM vocations have been developed in the last years. These programs are usually conducted at the universities that have well trained, motivated and sufficient faculty who implement them. As far as possible the support of the industry and business environment is also welcomed.

The combined effect of the need to attract students to telecommunication studies, having well-trained professionals in both teaching and research, and the support of the Regional Government to organize activities of vocational guidance, led the Telecommunications College of the UPV (ETSIT) to promote a number of activities of scientific-informative character for students aged 16 and 17 years old, and so *Telecochips* were born.

The reasons why a high school student decides for some and not for other studies are diverse (vocation, employability and economic retribution, skill and ability in the field, knowledge of studies, social recognition, geographic location, family tradition...) and complex. This work is not intended to be a study of them, or to solve the problem of loss of technological vocations that has been observed for more than a decade in all Western countries. We seek to provide an outreach activity conducted at the regional level, which has successfully solved a number of logistical problems inherent to these activities and has been well received by its target audience: students and teachers of secondary and high school. This paper presents a number of "good practices" in such actions, such as the choice of activities, dates or protocol to inform secondary schools, planning of the visit and attendance management .

The article shows an example of the state of the art of such practices at other universities; it continues with the presentation of the expected goals of the activity, the description of how it was carried out and the activities (workshops and conferences) that were designed and offered to visiting students, and finally the results of the study and its conclusions are developed.

II. PROMOTING STEM

The promotion and dissemination of science and technology has a long tradition, not only in universities but also by scientific societies and other public institutions. In Spain this task has largely been promoted by the Spanish Foundation for Science and Technology (FECYT). The most important objectives that universities seek with these initiatives are the promotion of scientific knowledge in their area of influence and attracting future students for their courses.

Initially these activities consisted of conferences or lectures. Afterwards, science fairs and competitions where to recognize the brightest and most talented students. Later on, more accessible activities that may arouse the interest of a greater number of students, such as workshops and some summer camps were implemented. In the workshops not only new information is provided to the student but it is also aimed to experiment with these contents. This transition has been similar to the one that has been carried out, for some time, in the classrooms of our schools, where the exclusive focus on the "know" has been moved to the "know how".

Telecochips can be framed within the outreach and engagement activities that a university must carry out in order to promote scientific knowledge within its community. In particular, it is addressed to students in high school, who sooner or later must decide whether to continue with their studies in a university or not, and in the first case in which degree they prefer to enroll. There is neither a unique way of setting these programs nor an exact target group of students. For instance, they can be addressed from grades 6 or 7 onwards, and in some cases they are also included in the first year in order to increase retentiveness. Their sessions structure covers a wide range of options, from 5-day campus sessions through conferences and visits to schools. Some examples of different programs with a similar scope can be found in [16], [17], [18].

III. INTENDED OUTCOMES

The intended outcomes of Telecohips were the following:
1. To increase the interest and motivation in STEM-related degrees, in particular in Telecommunications and Electronic Engineering.
2. To change the perception of secondary education and high school students concerning STEM studies and professionals.
3. To promote Telecommunications and Electronic Engineering studies, the Telecommunications College and the University among secondary and high school students.
4. To offer academic guidance concerning the professional opportunities that are linked to these degrees with the aim of impacting on the students' professional future.
5. To work more closely with teachers of secondary and high school providing them with tools for further study and discussion at classrooms.

As can be seen the targets are broad and difficult to measure objectively: how can university studies be promoted among teenagers? And how can the effectiveness of that promotion be measured? As a way to measure them, a satisfaction survey of the activity was developed, but it is only intended to assess whether the activity, which was the first time that was done, was satisfying and motivating for high school students. To measure the impact of the activity it would be necessary to track those students after several years.

The program was offered as an introduction to technology, so perhaps for some students it was their first contact with it. Therefore, there was no requirement that students participating in the program had to demonstrate their skills on STEM-related content. The proposed activities were not needed to be included in the curriculum of the students participating in the program; however, the program also supplied tools and content for further study after the visit to our college. Moreover, the program was conceived for learning and entertaining, as a first approach to some technology concepts, tools and systems, so the students did not need to show their competences in team working, communication of results, project design and development, etc.

IV. THE EXPERIENCE

Since 2007 some members of the ETSIT Faculty have been experimenting with the possibilities of using electronic music in the teaching of Telecommunications Engineering for explaining complex concepts such as superheterodinization, radiation, filtering, etc [20], [21]. They realized that it was very attractive to students, who were motivated by the application of their studies to a different field, such as music. Discovering this phenomenon led the teachers to the use of electronic music as appealing to high school students, who would feel motivated to choose studies in Telecommunications Engineering. Thus a series of informative workshops for high school students around electronic music were created. These workshops have been imparted since 2008, in different forms: as a talk accompanied by a concert, an interactive workshop or a jam session. There have been over 15 of such workshops with over 600 students attending.

In 2011, encouraged by the success of electronic music workshops, the ETSIT offered a series of informative lectures and workshops to secondary education students (16-17 years old) regarding the various fields of study and research related to the college. The experience in question is based on this activity but is much broader. Usual recruiting actions are addressed to students in their last year in high school, but at this moment most of the students have already decided which is the type of studies they prefer. Therefore, we focused on younger students who were about to choose a specific itinerary in high school (see also [22]).

Telecochips are expected to be an appetizer, like chips, of what Telecommunications studies are intended for, but it is also a pun about their content since these activities are like chips that a student can collect and connect in order to become a Telecommunications or an Electronic Engineer.

Telecochips were funded and supported by the UPV, the *Fundación para la calidad en la Educación* (FUNCAE) of Valencia Regional Government, and by the E-Skills project of the European Union.

The college contacted professors, researchers and students of Engineering who were willing to show their activities to high school students. These teachers and students presented projects of lectures or workshops, completely voluntary and without remuneration. A special mention should be made to Engineering students in their last year, who presented two workshops and a lecture, as well as to the researchers of the Laboratory of High

Power of the European Space Agency in Valencia (VSC-ESA) who gave a lecture. The projects covered many of the areas of Telecommunications: the use of electronic technology in music, computer vision, the birth of radio, the philosophy "Do it yourself", insecurity in wireless networks, satellite communication, signal processing of animal language and sustainable human development.

By designing the program, we intended to integrate the local strengths in it: professors and students of the ETSIT participated in the program; well-known local facilities such as the VSC-ESA and the aquarium of the city, *Oceanogràfic*, were included; furthermore, we also took advantage of the very well-known musical tradition of Valencia, since a significant number of students play some musical instrument.

When the contents cover a broad scope, one option can be to design a campus session of several days of length, but in this way the number of students that could benefit would be limited. So we decided to organize several sessions with 1 lecture and 2 workshops each. The duration of these would be a full morning from 9:00 to 14:00 hours. Two groups of students would attend each session. The day would begin with a collective lecture and then the groups would be separated into two workshops. The lecture should not be very long, up to 45 minutes, and its contents should be adapted to the academic level of the students attending. It was intended that the students could learn from the lectures and these would not be mere promotional talks about the degrees.

The workshop should be longer, 3 hours and 30 minutes, and interactive, with time for students to take a couple of breaks. The idea of separating the two groups is a matter of attention: a workshop is for small groups, 10 - 20 students maximum, but a lecture can still be fine even though the group is greater. In the same way, they were designed in order to permit interactivity with the students by some hands-on activities. As we have reported, in some cases collaboration of regular students of our college was expected. We consider that their participation in these activities can contribute to their training. Moreover, participants can feel closer to them than to professors due to the shorter difference of age.

The project dossier was submitted to the Vice-President for Students and Culture of the University, who showed her support for it. She put us in contact with the FUNCAE, that helped in the dissemination and organization of the workshops as part of the activities carried out in its orientation program. Unfortunately, due to the situation of economic crisis in the country, the FUNCAE has now been dismantled, and its activity has been absorbed by others, or gone. Telecochips also had the support of the E-Skills Week European Commission project [23], that aims to promote the study of information and communication technologies among the young.

A file with the contents of the various workshops and lectures and a cover letter to be sent to high schools inviting participation were developed. We contacted more than 200 high schools within a range of 60 km. The FUNCAE took care of the logistics: shipping dossiers, enrollment management, schedules, etc. The high schools participated in the activity for free: they only had to travel to the ETSIT where lectures and workshops were held.

Firstly, 6 days were organized on the 19th, 20th and 21st of December, 2011 and the 4th, 5th and 6th April, 2012. Those days were chosen because they coincided with the end of classes in high schools before the Christmas and Easter holidays, and the end of a semester.

The choice of dates is very important to ensure the success of this type of activities, as they must not hinder the teaching schedule. Therefore, choosing the last days of the semester, when scheduled teaching activities and evaluation is complete, is the best option. The number of sessions is also important since the offer should be enough to cover all the requests of the high schools to attend the different lectures and workshops. In this particular case 7 sessions were needed to cover the demand. A total of 492 students, aged between 16 and 18, and 26 high school teachers (Technology, Physics, Mathematics and Music) were enrolled, although the number of those who attended was finally lower.
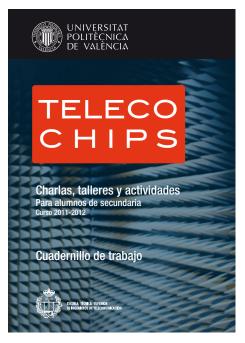

Figure 1. Activity book.

As additional material a workbook, Figure 1, was prepared with information on every lecture and workshop, and additional activities to be done after the event. 700 printed copies were delivered, both to the attendants and to the high schools that showed interest but finally could not attend.

In addition a web was developed, `http : / / museotelecomvlc . etsit . upv . es / telecochips`, Figure 2, where the same information as in the workbook was uploaded. The workbook has been downloaded more than 1000 times since then. In the website, audiovisual information is also included. Each lecture and workshop was recorded on video and a Youtube channel was used to upload them. For recording the videos the express consent of the parents of students attending (who were obviously minors) was required, so it was necessary to manage such consent before starting the workshops.

Moreover, the slides used by the teachers were uploaded on a Slideshare channel, and everything was embedded in the website. In this way any visitor to the website has some suitable material to follow up the project.

The Telecochips project could only be done during an academic year, for several reasons: the FUNCAE, the organization of the regional Government that gave us logistical support and access to secondary schools, was dismantled due to the economic crisis, and its activity was absorbed by other bodies or

Figure 2. Web TelecoChips.

disappeared. Besides, the activities were made by volunteers: lecturers and students of the ETSIT, since these activities are not recognized as part of the teaching / research activity of the lecturers, or part of the curriculum of the students, and entail a considerable time dedication. The activity was absorbed by the University in its programs Week of Science and Praktikum [24]. Fortunately, the initiative has recently been reactivated, this time related to the activities of the Science Museum of Valencia [25] leveraging the exhibition Comunicando about the History of Telecommunications, which is housed in the Museum from December 2014 until December 2015. This new edition will consist of 5 Telecochips workshops, on 5 dates throughout the year.

One of the major drawbacks of this type of activities is logistics: some place is required for conducting the workshops; they have to be need to be announced in advance; secondary schools need to be contacted to manage the attendance; the materials for the workshop must be chosen carefully in order to be really interesting... In short, these activities require a dedicated group of people and a minimum budget.

V. APPLICATION DESIGN

Workshops and lectures were given by college professors, researchers and students. They consisted of four parts: an introduction that was provided both in the workbook and on the web, the workshop/lecture with an explanation of the lecturers, the related activities the students attended or participated in and the postactivities that were specified both on the web and in the workbook. The idea behind these postactivities is that high school students can deep in the experience and the knowledge they have got after attending the sessions. Since the activities proposed are self-explanatory, they can work them out in the classroom or at home supported by the audiovisual material provided by the Telecochips website.

A. Workshops

A brief description follows of each one of the 5 workshops offered to the students.

Birth of Radiocommunication. This workshop proposed a journey through the history of science that led to the birth of radiocommunication. In the workshop a simple oscillator circuit was constructed that produced RF current which was coupled

to an antenna to generate radiofrequency electromagnetic radiation. Moreover, by interrupting this generation, a system of telegraphic transmission was introduced on our simple experimental radiofrequency generator. With a properly tuned receiver a complete and simple demonstrator of a radiocommunication system was produced. The students had the opportunity in this workshop to build their own telegraphic transmissor and to use it to send some Morse messages via radio.

Insecurity in Wireless Networks. This workshop addressed the vulnerabilities of security in wireless networks. How to protect home and corporate networks as well as the way in which a potential attacker could access them was discussed. Moreover, security in access controls and common wireless networks was also presented, in addition to actions that, once inside, could be carried out and effective countermeasures against a possible attack. The whole process was exemplified with several case studies and live examples with simulations of typical scenarios. Finally, attendees had the opportunity to test the effectiveness of various security protocols and case studies in several ISP deployments. This workshop was conducted by a student who is now getting his degree on Telecommunications Engineering at the ETSIT.

Use of Electronic Technology in Music. This workshop offered a practical look at the history of the use of electronic technology in creating music, using as a starting point a "theremin", considered the first electronic musical instrument in history, and up to this day. The tour analyzed also the beginnings of solid state electronics, which replaced electronics based on vacuum tubes [26]. Towards the end of the tour it was presented the use of digital electronics and signal processing in real time in the creation of new musical instruments and a new creative language. The most interesting aspect was to see how many techniques and algorithms used in this creative field belong to the world of telecommunications. Students were able to mount a theremin, playing a tenori-on, mixing their own voice or making music with Nintendo, as can be seen in Figure 3.

Figure 3. Students playing a tenori-on.

"Do It Yourself" Philosophy. "DIY" is a term used to describe building, modifying, or repairing something without the aid of experts or professionals. This trend is booming due to the current economic environment. This philosophy was treated in the workshop from a technological point of view based on various aspects of telecommunications (for example, discussing how to address the obsolescence of printers or unlocking hidden features of new generation TV). We tried to awaken the spirit of research in students through curiosity by providing starting points for finding this type of information. During the workshop concrete examples of home furnishing and appliances modifications were displayed, and then activities students could do at home were shown. This workshop was also conducted by two

students who are now getting their degree in Telecommunications Engineering at the ETSIT.

Applications of Computer Vision. Computer Vision is the branch of Telecommunications Engineering in charge of different types of information from images and video. Computer vision is based on various disciplines such as computer programming, geometry, physics, mathematics and signal processing. In this workshop some of the possible contemporary applications of computer vision in fields as diverse as traffic analysis, video surveillance or people counting were presented. During the workshop, real-time operation of all the applications was displayed. The workshop also showed some special cameras as stereoscopic, thermal cameras or 3D cameras and the students had the opportunity of recording and processing images with them (Figure 4).

Figure 4. Setting a 3D video recording.

B. Lectures

Three lectures complete the experience, a summary of which is shown next.

Will it Work in Space? RF systems play a key role in space applications. They are essential to communicate with the satellite and receive the data generated, but also form the basis of global telecommunication and radionavigation systems. During the lecture, the European Laboratory for High Power Radio Frequency VSC-ESA [27] was presented, as well as its activities (research and tests related to RF breakdown phenomena and passive inter-modulation), in a didactic and comprehensible way. Thus various videos of the laboratory and its experiments were shown.

Understanding the Language of Cetaceans. During the lecture the main results of research in underwater bioacoustics of cetaceans (beluga whales and dolphins in particular) were displayed. It was also displayed how signal processing techniques and audio recognition, typically employed in processing the human voice, can be successfully used to detect, analyze and classify the sounds made by cetaceans. The lecture was illustrated with some examples, such as a system to automatically monitor the level of welfare of beluga whales through their vocalizations rate. Belugas are also known as 'sea canaries' because they love to sing. They have a full repertoire of chirps, warbles, clicks, squeals and "laughs" that can be heard in and out of the water, and even through the hulls of ships. Belugas are very popular in Valencia since in the aquarium of the city they are the most visited animals [28]. After the lecture an activity was proposed: listening to a series of sounds of beluga whales and bottlenose dolphins, as well as the visualization of time-frequency diagrams using a free audio editor.

ICT and Sustainable Human Development. This lecture aimed to provide a brief introduction to and a first contact with some basic aspects of cooperation for development, in order to understand the meaning of sustainable human development. It also discussed the main causes of poverty and inequality in the world as well as the impact of human activities on planet Earth. Then the great potential of telecommunications to reduce inequalities was addressed, and some examples of appropriate and inappropriate use of these technologies for the promotion of sustainable human development were proposed. In this context we introduced the concept of appropriate technology, which helped us to reflect on the type of technology best suited to be applied to solve each problem in each particular environment.

VI. FINDINGS

Having into account that the intended outcomes of this activity are related to the recruitment of new students and to the improvement of the perception that secondary education students have concerning STEM studies, we needed to assess to which extent the activity had matched the objectives planned.

There are specific instruments to assess innovations in University Education, either for freshmen or for senior student. For example the Transferable Integrated Design Engineering Education (TIDEE) consortium [29] has developed assessment tools for Design Team Knowledge, Performance and Reflection. Moreover, other initiatives such as E-Skills [30] has developed tests for creating a career profile or for assessing the competence, actitude and skills of students to become ICT professionals. Nevertheless, none of these instruments suited the proposal, so an ad hoc evaluation was selected. This decision was reinforced by the fact that similar activities [16], [17], [18] also developed ad hoc surveys to study their impact.

Finally, 14 high schools participated in the project, with 480 students and 36 teachers. The opinion of the attendees was tracked with the following survey, that was answered by 230 students and 14 teachers from 7 different high schools.

The questions made to the students were the following:

- Questions related to Outcome 1
  1. What have you liked most of this day?
     Students assessed as more positive the practical part of the workshops over theoretical explanations, as well as the capacity of the speakers and the facilities of the University.
  2. Would you recommend participating in this type of session to your peers?
     96 % of students would recommend this type of activities to their peers.
  3. Would you be willing to participate in such initiatives in the future? Tell us why.
     78% of students would be willing to participate in such these initiatives in the future, nevertheless, they do not explain why they would do so.
- Questions related to Outcome 2
  1. What is your overall rating of this day?
     13 % of the students considered the day very positively, 63 % considered it positively, while only 4% and 1% considered it negatively or very negatively respectively.
  2. What do you think of the lecture you attended?
     The average assessment of the lectures was 3.55 points over 5.
  3. What did you think of the workshop in which you participated?

The average assessment of the workshops has been 4.1 points over 5.

4. Set your review concerning the explanations of the professors at the ETSIT.

    Professors have been rated with 4.1 points over 5.

- Questions related to Outcome 4

1. Do you think that participating in this type of session can be of help for your academic future?

    26 % of attendants think that these days can have a very high impact on their academic future, 33 % think that the impact can be high, while 10 % and 6 % think that the impact can be low or very low respectively.

- Suggestions for improvement of the activity.

    The main suggestions for improvement were: shorter talks, greater interactivity, more students practice, attending all workshops, spending all day at the university, doing more workshops throughout the year.

The teachers answered some different questions of the survey:

- Questions related to Outcome 1

1. Do you think the contents covered in this day are appropriate to students this age?

    21 % of teachers considered the contents very appropriate, 43 % considered them appropriate, only 14 % considered them less appropriate and nobody considered them inappropriate.

2. Do you think this type of session is motivating for students and can be of assistance in your daily work at your school?

    22 % of teachers considered the activity highly motivating, 64 % considered it motivating, nobody considered it less motivating or dismotivating.

- Questions related to Outcome 2

1. What is your overall rating of the day?

    29 % of teachers considered the day very positive, 50 % considered it positive, only 7 % considered it negative and nobody considered it very negative.

2. What is your overall rating of the lecture?

    The lectures were rated with an average of 3.7 points over 5.

3. What is your overall rating of the workshop?

    The workshops had an average rating of 4.3 points over 5.

4. What is your assessment concerning the intervention of the professor at the ETSIT?

    The lecturers were rated with 4.2 points over 5.

- Questions related to Outcome 5

1. What is your assessment concerning the duration of the day?

    72 % of theachers considered the duration suitable, while 14 % considered it brief and 14 % extense.

2. What is your assessment concerning the overall organization of this day?

    The organization was rated as very good by 7 % of teachers, good by 50 %, only 7 % considered it bad and nobody considered it very bad.

3. Would you change some aspect referring to the development of this day? Should it be so, indicate which.

    Teachers made the following suggestions regarding the performance of the workshop: increasing student participation, possibility of attending the two workshops on the same day, shorter talks, prior availability of the material, lower technical level, more practice and interaction and showing more material.

4. Would you be willing to participate in such initiatives in the future? Tell us why.

    All would participate again and found the experience interesting and motivating.

The following lessons can be learned from the answers of attendees, both students and their teachers: the activities should have a wider duration across the academic course, with more sessions or even with a regulated program of activities on a periodic basis; the interactivity of a workshop is better rated than the passivity of a lecture, the students and their teachers are interested in experimenting the science rather than being told about the science; the activity has to be done at the university premises (the students have rated very possitively having the opportunity to visit a university campus, so the scenario is important).

To assess Outcome 3 the Telecochips project followed up on the 480 students who attended the experience. 158 of these students were in their first year of high school (16-17 years old), while 322 were in their 4th year of secondary school (ESO in Spain) (15-16 years old). For high school students 2013-14 was their first year in college, while for the 4th of secondary education course this would be 2014-15. The analysis is presented separately, since students that arrive to the first year of high school later massively enter the university system, while the students of 4th of ESO can choose to enter university or drop out when they finish the compulsory secondary education. In this study the percentage of attendees who then chose the UPV as their university to pursue higher education is presented, and of these, those who opted for the ICT branch, i.e. studies that include information technology and communications, understanding that the potential impact of a motivating activity such as this one can lead students to decide on any degree in this branch, not only on Telecommunications Engineering.

Among students in their first course of high school 67 accessed the Polytechnic University of Valencia (42.4 %), 16 of them (23.8 %) opted for the ICT branch of study at the UPV. We do not know if students who did not access the UPV applied to another university or dropped out. Among students in their 4th course, only 60 (18.6 %) are currently studying at the UPV, and of these, 22 (36.7 %) opted for the ICT branch. We do not know whether students who do not study in the UPV chose to abandon their studies or chose another university.

The UPV annually offers 4500 places for new students, of which 14 % belong to the ICT branch. The data show that of those students attending the Telecochips who chose to come to the UPV on the ICT branch, 23.8 % were in their first year in high school and 33.7 % were in their 4th when they participated in the experience. This is higher than the number of places that the university offers, usually suited to the demand; besides, the impact is greater for the younger students participating in the experience.

VII. CONCLUSION

The number of students enrollment has been steady in the ETSIT during the past four years. Nevertheless, due to the economical crisis, the reduction of grant budget in Spain and the increase in the prices of college tuition, the overall recruitment was reduced by 20% in the UPV last year, but the numbers in Telecommunications Engineering have not changed, what is quite promising.

We have not been able to measure if this activity has had a de-

cisive impact for promoting ICT studies among young students, but at least it has contributed in some sense. We understand that an activity with a limited time has, in general, a small impact on such an important decision as to choose a professional career. Nevertheless, the evaluation of the students and their teachers of the Telecochips pool of activities is strongly positive and it encourages us to go on with them. It seems that they are a very productive way of spreading the knowledge and the results obtained in the University to the rest of the society, and we foresee that they will have a positive impact on future technological vocations. In this way, and with the lessons learned from the first edition, we have initiated a second edition taking profit from the infrastructure of the Science Museum Príncipe Felipe of Valencia.

The fact that the number of vocations in the ICT sector is decreasing is indisputable. Nevertheless, this tendency must be reverted to maintain progress in research, development and innovation. Actions at different levels are required. It is needed to increase the relationship with secondary schools to promote early technological vocations, to transfer the idea that ICT studies are not impassable and to improve the satisfaction rates of graduated ICT students. The assessment of high-school students and teachers of Telecochips activities is very positive and encourage us to follow with them. They seem a very productive way to disseminate the knowledge and the results developed at the university to the rest of society. Nevertheless, in order to revert the current situation of lack of technology vocations, more aspects have to be considered: the set up of high school education programs, society's perception of technology professionals or the economic capacity of the families.

CONFLICT OF INTERESTS

The authors declare that there is no conflict of interests regarding the publication of this article.

ACKNOWLEDGMENTS

REFERENCES

[1] Instituto Nacional de Estadistica http : / / www . ine . es / jaxi / menu . do ? type = pcaxis & path = \ %2Ft13 \ %2Fp405 & file = inebase & L = 0 Last accessed, June 26th, 2015.

[2] Blog of Neelie Kroes, Vice-President of the EC. *Europe urgently needs the right jobs and skills? My mission in Davos.* http : / / ec . europa . eu / commission _ 2010-2014 / kroes / en / blog / davos-jobs-skills Last accessed, June 26th, 2015.

[3] OECD. *Employment Outlook 2013* http : / / www . oecd . org / els / emp / onlineoecdemploymentdatabase . htm # unr Last accessed, June 26th, 2015.

[4] Boletín Oficial del Estado (Spain) Real Decreto 1467/2007, de 2 de noviembre por el que se establece la estructura del bachillerato y se fijan sus enseñanzas mínimas.

[5] Ministerio de Educación Cultura y Deporte. *Sistema educativo español.* http : / / www . mecd . gob . es / educacion-mecd / areas-educacion / sistema-educativo . html Last accessed, June 26th, 2015.

[6] OECD. *Program for Interanational Student Assessment (PISA). Results from PISA 2012 for Spain.* http : / / www . oecd . org / els / emp / onlineoecdemploymentdatabase . htm \ #unr Last accessed, June 26th, 2015.

[7] everis y e-motiva. *Factores influyentes en la elección de estudios científicos, tecnológicos y matemáticos. Visión de los estudiantes de 3° y 4° de ESO y Bachillerato.* http : / / www . everis . com / spain / WCLibraryRepository / References / estudio \ %20vocaciones . pdf Last accessed, June 26th, 2015.

[8] El Ingeniero de Telecomunicación: Perfil Socio-Profesional. Ed. Colegio Oficial de Ingenieros de Telecomunicación y Asociación de Ingenieros de Telecomunicación. Madrid, 2013.

[9] CSI: Crime Scene Investigation http : / / www . cbs . com / shows / csi / Last accessed, June 26th, 2015.

[10] The Big Bang Theory http : / / www . cbs . com / shows / big_ bang _ theory / Last accessed, June 26th, 2015.

[11] J. Steinke. *Cultural representations of gender and science: Portrayals of female scientists and engineers in popular films.* Science Communication, **27**, (2005) 27-63.

[12] J. Steinke, M. Long, M.J. Johnson, and S. Ghosh. *Gender stereotypes of scientist characters in television programs popular among middle school-aged children.* Anual Meeting of the Association for Education in Journalism and Mass Communication, 2008 AEJMC.

[13] N. Anderson, Cl. Lankshear, C. Timms, and L. Courtney. *"Because it's boring, irrelevant and I don't like computers": Why high school girls avoid professionally-oriented ICT subjects.* Computers & Education, **50**, no. 4, (2008) 1304–1318.

[14] S. Lewis, C. Lang, J. McKay. *An inconvenient truth: the invisibility of women in ICT.* Australasian J. of Inf. Systems. **15**, no. 1, 2007.

[15] L. Jofre, J. Córdoba, and L. Robert. Attracting student vocations into engineering careers: EnginyCAT:Catalonia promotional and prospective plan. Proceedings of the Education Engineeing (EDUCON), 2010 IEEE, 1759-1762. ISBN: 978-1-4244-6570-5.

[16] C.E. Davis, M.B. Yeary, and J.J. Sluss Jr. *Reversing the trend of engineering enrollment declines with innovative outreach, recruiting, and retention programs.* IEEE Trans. Educ., **55** no. 2, 2012, 157–163.

[17] P.G. LoPresti, T.W. Manikas, and J.G. Kohlbeck. *An Electrical Engineering summer academy for Middle School and High School Students.* IEEE Trans. Educ., **53** no. 1, 2010, 18–25.

[18] A. Mehrizi-Sani. Everyday Electrical Engineering: A one-Week Summer Academy Course for High School Students. EEE Trans. Educ., **55** no. 3, 2012, 488-494.

[19] C. Bachiller, J.V. Balbastre, and J. Oliver. *Promoting vocation for Communication and Electronic Engineering.* Proc. Int. Conference on Engineering Education (ICEE-2010), Gliwice, Poland (2010).

[20] C. Bachiller, C. Hernandez, and J. Sastre. *Collaborative learning, research and science promotion in a multidisciplinary scenario: information and communications technology and music.* Proc. International Conference on Engineering Education (ICEE-2010), Gliwice, Poland, (2010).

[21] C. Bachiller, J. Sastre, A. Ricchiuti, H. Esteban, and C. Hernández. *Study of the Interference Affecting the Performance of the Theremin.* International Journal of Antennas and Propagation, **2012**, Article ID 348151, 9 pages, 2012.

[22] S. Berryman, *Who will do science? Minority and female attainment of science and mathematics degrees: trends and causes.* New York: The Rockefeller Foundation (1983) 65–76.

[23] Fundación Tecnologías de la Información. *The eSkills Week* http : / / www . fti . es / evento / teleco-chips-ii-evento-eskills-week-2012 Last accessed, June 26th, 2015.

[24] E. García-Félix, J.A. Conejero, and J.L. Díez. *Entering University: a challenge for the academic guidance.* To appear in REDU. Rev. Doc. Universitaria **12**, 2014, 255-280.

[25] Museo de la Ciencia de Valencia. *El primer taller "Telecochip" muestra a un grupo de escolares qué es la realidad aumentada* http : / / www . cac . es / prensa / noticia / ?contentId = 130167 Last accessed, June 26th, 2015.

[26] Theremin World http : / / www . thereminworld . com/ Last accessed, June 26th, 2015.

[27] European Space Agency (ESA) and Val Space Consortium (VSC) High Power RF Space Laboratory http : / / www . val-space . com / highpowerlabrf / ?lang = en Last accessed, June 26th, 2015.

[28] Oceanogràfic de Valencia http : / / www . cac . es / oceanografic / animales / ficha / ?contentId = 119207 & languageId = 1 Last accessed, June 26th, 2015.

[29] Transferable Integrated Design Engineering Education (TIDEE) consortium. http : / / www . tidee . wsu . edu / index . html Last accessed, June 26th, 2015.

[30] E-Skills Tests. http : / / eskills . eun . org / web / guest / tests Last accessed, June 26th, 2015.

Carmen Bachiller Martín B.S. in Telecommunications Engineering and Ph.D. in Telecommunications by the Universitat Politècnica de València (UPV) since 2010. Her research is based on the study of electromagnetism, in particular in passive microwave devices for communications. She is an associate professor of the Communications Department of the UPV, where she teaches in the degree on Telecommunications Technology Engineering, in the master's degree on

Aeronautical Engineering and in the master's degree on Music. She has participated in several outreach programs for high school students since 2007. Now, she is Secretary of the Escuela Técnica Superior de Ingenieros de Telecomunicación of the UPV and Director of the Museo de la Telecomunicación Vicente Miralles Segarra.

J. Alberto Conejero B.S. in Mathematics by the Universitat de València and Ph.D. by the Universitat Politècnica de València (UPV) since 2004. He is an associate professor of Applied Mathematics at the ETS de Ingeniería Informática (iSchool) of the UPV. He develops his research on linear dynamics and on multidisciplinary applications of Graph Theory. In the last years he has participated in the coordination of several programs addressed to high school students and freshmen from the Vice-rectorate for Student and Culture of the UPV, where he served as Head of the Academic Performance Evaluation and Curriculum until 2013.