Using Service Learning for Improving Student Attraction and Engagement in STEM Studies

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ABSTRACT

Both in Europe and around the world, there is a lack of STEM (Science, Technology, Engineering and Maths) graduates. The Universities that offer STEM studies face two common problems, the first of which is the lack of technological vocation. Despite the need in Europe for more engineers, and while STEM graduates enjoy almost full employment, few students decide to enrol for these degree courses. The second problem is that engineering studies traditionally have one of the highest dropout rates in Higher Education. One of the reasons for this is that students perceive engineering courses as highly technical and difficult, and with little relation to social progress. They are not aware of the creative nature of such studies, or the contribution to human development made by engineers. In order to tackle these problems, we are advocating the use of Service Learning. The projects resulting from this initiative will be able show future graduates the importance of creativity and the important role of science and technology in the future welfare of society; two points capable of inspiring vocation and enhancing the sense of belonging to the STEM collective in the first STEM degree courses. In this paper, we present the project and describe some of the experiences we have identified at our university, with the aim of using them for student attraction and engagement.

Conference Key Areas: Attract youngsters to engineering education, Gender in engineering education, Sustainability in engineering education

Keywords: Service-Learning, Student Attraction, Student Engagement, Changing Society's Engineering Perception, Diversity in Engineering

1 INTRODUCTION

1.1 Europe and the STEM workforce

According to a report by the European Parliament Committee on Employment and Social Affairs (Caprile et al., 2015), employment of STEM skilled workers in the EU28 (the study was done before the brexit) was increasing in spite of the economic crisis, and demand was expected to grow. Since the beginning of the 2000s, the

unemployment rate for this type of worker has been very low and clearly inferior to the total unemployment rate, even in countries particularly affected by the crisis, such as Greece, Portugal and Spain. In parallel, high numbers of STEM workers are approaching retirement age. Around 7 million job openings are forecast until 2025. A large majority of Member States have recently experienced recruitment difficulties in regard to STEM skilled workers. Challenges arise from the insufficient number of graduates and a lack of experienced staff.

Concerns about this situation arise from two facts: the proportion of students enrolling for STEM degrees is not increasing at the required level and the underrepresentation of women persists.

The proportion of university graduates in STEM at EU level in the period 2006-2012 remained basically stable, with a variation from 22.3% to 22.8%, while the demand for STEM professionals is expected to grow by 8% between 2013 and 2025 (Caprile et al 2015, Eurostat 2015). Furthermore, according to Burchell et al. (2014), STEM is male-dominated area: women account for just 24% of science and engineering professionals, and in 2012 only 12.6% of those who graduated in STEM-related subjects were female as compared with 37.5% of male graduates.

However, these figures are not evenly distributed across all STEM studies. While it is not expected employment grown on some STEM sectors, 674,000 new jobs are expected for 2020 in the ICT sector (Information and Communication Technologies), but a shortage of 756,000 jobs is also predicted. In other words, the labour market will be able to absorb 756,000 additional workers (Hürsing, Korte, and Dasja, 2015). In addition, according to the European Commission (2013) only 4 out of every 1,000 female tertiary graduates work in ICT fields, compared to 20 men (5 times more).

EU member states and other countries in the world are designing initiatives and programmes to tackle STEM issues at a national level by focusing on science education and attracting young people to science, with a special emphasis on girls.

1.2 Think globally, act locally

26,210 students enrolled at our University in the 2015-2016 academic year. Although it is a University with an international presence (3,126 students are foreigners - 11.9%) foreign students are mainly engaged in Master and Doctorate studies. Less than 5% of foreign students are doing degree courses, most of whom are first-generation immigrants who arrived with their families a few years before enrolling at university. Thus, in order to make STEM degree courses more attractive to students, it is necessary to focus on the potential local student population. Is the STEM workforce situation in Catalonia, our region, similar to that in the EU as a whole?

Catalonia has a population of about 7.5 million people. Compulsory secondary education in our country ends at the age of 16, at which point students may choose between leaving the education system, starting Vocational Education and Training courses (VET) or enrolling for preparatory university courses that last two years.

According to our Government Statistics (Generalitat de Cataluya 2016) only 12.7% of VET students choose STEM-related studies. Furthermore, while gender parity exists (50.9% women and 49.1% men) in all VET courses, statistics show that in STEM studies only 14.4% of students are female.

With respect to preparatory university studies, three categories exist: arts (7% of enrolled students), humanities and social sciences (46.4%) and science and technology (46.6%). While in the courses overall 53.5% of students are female, in science and technology this figure falls to 44.5%. Although these percentages show no appreciable difference, it should be remarked that the science and technology

category includes not only STEM studies, but also life studies, so these figures for STEM are not an accurate reflection. If we consider enrolment at our universities in June 2016, only 24.6% of students joined STEM studies, and although 55.1% of new university students are female, this number drops to 30.3% in STEM studies.

In the case of ICT University courses, 10.1% of students enrolled for ICT in 2001, while in 2014 this figure was 4.9%. As regards gender distribution, 18% of ICT workers are female. Moreover, women account for only 11% of ICT university students, and less than 1% of female students choose ICT studies, while ICT represents 2.7% of current workplaces.

These figures lead to the conclusion that in Catalonia the problem is similar to that in the EU as a whole, and that similar measures can be applied in both cases.

1.3 Two problems: attraction but also retention

The problem cannot be reduced to the small number of students starting STEM degree courses. Traditionally, STEM and especially engineering studies have one of the highest drop-out rates in all courses. In our case, 20% of students ceased their studies because they failed the first year (our regulations require that students must pass all subjects in the first year in a maximum of two academic years). In addition, a further 17% of students dropped out before graduation. Thus, this is not only a matter of lack of vocation, but also about how to deal with those students who already have this vocation when they arrive at the university.

1.4 Catalan government plans and the role of UPC

In February 2017, Catalan government created a workgroup known as the STEMcat consisting of members of the Ministry of Business and Knowledge, the Ministry of Education and the Ministry of the Presidency, together with representatives from each of the regional Universities. The mission of this workgroup is to develop a plan for the promotion of vocation in STEM studies. Four working lines have been defined: a) Enhance teacher-training in STEM fields; b) promote STEM skills among students and develop tools to evaluate them; c) encourage the participation of STEM companies in school training; and d) promote STEM in society. Our university is the only technical university in the region. Other Universities have some STEM degree courses such as those in Mathematics, Physics or Chemistry, but ours is the only one that offers degree courses in Architecture, Civil Engineering or Chemical Engineering, for example. So our role in this workgroup acquires a special importance.

2 ATTRACTING AND ENGAGING STUDENTS

2.1 Student attraction

A study from “Science” (Tai et al 2006) shows that we should pay close attention to children’s early exposure to STEM at middle and even earlier grades. Universities make great efforts to attract students in higher grades, but this is really a question of marketing rather than awakening vocation. The study in “Science” shows that students graduating in STEM degrees have already decided to study physical science/ engineering degrees at the age of 13. The study stresses the important influence that mathematics and science courses taken at age of 12 and 13 has on the future STEM workforce.

There are several reasons that predispose young people to STEM studies (Orsak 2003, Laut, Bartolini, and Porfiri 2015). First, surveys show that children of engineers have a much higher likelihood of becoming engineers than those students without any personal connection to the field. Also all teachers are familiar with the question

"When am I ever going to use this?" In the case of STEM, do teachers, and society as a whole, have any meaningful answers? Real exposure to engineering is necessary to stimulate student attraction, but it is also important for young adults to learn about subjects that are fundamental not only for them but for society at large. Life sciences are considered important for the common good, but despite the importance of STEM in daily life, technology is regarded more from the user point of view than from the designer perspective. For instance, students are exposed to technology at school when learning about Scratch and Robotics, but the leading issues must be: What are programming and robotics for? How can I make the world a better place by using STEM? Stressing the importance of creativity and the vital role of science and technology for the future welfare of society is fundamental for awakening vocation, especially among girls and minority or disadvantage groups.

2.2 Student engagement

Two major variables are involved in the decision to drop out of university: academic performance and academic commitment (Wood, 2014). On the other hand, however, some studies show the relationship between both: the greater the academic commitment, the higher the academic performance (Boekaerts 2016). There is much discussion among experts, but the most prevalent conceptualization in the literature is that engagement consists of three dimensions (Fredicks, Filsecker and Lawson 2016): 1) *behavioural*, in terms of participation, effort and positive conduct; 2) *emotional*, focused on the positive and negative reactions to teachers, classmates, and school, but also on sense of belonging to and identification with the school or the studies themselves, and finally 3) *cognitive*, self-regulated learning using deep-learning strategies and exerting the necessary effort for the comprehension of complex ideas. STEM degree students are good at maths, physics and similar subjects, and are familiar with deep-learning strategies, making the required effort and having a positive conduct. Thus, it appears that the real problem resides not in the behavioural and cognitive dimensions, but rather in the emotional sphere.

According to Astin (1999), and Krause and Coates (2008), in order to engage first-year students emotionally, it is necessary to: 1) Encourage them to participate in challenging activities; 2) Show them that the knowledge they are acquiring is relevant for their professional future; 3) Convince them that the profession they chose has a real impact on the world, stimulating them to reach creative solutions for resolving real problems; and 4) Create collaborative activities to enable students cooperate both mutually and with the teachers in order to achieve a deep knowledge of their profession

Instead of being guided by these ideas, students often find themselves in what they perceive as difficult, boring and passive classes, where they do not understand the use of what they are learning, where no cooperation is encouraged and the only challenge they are faced with is passing the next exam. How may this situation be changed?

3 THE PROJECT

3.1 Service learning

Service-learning (SL) is an educational methodology that combines several processes related with learning. The Corporation for National and Community Service (1990) defines SL as a methodology by which students learn by performing a useful service to the community to which they belong, and by undertaking well-articulated and integrated tasks in the curriculum, all structured to stimulate thought

and to expand what they have learned in the classroom. Robert Sigmon (1994) defines SL as an experimental approach in which mutual benefit occurs. According to the author, SL is distinguishable from other educational approaches by its intention to benefit both the supplier and the recipient of the service. Moreover, focus is put on both learning and service.

3.2 Why Service Learning?

For many years, our University has instilled a culture of cooperation and sustainability as its guiding principle.

As regards sustainability, UPC issued a statement of sustainability in 2008 as part of the 1st Sustainable UPC Conference in 2007. It has a doctoral program in sustainability, a UNESCO Chair of Sustainability and an Institute of Sustainability. Research groups exist within the UPC in areas of sustainability dealing with issues as diverse as construction, energy and information technology. These groups transfer the knowledge acquired during their research work into their teaching.

Where cooperation is concerned, we have a Centre of Development Cooperation (CCD), a unit of the UPC that was created in 1992. The aim of the CCD is to encourage the commitment of the university in cooperation for development and to support initiatives within this field among the UPC community members. The CCD also has the function of raising awareness and providing useful training, as well as debating and reflecting on cooperation and its related problems. The CCD is currently financing a series of cooperation projects using the funds collected by the so-called 0.7% campaign. Research and educational projects that received funds give 0.7% of them to the campaign. Furthermore, students can voluntarily make a donation when they pay their tuition fees, and the university staff can opt to give part of their salary to the campaign.

As for the teaching-learning process, the commitment of the UPC was explicitly stated when the adaptation of degree courses to the EHEA framework was defined. We set out seven generic (or professional) skills that all our graduates should acquire, one of which is "Sustainability and Social Commitment". Given this environment, Service Learning is a natural way of integrating research and cooperation into the teaching-learning process.

3.3 The goals

This is a work-in-progress project consisting of three steps.

- First, detecting Service Learning experiences that have taken place at our University. Some teachers have been using Service Learning for years, but on their own initiative rather than as part of an institutional plan. These experiences have not been publicized among our students, or among potential future students when deciding what degree course to follow. We wish to collect and analyse these experiences and use the acquired know-how to develop new ones, defining Service-Learning as an important feature of UPC defining spirit and encouraging teachers to use it.
- The second step is to use this information for attracting and retaining students by presenting engineering as a creative, challenging field where graduate work has a real impact on the progress of humankind.
- The final step towards this goal is to increase the number of Service Learning experiences in the first year of degrees at our University, since we have found that most SL experiences take place in the final semesters. Service Learning

can be of great help in student engagement, but clear action is required in the first semesters, which is when most students tend to drop out.

The project is being conducted by the Institute of Education Sciences, a unit of UPC, with a three-fold mission: 1) offer training in educational methods and tools to new and senior lecturers at our university; 2) offer training and advice on STEM issues to K-12 teachers, as well as stimulating STEM vocation among young people; and 3) promote Engineering Education innovation and Research among our academic Staff. This project has the support of the University Rector.

For research into Service-Learning experiences, we first asked the Centre of Development Cooperation for a list of lecturers who have been involved in the CCD-funded cooperation projects. Then we checked our publication database, searching for papers or projects connected with service learning, sustainability, education, cooperation, and so on. These two measures provide us with a list of lecturers who may be able to work (or may work in the future) with this methodology. The next step is to organize meetings on every campus (we have eight different campuses in six different towns and cities), issuing personal invitations to the lecturers on the list to attend the meetings, which are open and publicized to all the staff.

The purpose of these steps is to determine who is currently working on initiatives that are or can be easily be adapted to SL experiences. We also wish to encourage our lecturers to carefully consider the opportunities for SL, and to evaluate if they can combine their expertise in teaching and research to create new experiences. It is our mission to create the right environment to help these initiatives flourish, but also to use them to increase student attraction and engagement.

3.4 Some experiences detected

We were already familiar with some of the initiatives; some in fact have already been promoted by the CCD and the Institute of Education Sciences. We also found initiatives that we were not aware of before. One positive aspect is that they cover a broad range of typology and fields of knowledge. We have divided the experiences into 6 categories:

- Specific initiatives, which can be applied to very few subjects. These initiatives are confined to a very specific field of knowledge and cannot easily be exported to other subjects, even at the same school. One example is a topic at the School of Architecture, where students analyse building accessibility for people with disabilities moving about inside a building in a wheel chair or blindfolded and with the aid of a stick. They analyse public buildings or small commercial premises, and the resulting analysis and the solutions proposed are passed on to the owners of the buildings to help them adapt these spaces.
- Specific initiatives, which can be applied to several subjects in the same field of knowledge. One example is in the Eyecare Clinic, where students pursuing different subjects and degree courses at the Optic and Optometrist School can practice their skills; in particular, by offering the Clinic services for disadvantaged groups in society, such as children from deprived families. A further example is the refurbishment of old computers undertaken by Computer Science students for the subsequent donation of this equipment to NGOs and schools.
- Volunteer projects, based on service but with small learning component. One example is the ICT volunteer program in which students help non-profit organizations in basic technical problems; for instance, courses for the elderly to teach them how to use the Smartphone GPS and navigator, or how to use

Skype to talk with distant relatives. Although this is an important learning activity from the personal point of view, very little technical learning is involved.

- Medium size projects, oriented towards final degree projects or master theses, such as the development of support software for the refugee children vaccination program or the development of drones for the detection of anti-personnel mines.
- Application of basic research, such as the development of mathematical models to address challenges posed by malaria: understanding the dynamics of the parasite in the lungs and the dynamics of the epidemic in big cities.
- Applied research in projects, for instance, the development of a robotic pet to reduce pain and anxiety in hospitalized children. This began as a European-funded research project and has become a spin-off.

4 CONCLUSIONS AND FUTURE WORK

We have identified several initiatives in our university that are or can easily be adapted to Service Learning. It is important find local university initiatives, since students will not find attractive initiatives undertaken at the MIT, for example. It is important for them to engage in initiatives that have been carried out in or close to where they live, and by their (current or future) university teachers and classmates.

These initiatives can be used to increase student attraction: all of them focus on the creative endeavour of STEM professionals and their contribution to human development. The use of these examples in primary schools can stimulate new vocations. It is important to make pupils and students aware that science and technology are changing the world we all inhabit, and that a new generation of creative scientists and engineers is required to tackle these challenges. Schemes such as those described above bring young people into direct contact with the real-world problems STEM professionals are required to solve, as well as showing that the real challenge involved in STEM is not learning maths, but finding imaginative and effective solutions. By developing a vision of the future, they will discover that the ability to solve such problems is a matter of human creativity rather than gender, ethnicity or social class.

Engaging first-year STEM students in these or similar projects deepens and extends their relations with their teachers, their schools and their future profession, thus creating a sense of belonging and a greater emotional commitment to their studies, resulting thereby in a better academic performance.

At this stage of the project, the proposal set out herein is simply a work-in-progress. More work and research is required to determine the best way to use this information for stimulating a sense of vocation and increasing first-year academic performance. It is our aim to encourage other universities to put Service Learning methodology into practice, not only as a service to the community, but also to enrich the learning experience of students as well as providing them with local examples to enhance attraction and engagement.

REFERENCES

[1] Caprile, M., Palmén, R., Sanz, P. and Dente, G (2015). Encouraging STEM Studies for the Labour Market. *European Parliament's Committee on Employment and Social Affairs*. On line at: www.europarl.europa.eu/studies

[2] Eurostat (2015). Tertiary Education Statistics. Available at http://ec.europa.eu/

eurostat/statistics-explained/index.php/Tertiary_education_statistics

[3] Burchell, B. Hardy, V., Rubery, J. and Smith, M. (2014): A New Method to Understand Occupational Gender Segregation in *European Labour Markets*. Publications Office of the European Union, Luxembourg.

[4] Hürsing, T, Korte, W.B., and Dasja, E. (2015) s-Skills in Europe. Trends and Forecasts for the European ICT Professional and Digital Leadership Labour Markets (2015-2020). Available at: http://eskills-lead.eu/fileadmin/lead/working_paper_-_supply_demand_forecast_2015_a.pdf

[5] European Commission (2013). Women active in the ICT sector. On line at: https://bookshop.europa.eu/en/women-active-in-the-ict-sector-pbKK0113432/

[6] Generalitat de Catalunya (2016). Departament d'Ensenyament. http://ensenyament.gencat.cat/ca/departament/estadistiques/informacio_estadistica_cursos_anteriors/curs-2014-2015/ensenyaments-regim-general/

[7] Tai R.H., Liu C.Q., Maltese A.V., and Fan W. (2006) "Planning early for careers in science" Science vol. 312 no. 5777 pp. 1143-1144.

[8] Orsak, G.C. (2003) Guest editorial K–12: Engineering's new frontier. IEEE Transactions on Education vol. 46 no. 2 pp. 209-210 May 2003.

[9] Laut, J., Bartolini, T., and Porfiri, M. (2015) Bioinspiring an Interest in STEM. IEEE Transactions on Education, 58(1). Feb. 2015

[10] Fredicks, J.A., Filsecker, M., Lawson, M.A (2016). Student Engagement, Context, and Adjustement: Addressing Definitional, Measurement, and Methodological Issues. Learning and Instruction 43, 1-4

[11] Wood, J. L. (2014). Examining academic variables affecting the persistence and attainment of black male collegians: a focus on academic performance and integration in the two-year college. Race Ethnicity and Education, 17(5), 601–622.

[12] Boekaerts, M (2016). Engagement as an Inherent Aspect of the Learning Process. Learning and Instuction 43 (76-83)

[13] Astin, A.W. (1999) Student Involvement: A Developmental Theory for Higher Education. Journal of College Student Development, 40(5), pp. 518-529

[14] Krause, K-L., and Coates, H. (2008) Students' engagement in first year university, Assessment & Evaluation in Higher Education, 33:5, 493-505

[15] Corporation for National and Community Service (1990). National and Community Service Act of 1990.

[16] Sigmon, R.L. (1994). Serving to Learn, Learning to Serve. Linking Service with Learning. Council for Independent Colleges Report.