Fostering Professional Competencies in Engineering Undergraduates with EPS@ISEP

Benedita Malheiro
ISEP/IPP-School of Engineering, Polytechnic of Porto & INESC TEC, Porto, Portugal
mbm@isep.ipp.pt

Manuel F. Silva
ISEP/IPP-School of Engineering, Polytechnic of Porto & INESC TEC, Porto, Portugal,
mss@isep.ipp.pt

Paulo Ferreira
ISEP/IPP-School of Engineering, Polytechnic of Porto, Porto, Portugal,
pdf@isep.ipp.pt

Pedro Guedes
ISEP/IPP-School of Engineering, Polytechnic of Porto, Porto, Portugal,
pbg@isep.ipp.pt

***Abstract* – Engineering education addresses the development of professional competencies in undergraduates. The critical set of professional competencies include critical thinking & problem solving, effective communication, collaboration & team building and creativity & innovation – also known as the four C – as well as socio-professional ethics and sustainable development practices – referred in this paper as the two S. While the four C were identified by the associates of the American Management Association from the needs identified by the society, professional associations and businesses, we, additionally, claim that the two S are essential to ensure the well-being of individuals and of the society. This work proposes 4C2S as a tangible framework to analyse the contributions made by engineering capstone programmes to the development of this set of core professional competencies. To illustrate the application of 4C2S, we analyse the European Project Semester (EPS) offered by the Instituto Superior de Engenharia do Porto (ISEP) and, then, apply it to the specific case of the EPS@ISEP Pet Tracker project developed in 2013. This case study constitutes, in addition, a road map for the application of the 4C2S framework to engineering capstone programmes.**

Keywords – 4C2S Professional Competencies Analysis Framework, Capstone Programmes, Engineering Education, European Project Semester.

INTRODUCTION

Engineering education aims to prepare professionals to address the challenges of the future. This is a highly demanding goal since it implies, not only, to forecast future needs, but anticipate scientific and technological advancement trends. Society (while beneficiaries), academia (while educators) and businesses (while employers) must work together to define the set of core competencies of future engineers. According to a survey distributed by the American Management Association (AMA) among its associates, the 21st century business requires, beyond the basics of reading, writing and arithmetic (the three R), skills such as *critical thinking & problem solving*, *effective communication*, *collaboration & team building* and *creativity & innovation* (the four C) (AMA, 2012). Specifically, AMA defines *critical thinking & problem solving* as the ability to make decisions, solve problems and take action as appropriate; *effective communication* as the ability to synthesise and transmit ideas both in written and oral formats; *collaboration & team building* is the ability to work effectively with others, including those from diverse groups and with opposing points of view; and *creativity & innovation* is the ability to see what's not there and make something happen. Additionally, we argue the need to imprint s*ustainable development* and *socio-professional ethics* (the two S) in the engineering practice. By *sustainable development practices*, we are referring to "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987) and, by *socio-professional ethics*, "the ability to think critically and independently about moral issues and to apply this moral thinking to situations that arise in the course of professional engineering practice" (Fleddermann, 2012).

The inclusion of the 2S in this framework results from the need to educate engineers for sustainable development and ethical conduct, as recommended by the United Nations Educational, Scientific and Cultural Organization (UNESCO). In 2010, UNESCO identified engineering as one of the most important profession for sustainable development and recommends that engineers should learn to include broader societal necessities such as minimizing water, energy and materials use, respecting human and cultural rights, and looking out for health and safety, not only within the work but also in its impacts" (UNESCO, 2010). More recently, in 2015, the United Nations has reaffirmed "the improvement of the quality of life on the planet for all" as a main objective of the organisation, defining 17 Sustainable Development Goals to be met by all countries in 2030 (United Nations, 2015).

We propose the adoption of the 4C2S engineering professional competencies framework, which was derived from the needs of both business and society, to analyse engineering capstone programmes. The framework allows the adoption of an evidence-based approach to identify how a capstone programme contributes to the development of these competencies in future engineering professionals.

The main contribution of this work is the framework and methodology proposed, which attempts to identify and quantify evidences of the development of professional competencies within an engineering capstone programme.

METHODOLOGY

The proposed method analyses the programme and the learning process of the students throughout one semester, searching for evidences of the development of critical professional competences, including the deliverables and the activities performed by the team. Specifically, we looked for signs of professional behaviour and team work, e.g., the ability to meet deadlines, define agendas, lead meetings, solve conflicts, report and discuss findings and together reach a solution to an open problem.

First, we identify the learning outcomes related with the six core competencies of the framework. Then, at the programme level, we match these outcomes against those of the EPS@ISEP programme and learning process. The process includes the scheduled activities – the project weekly meetings, the supportive module seminars, invited talks, presentation and assessment events – and multiple milestones involving the handing-in of different deliverables – Gantt chart, cardboard model, structural and control drawings, list of materials, components and providers, leaflet, brochure, report, poster, video, wiki, prototype, etc. Finally, we apply this analysis to the Pet Tracker project case to quantify the evidences of the development of the 4C2S competencies by the team.

FINDINGS

The goal of the Pet Tracker project was to maintain pet owners informed of the whereabouts of their pets, reducing the number of pets lost. In 2013, a multicultural and multidisciplinary team of students embraced successfully this challenge, involving the design, implementation and test of a prototype based on state of the art, marketing, sustainability and ethics studies (Borzęcka et al., 2016).

The learning process of the team along the semester was analysed to gather evidences from the uploaded deliverables and the conducted activities. The different types of deliverables produced by the team show the development of the 4C2S professional competencies. The project wiki as whole and, specifically, the project logbook provides multiple evidences. *Effective communication*, *critical thinking & problem solving*, *collaboration & team building*, *sustainable development* and *socio-professional ethics* are predominant. While the logbook provides few *creativity & innovation* and *sustainable development* evidences, the paper, report and video are more illustrative. The report includes dedicated chapters on sustainability and ethics, the paper discussion chapter exemplifies critical thinking capabilities, the presentations, poster, leaflet, brochure and video show effective communication and the video documents collaboration and teamwork.

CONCLUSIONS

This paper proposes the 4C2S framework, based on the needs identified by the society and businesses for Engineering education, as well as provides a road map to determine the extent to which engineering capstone programmes develop the desired professional competencies in engineering undergraduates. These core professional competencies cover the scientific, personal, societal, ethical and environmental dimensions of the engineering practice.

The results of the application of the framework to the Pet Tracker project show that the EPS@ISEP learning process helped the Pet Tracker team develop the six desired professional competencies.

REFERENCES

AMA (2012). "AMA 2012 critical skills survey," American Management Association, http://playbook.amanet.org/wp-content/uploads/2013/03/2012-Critical-Skills-Survey-pdf.pdf, Last accessed on January 2019.

WCED (1987). "Our common future (Brundtland Report)," United Nations, Oxford University Press, ISBN 978-0192820808.

UNESCO (2010). "Engineering: Issues, challenges and opportunities for development," UNESCO Publishing, ISBN: 978-92-3-104156-3.

UN (2015). "Transforming our world: the 2030 Agenda for Sustainable Development," United Nations, https://sustainabledevelopment.un.org/post2015/transformingourworld, Last accessed on January, 2019.

C. B. Fleddermann (2012). Engineering Ethics, 4th Edition. Prentice Hall, ISBN: 978-0-13-214521-3.

A. Borzęcka et al. (2016). "Educating global engineers with EPS@ISEP: The "pet tracker" project experience," 2nd International Conference of the Portuguese Society for Engineering Education (CISPEE), Vila Real, 1-10. doi: 10.1109/CISPEE.2016.7777740.