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Service Learning for Engineering Education for Sustainability

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Introduction

Sustainability issues are widely recognized as wicked problems [1], which should not be considered as problems to be solved, but as conditions to be governed [2]. There is a general agreement on the need to reform scientific expertise to deal with sustainability challenges, by developing new ways of knowledge production and decision-making. In that sense, Sterling [3] maintains that the nature of sustainability requires a fundamental change of epistemology and education. Transdisciplinary approaches to knowledge emphasize phenomena complexity, disrupting and transcending epistemological structures to progressively reflect and gain understanding [4]. In relation to engineering education, the Barcelona Declaration [5] highlights the sustainability competences, that engineering students should achieve.

The Universitat Politècnica de Catalunya (UPC Barcelona Tech), aware of the new sustainability competences that engineers should have, offers a master degree in Sustainability Science and Technology that trains students to become agents of change for sustainability. Transdisciplinarity (Td) and Service learning (SL) are approaches applied. Learning environment, challenges and lessons learnt when applying such learning approaches are explained in following sections.

Course structure and results

The course Action Research Workshop on Sustainability Science and Technologies (5 ECTS), given within the Master of Sustainability Science and Technology applies the SL pedagogical approach, using a constructive and community oriented learning which has shown to be the most efficient way to train students in sustainability science competences [6]. When finishing the course, students will have been trained in competences that allow them to reflect on, identify and understand: implications, impacts, potential risks and challenges of their work, locally and globally in society and environment; social new dynamics when applying engineering approaches in real sustainability challenges.

The course structure is organized around five areas: Research paradigms, AR methodologies, Dimensions of AR, Research tools and Real projects. First students are faced with different research paradigms: Positivism, Constructivism, Critical theory, Pragmatism and their features to facilitate reflection on future professional research. Next, students are trained in the main features of AR methodologies. After that, they learn about the main types of AR (Participatory; Action learning; Critical; Collaborative inquiry). Finally, students are trained in qualitative, quantitative and mixed research tools and methods used in AR: Conceptual maps, questionnaires, interviews, backcasting, network analysis, etc. Students work on real-life projects, related to local sustainability problems, represented by a community entity, under the SL paradigm [7], creating Td learning spaces [8].

Service Learning and Transdisciplinarity approaches

Service learning is an innovative teaching and learning method with experiential character that integrates service to the community and critical reflection with the academic learning, personal growth and civic responsibility, to form competent engineers and citizens, capable of engage in social needs [7] and transforming society. SL contributes to develop critical thinking, values, self-efficacy and self-confidence [9] and awareness of social justice [7].

In a Td learning space, researchers become representatives of an “epistemic community” in which certain knowledge has been constructed [8], under the following requirements “a) focussing on a societally relevant problem; b) enabling mutual learning processes among researchers from different disciplines; c) aiming at creating knowledge that is solution oriented, socially robust [...] and transferable to both, the scientific and social practice” [10].

The experience at UPC

The last three years (including 2017), the course has been organized around current sustainability relevant topics, broadly related to unsustainability aspects, analysed in different local organisations, real-life projects, real situations, needs or challenges. Table 1 show: general topics, leading organisations and the research question for each of them.

Table 1. Service learning projects ran at UPC

	Topic	Stakeholder	Real-life projects	Research question
2015	Energy poverty (EP) in Catalonia	Energy Bank Association (EB)- Municipalities Premià/Sabadell	Detection of motivations to participate in the EB	What are the factors that influence the decision to join or not the driver group of BE?
			Implementation Phase 1 of the EB in Sabadell	What key factors encouraging real participation in a local energy program can be used for BE?
2016	EP in Catalonia	Energy BE - Premià	Implementation Phase 2 of BE in Premià: private sector	What affordable and sustainable offer could facilitate the organizations involvement to BE?
	Gas Geopolitics	OdG- Debt Observatory in Globalization	MIDCAT, mega-pipeline for gas connection France-Spain	What is the capacity of this civil campaign, facing to maximize public accountability?
			Gas imports of the Port of Barcelona	Which city responsibility on the perpetuation energy model based on natural gas?
UPC's 'wm' teaching	EWB- Engineers Without Borders	What kind of 'wm' (<i>water management</i>) promotes UPC?	Does UPC research and curriculum respond to ensuring the human right to water?	

Assessment of the course

To evaluate the course two reflexive questions are asked to the students: What have I learned? What do I think about the course structure? About learning, reflections emphasized the interest in participating in real-life project. They value learning to work together and communicate with different disciplines, experiences and schemes, achieving tolerance, mutual learning and robust knowledge, from the different needs and concerns of stakeholders. Finally they recognized the relevance of qualitative aspects "needed to see beyond numbers". About the course, students valued the organization and group work in class, listening and learning from others. The main criticisms were related to the low degree of initial directness (deliberate in order to train students in dealing with different interests in real settings). The course coordinators introduced an Emotional Intelligence module, with the aim to allow students obtaining some experiential knowledge related to emotional intelligence (EI) and interpersonal related competences, rarely taught but claimed and studied [11]. After a framing theoretical introduction students experienced therapeutic theatre dynamics, in which experientially recognized some emotions, self-competence and perception, understanding and facilitation of emotions.

Conclusions

Conclusions after three years are: First, students realized the significance of investigate under a research methodological framework that allows bringing research to the commu-

nity, enhancing transdisciplinarity in any action. Second, the problem formulation became an arduous task, due to the perception of the problem from distinct community group motivations. Third, interaction, communication and role recognition of stakeholders was problematic, as engineering students are not usually trained to neither work in wicked problems nor accompany stakeholders. Finally, conflict and frustrating situations raised in the process, led to introduce an Emotional Intelligence module, which proved useful in helping students to solve some paralyzing situations, which could otherwise have stopped the progress of the project. We suggest that engineering students need specific training in transdisciplinary research and in conflict resolution, to avoid collapsing in frustration when dealing with real transdisciplinary sustainability transitions.

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