SERVICE-LEARNING IN ENGINEERING: ANALYSIS OF STUDENTS EXPERIENCES IN DEVELOPMENT COOPERATION

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ABSTRACT

For several years, engineering students from the Escola Politècnica Superior d'Enginyeria de Manresa have been participating in development cooperation projects as activities of the non-governmental Organization Mining for Development, with the support of the Center for Development Cooperation of the UPC. Activities were carried out in several mining sites in South American countries, mainly in Bolivia and Peru. Although the motivation for the students may have been initially a desire for adventure and volunteering, the experience turned into meaningful learning, as intended by the faculty leading the project.

This paper presents the findings of a study carried out to analyze how these experiences contributed to the learning of engineering students, within the framework of what is known as service learning. The study is based on the reports written by the students at the end of the experience and interviews conducted afterward when the experience had been fully internalized.

The characteristic elements of service learning have been identified. In addition, the analysis revealed how the experiences had a significant impact on subsequent learning, even beyond the initially intended objectives.

1   INTRODUCTION

Engineering is naturally associated with the solution of society's problems, so it can be seen naturally as a profession at the service of society in multiple fields: structures, industries, electronics, robotics, telecommunications, biotechnology, etc. It is not surprising that it is an ideal field for the cultivation of methodologies such as problem-based learning, challenge-based learning, or service-learning methodology.

However, while some educators view "service learning" (SL) as a new term that reveals a rich, innovative, pedagogical approach for more effective teaching, others view it as simply another term for well-established experiential education programs. For years, education researchers and practitioners struggled to determine how to best characterize SL. In 1979, Robert Sigmon defined SL as an experiential education approach that is premised on "reciprocal learning" [1]. In Sigmon's view, SL occurs only when both the providers and recipients of service benefit from the activities.

In the USA, higher education experienced tremendous growth in SL courses during 1990. This growth was supported by the Corporation for National and Community Service [2]. Service learning was seen as a "method under which students learn and develop through active participation in thoughtfully organized service experiences that meet actual community needs, that [are] integrated into the students' academic curriculum or provide structured time for [reflection, and] that enhance what is taught in school by extending student learning beyond the classroom and into the community..." (Corporation for National and Community Service, 1990). The National Society for Experiential Education, which for years has focused on various types of experiential education programs, broadly defines SL as "any carefully monitored service experience in which a student has intentional learning goals and reflects

actively on what he or she is learning throughout the experience." (National Society for Experiential Education, 1994).

For example, Engineering service-learning and Humanitarian Engineering (HE) programs at The Ohio State University have been in existence since 1979 [3]. Another well-known SL program is Engineering Projects in Community Service (EPICS), that was initiated at Purdue University in the Fall of 1995, [4]. It was extended to many engineering service-learning projects in other universities, being the largest and longest-standing in the U.S., and/or into international experiences providing engineering services and solutions to the developing world, e.g. through cooperation with Engineers Without Borders (EWB). See [5] for updated information.

Regarding institutionalizing plans, it is worth noting that Bringle and Hatcher described in 1996, cf. [6], a Comprehensive Action Plan for Service Learning (CAPSL): planning, awareness, prototype, resources, expansion, recognition, monitoring, evaluation, research, and institutionalization.

Currently, engineers have a significant opportunity to help solve many of the world's greatest challenges. Getting involved in humanitarian engineering does not necessarily require a total change in career or lifestyle but can still have a major impact. Thus, engineering is in the spotlight with a key role in reports on Society development and challenges. See for example UNESCO report (2010), [7] or the National Academy of Engineering's (NAE) Grand Challenges, [8].

In consonance with this global context, some initiatives of SL carried out at the Universitat Politècnica de Catalunya (UPC) are presented. Section 2 is devoted to presenting the context at UPC, namely the Centre for Development Cooperation and the Manresa School of Engineering, where the SL activities we deal with in this study are designed. Section 3 details the methodology used for the analysis. Section 4 contains the results of the analysis of students' experiences, identifying the phases of service-learning and showing the relationship between students' experiences and competencies.

2   KEY AGENTS AT UPC

2.1 The Centre for Development Cooperation

The Centre for Development Cooperation (CCD) was created at the UPC in 1992. It coordinates programs related to development cooperation with the participation of UPC's social volunteers such as students and teaching staff. The cooperation programs aim to fight against poverty, inequalities, and exclusion in the form of values so that other realities can be implemented both globally and locally. The actions carried out aim to contribute to improving people's lives. Moreover, for the students of the UPC who participate, it becomes an apprenticeship that helps to train future professionals to have a more just and sustainable commitment to the planet.

The CCD organization is present in all teaching centers of the university and coordinates and gives support to development cooperation activities. The funding for

the different projects comes from institutional contributions such as educational cooperation agreements and voluntary contributions from students or part of the teaching staff's salaries, collected in the so-called 0.7% campaign. It is also open to external funding such as companies and entities whose objective is the development of specific projects. During their university studies, future engineers working in cooperation and development projects not only acquire technological knowledge but also learn social values that are very remarkable once they enter the professional and working environment.

2.2 Projects from EPSEM

The Manresa School of Engineering is the school of UPC located in the city of Manresa. Students can enroll in bachelor's degrees in several Automotive Engineering areas, such as Automotive, Industrial Electronics and Automatic Control, ICT Systems, Mechanical, Chemical, and, last but not least, Mineral Resources and Recycling. It is the only university center in Catalonia where you can study the Bachelor's degree in Mineral Resource and Recycling Engineering, several Master's degrees related to Natural Resources and Mining Engineering, or the Natural resource and Environment graduate program, all of them inside civil engineering area. Among their responsibilities are the control and use of explosives in civil works projects. Like all engineering, but in this one even more so, social commitment and ethical values are very important.

The degree is organized into four years, and eight semesters. The number of students per course is not very high and the relationship with teaching staff is very good. They have dedicated laboratories with advanced equipment and a group conscience is generated, which facilitates interaction between students from different courses.

During the regular semesters, fieldwork is carried out, with visits and internships at sites in the area. In the summertime, when there is no schedule, extra opportunities to be in other mining areas around the world are offered to students. But this is not just an internship, but a real cooperation project as mining activities or, in general, the extraction of natural resources is an important issue in developing countries, especially in Latin America. In many cases, there are problems concerning environmental pollution such as the use of mercury for gold mining, the health of the workers, or economic conditions that hinder the efficient extraction of resources. Cooperation projects mainly serve to deliver improvements in sustainable mining, safe working environments, and improvements in mining performance. Thus, these projects are a real service-learning experience.

The projects involve the participation of professors, who travel with the students. The CCD provides some funds and some training course.

3 METHODOLOGY

The analyzed sample contains nine cooperation and development projects carried out at EPSEM in the field of mining and natural resources, in the years 2016-2021. All of them have been developed at mining sites in Bolivia and Peru. Because of the covid pandemic, in 2020 students did not travel there, but worked by using samples from the previous year, and keep in touch with university staff there.

For each project, a previous report was prepared, to plan the activity and to ask for financial support and the authorization of the university. The duration of the stay oscillates between 25-50 days in summer. The more technical part of the experience, related to content learning is included in the final degree project or projects belonging to subjects for the following semester. In addition, the students write a personal assessment report of the experience.

We analyzed 18 reports written by 13 participants, as 5 of them participated for 2 consecutive years. The following table lists the reference number of the projects, containing the year, and how many reports of each project were considered, indicating how many come from females or males. All the projects considered were led by Professor Pura Alfonso, who also traveled with the students.

Table 1. List of projects and reports analyzed

Project	Num. reports	female	male
P-2016-O013	2	1	1
P-2016-U006	2	1	1
P-2017-O014	1	1	0
P-2017-O013	2	1	1
P-2018-U017	2	1	1
P-2018-O026	1	1	0
P-2019-B005	4	0	4
P-2020-B006	3	0	3
P-2021-G007	1	0	1

To conduct a deeper analysis, an interview was conducted with three students corresponding to three different situations to follow up on the experience after some years:

- student A (male, aged 21), undergraduate student, between 1st and 2nd experience,
- student B (male, aged 23), master student, 2 years after the 2nd experience,
- student C (female, aged 28), graduate student, 5 years after the 2nd experience.

4   ANALYSIS OF STUDENTS EXPERIENCES

4.1 Phases of student involvemnet

The sample of students assessment have been analysed to check the progress of student involvement in SL. Five phases have been identified, according to the student development model provided by Delve, Mintz, and Steward [9]. We quote student fragments for each phases:

a) *Exploration* (naive excitement)

"Once we got to the mining area, I saw that the situation was much worse than I could have imagined". "It has been a unique, enriching, and highly recommended experience". "Lack of basic services such as running water, solid electricity, decent housing, and good roads, among others".

b) *Clarification* (on values)

"Workers are at great risk, as safety measures are minimal in the mine, in many cases, it is a lack of knowledge as they have done so all their lives and do not see so much danger, so it is necessary to work to make them aware of the risk they are taking". "Many of these problems are caused by extreme poverty, which means that the population does not have enough resources to have a good education".

c) *Realization* (insight into the meaning of service)

"I have taken samples and will be testing these samples which will help the miners to know more about the material and learn how to make them myself, so I think it has been very positive for both parties".

d) *Activation* (participation)

"You learn to see things from a different point of view and to make decisions in order to carry out projects with very scarce resources". "Personally, it has been my second year traveling to the same villages and I have been able to see the first improvements, especially in terms of organization and awareness of issues such as health and safety". "The part of collecting samples allows to see of the way that works, what dimensions covers the exploitation and also allows to know in first person the experience of the own workers of the cooperatives".

e) *Internalization* (the service experience influences career and life choices)

"Sharing my day-to-day life with classmates from here and with partners from there is also a lesson for me". "I think the project can have good continuity and that the relationship we started this summer can continue for years to come. I believe that we can contribute to a more sustainable development of this area, but I hope that with the work we are doing soon we will not have to cooperate again in this area". "I'm glad I was able to relive this experience where I was able to learn a lot again and become aware of what's really important".

4.2 Service Learning and the competences

Within the framework of EHEA, the need for greater development of transversal competencies in Higher Education is a topic of interest. Service-learning, as a methodology centered on students' experience, can play a significant role.

Several authors as Fuertes et al. [10] studied how SL influenced the interpersonal skills requested by the community. Researchers recognized that it could be worked through experiential and practical methodologies in the learning process so SL could play a key role, also when employability is considered [11].

On the one hand, focusing on the importance that SL attaches to the reflection on experience, SL can contribute [12] to the development of the analysis and synthesis skills among university students in an era of great complexity and uncertainty. Also the impact of SL in other competences, interpreted as psychoeducational variables of university students variables, are studied in [13].

On the other hand, the work of students in SL is considered to be one of the most appropriate ways to develop ethical and civic competencies [14]. As an example, they remark that at the UNED, these competencies are related to the application of democratic values linked to fundamental rights and equality. They also refer to the statements by Universitat Autònoma de Barcelona "to promote values, behaviors and sustainable practices that guarantee gender equality, equity and respect for human rights". At the UPC, and other catalan universities, similar statements are also found, even at their statutes, prior to the formulation of the EHEA.

An empirical approach to the influence that transversal competencies (soft skills) may have on the degree of employability of university students has been conducted in [11]. They found differences between the students who participated in experiential activities and those who did not, in favor of the former and explored theoretically whether the pedagogical approach of SL might contribute to a better connection between transversal competences and employability.

Our study on the students' reports and the following up on the students participating in the projects also confirm a good correlation between the student's perception of their skills, after the development of the projects, and external evaluation, from employers, internships, employers, etc.

5   ACKNOWLEDGMENTS

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