COLLABORATIVE LEARNING AND PRACTICAL EXPERIENCES IN ENGINEERING STUDIES: WORKING ON SUSTAINABLE DEVELOPMENT GOALS

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Abstract

In the present work, we present a learning experience developed within the frame of an interdisciplinary project funded by the University of the Basque Country, UPV/EHU (Campus Bizia Lab Program) in which professors from different departments, students doing their Final Bachelor Degree Project as well as researchers, PhD students and administrative personal work together in a collaborative project. The main goal of this practice has been to widen the practical work related to sustainable development in the curriculum of engineer students and to create actual experiences developed in the close surroundings so that the learning content is closer to the professional practice of the future engineers.
The specific topic of the case was the use of renewable energies in the buildings and installations of the university campuses and, specifically, the supply of biogas produced from organic residues generated in the canteens of the campuses. The project started on September 2021 and, since then preliminary work related to data collecting and processing, statistics and calculations of the energetic potential of the organic waste of several points, as well as logistics issues has been done. The current part of the study is covering the simulation and design of a pilot plant to obtain the biogas and the potential uses that this biofuel could have in the campuses. The development of this project includes the consideration of sustainable development goals, in terms of environmental, social and economic impacts, allowing the insertion of these concepts in the intrinsic studies of engineering.
The experience of working in a multidisciplinary atmosphere, combining different fields of knowledge and working in an actual case, has been positively evaluated by the students, who have indicated their satisfaction with the learning procedure in a final quiz, highlighting the acquired skills, such as initiative, autonomy, working in complex open cases and developing actual installations in situ.

Keywords: *Sustainable development in engineering, collaborative learning, renewable energies, biogas.*

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1. Introduction

An unstoppable technological development in design and production systems is being demanded by nowadays society. Challenges related to energy supply, logistics, communication tools and many other sectors are requiring new engineering processes, systems, products and technologies (Díaz Lantada, & De María, 2019). This reality should have a direct impact in engineering studies that need to connect to changing industrial environments, evolve in parallel and incorporate new contents and learning strategies, flexible and adaptive to promote innovation, creativity and entrepreneurship (Keinänen & Kairisto-Mertanen, 2019).

The Final Bachelor Degree Project (FBDP) is the learning activity, which better represents the actual professional practice, as it implies the resolution of a complex and often transdisciplinary project. The student will need to apply the acquired fundamental knowledge in different scientific disciplines, and combine and interconnect it in a holistic learning environment. Therefore, it is an optimum moment to design a learning activity as collaborative and practical as possible, to offer the experience of learning by doing, enhancing autonomy, critical thinking, teamwork, creativity, responsibility, lifelong learning and project management skills. Even if this is probably the most effective way to reach the best learning outcomes, it is also true that organizing collaborative FBDPs is a quite demanding activity in terms of teacher's dedication and material resources.

This paper describes the design, organization, coordination and development of collaborative FBDPs for the Bachelor Degree of Renewable Energies Engineering, of the University of the Basque Country (UPV/EHU).

The collaborative project, that has been developing since September 2021, has been the framework of the FBDPs of 6 students and has been supported by 4 professors from three different departments and fields of knowledge plus 2 quality management technicians. The topic focused on the study of buildings and installations of the university campuses, specifically, through the evaluation of their renewable energy consumption and the possibility of increasing the existing ones or adding another renewable option to the existing energetic mix. The selected technology was anaerobic fermentation to produce biogas from organic residues generated in the canteens of the campuses. Initial research work was directed to the collecting and processing of data related to the energetic potential of the organic waste of several points. Then, the project is covering the simulation and design of an actual pilot plant to obtain the biogas and the most efficient uses for the generated energy.

2. Methodology

The methodology for the organization of the FBDPs was structured in three lines:

- Human resources available to articulate the projects: professors from different departments, personnel from administrative services, technicians.
- Material resources available to conduct the practical work and experimental tasks.
- The organization of the students willing to complete their FBDP within the frame of a big, complex collaborative project.

2.1. Human resources

It is important to create a solid community of professors from different disciplines willing to take an active role in the design and development of the project. We decided to involve professors working in the same campus to facilitate the coordination, mutual communication and tutoring of the students' FBDPs. Moreover, a big effort was done trying to include professionals from other statements in the university, such as personnel from administrative services or technicians. As the topic of the project was to produce biogas from organic waste generated in the canteens of the university buildings, the Waste and Environmental Quality Manager Technician was a key person who could offer deep knowledge about figures, procedures, management, etc. This information including actual data is not easy to find and it is compulsory to properly define the scale of the system.

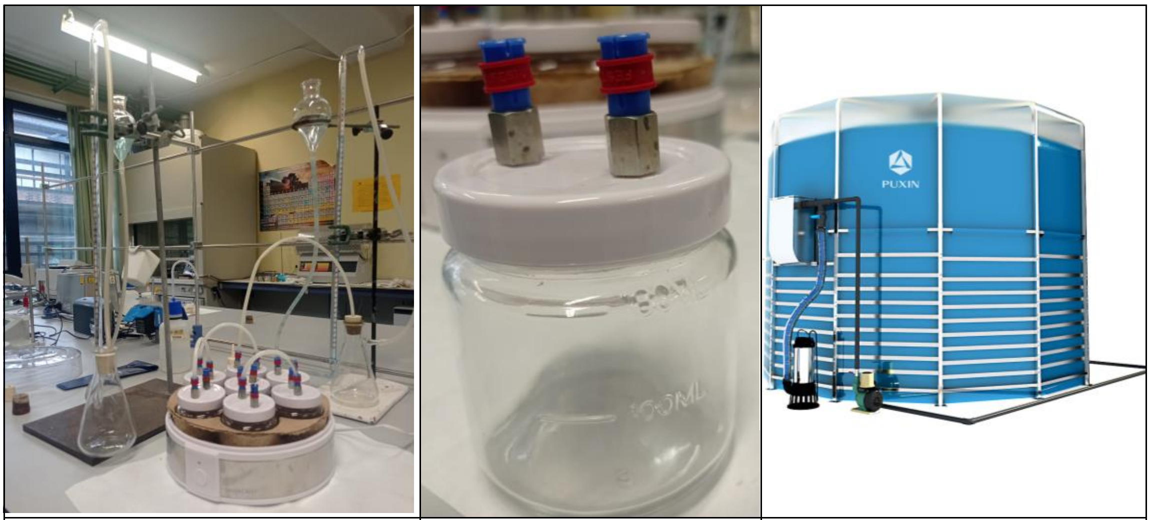
Each student was assigned to a team of two professors: one as the reference mentor during the development of the FBDP and the other one from a different field of knowledge that would give the transdisciplinary point of view. Furthermore, a shared platform was created in order to upload all the data and contents as well as to facilitate communication within the group.

Finally, we try as well to enhance interconnections between academia and industry, being in constant communication with the local industrial sector in order to offer to the students the possibility of solving actual entrepreneurial challenges and to facilitate the jump into the work market.

2.2. Material resources

Another aspect that we wanted to reinforce was the practical work that the students would develop during their FBDPs. The more experimental tasks in which get involved, the better for the learning process. Thus, a big effort was done trying to simulate, design and create an actual installation to generate the biogas in situ. Two stages were defined, one at laboratory scale and other at pilot scale. The goal was to help the students to create a self-made lab-scale device with a suitable configuration to experimentally generate biogas from the organic residues of the canteens and be able to store it and measure some basic characteristics. Then, the next step would be to move to pilot scale. For this part, the proposal was to find the most suitable commercial plant to process the calculated quantities of organic waste, transform it into biogas, upgrade it (remove some contaminants and increase the percentage in methane) and convert it into electricity. Different photographs of the experimental device to generate biogas at lab scale (Images a and b) as well as the selected commercial model (Biogás Puxin) for the scale up to pilot plant are presented as Figure 1.

Figure 1. Laboratory device for biogas production (images a and b) and selected commercial pilot plant from Biogas Puxin (image c).



a)	*b)*	*c)*

It can be seen how the experimental device at lab scale was specifically designed for this set of measurements and included 7 glass flasks with a tap in which two direct connections were inserted to make it possible to purge the air content once the organic substrate was inside. One flask was used as reference and the other 6 were used to evaluate three different variables (substrate type, concentration, etc.) in duplicate experiments. Then, the generated biogas was conducted through the exiting connections to allow the measurement of the resulting flow to determine the amount of biogas produced. From there, the gas was stored in a sealed plastic bag for gas characterization.

The design of the device is an important part of the learning content because, in order to get proper measurements and data to present as project results, students need to deal with the development of a system that may be simple but needs to cover several specifications and, for this purpose, the theoretical fundamentals need to be well established. Finally, the results obtained at lab scale will be the starting point to design the bigger plant and, therefore, it is a crucial point to check before passing the information to the mate responsible of the scale up.

The definition and installation of a commercial model is a big opportunity to learn transversal skills related to writing proposals to present to competitive calls and earn funding to acquire the required equipment. The location of the plant and its accesses are other factors, which require a deep analysis offering another set of concepts from which learning direct and transversal knowledge.

2.3. Students' organization

As mentioned before, a fluid communication and cooperation between all the members of the project was crucial to move forward and not get lost. This was especially sensitive among the involved students as they were continuously incorporating to the project at different moments. Therefore, the mentoring between mates was enhanced so that the ones that had already been working for a while could share the acquired knowledge with the ones that were progressively being incorporated. Even if each of them should prepare an individual work and present it as a final report and oral presentation to cover the requirements of the FBDP, the contents were coordinated to have coherence and the work of the rest of the mates in the project was referenced along the documents prepared by the rest of the team.

In order to reinforce the mentoring system, a mandatory condition for a student to get his/her access to the defence in front of the experts' panel was to have a positive evaluation from the student's peers.

3. Results

3.1. Academic results

A partial evaluation could be done already, as some of the students have already finished and defended their FBDPs. For the moment, all of them have been positively evaluated by the experts' panel and many of them are still involved with research work related with the learning contents of the project. There were no students leaving the project before finishing the established work, preparing the final report with the discussion of the obtained results and the final presentation to the examination panel.

This is a very positive point in a complex project as, when working with students in individual projects with a high load of experimental work, there is a percentage of them leaving the project and changing the topic to a more theoretical one.

Regarding the evaluation of the experience from the students' point of view, the opinions collected in a final survey were enthusiastic about the extra skills developed when working in a multi-layered transdisciplinary complex project. They were asked about their degree of satisfaction with the project organization, coordination, mentoring, engineer-related and transdisciplinary content, workload and work environment. The feedback of the students was very positive highlighting the collaborative atmosphere as a powerful tool to face and solve actual complex problems.

Team-work was identified as one of the main factors which produced cohesion and identity in relation with the research project. As a group, students felt more capable of reaching optimum solutions for the project-related challenges as well as more confident when facing disciplinary, bureaucratic, or organizational issues. Other authors have reached similar conclusions about the capability of team-work to improve the working environment (Buch and Andersen, 2015).

Another noteworthy aspect was the acquired competences related to sustainable goals in applied engineering projects. Both students and professors agreed that the development of the collaborative FBDP in a topic related with an actual application of renewable energies engineering in the university campus facilitated the implementation of concepts related to sustainable development goals.

4. Conclusions

The development of a collaborative, transdisciplinary, multi-layered project organized by a group of professors and technicians with different backgrounds was the context offered to a group of students to develop their FBDP. Special attention was given to the experimental work load and the design and creation of self-made technological devices for the process development. The development of knowledge related to sustainable goals in engineering projects was another key point of the work.

As a main conclusion, both professors and students agreed that team and collaborative work is by no means the closest example to work practices and that the present project was a huge opportunity for the students to move from theoretical concepts to a practical frame. The development of an actual case to be applied in the very university campus was a motivation point for the students and it reached attention from the local industrial partners attracted by the renewables energy sector possibilities. Therefore, the collaboration between researchers, professors, industrial enterprises was favoured, which is a win win experience for the students.

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