Article

Preparing Sustainable Engineers: A Project-Based Learning Experience in Logistics with Refugee Camps

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Abstract: This article describes an intrinsic case study of project-based learning (PBL) experience involving an NGO as an external client to promote sustainability competencies. Two research questions are posed: (1) How did this experiential PBL approach impact students learning to develop sustainability competencies by incorporating a responsible engineering perspective? (2) How did college students become engaged with social and sustainable PBL projects when external clients of developing economies were involved? The project-based design involved two subjects in the second year of an Industrial engineering degree. The client was an NGO with an existing project to improve the supply chain logistics of three refugee camps managed by women. Students had to cooperatively develop a sustainable proposal for the NGO with a global mindset. Findings obtained from the analysis of the reflections of students and teachers indicate that this methodology helps students to acquire comprehensively learning outcomes and to develop sustainability competencies. Sustainable and socially responsible engineering were achieved through a methodology that considers the UN Sustainable Development Goals (SDGs) and engages students in real projects. This approach promotes student awareness on the importance of their actions and their personal behavior as engineers, including a gender perspective, while training them to move towards SDG4 and 5.

Keywords: Project-Based Learning; sustainable competencies development; social responsibility; cooperation projects; engineering education; SDG

1. Introduction

In 2004, the Declaration of Barcelona [1] supported that engineering education should prepare their students to work in a globalized world. In addition, the 'Shanghai Declaration on Engineering and the Sustainable Future' [2] called upon the engineering community, as well as governments and international organizations, to promote engineering for a sustainable future. Engineers, nowadays, must address the complex issue of social sustainability. In addition, the United Nations has attempted to implement several strategies to achieve sustainability, first with the approval of the Millennium Development Goals [3] followed by the UN Sustainable Development Goals (SDGs) for 2030. The SDG is "a plan of action for people, planet and prosperity" [4] with a set of 17 objectives and 170 targets to be achieved. In particular, UNESCO [5] highlights the importance of SDG4, "Quality Education" because it plays an important role to accomplish the 2030 agenda. Therefore, universities must teach students to be drivers of innovation, social commitment and economic development [6–8]. Students must be

responsible, ethical and aware not only of the cultural and environmental impacts of their professional activity, but cognizant of the contribution that engineering can make to societies and quality of life [9].

Humanitarian engineering activities or projects may provide these skills as they open students' minds to new and relevant socio-technical issues [10–13]. Therefore, different approaches to Engineering Education for Sustainable Development (EESD) have been carried out focused on the UN SDGs while training students to find solutions within a sustainable framework [14,15]. Therefore, teachers must adopt approaches that support students not only in their interactions with society, but also in their awareness of the social and environmental impact of their projects, that is, acquiring broader capabilities and values [16]. Faculty need to be aware of which key competencies they want students to develop, and which real-world learning model provides the appropriate opportunity to do so. Service-learning, internships [17,18] or problem and project-based learning methodologies (PBL hereafter) have been found to be an effective approach to include these issues in the curricula [19–25], while focusing on real-world problems. Hence, universities curricula must connect sustainability competencies and their related learning outcomes to train responsible students [26–28]. The use of PBL to integrate sustainability in engineering education have been published by several studies [29–33]. Using PBL with real NGO projects makes students learn in-depth contents useful to their future careers, while at the same time, is useful for disadvantaged people and/or people with special needs, and therefore, educating them also in values [19,34]. These real-world learning opportunities allow students to gain hands-on experience in how to link knowledge to action for sustainability.

Within this framework, the academic model of the Engineering, Architecture and Design School of the Universidad Europea de Madrid is centered on the PBL methodology. Our students carry out at least one team project per academic year [35]. Sometimes, they work on a problem provided by an external, 'real-world' client located in a developing economy, which can be complemented by an in situ [23]. Through these kinds of projects, the intention is to contribute to sustainable education by proposing PBL experiences in a real-world context integrated into their engineering curriculum, so students develop sustainability competencies.

The aim of this paper is to describe an intrinsic case study where a project-based learning experience was used that incorporates a multi-factorial perspective on sustainability competencies, and how students perceived the experience. Therefore, the research questions that guide this paper are:

- RQ1: How did this PBL approach impact student learning to develop sustainability competencies by incorporating a socially responsible engineering perspective?
- RQ2: How did college students become engaged with social and sustainable PBL projects when external clients of developing economies were involved?

2. Method

The method used was the intrinsic case study. Stake [36] uses this term to refer a case of an exploratory study in which researchers have a genuine desire to understand more. The purpose is not to come to understand some abstract construct or generic phenomenon, neither to make a comparison to other cases nor to develop a general understanding.

The case of study is the project itself. Therefore, we collect data from several sources of evidence, as follows: Project description, phases and method; student portfolio with the final report; university surveys about student satisfaction, and teachers' and students' reflections based on semi-structured interviews.

The use of multiple sources of data (data triangulation) is a way of increasing the internal validity of a study. The goal was to build means from the categorization of the data obtained. A quantitative and qualitative analysis about the characteristics of the course, student reflections, course surveys and semi-structured interviews with teachers and students involved were carried out.

The interviews [37] were conducted on the following dimensions related to the value of sustainability: autonomous learning, global mindset, ethical values, problem-solving, communication skills, project management, sustainability, teamwork, entrepreneurship, organizational and planning

management, doubts and difficulties arisen and suggestions for improvement. The definitions of the main concepts associated with these dimensions were previously explained to the interviewed students. The students were informed about the purpose of the study and were invited to participate voluntarily in the interviews. At the end, 95% of the students enrolled in the courses participated (n = 67, 15 females, coded with F, and 52 males, coded with M). Interviews were taped and then transcribed verbatim.

These interviews were analyzed qualitatively by content through coding and interpretative analysis techniques [38] using NVivo12. The specific methodology followed in this study consisted of the following steps:

1. Creation of distinct categories of description related to the learning objectives of the project or to the sustainability competencies they should have developed (Table 3).
2. Breaking up of the students' responses into sentences with a main idea.
3. Labelling off the sentences extracted, assigning them to the pre-defined categories from step 1 or to sub-categories merged.
4. Finding important quotes that describe the main ideas found, group them to examine the general ideas and find the correlations between them.
5. Constructing a narrative that connects the findings.

3. Framework: PBL, Courses and The NGO Tatreez Project

Spanish Universities [39] are involved in introducing sustainable development activities in their curricula by incorporating learning outcomes and competencies. The objective is to train our students in decision-making processes to reach the targets proposed in each SDG by the UNESCO [40,41]. Project-based learning (PBL), is widely used to incorporate sustainability into the curricula [19,21,22,25,33]. It is used to confront students to real-world problems, simulating professional situations they will face in their future. Skills and knowledge acquired in the classroom find a connection in real situations, and students develop some new competencies and learnings. Working with a project-based learning methodology, SDG17 "Partnership for the Goals" is always worked, as the learner understand global issues and becomes aware of global partnerships for sustainable development [28].

In our university, undergraduate students in Industrial Engineering Degree work using the PBL methodology. They carry out one team project per year during the first three years of each degree, and in their last year, they develop their final degree project. On these engineering projects, teams must reach solutions to open-ended problems. Sometimes, for a better connection with "real-world", a company or institution proposes the problem to solve.

We present the project developed by students during their second year within the Business Organization and Industrial Production Systems courses (Table 1) and their experiences. These subjects take place during the second semester and cover Logistics, Supply chain, Demand calculation and control, MRP (Material Requirements Planning) systems, Inventory management and Production planning. The project runs over two subjects and requires a dedication of 25% of the students' time in each. It is worth 20% of the final grade in each subject. The experience took place on two consecutive academic years, involving a total of 67 students (30 students the first year and 37 the second one).

Table 1. Project form.

Project Name	*Consulting Project to Improve Embroidery Process in Refugee Camps*
Degree	**Industrial Engineering**
Year of Study	Second year of study/ Second Semester
Project Description	See Table 2

General objectives:

- To know the production systems and how operations are carried out;
- To understand companies' organization in general and the internal processes of the company and the company's relations with the environment;
- To handle specifications, regulations and mandatory standards;
- To apply principles and methods of quality; analyze and assess the social and environmental impact of technical solutions;
- To relate the learnings of the project with some of the SDG of the UNESCO.

Sustainability Competencies of the Project:

- Ability to solve problems with initiative, decision-making, creativity, critical reasoning that promotes sustainability;
- Ability to communicate and transmit knowledge (written and orally);
- Organizational and planning ability in the field of business, with processes that promote sustainability;
- Global mindset: Being able to show interest and understand other standards and cultures, recognize one's own predispositions, and work effectively in a global community;
- Ethical values: Ability to think and act according to universal principles based on the value of the person who is directed to their full development and that entails an ethical commitment to sustainability in personal and professional behavior in social values;
- Entrepreneurship: Ability to take on and carry out activities that generate new opportunities, anticipate problems or bring improvements to promote sustainability.

Learning Outcomes and Tasks:

- To identify potential opportunities to contribute to local development;
- To understand the concept of the company (institutional and legal framework);
- To identify the conditions on environmental, social and economic sustainability to be managed;
- To understand sustainable operations management both internally and with the environment:

    - Definition of operation management,
    - Business strategy,
    - Strategic decisions in operation management.

- To understand sustainable operations design:

    - Lifecycle of the product, product selection, design and documentation,
    - Process design,
    - Productivity.

- To understand the main aspects of strategic direction in a company through the main KPIs with sustainability;
- To understand logistics and supply management in the context of developing countries: planning; purchasing; inventory management; planning needs; production logistics.

Courses Involved in The Project	Business Organization Industrial Production Systems
Project Schedule	The project starts on the third week after the classes have begun. The project requires a dedication of 25% of the students' workload for each course
Assessment Procedures and Tools	Given in an annex Twenty percent of the final mark Rubrics will be used.
Deliverables	- Summary of the SDG Conference and its relationship with the project - Preliminary approach to the problem - Preliminary project report - Teamwork assessment rubrics - Final project report - One-minute video of the final solution proposed

Table 2. Project background form.

Tatreez—Project Management in Refugee Camps	
Requirements	- Improve supply chain and resources management - Improve inventory management and budgeting - Improve quality controls and product standardization - Improve new selling channels and demand forecasting methods
Constraints	- No digital or computer infrastructure available - High levels of illiteracy among the embroiders - Supply chain often fluctuates, due to availability of products - Difficulties to get material resources into the camp - Responsibilities unclear—women work as a cooperative business
Background Data	- Sewing and embroidering is done in the three camps, each specializing in different kinds of products (around 30 products main catalogue) - The main camp (Ein el Hilweh) centralizes the gathering of material - Supervisors in each workshop note down the work carried out, check the quality and oversee the payments - Communications among camps are via WhatsApp and rarely by email

Syllabus, Learning Outcomes and Competencies

The defined competencies in the syllabus of the Business Organization and Industrial Production Systems courses are:

- Ability to solve problems with initiative, decision-making, creativity, critical reasoning, and to communicate and transmit knowledge, skills and competencies in the field of Industrial Engineering.
- Ethical values: Ability to think and act according to universal principles based on the value of the person who is directed to their full development and that entails a commitment to certain social values.
- Entrepreneurship: Ability to take on and carry out activities that generate new opportunities, anticipate problems or bring improvements.
- Global mindset: Being able to show interest and understand other standards and cultures, recognize one's own predispositions, and work effectively in a global community.

The expected learning outcomes are:

- To characterize the processes of the direction of operations and their relationships;
- To understand and apply business resource management methods;
- To evaluate systems of decision-making of productive plants;
- To analyze the production capacity and optimization methods.

Based on these learning outcomes and competencies, teachers build a project-based on the PBL methodology and connected to the SDG. The PBL experience is developed around SDG 4 and SDG 5. The project promotes a meaningful learning experience to students by focusing on a female developed project in a refugee camp. Hence, the experience contributes to both goals, one having as a beneficiary subject the students and the other, having both the students, and entrepreneurial women as beneficiaries. To do so, teachers fill in the 'Project Form' (Table 1). The 'Project Form' defines the general objectives of the project to be carried out by the students and shows the sustainable competencies [42] and learning outcomes they must acquire during its progress. The project has an external client (an international cooperation project, Tatreez) presented in the next section. Hence, students have the

opportunity to work closely with this institution to gain valuable insight into the cultural and technical issues that facilitate the development of appropriate solutions. As students must acquire the learning outcomes defined in their syllabus, teachers carefully follow up the development process to offer a suitable challenge.

4. Description of The Learning Experience

This section presents how the Tatreez requirements were integrated into the projects developed by the students in their courses. The project was organized in four phases, as can be seen in Figure 1. Once the project was completed, the process re-started again from the improvements proposals in the next academic year with new students and in the same subjects.
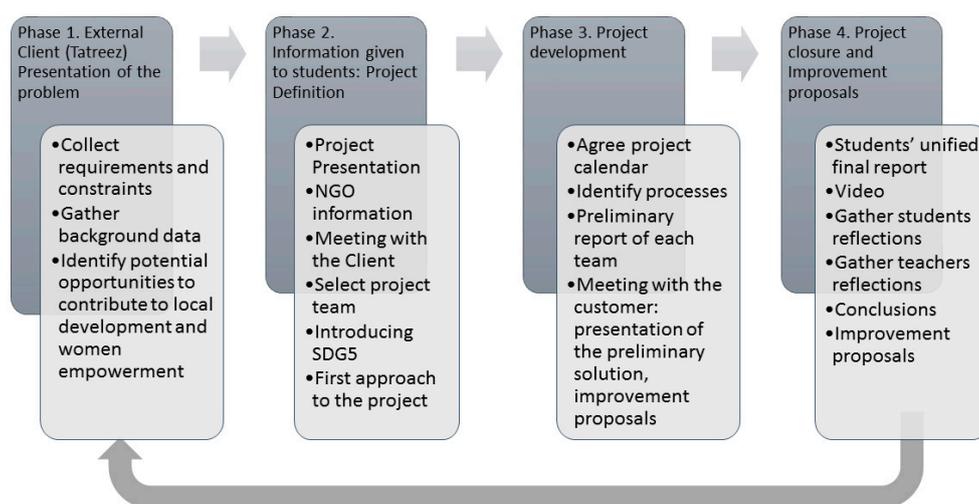

Figure 1. Phases of the work done for the learning experience.

4.1. First Phase: External Client (Tatreez Project) Presentation of the Problem

The Tatreez Project is an international cooperation and development project funded by the European Union in Lebanon [43] and implemented by the Spanish NGO Cives Mundi [44] and the Lebanese NGO Najdeh [45]. Specifically, it works in three Palestinian refugee camps, Ain al-Hilwe (in Saida), Rashidieh (in Tyre) and Beddawi (in Tripoli), which are the most populated and conflictive camps in Lebanon. Unemployment is one of the main problems among the refugee camps inhabitants, being women the most vulnerable group, in need of economic independence. The name of the project, Tatreez, refers to the traditional embroidered Palestinian that women carry out as a principal activity to increase their income. The target of Tatreez' project is the economic protection of these women by increasing their economic sources of income. To do so, women receive professional training on: Traditional Palestinian embroidery; design; national and international marketing of embroidery products; and creating small businesses. This training is carried out through small workshops in each of the three camps. In these workshops, women manufacture unique pieces, such as bags, shawls, cushions, vests, belts, poaches, scarves, clutches and other accessories, all these items decorated with intricate Tatreez patterns. At the end of the project, these women should be able to create a cooperative of women in three headquarters, one in each camp, and to sell their creations in an online shop. However, many difficulties arose as the Tatreez Project started to grow. Women in Tatreez were not able to detect where the problem was.

It was in this context when the Tatreez representatives asked the University for academic and professional advice to better manage their project. Faculty proposed them to share their concerns with our students so that they could obtain diverse and probably more creative solutions.

Therefore, during the first phase, the teachers hold several meetings with Tatreez representatives to collect details about the requirements and constraints of the NGO and of their users. Meetings included

gathering background data about their work in Lebanon regarding the refugee camps and their embroidery workshops. This information was gathered using the form described in Table 2. This form is very important to integrate the student's projects with the real project, and to define the project learning objectives in the frame of the Engineering courses.

4.2. Second Phase: Information Given to Students. Project Definition

In the classroom, the first session is dedicated to presenting the competencies and learning outcomes of the courses. Within the framework of PBL, particular emphasis is placed on their relationship with the UN Sustainable Development Goals (SDG). After this session students must attend a conference about the UN-SDG before starting the project itself.

Three weeks later, the project is explained to the students, as well as to the external client: An NGO called "Cives Mundi" that is working in an international cooperation and development project called Tatreez [43]. At this point, we remind them that, as responsible engineers, their work must consider different cultural, social and political contexts. Students are organized in teams of 4 to 5 people and provided with the information of the project (Tables 1 and 2). Working for an external client means that they are required to participate actively in their team discussions to reach a suitable solution. They must act as engineers responsible for the future and wellbeing of the project. They are informed about the main difficulties the organization faces. For instance, they should consider the major differences in the availability of resources between what they may suggest might be budgeted for Spain, as opposed to the Tatreez circumstances. Teachers explain to students that Tatreez works as a cooperative business. To assure the continuity and success of the project, the women and NGO's working among them identified the main weak points, where action should be undertaken (Table 2).

In the second session of the class, the NGO is invited through a video-call, so they feel the customer quite near and raise their awareness about the economic, social and political context of the project. From this video call, we ask students to retrieve the first constraints and requirements they think the project has had at this point. These are listed below:

- Coordination among the three camps is key, although access to computer-based communications and management software is unavailable.
- In the same sense, there are difficulties in exporting products to potential international web-based markets, limiting the sales to handicraft fairs and selected Lebanon shops. Their webpage did not work as an online shop, making the process for acquiring products very difficult.
- Since the project had grown rapidly, problems related to supply chain, production organization and quality controls had arisen:

  - Channels to gain potential customers and increase the market are very limited
  - Paying for the materials in advance, without guarantees of selling them and gaining returns make these entrepreneurial women struggle with a monetary strain.

At the end of the call, there is a session about the relationship of the project with SDG5 (gender equality and women's empowerment) and an open debate with the students.

4.3. Third Phase. Project Development

Project development was divided into two stages as the NGO wanted one unique solution for their project.

4.3.1. First Stage of The Project: Solutions of The Different Teams

Once the students have the project information, they are asked to identify all the processes of the project, from the acquisition of raw materials to the payment by the customer once the piece was sold. Each team had to be aware of the distinct stages, processes and people involved in each one.

They were also asked to identify the problems associated with each process and suggest workable solutions, as well as the means necessary to carry them out.

This first stage of the activity does not entail communication among the different teams. Teachers monitor students while they move around the classroom, asking key questions related to the learning outcomes, and pointing out details not caught by the students and that they should consider. This tracking, hence, serves to re-focus objectives and tasks so as to achieve a feasible solution for the project. Teachers, therefore, support student teams in knowledge acquisition, methodology, project management, teamwork and in engaging with the customer.

At the end of this first stage, each team must hand over a preliminary report with justification and analysis of proposals for improvement.

4.3.2. Second Stage of The Project: Unified Solution for The Client

A second stage starts when the students deliver their preliminary report of their project, and orally present their proposals to the rest of the class. During this oral presentation, debate was encouraged. During this phase, they are encouraged to look for ways to integrate different ideas, coming to an agreement on how the main targets should be approached and solved. This second stage incites many useful comments about how they faced the task and their perception of the women, the camp and the business.

At this stage, once the action plan has been agreed upon, their work consisted of writing up a preliminary report for Tatreez and having a video call with a volunteer in Beirut from the Spanish NGO. In doing so, they could ask more questions to clarify some critical issues and retrieve more information for the final solution to be given in their project. Students presented the conclusions reached, and the chances of implementing them. This video-call was also used to agree upon the next steps, and follow-up with the NGO's representative, in order to advance the work with the organization.

4.4. Fourth Phase: Final Report and Improvement Proposals

To close the project, as their solution must be applied, there can only be one project carried out. Accordingly, all the students worked together and prepared and delivered a unified final report to Tatreez. It included the latest information gathered during the previous video call, and the final solution agreed upon for the project.

4.4.1. First Stage: Students' Solution for The Tatreez Project

As a result, students provided Tatreez organization with several ideas for improvement in different areas:

- Product sales: Improve the webpage online shop procedures (PayPal implementation) and in the meantime, manage the email account more diligently;
- Procurement of materials: Prepare a detailed shopping list, benchmark providers, estimate quantities and qualities in advance;
- Material distribution: Create a Bill of Materials for each product, prepare packages with raw materials for a seamstress, and calculate more accurate prices;
- Product Specialization: Reduce the catalog, specialize the seamstress and provide training to improve the qualifications of the staff;
- Quality controls: Create patterns, have a "golden bag" (model to physically compare the production) and allow the supervisors to check the work in process;
- Warehouse: Conduct an inventory and organize shifts to take care of the warehouse organization;
- Visual management: Implement the concept of Obeya Room in the workshop.

4.4.2. Second Stage: Improvement Proposals

All the data collected are used as the starting point in the next academic year. Also, the project deliverables are implemented in place, and some new areas of improvement are identified. The following academic course, students collect this information and prepare a new proposal for continuous improvement.

During the last phase we collected the opinion of teachers and students about the procedure and project development. Both teachers and students were invited to participate in semi-structured interviews [37].

In addition, quantitative results were collected via institutional surveys about the satisfaction of students with the subject, as well as with the teaching methods.

5. Findings and Discussion: Competencies and Learnings

In this case study, we have answered the guided research questions through a quantitative and qualitative analysis of the students' reports, course surveys about their learning and teaching, as well as students' and teachers' perceptions through semi-structured interviews.

We believe that the students and teachers can make the world a better place through experiences, such as the one presented in this paper. Faculty and universities, in general, need to continue inspiring changes every day through education. Some of these findings can be found in J. Peris et al. [46], in Fernández-Sánchez et al. [47], in Moskal et al. [48] or in Wiek et al. [21] who stand that these kinds of activities develop a different understanding of engineering beyond conventional learning objectives. In our case, to assess them, we used rubrics from Terrón-López et al. [49], and an Agile philosophy was followed to ensure individual work within the team [50].

Findings provide valuable information about how this course approach was meaningful for students, teachers or the NGO answering the two posed research questions: (RQ1) How did the PBL approach impact students' learning to develop sustainability competencies and learning outcomes; (RQ2) how did students become engaged with social and sustainable PBL projects when external clients of developing economies are involved.

A narrative was constructed connecting the findings from the interviews. The relation between the sustainability competencies in the project and the categories that merged from the interviews are shown in Table 3. These are shown highlighted in bold within the narrative constructed.

5.1. About the PBL Approach

The teachers involved in this project have extensive experience in PBL methodology. They also have experience in volunteer and cooperation projects. Hence, this provides the teachers working with this project with the needed engagement and preparation to integrate sustainability competencies into courses. We must bear in mind that a key piece for the proper development of these methodologies is that teachers are also committed to this perspective. In the beginning, the integration consisted in the inclusion of theoretical concepts, then some cases designed by the teachers. Compared with other methodologies, PBL requires students to act and make decisions while they reflect on their own learning.

The analysis of the interviews highlights how participation in this project with external clients has helped our students develop sustainability competencies.

Autonomous learning was developed, as students were actively encouraged to gather and interpret data to give an informed opinion. For instance, very soon in the project, they identified family members and friends who had experience sewing in similar conditions.

'Yes, I had to learn new things to understand the project. Some of our mothers and grandmothers also worked embroidering and sewing by pieces, and we have never done so. So . . . their experience has been very useful in this project. Thanks to them, we have learnt more, much more. [M-43]

Table 3. Sustainability competencies and related categories.

Project Sustainability Competencies	Categories
Ability to solve problems with initiative, decision-making, creativity, critical reasoning that promotes sustainability	Interconnected thinking Critical reasoning Decision-making Creativity Ability to solve problems and make decisions with sustainability Self-confidence
Ability to communicate and transmit knowledge (written and orally)	Communication skills
Organizational and planning ability in the field of business, with processes that promote sustainability	Complexity management Project Management Develop different options for action based on present conditions Consulting Create common visions, action strategies Organizational and planning ability
Global mindset	Tolerance for ambiguity and uncertainty Collaboration/teamwork Global mindset SDG4 and 5
Ethical values	Social and ethical issues Motivation
Entrepreneurship	Innovative transformations Entrepreneurship Autonomous learning

During their project, students were expected to use their capacity to learn new methods and theories not given by their teachers, and to adapt to new situations, developing the competency of a **global mindset.** For instance, a student said: *'It is difficult to start, there are too many things to contemplate and we cannot imagine what life is really like there. On the one hand we thought about production but then you told us that if we had thought about distribution or payments and the problem was very complicated'* [F-13].

Her teammate, both with a very creative solution that transformed the embroidery workshop into a fast food restaurant type of craft, while talking about "project management" indicates *'we were missing a lot of information but I think that's good, I've foreseen the situation where I will be tomorrow in the real world, in which I am supposed to calculate based on the demand, but, . . . it turns out that I do not know what the demand is.'* [F-3]

During the experience, time to work outside the classrooms was given to come up with new lean manufacturing tools relevant for the project at hand.

They had to think about relevant social, scientific and **ethical issues,** considering human rights, democratic principles and equality between genders, as well as the principle of solidarity, and the protection of the environment. The students used their **ability to solve problems and make decisions**. They had to be creative and develop critical reasoning to be able to present a very professional and comprehensive solution to their "client", Tatreez. All the ideas included in their solutions were adapted to the kind of stakeholders targeted by their project and their particular needs. For instance, early on, students became aware that reading and writing skills and the level of proficiency using IT Tools would be one of the main constraints of their clients when solving the problem proposed to them:

'Yes . . . as we saw that the way to communicate with them was the email, I sent them an email and they took more than a week to answer us' [F-9]

This feeling, related to **tolerance for ambiguity and uncertainty,** was sometimes stressed by students. One points out: *'I couldn't imagine I could work in such projects where the target is not well defined'*[F-3].

Teachers identified the importance of insisting about the constraints of a project because all the students assumed, in the beginning, that the women in the refugee camps in Lebanon have access to the same technology they have at the university.

'Do you really think all these women know how to use to Microsoft Office? Even more, do you really think they can all read and write?' [T1]

Related to the project **communication** needed within the project development, students demonstrate their skills even to a non-specialized audience. Several decisions were taken early in the project to ensure seamless communication. For example, students agreed on the type of virtual tools to work online. They also agreed early in the project on how to: Communicate with their client representative (by mail and skype), exchange questions, complete a thorough presentation with their conclusions, and on how to evaluate with the ONG the best way to implement them.

Organizational and planning ability was also developed: Students completed all the tasks demanded on time, and the teams worked professionally.

'As our teachers were posing questions about the project continuously during the classroom sessions everyone in the team worked to come with it' [M-5]

'We knew that the Tatreez representative was going to have a video call with us. We knew we were going to have a video call with the client. And we couldn't let him down. We had to have the first version of the project on time. We couldn't leave those women out.' [M-37]

Even though **teamwork** is a skill which is developed in every PBL, in this case, they showed an even more efficient and cooperative teamwork, while establishing good relationships and exchanging information.

'yes, it is the first time this happens to me. And, we've been able to organize our tasks without problems . . .' [F-9]; *'it is something we have shared, that no tensions have arisen in any of the groups!'*[M-3]

In particular, to complete the project, the students auto organized themselves in teams of five people each in order to come up with different proposals. These were then debated upon to come up with a common solution accepted by the whole class.

'One of the most important skills I learned during the project was how to facilitate discussion around sensitive issues. I mean, when topics are, . . . , well, when you need to do it in a positive way.'[M-43]

'We got a broader range of knowledge as listening to the others . . . I mean . . . brainstorming and listening to other views got me to appreciate what I would have never thought' [F-3]

'The day we got the final solution after the class I couldn't believe it! This was really teamwork, like when I am in the rugby field, all different, but together with same objective, wow' [M-8]

While collaboration is not always easy [50], and students confessed that some tensions arose during the project, having a common goal in a real-world environment made student teamwork adequate and productive. They were proud to deliver a proposal thanks to the contributions of all the teams.

The process of designing and launching good solutions for the Tatreez project developed their **entrepreneurship skills**. Students were encouraged to face challenges and problems related to their scope of knowledge with flexibility, initiative, innovation and dynamism. They completed their assignment to the entire satisfaction of both teachers and the NGO's representatives. Moreover, they could do it in an international setting where one of the challenges was to understand the environment, refugee camps in Lebanon, alien to students.

Self-confidence was also quite important. Students were led to achieve high levels of performance in their work and to positively contribute to Tatreez displaying a results-oriented kind of behavior. Students certainly were also able to use tools they had just learned to a new project that was real.

'Well, there was something we commented a lot in our team. The value of our learnings. We felt that our efforts had a kind of reward. We have the feeling that we have had an important role in the development of these women in their community. It is a kind of feeling of responsibility.'[F-9]

Appreciation of the cultural influences on an engineering problem and the implications on the community arose also. Hence, students develop **intercultural competencies**.

Oh yes, the web must have a store if they want to maintain the export, with a PayPal system since the complication of the email discourages many purchases [F-1]

Yes, yes, that is one of the problems we had to solve [M-1]

"I learned that women have it tougher in these situations but that with creativity, motivation and a little help from the community they can improve their reality" [F-8]

Even though some students have not been involved in such a personal way: 'I do not know how real this is. I know that I have given them a solution that is good for me, but they surely get there, read it and discard it' [M-15]

From their cooperation, after the video call took place, they even suggested some improvements as they were asked to give **sustainable solutions**: *'Surely, they already have a pattern by product that indicates how the product correctly, however they said that defective products arrived in Europe ….and, thinking about what we had been told that the project had to be sustainable, we thought it would be good for the supervisor to do check-ups in the intermediate stages, not only in the end, since waste of material is avoided, and time, if you discard from the beginning what cannot prosper.' [M-26]*

Yes, yes, and talking to our mothers we realized that it would be practical to make the cut of the pieces before the embroidery. [F-5]

Therefore, it seems that the participant students show adequate acceptance regarding the scope and target of the activity, although they pointed out the difficulties they faced and concerns about the implementation.

Most of them pointed out that with this activity they had **become aware of multiculturalism, the role of education, ensuring the participation of women and other ways of living (SDG4 and 5)**.

'I have never before have had contact with refugees. I had no idea about their way of living' [F-13]

"I had no idea what the circumstances were in a refugee camp and I was amazed that this kind of Project was possible. Women who are illiterate in many cases now may have better opportunities for their daughters" [M-7]

Finally, most of them indicate that they become conscious of the need for economic independence of women and the role education plays in this (**SDG4 and 5**):

'At the beginning I thought It was impossible then, I became conscious that this was a way for these women to be independent and have their own income'[F-6]

'I am more aware of issues now I didn't know and, I feel like I have a way to contribute to ensure the participation of women in their community' [M-15]

'It is clear that people in general need education. In the first debates some mates said things I didn't agree. But, with this project I think everybody has learn a lot about how, as Mandela says, education is powerful' [F-8]

In PBL, knowledge and technical skills acquires meaning in relation to a professional context. When solving real-life situation embedding cultural and social diversity, such as in this case study, students can make relations between professional and societal context. The projects in a PBL environment become the drivers for creating contextual learning. This provokes students to create meaningful connections between theory and practice, doing significant work in a collaborative way, nurturing the individual and reaching high standards [51]. As a student says:

'This kind of projects is the way in which you learn the best. You truly have a linear progression, each day you learn a bit more, you retain more, you learn much more than with just the classes.' [M-8]

From the analysis of the academic results of our students, we have found that the experience has led to goals related to their academic and professional education, and education values. This kind of projects and living experiences, help students to find meaning in context, obtaining deeper learning because it comes from outside their classrooms. Learning objectives of the courses were also fully met during project development. The external client, "Tatreez", told the students that they had produced remarkably good work, **creating common visions and action strategies**.

The need to acquire the **competency of consulting** arose during the project. One of the teachers assigned to this project had more than 20 years of experience working as a consultant. As her work is to improve operations in industrial and services sectors, she shared with the students, relevant experiences and insider knowledge, while they were developing their own consulting mission for Tatreez. Students achieved the **learning goals related to Project Management**. They never lost sight of their deliverable and of their constraints in terms of time, cost and quality and proved their capacity to manage activities of sustainable engineering projects within the scope of the Industrial Engineer degree and to deliver the complete scope of their project on time and with the expected quality.

'As a result, from this project I think we have learnt a lot, I have realized how difficult, but how important is to work with communities with this kind of need (developing countries? Mmm..), how if we make a detailed work it can be a great work for them which made me to deepen my theoretical knowledge.'[F-2]

Not only the **complexity management** was learnt, but also **social and ethical issues** arose during the project development.

'I thought the prices of the items sold were very expensive, but then if you take into account the conditions in which they are manufactured, taking care of the children and in markets where women are not respected, they are priceless' [M-9]

5.2. About the Engagement

The design of PBL-based courses has allowed students to work on sustainability competencies in depth. In the interviews, teachers remark that the project and the contents of the courses must not be considered as isolated elements. To achieve this, the relationship of the courses learning objectives, the competencies, and the project to be developed must be established. Hence, the design of the PBL-based project must be done in detail. They point out how important it is to have the project forms (Tables 1 and 2) to fill in with all the needed information and to have previous meetings with the NGO. These allow detecting the limitations and the constraints necessary to adapt the real project to the required learning outcomes and competencies of the courses. Having these forms filled out helped their students, and as a result, the teachers believe that feeling accompanied during the process helps to create student commitment to the project [18]. However, ensuring that students acquire the required learning outcomes in a real changing environment, created stress for teachers. Nonetheless being able to rely on project forms and having the support of the NGO at all the times, motivated them to face the challenge.

In solving the proposed project by Tatreez, our students confronted a real-life situation far from their environment. While working on it, they had to confront the economic, social and multicultural dimensions of the project. It is at this moment that the relationships between professional practice and the learning acquired with PBL take meaning [33]. Hence, students feel that their work is relevant for the women of the refugee camp and feel proud of it.

'The video calls were very important for us. These days were when we really became engaged with the project. Asking questions and getting answers in concrete terms with specific examples. This had [a] positive impact on my work' [M-50]

This feeling of responsibility is an added value of this type of learning experience connected with a socially responsible world, as the typical assignments in classrooms do not normally involve collaboration between students and customers [52]. As a result, it allows students to participate and engage in collaborating actively because they feel the need to become involved with different degrees of intensity [18]. They feel that as they are collaborating with the stakeholders and experts who have different approaches as the ones seen in the classroom, they arrive at different understandings of the problems. This also allows them to become familiar with different perspective views (sometimes conflicting), and they begin understanding the different contexts within which a sustainable problem can be addressed and how all the solutions can help to achieve what is pursued.

One student said *'at the end, I felt we had directly contributed to the transformation of these women life, and, somehow we helped them to make their business more sustainable'* [M-23].

Teachers also agree that students seem more engaged when working on real problems in which an external client can give important insight into the real situation. They point out that the video-calls done in the classroom with the NGO was an important key as it brought the project even closer to the students. They say that integrating sustainability into real projects with external clients of developing economies tends helps to make the sustainability competencies more visible, and it seems that their students were more involved than in previous academic years. This is also reflected in the high percentage of students who voluntarily participated in the interviews. In addition, the number of dropouts in these courses was very low (only two students in the first year and one in the second one).

Every year, students' opinions about the aspects of their teaching-learning experience are collected in the university using a satisfaction feedback survey with 20 questions. This Likert questionnaire (1 being is the lowest grade and 5 the highest) is standardized for all university degrees. It aims to seek information on several aspects of teaching, assessment and support provided in each course. In this case, we have only analyzed questions related to the methodology, the assessment system and the perception the students had about their learning. During the two academic years, students have been very pleased both using the methodology, for their learning and with the teachers being the mean = 4.4 and the standard deviation SD = 0.2 (n = 67).

6. Conclusions and Future Works

This paper has explored and described an intrinsic case study of project-based learning experience to develop sustainable competencies in engineering students from a multi-factorial perspective.

This intrinsic case study has identified several important points to consider when designing PBL-based courses to integrate learning outcomes and sustainable competencies with the needs of an NGO as an external client:

- The importance of faculty involvement: Teachers are required to be familiar with the development of sustainability skills and with the PBL methodology,
- The need for of a well-designed PBL-based project according to the stakeholders' needs,
- The imperative of connecting students with the client during the process,
- The requirement of providing all the necessary information to students so they may carry out the project in a structured way,
- The value of good the coordination between the teachers and the NGO.

Findings obtained from the reflections of students and teachers indicate that this PBL methodology approach for carrying out projects with external clients, such as NGOs, has helped our students develop competencies related to sustainability and acquire comprehensive learning outcomes.

Teachers must integrate sustainability competencies into the curriculum. The objective is to ensure that future engineers are aware that they must address the needs of companies, while also being fully conscious of the importance of their decisions and of how their acts affect people and the environment. This integration in the curriculum should not remain only in theoretical concepts that, many times, are insufficient for a complete understanding. Sustainability and socially responsible engineering are achieved through a methodology that integrates SDGs into real projects, therefore engaging students. To conclude, this approach promotes students' awareness of the importance of their actions and personal behavior as engineers, including a gender perspective, training them to move towards SDG4 and 5.

The participation of a humanitarian organization in the project developed by students creates situations that sometimes are quite complex. As a result, this project requires students to think holistically when facing the challenges associated. Hence, students feel that they learn deeper and better, because they must make decisions and use critical thinking skills, considering the context in which there is a sustainability problem and to what extent this context influences the solutions proposed. In doing so, they learn to work on a common proposal, even though they did not always approach teamwork in a positive manner, due to tensions that sometimes arose. However, it seems that when working on cooperation projects, teamwork is more effective as they say there are not so many tensions.

It appears that these interdisciplinary collaborative projects are highly valued by our students and that they become engaged. Once the project was finished, some students showed interest in volunteering stay in the Refugees camps. However, this step requires institutional support for its development and implementation. To combine this experience with volunteer stays (internship) and to study how it impacts the acquisition of sustainability competencies has arisen as a future line of study, thanks to this study.

The ideas for proposed improvements presented to Tatreez will be implemented, and this project has become the first step towards a long-term relationship between Tatreez and Universidad Europea. Important is also the fact that the project has been carried out with the same organization several consecutive academic years. This means progress can be reviewed each year and allow students to reflect on the results achieved by their peers. In addition, the relationship between the university and the organization fosters greater mutual knowledge and better coordination. This process has been improved year by year.

Although this intrinsic case study led to relevant indicators regarding the acquisition of sustainability competencies, using PBL and counting on an external NGO partner, there are some limitations, which call for future studies and reflections.

Were there more students enrolled, the number of groups per year could have been two, allowing the use of another experimental design—where one group worked with the NGO and the other one did not, serving as a control group, for example. This approach would have made it possible to establish a comparison of the degree of competency development in both groups, instead of using a case study.

More studies are needed not only to better bring the knowledge on the development of sustainability competencies in engineering students, but also to better understand the impact of PBL with real sustainability projects on the teaching-learning processes.

It may also be interesting to comprehend whether maturity and prior knowledge of students influences the in-depth acquisition of sustainability competencies. It is very important that teachers have good PBL training to ensure that the students fill in any potential 'subject area gaps', when the need arises.

From the faculty point of view, establishing and maintaining the relationship with partners, as well as coordinating the project, requires an additional workload. Therefore, it is necessary to provide incentives to those teachers who are willing and qualified to supervise such a learning opportunity.

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