THE SUSTAINABLE DEVELOPMENT GOALS (SDGS) APPLIED TO HIGHER EDUCATION. A PROJECT BASED LEARNING PROPOSAL INTEGRATED WITH THE SDGS IN BACHELOR DEGREES AT THE CAMPUS ALCOY (UPV)

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Abstract

The Sustainable Development Goals (SDGs) proposed by Union Nations were defined in Rio+20 Conference. These SDGs are 17, and they define 169 different goals that countries have to reach in 2030. The awareness and implication of people about the importance of the SDGs enable the fulfilment of these goals in a satisfactory way and therefore, the university community must take part of these objectives and integrate the SDGs within their curricula in the different bachelor and master degrees. In light of this, students must also integrate the specific competences, outcomes competences and SDGs in their learning process. To reach this integration, it is necessary that lecturers develop active methodologies in which students work competences and SDGs jointly. This article shows a proposal that is being developed in the Campus of Alcoy at the Universitat Politècnica de València (UPV) to define a Project Based Learning (PBL) model integrating the SDGs. The proposal shows how PBL can support students and lecturers to promote the teaching of key competences for sustainability that are relevant for the SDGs.

The article discusses the concept of PBL and SDGs; accounts for the general students' capabilities, highlights the integration of SDGs in the PBL methodology into Bachelor and Master Degrees curricula at the Campus Alcoy (UPV). Moreover, it shows an alignment analysis performed between the SDGs and a PBL model in a case study.

Keywords: Sustainable Development Goals, Project Based Learning, Target, Alignment, Educational Innovation and Improvement Projects.

1 INTRODUCTION

The United Nations Sustainable Development Goals (SDGs) appear as a consequence of the agreement reached by the Member States of the United Nations and end up embodied in a declaration based on 17 Sustainable Development Goals and 169 goals [1]. The achievement of these objectives involves, generally speaking, the whole society but it is also important to highlight that the main pillar that should promote SDGs implementation is the public and private sector at all levels. Fig. 1 shows the main SDGs , presenting the areas with which they are related.

Education is present in many of the SDGs, but we would like to highlight the fourth SDG, particularly the goal 4.3 that states: "By 2030, ensure equal access for technical training for all men and women, professional and superior quality, including university education".

Moreover, the rest of the goals are also closely related to higher education, because education becomes an instrument to achieve them such as: end of poverty (SDG 1); health and wellness (SDG 3); gender equality (SDG 5); decent work and economic growth (SDG 8); responsible production and consumption (SDG 12); climate action (SDG 13); and peace, justice and strong institutions (SDG 16).

Figure 1. SDGs proposed by UNESCO [1].

The achievement of these goals is closely linked to the fact that students, in their undergraduate and postgraduate phases, integrate them into their subjects. Therefore, the current structure and contents of subjects have to involve aspects such as ethical, environmental and sustainable results and carry out final degree projects in which these goals are present.

To carry out this integration, it is necessary that higher education systems are correctly established and regulated to guarantee access, equality, quality and adequacy to such goals. Moreover, the teaching contents and learning process should guarantee sustainable development, taking full advantage of the technologies, resources and trainers involved in the sustainability educational context.

Particularly in this regard, the UNESCO Institute for Statistics is in charge of monitoring the goal 4.3, through the indicator of “the gross enrollment rate in higher education” [1].

2 CONTEXT OVERVIEW

One of the Higher Education Centers of Universitat Politècnica de Valéncia (UPV) is Campus of Alcoy, also known as Escuela Politècnica Superior de Alcoy (EPSA). This campus adapted its bachelors’ and masters’ degrees according to the new European Higher Education Area, which is based on Bologna Process. This adaptation considered the social and economic constrains and the campus proposed the following degrees, which are represented in Fig. 2.

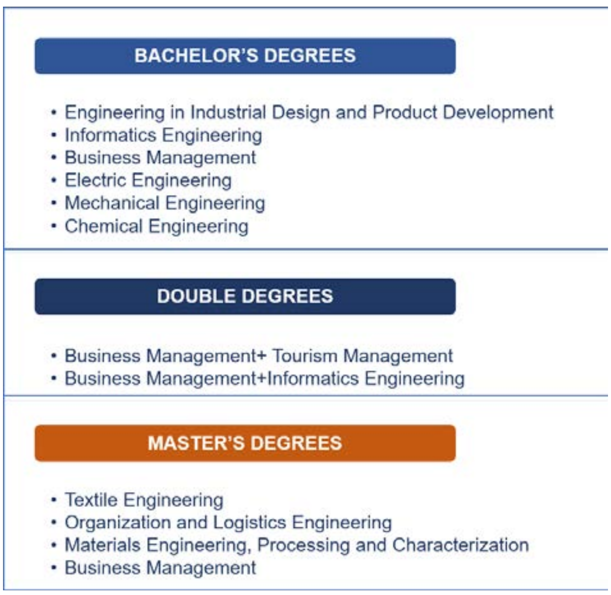

Figure 2. Bachelors’ and Masters’ degree in the Campus of Alcoy.

In addition to the incorporation of the new study plans, the Spanish university teaching context has modified the classic teaching-learning schemes in which the master class was used by most professors in order to train students. The new technologies and the new learning strategies made possible this change. In the EPSA, this fact has not gone unnoticed and different projects have been launched to improve the acquisition of learning results. These projects have been developed through the promotion of institutional programmes such as: Network Teaching Plan, Educational Innovation and Improvement Projects (EIIPs) and Innovation Teams in Teaching Quality (ITTQ). Online Teaching has been established since 2010 and its objective is to encourage teachers to prepare reusable educational materials in digital format. The EIIPs, which were also proposed in 2010, are projects promoted by a group of teachers from the same department or different departments that have a notable impact on the development of more active teaching, aimed at improving the quality of students learning. Finally, the ITTQ are teaching teams that look for new models of training for teaching based on the idea of combining innovation and training, so that practice is the element that gives meaning and guides the study of possible alternatives for improvement and innovation.

In this line, EPSA started a new institutional EIIPs last year. One EIIP is being developed in the 6 bachelor's degrees. The development is focused on project-based learning (PBL), building a vertical and cross coordination between knowledge areas and subjects. PBL is an active methodology that organizes learning around projects. Projects are student-driven and provide more tangible results what has been considered as a positive aspect to deepen and retain knowledge. PBL allows students to learn curricular content and put into practice key competences.

The definition of the different PBL models in the EIIP is based on the Larmer and Mergendoller principles [2]: (i) the PBL models have to teach significant content; (ii) they require critical thinking related to the SDGs, problem solving, collaboration, and various forms of communication; (iii) they require inquiry as part of the learning-process to construct something new taking into account the SDGs; (iv) they are conducted around an open-ended driving question; (v) they are based on the reverse learning process: from the final idea of project to the process of construction; (vi) they allows students' independency in the decision-making process about which actions performed to enhance SDGs; (vii) they give a great amount of feedback and (viii) allow to be presented explicitly to others and promote the awareness of the SDGs.

Considering the SDGs, the different subjects establish correlation between the project and the SDGs, increasing the reached social value in the students' learning-result.

In this EIIP, whose main objective is the inclusion of PBL methodology in the last courses (3rd and 4th years) of the 6 bachelors' degrees, 13 PBL models have been defined: four PBL models related to mechanical engineering, two PBL models that deal with business management issues, four PBL models associated to informatics and computers, one PBL model related to industrial design engineering, another one related to chemical engineering and the last one in line with electric aspects. This EIIP involves 64 different subjects and more than 60 lecturers. Moreover, it is also important to highlight that the PBL models are very different in nature, but almost all of them deal directly or partially with some aspects related to SDGs. Table 1 shows a summary of the 13 PBL models that are being defined and the subjects involved in each PBL model as well as its main characteristics.

Table 1. Summary of the inclusion of the PBL methodology in the Campus of Alcoy.

Bachelor	***PBL Model***	***Subjects***	***Course***	***Semester****	***Type***
Mechanical Engineering	Project Engineering	Industrial Structures and Constructions	3	Y	Obligatory
		Fluid-mechanical Engineering	3	B	Obligatory
		Industrial Structures I	4	A	Optional
		Union Engineering	4	A	Optional
		Industrial Structures II	4	B	Optional
	Vehicle Design and Engineering	Thermal Machines	3	B	Obligatory
		Materials. Design and Restyling	4	A	Optional
		Engines	4	B	Optional
		Advanced Assembly Techniques	4	B	Optional
	Design and Calculation of a Pressure Tank with Solid Works using Composite Materials	Engineering of Composite Materials of Polymeric Matrix	4	B	Optional
		Forming Processes of Composite Materials of Polymeric Matrix	4	B	Optional
		Advanced Design with Polymers. Project with Composite Materials	4	B	Optional

Bachelor	PBL Model	Subjects	Course	Semester*	Type
	Design and Manufacturing of Machines and Prototypes	Machine Theory and Design Practices	3	A	Obligatory
		Concurrent Engineering	4	A	Optional
		Faults Diagnosis and Correction in Machine Components	4	B	Optional
Business Management	Consulting and Finance	Banking and Stock Market	4	A	Optional
		Advanced Techniques for Financial Simulation	4	B	Optional
	Business Management and Organization	Information Systems Management	4	A	Optional
		Development of Management Competencies and Teamwork	4	A	Optional
		Strategic Control Systems	4	B	Optional
Industrial Design and Product Development Engineering	Sustainable Chair Design and Prototype	International Trade and Cooperation	2	A	Optional
		Advanced Prototypes	3	A	Optional
		Industrial processes	3	T	Obligatory
		Packaging and container	3	B	Obligatory
		Design Workshop II	3	B	Obligatory
		Materials Resistance	3	B	Obligatory
		Equipment Product Design	4	B	Optional
Informatics Engineering	Programming	Programming	1	B	Obligatory
		Data Structures and Algorithms	2	B	Obligatory
	Software Engineering in Business Contexts	Software Engineering	3	A	Obligatory
		Project management	3	B	Obligatory
		Business Requirements Analysis	3	B	Optional
		Business Models and Functional Areas of the Organization	4	A	Optional
	Video Games Development	Introduction to Video Game Programming	4	B	Optional
		Synthesis of Digital Image	4	B	Optional
	Web Applications Development	Web development	3	B	Optional
		User Centered Development	4	A	Optional
		Applications Integration	4	A	Optional
Chemical Engineering	Design of an Adsorption Column for Textile Water Purification	Mathematics I	1	A	Obligatory
		Graphic Design	1	A	Obligatory
		Business and Industrial Economy	1	B	Obligatory
		Fundamentals of Chemical Engineering	2	A	Obligatory
		Chemical Kinetics and Catalysis	2	B	Obligatory
		Chemical Engineering Experimentation I	2	B	Obligatory
		Mass Transfer	2	B	Obligatory
		Chemical Engineering Experimentation II	3	A	Obligatory
		Separation Operations	3	A	Obligatory
		Chemical Engineering Experimentation III	3	B	Obligatory
		Process Analysis and Simulation	3	B	Obligatory
		Control and Instrumentation of Chemical Processes I	3	B	Obligatory
		Chemical Reactors	3	A	Obligatory
		Enterprise Organization and Production Systems	3	B	Obligatory
		English	3	B	Optional
		Chemical Engineering Industrial Processes	4	A	Obligatory
		Chemical Engineering Projects	4	A	Obligatory
		Control and Instrumentation of Chemical Processes II	4	A	Obligatory
		Integrated Laboratory	4	A	Optional
		Industrial Organic Chemistry	4	B	Optional
		Solid Waste Treatment	4	B	Optional
		Industrial Applications of Photochemical Processes	4	B	Optional
Electric Engineering	Sustainability in the Business Context of the Electricity Sector	Enterprises	2	A	Obligatory
		Business Organization	2	B	Obligatory
		Environmental Technology	3	B	Obligatory
		Renewable Energy	4	A	Obligatory

**Semester: A-From September to January; B- From February to June; Y - Yearly*

3 RESULTS

3.1 Expected impacts

The original expected impacts of the institutional EIIP were:

- To improve students' learning, that will be assessed through the students' performance rate of the subjects involved.
- To increase students' motivation.
- To increase the involvement and participation of lecturers of different areas, departments, and bachelors, promoting the PBL visibility and awareness among the university community.
- To improve the coordination among subjects to integrate sets of competences and skills.

However, during the definition of the different PBL models, it was identified the alignment between some outputs of the activities defined in the PBL models and the SDGs. This identification has allowed the EIIP to include an additional expected impact that is to work on the SDGs through the active methodology of PBL while students are development their projects. Section 3.2 defines a case study of a subject of the Mechanical Engineering Bachelor in which the identification of the alignment between the activities of the PBL model and the SDGs have analysed.

3.2 Alignment between SDGs and PBL models. The Case Study of Fluid-mechanical Engineering

Fluid-Mechanical Engineering is a subject, which is taught on third year of Mechanical Engineering Degree. The subject is focused on analysing the pumps-operation principles (velocities triangle and Euler's equation) as well as the machines selection and their regulation according to demand. The students are between 20 and 26 years old and there are around 140 students enrolled in this subject each year. These students are divided into two theory groups and three practical groups. This subject is involved in the PBL model 'Project Engineering' as it is shown in Table 1. During the theoretical classes, the essentials of the Fluid-Mechanical Engineering aspects are detailed to students to facilitate the further development of the projects based on the PBL methodology. These theoretical sessions involve the presentation of a set of fundamental concepts, necessary for the project development. Table 2 shows the essential contents linked to the necessary competences to tackle the project development.

Based on all these contents, students have to develop a hydraulic project following the active methodology of PBL. The project development is held during the practical sessions. In these sessions, students have, among other activities, to calculate, apply and analyse indicators that are related to sustainability aspects. While developing the project, one of the main dimensions of the project to take into consideration is to try to minimise the environmental impact. A rubric, which has 19 different descriptors, has been designed to be used and to assess students' outcomes. Such a rubric is also really useful for students as it provides them with valuable information about the essentials that they should consider in the project development, in this case from an environmental perspective. Moreover, the students have the rubric to know the evaluation criteria previously. The 19 descriptors are aggregated into three main indicators, that are:

a) **Energy considerations**: these descriptors measure the sustainability degree, which is reached in each of the projects developed by the students.

b) **Economic analysis**: the students have to estimate a budget of the project and they should analyse its economic feasibility and taking the energy considerations of the previous indicator, they will have to take the appropriate decision to achieve a trade-off between sustainable issues and economic aspects.

c) **Engineering programming**: The third aggregated indicator is related to the different programming techniques to establish the operation rules as well as the size of the network.

Table 2. Summary of the main contents of the theoretical classes of Fluid-Mechanical Engineering

General Contents	Specific Contents
Hydraulic machines. Fundamentals	• Fundamentals of hydraulic machines
Hydraulic turbomachinery	• Fundamentals of hydraulic turbomachinery • Similarity in turbomachinery • Dimensional analysis applied to turbomachines
Hydraulic turbines	• Action turbines • Reaction turbines
Introduction and classification of hydraulic pumps	• Classification of hydraulic pumps • Positive displacement pumps • Turbo pumps
Transformation of energy in a pumping system	• Characteristic curves of the pumps • Operation point of an installation
Regulation of turbopumps	• Variation of the characteristic curves of a turbo pump by varying the speed of rotation • Variation of the characteristic curves of a turbo pump when turning the impeller
Operation of the turbo pumps	• Setting up the pumps • Dragging the bombs • Cavitation in the turbo pumps • Evaluation of cavitation in turbo pumps. NPSH • Pumps running in groups. Arrangement in series and in parallel
Pumping facilities	• Overpressure installations • Composite facilities • Regulation of turbopumps by by-pass • Building details of a pumping installation

As the main objective of the hydraulic project is the water supply, depending on the context (underdeveloped countries, rural zones…), different SDGs could be addressed. Table 3 presents an overview of the relationship among different targets of diverse SDGs.

Table 3. Relationship among targets of SDG and the macro-indicators of the PBL hydraulic model.

			Macro Indicators		
SDG	**Target #**	**Target Description**	**Energy**	**Economic**	**Engineering**
1	1.4	Ensure that all men and women have access to basic services and natural resources such as water.	✓		✓
	1.5	Build the resilience of the poor and reduce their vulnerability to environmental shocks and disasters			✓
2	2.3	By 2030, double the agricultural productivity and incomes of small-scale food producers.			✓
	2.4	By 2030, ensure sustainable food production systems and implement resilient agricultural practices that strengthen capacity for adaptation to drought.			✓
3	3.3	By 2030, end the epidemics of water-borne diseases		✓	

SDG	Target #	Target Description	Macro Indicators: Energy	Macro Indicators: Economic	Macro Indicators: Engineering
4	4.4	By 2030, substantially increase the number of youth and adults who have relevant skills, including technical and vocational skills, for employment, decent jobs and entrepreneurship	✓	✓	✓
	4.5	By 2030, eliminate gender disparities in education and ensure equal access			
	4.7	By 2030, ensure that all learners acquire the knowledge and skills needed to promote sustainable development	✓		
6	6.1	By 2030, achieve universal and equitable access to safe and affordable drinking water	✓	✓	✓
	6.3	By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials,	✓	✓	✓
	6.4	By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity	✓	✓	✓
	6.5	By 2030, implement integrated water resources management at all levels, including through transboundary cooperation as appropriate	✓	✓	✓
	6.6	By 2020, protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes	✓	✓	✓
7	7.3	By 2030, double the global rate of improvement in energy efficiency	✓		
8	8.4	Improve progressively, through 2030, global resource efficiency	✓		✓
11	11.4	Strengthen efforts to protect and safeguard the world's natural heritage	✓		✓
12	12.2	By 2030, achieve the sustainable management and efficient use of natural resources	✓	✓	✓
15	15.1	By 2020, ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services	✓	✓	✓

The first approximation of the three macro-indicators of this case study indicates that they are aligned to 18 targets belonging to 10 different SDGs. Based on the results obtained in Table 3, a general description about which issues should cover the hydraulic project has been performed as it is shown in Table 4.

Table 4. Alignment between the SDGs and the PBL hydraulic model.

#	SDG	PBL Hydraulic Model characteristics
1	End poverty in all its forms everywhere	The hydraulic project should be designed to guarantee the water supply in the appropriate conditions. Moreover, it will also be designed as resilient as possible to face up to each kind of threat.
2	End hunger, achieve food security and improved nutrition and promote	The hydraulic project should ensure the water supply to facilitate the agricultural tasks and improve the adaptative capacity in case of drought.
3	Ensure healthy lives and promote well-being for all at all ages	The hydraulic project should ensure not only the water supply but also the quality of the water for people consumption
4	Ensure inclusive and equitable quality education and promote lifelong learning	The hydraulic project proposal should ensure the acquisition of the basic and specific competences as well as the sustainable awareness. Moreover, the team group will be promoted and within the team group, the gender equality will be also encouraged.

#	SDG	PBL Hydraulic Model characteristics
6	Ensure availability and sustainable management of water and sanitation for all	The initial project proposal and context description should be addressed to fulfil a set of requirements such as: water access, water-related ecosystems, efficiency, water quality, among others.
7	Ensure access to affordable, reliable, sustainable and modern energy for all	The hydraulic project will improve the energy efficiency.
8	Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all	
11	Make cities and human settlements inclusive, safe, resilient and sustainable	The hydraulic project should guarantee the protection and conservation of the natural heritage when supplying water
12	Ensure sustainable consumption and production patterns	The hydraulic project should guarantee the efficient supply of water
15	Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss	The hydraulic project should guarantee the protection of important sites for terrestrial and freshwater biodiversity

4 CONCLUSIONS

The integration of the SDGs into the different PBL models and subjects will allow students to be able to develop a certain degree of critical, imaginative and innovative thinking about sustainable development, in general, and the SDGs, in particular. This fact will allow students to interrelate the basic and specific competences of the degree and the outcome competences, transferring the acquired knowledge to the improvement of the SDGs within disadvantaged areas, which improve the quality of life of people (Fig. 3).

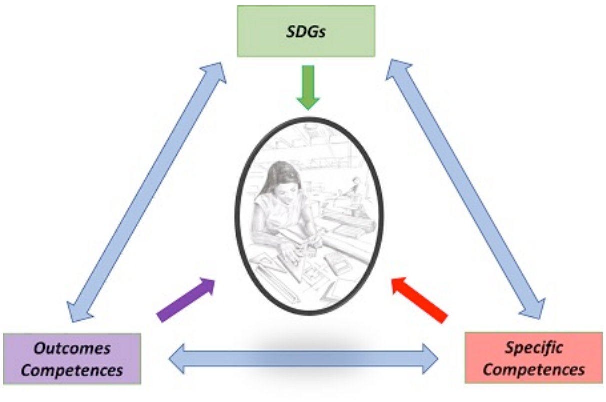

Figure 3. Connection between competences and SDGs in the students' training.

This integration of SDGs should be included in the development of the teaching guides in order to guarantee that students work all SDGs during their training programmes. This inclusion should be similar to outcomes competences in which each subject work different outcomes and evaluate some of them.

Professors have to consider the teaching triangle in which the specific learning results have to be interrelated with the outcomes competences and SDGs, allowing students to develop sustainable global thinking to solve the future challenge of the society through the PBL methodology.

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