SUSTAINABLE DEVELOPMENT GOALS AND THEIR IMPLEMENTATION IN PHYSICS

S. Castiñeira-Ibáñez, D. Tarrazó-Serrano, M. Gasque, C. Rubio, A. Uris

Departamento de Física Aplicada, Universitat Politècnica de València (SPAIN)

Abstract

Sustainable Development Goals (SDGs) currently represent a challenge for the future and are already being implemented in different working areas. That is why, from the moment a student starts university education, professors must take the lead to include them in the different subjects offered in the curricula of the different Degrees. Physics is a subject that represents a fundamental basis in many engineering degrees studies. On the one hand, the importance of this subject for the future of students is well known. However, this fundamental nature means that it is perceived by the students as a subject with no connection with the degree they aspire to achieve. Additionally, the heterogeneous level of training of the students, especially in the first courses, is a limitation. This makes it difficult to relate the content of the subject with the everyday phenomena and favours the lack of interest in them. One way to motivate students and use the active and constructive teaching methodology is to introduce SDGs within the subject, given the high sensitivity of current generations on Planet Earth. The introduction of these new training tools is not easy because the teaching of the fundamental bases requires most of the available time. This work aims to bring Physics closer to society through SDGs. For this purpose, a challenge is incorporated into the subject's curriculum for each thematic block that students must overcome. In this way, two important training actions are combined, efficient teaching is carried out, and the students become aware of SDGs, which are necessary for their future work. PoliformaT, the e-learning platform implemented in the Universitat Politècnica de València, facilitates the use of these new teaching methodologies that combine traditional on-site laboratory tasks with other learning assignments carried out autonomously online by students.

Keywords: Sustainable Development Goals, active learning, meaningful learning, learning and teaching methodologies.

1 INTRODUCTION

As a public service, the university is understood to have three primary missions (Figure 1). However, it must be borne in mind that it must develop them in a society undergoing profound, rapid, and global change and must be rooted in the territory where it is located.

For knowledge transfer, economic development, and lifelong learning to be achieved, we must understand that the university is immersed in a society directly linked to technology as part of its life. Those citizens in this situation should not suffer from a "technology gap", mainly digital. The university must take this into account to find ways to avoid this gap through its functions and objectives.

In 2015, United Nations (UN) adopted the 2030 Agenda for Sustainable Development [1]. This is an opportunity for countries and their societies to start on a new path to improve the lives of all, leaving no one behind. The Agenda has 17 Sustainable Development Goals (SDGs) [1], ranging from eradicating poverty, combating climate change, education, women's equality, and environmental protection to the design of our cities.

Citizens are becoming aware of these issues. The university must be a leader and guide regarding the consequences of climate change (mitigation, adaptation, and regeneration), sustainability related to the 2030 Agenda, and the 17 SDGs. These aspects, accelerated because of the COVID 19 pandemic and its impact worldwide, oblige the university to become a driving, active, collaborative, inclusive and supportive agent.

Figure 1. Purpose and mission of the University

The Universitat Politècnica de València (UPV) has created a tab on its institutional website dedicated to " SDGs in Spanish universities", including various reports. We highlight: " SDGs. Keys for a university in constant change" [2]. In line with these actions, we can contribute to raising students' awareness of SDGs to improve society's well-being through them.

We have the opportunity to combine student awareness of the importance of the SDGs, the work on transversal competencies and the active participation of students in their training, all aligned with the movement in the content of the subjects we intend to work on. In this sense, the work presented here is focused on students taking General Physics subjects in Engineering Degrees. The general objective is to propose solutions to social challenges based on the physical justification that helps meet SDGs. In this way, students will see that they will solve everyday, environmental, and socio-economic problems by applying the laws of physics. To this end, they must propose physical experiments that contemplate the theoretical-practical contents studied in the subject and incorporate at least one of the SDGs. In addition, this will mean facing a challenge and successfully achieving some learning objectives.

We aim to raise awareness of the importance of SDGs among students of Physics subjects in the first year of Engineering to identify how Physics can contribute to the achievement of these SDGs. On the other hand, it will also be an excellent opportunity to work on different transversal competencies, as challenge-based learning can motivate students to look for experiments or experiences related to everyday phenomena. This challenge is twofold, as students must make the experiment work and integrate environmental and socio-economic objectives that help meet SDGs. Setting challenges makes the students perceive the achievement as their own, which appears as a motivating element for learning [3].

The crisis caused by Covid19 has allowed us to rethink and redesign our educational model. Maintaining the technological tools, we will have learned to use "on the way" seems logical to guarantee more excellent students' equity, inclusion, and involvement. All this requires changes in the mentality of professors and students. To conclude this analysis of possible horizons, we would like to highlight the positive aspects and opportunities this crisis has given us. Among them: opportunities to rethink how we work, how we cooperate, how we collaborate, what we value as quality, to outline and adapt what the institution's missions should be, etc. in the hope that our decisions will be deeper, better informed. and more sustainable and inclusive. With this philosophy, we intend to carry out this teaching innovation.

2 METHODOLOGY

Following the SOLO Taxonomy (Structure of the Observed Learning Outcome) [4], given that students have to be able to find an application at the end of the thematic unit explained, they need to have well assimilated the physical phenomenon involved, as they must go from a theoretical concept to being able to translate it into reality. Having to end with a real application that can provide a solution to the achievement of an SDG, we believe, will motivate students to develop the knowledge acquired in the

theoretical-practical sessions. To end the process with an experiment, they must know the physical theory underlying the concept to be applied and have carried out an analysis of it to be able to transfer it to a real problem related to an SDG. In addition, their creativity, capacity for self-learning, and self-esteem for having managed to overcome a challenge are enhanced. They have been given challenges of real situations that also have to do with the fulfilment of an SDG. With this approach, relations with other elements outside the activity become necessary.

Furthermore, having to elaborate on the experiment gives the student a significant learning experience, which will allow them to relate the Physical Law or Principle to other areas of their studies in which it is involved. Throughout the four months, the teaching staff will carry out different actions to provide the students with the necessary material to progress in the proposed activities and achieve the objective pursued. Figure 2 outlines the key moments and the teaching staff's steps to carry out. At the beginning of the term, a survey will be carried out to assess the students' level of knowledge of SDGs, and a brainstorming session will be held so that they can initially relate each of the thematic blocks to be studied to one of the SDGs. Throughout the term, the teaching staff will provide a resource (lecture or audiovisual material) to help students discover new possibilities for real SDG problems. At the end of the training period, an assessment will be made of what has been learned, and the solutions proposed by the different working groups will be made visible.

Students in working groups (to be determined in each case according to the number of students enrolled) will also have to carry out different activities. Firstly, they must be familiar with both SDGs and the thematic blocks that make up the subject. In this way, each group will choose the thematic block and, therefore, the concepts and physical laws related to one of the SDGs. Once this has been selected, the first activity for each group will be to produce a report (report 1) in which the physical law that will be involved with the objective they intend to work on is recognised. The second activity will propose a solution to a real problem based on the result obtained in activity 1. Finally, based on what they have worked on in the previous activities and the feedback received from the teachers, they must carry out and present an experiment that validates the above. This activity will take the form of audiovisual material (presentation, poster, etc.) so that the rest of their classmates can benefit from the work of the other groups. Figure 2 outlines the work methodology. The teaching staff will assess and report on the results of the activities and insufficient time to carry out the next activity.

The general objective of this project is to propose solutions to social challenges based on actions with the physical justification that help meet SDGs. In this way, students will see that they will solve everyday, environmental, and socio-economic problems by applying the laws of physics. They must propose physical experiments that contemplate the theoretical-practical contents studied in the subject and incorporate at least one of the SDGs. In addition, this will involve facing a challenge and successfully achieving some learning objectives.

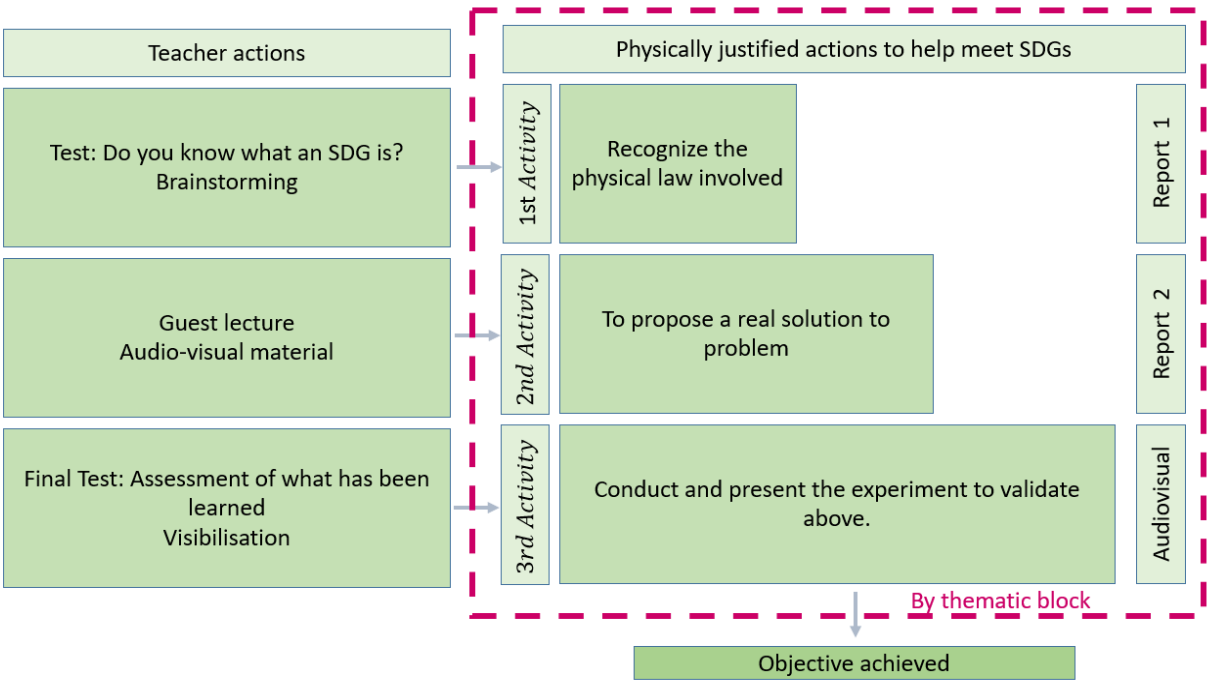

Figure 2. Activities and achieve the objective pursued

For this purpose, specific objectives will be defined, together with several descriptive examples, which will guide students in achieving the general objective. These specific objectives are: SO1 to design and plan the development of challenges linked to SDGs in Physics subjects and promote teamwork. SO2 to propose real, reasoned, consensual, and easily applicable solutions that help meet SDGs related to the challenges posed. SO3 Implement an experiment applying the chosen physical law to solve the challenge, justifying and demonstrating, through an audiovisual resource, the set-up of the experiment carried out. As an example, Figure 3 presents the innovation objectives with SDGs and the Physical Laws or actions that could be worked on.

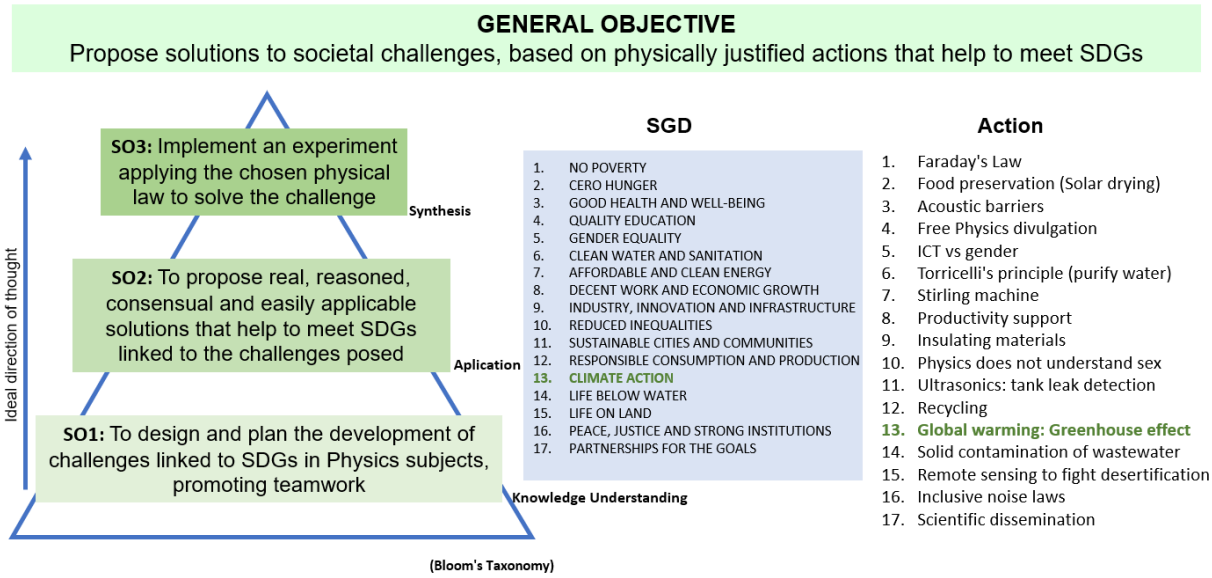

Figure 3. Innovation targets SDGs and Physical Laws or actions that could be worked on in one of them

3 RESULTS

This section presents the students' projects covering different steps for each activity by way of example. They have been divided into three tasks according to the three specific objectives proposed. Only one example is shown, the result obtained for the achievement of SDG 13: Climate action.

3.1 1st Activity

1st Activity	**Title. CLIMATE ACTION** **Description.** The fight against climate change, reducing greenhouse gas emissions, and adapting to climate change are global priorities. The objective is to prepare ourselves to face the impacts of climate change, lay the foundations for an emission-neutral economy, and accompany the most vulnerable groups in the transition process, involving all administrations and actors in civil society and the academic and scientific world. Agriculture, tourism, water and energy are sectors that are particularly vulnerable to the impacts of climate change. **The expected outcome of this activity.** Recognise the Physical Law that can be applied to help meet SDG 13. **Evidence of whether the expected result has been achieved.** Description of the Physical Law or Physical Principle involved and its relation to SDG. A justification should be given for the goal to be completed. **Activity coordinator.** One of the students will be the coordinator. **Participants and responsibilities.** Small group. Shared responsibility. Group work will favour the relationship between students and collaborative practice. **Timeline.** The teacher evaluates the task (report 1) and gives feedback for the next activity.

3.2 2nd Activity

Besides the steps above mentioned for this activity, they also have to fill these specific steps fully.

2nd Activity	**Title CLIMATE ACTION** **Expected outcome of this activity.** It is sufficient that the solution provides an outcome whose final target is related to SDG concerned. **Evidence of whether the expected result has been achieved.** A report (report 2) will be submitted showing that a real problem solution has been found. **Material resources you need to carry it out.** Office tools. **Timeline.** The teacher evaluates report 2 and gives feedback for the next activity.

3.3 3rd Activity

A possible experiment is given as an example. Of course, students have to come up with different solutions.

3rd Activity	**Title CLIMATE ACTION** **Expected outcome of this activity.** Description of the greenhouse effect phenomenon and experiment justifying its existence. **Evidence of whether the expected result has been achieved.** Poster or audiovisual material (5 min maximum) explaining the phenomenon and showing that the challenge has been achieved. **Material resources you need to carry it out.** A container with water, e.g., a basin, is surrounded by a translucent plastic or glass material and exposed to the sun's rays for a period. It should be observed that the temperature of the water rises considerably. At least 7 measurements, spaced in time (every 5 min), of the water temperature shall be made. The evolution of the temperature will be represented in an Excel sheet, explaining the phenomenon. **Timeline.** The group must submit through the UPV teaching platform (PoliformaT) the poster or audiovisual of the experiment that shows that they have managed to solve the challenge. It will be viewed by the rest of the groups.

The crucial moments of this teaching innovation are:

Beginning: A survey will be passed around with SDGs in which the student will have to indicate how many of them they think is related to the course's subject matter.

During: At the beginning of each thematic block, the contents will be related to at least one SDG. In addition, the presence of professors from other degree studies that can provide an interdisciplinary character will be facilitated, as they will give a complementary vision of the content being studied and one of the SDGs.

Final: As mentioned above, this process should culminate with planning an experiment that relates the content of one of the parts of the subject to an SDG. Each of the processes leading up to the planning of the investigation will be assessed using a rubric that the students will be familiar with beforehand. In addition, to make this action visible, an audiovisual will be made. The relationship between physical concepts and an SDG will be visually simplified.

4 CONCLUSIONS

This work aims to combine student awareness of the importance of SDGs, the yield on transversal competencies, and students' active participation in their training, all aligned with the movement in the content of the subjects we intend to work on. The work presented here is focused on students taking General Physics subjects in the first years of Engineering. The general objective is to propose solutions to social challenges based on actions with the physical justification that help meet SDGs so that students will see that they can solve environmental and socio-economic problems every day by applying physics laws. They must propose physical experiments that contemplate the theoretical-practical contents studied in the

subject and incorporate at least one of the SDGs. In addition, this will involve facing a challenge and successfully achieving some learning objectives. We believe we are coherently ordered and that students will accomplish in a reasoned manner; three specific goals have been established. This teaching innovation will be known in the academic year 2022-2023. Given the experience with other innovations that we have developed [5-6], we are convinced that it will improve the students' perception of the subjects involved. We are sure that with this teaching innovation, we will raise awareness among a large part of the student body at an early stage of their degree course. This will enable students to continue working on SDGs, and they will be able to transfer what they have learned to other areas of engineering.

ACKNOWLEDGEMENTS

The authors would like to thank the educational innovation group “Multidisciplinary Teaching Innovation Methodology (Teach- Inn)” (GIE-64) from Universidad de Las Palmas de Gran Canaria.

REFERENCES

[1] Sustainable Development Goals (2015) Retrieved from: https://www.un.org/sustainabledevelopment/es/, [Consultation: 2022/03/20].

[2] Los ODS. Claves para una universidad en constante cambio. València: Universitat Politècnica de València. Retrieved from: https://riunet.upv.es/bitstream/handle/10251/159792/CCDLibroODS_16Dic2020.pdf?sequence=3&isAllowed=y, [Consultation: 2022/03/20].

[3] Gourdarz, P.; Doss, T.P.; Broadbent, R.; Knight, G. "Developing Global Engineers Through Interdisciplinary PBL and Design Thinking". *2021 IEEE Global Engineering Conference (EDUCON).* Vienna (Austria): IEEE.

[4] Biggs J.B. and Tang C. Teaching for Quality Learning at University, Glasgow (UK): McGraw-Hill, 4th edition 2011

[5] Castiñeira-Ibáñez, S., Tarrazó-Serrano, D., Pérez-López, S., Uris, A., and Rubio, C. (2018). “Teaching advantages of the use of numerical models for understanding the operation of acoustic resonators”. *12th International Technology, Education and Development Conference INTED 2018* (pp. 5635-5640). Valencia (Spain): IATED.

[6] Rubio, C., Castiñeira-Ibáñez, S., and Sánchez-Pérez, J. (2013). “The challenge of modelling to improve teaching in classroom. Application to resonators”. *ICERI 2013* (pp. 1109-1116). Sevilla (Spain): INTED.