EXPERIENCE IMPLEMENTING CURRICULAR ACTIVITIES IN PHYSICS TO FAMILIARIZE STUDENTS WITH SDGS 5 AND 7

EXPERIENCIA EN LA IMPLEMENTACIÓN DE ACTIVIDADES CURRICULARES EN FÍSICA PARA FAMILIARIZAR AL ALUMNADO CON LOS ODS 5 Y 7

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Abstract

This paper presents an experience of implementing curricular activities that aim to familiarise students with the Sustainable Development Goals (SDGs), thus promoting sustainability and the critical contextualisation of knowledge and highlighting the scientific contributions of women. The pedagogical experience was carried out in the Physics subject of the Chemical Engineering degree at the University of Santiago de Compostela (USC). First, a questionnaire was administered to assess students' prior knowledge of these goals, especially SDG 5: «Achieve gender equality and empower all women and girls» and SDG 7: «Affordable and clean energy», in the first-year Physics subjects of the Chemical Engineering and Biotechnology degrees of the USC to determine the influence of the degree. The results showed that students in both degrees knew the SDGs but had difficulties identifying SDG 7. Similarly, male students of Chemical Engineering had more difficulty in identifying SDG 5. Subsequently, the classes, academic content and activities of the Physics subject of the Chemical Engineering degree were planned to raise awareness

among students about the current climate, energy and social emergency in which we find ourselves, as well as the gender inequalities that persist in society. In this way, the aim was for students to acquire critical thinking skills to avoid gender blindness and to face a future with fewer and fewer mineral and energy resources. The experience was satisfactory for the students, demonstrating the importance of teaching this content in scientific subjects because they enabled reflection and critical capacity, which are essential for understanding and dealing with reality.

Keywords: SDG 5, SDG 7; Competences; Physics; Gender perspective; Energy; Critical thinking; Engineering Education.

Resumen

Este trabajo presenta una experiencia de implementación de actividades curriculares que pretende familiarizar a los/as estudiantes con los Objetivos de Desarrollo Sostenible (ODS), promoviendo así la sostenibilidad y la contextualización crítica del conocimiento y destacando las aportaciones científicas de las mujeres. La experiencia pedagógica se llevó a cabo en la asignatura de Física del grado en Ingeniería Química de la Universidad de Santiago de Compostela (USC). En primer lugar, se administró un cuestionario para evaluar el conocimiento previo del alumnado sobre estos objetivos, especialmente el ODS 5: «Lograr la igualdad entre los géneros y la autonomía de todas las mujeres y niñas» y el ODS 7: «Energía asequible y limpia», en las asignaturas de Física de primer curso de los grados de Ingeniería Química y Biotecnología de la USC para determinar la influencia de la titulación. Los resultados mostraron que el alumnado de ambas titulaciones conocía los ODS, pero tenía dificultades para identificar el ODS 7. Igualmente, los estudiantes varones de Ingeniería Química tuvieron mayores dificultades para identificar el ODS 5. A continuación, se planificaron las clases, los contenidos académicos y las actividades de la asignatura de Física del grado en Ingeniería Química con el objetivo de concienciar al alumnado sobre la actual situación de emergencia climática, energética y social en la que nos encontramos, así como sobre las desigualdades de género que persisten en la sociedad. De este modo, se pretendía que el estudiantado adquiriera competencias de pensamiento crítico para evitar la ceguera de género y para afrontar un futuro con cada vez menos recursos minerales y energéticos. La experiencia fue satisfactoria para el alumnado. Esto demuestra la importancia de impartir estos contenidos en asignaturas de corte científico, pues se logró despertar la reflexión y la capacidad crítica, que son indispensables para comprender y afrontar la realidad.

Palabras clave: ODS 5; ODS 7; Competencias; Física; Perspectiva de género; Energía, Pensamiento crítico; Enseñanza de la Ingeniería.

1. INTRODUCTION

In 2015, the United Nations approved 17 Sustainable Development Goals (SDGs). These goals, which will be achieved by 2030, have 169 targets related to poverty reduction, protecting the planet, and improving people's lives and prospects worldwide (UN General Assembly, 2015). In the 2030 Agenda, gender equality is a recurring theme, being not only one of the explicit goals to be achieved, SDG 5: «To achieve gender equality and empower all women and girls», but also transversal to the other 16 goals (UN Women, 2018). Thus, to comply with this Agenda by 2030, it is necessary to prioritize gender issues in all areas of the SDGs (Leal-Filho et al., 2023).

Universities have an essential duty fulfilling the 2030 Agenda because of their vital role in human training, knowledge production and innovation. Currently, many universities have integrated these goals into their institutions, university life, and university teaching (Crespo et al., 2017; Miñano & García-Haro, 2020; Sánchez-Carracedo et al., 2021; Zamora-Polo & Sánchez-Martín, 2019), with SDG 4: «To Ensure inclusive and equitable quality education», being the predominant goal internationally in publications on the SDGs universities implementation (Alcántara-Rubio et al., 2022). This SDG is linked to gender equality. Specifically, target 4.7 states that:

> By 2030, all students should have acquired the knowledge and skills necessaries to promote sustainable development, including, among others, those related to human rights, gender equality, the promotion of a culture of peace and non-violence, global citizenship and appreciation of cultural diversity. (UN General Assembly, 2015, p. 17)

Therefore, we would expect to find many articles in the literature integrating SDG 5 in classrooms, thus complying with the current legislation at both the European and national levels. However, the review by Merma-Molina et al. (2021) shows «the scarcity of articles reporting experiences and practical cases of the integration of SDG 5 in the classroom» (p. 67). The reason for this may be because «the integration of gender perspective in teaching still lacks explicit recognition in the careers of teaching and research staff and continues to be a matter of individual will» (Gender Equality Units for University Excellence [RUIGEU for its initials in Spanish], 2022, p. 64).

Moreover, in the current context of ecological and social crisis, universities via research outreach, and curricula greening play a vital role in achieving SDG 7, «Affordable and clean energy», through their actions of greening curricula, outreach, and research (Salvia & Brandli, 2020). Since engineering is at the heart of developing new technologies aimed at achieving the SDGs, engineering education should integrate these goals (Kolmos, 2021), something which has not yet been achieved (Aginako & Guraya, 2021; Leiva-Brondo et al., 2022). Target 4.7 is closely linked to SDG-7 (Shulla et al., 2020), and some publications analyze the potential of using some engineering subjects to integrate this goal into Spanish university education (Álvarez et al., 2021; Pedrosa et al., 2022).

For the 2030 Agenda goal, it is essential to share experiences integrating the SDGs into the curriculum with a focus on gender perspective because these experiences can serve as inspiration and guidance for teachers. As such, this article presents a teaching experience that integrates SDGs 5 and 7 into one of the courses of the Chemical Engineering degree. The aim is to help students acquire the transversal competencies that will enable them to avoid gender blindness in their professional future, and to face the current eco-social and environmental challenges that are calling for a change in habits and attitudes. Because as Martínez-Aznar et al. (2022) point out, «we are heading towards a world with fewer resources (Valero et al., 2021) and without cheap and abundant energy (Turiel, 2020), which, in order to avoid unfair change, is forcing a profound reorganization of society (García-Díaz et al., 2017)» (p. 258). In this context, «education is a place to forge glasses that will allow us to look at the world through another model» (Herrero, 2022, p. 35).

The objectives of this teaching experiment, which are explained in detail in the following sections, were:

- To familiarize students with the SDGs, particularly SDGs 5 and 7.
- To contribute to student's acquisition of the cross-cutting competency of critical thinking.
- To contribute to the students' knowledge of relevant women scientists and engineers in the development of renewable energy and to learn about gender inequalities in the energy field.

2. METHODOLOGY

The curricular resources to familiarize students with the SDGs were used in the Physics course of the Chemical Engineering Degree at the University of Santiago de Compostela (USC), a first-year, year-long 9-ECTS-credit mandatory course, with 73 students enrolled (30 women and 43 men). This course teaches the basic physical principles used in technological developments, focusing principally on the fundamental concepts of thermodynamics and electricity. It, therefore, aims to provide knowledge of the energy-related SDGs (Calvo et al., 2022). In addition, this subject is taught at the USC School of Engineering which, according to its presentation on its website, declares a commitment to gender equality and sustainability.

2.1. Experience implementing the curricular activities

First, a questionnaire was administered to elicit the students' prior knowledge of the SDGs and then activities related to SDGs 5 and 7 were conducted. These activities were mainly within the topic of Thermodynamics.

2.1.1. SDG survey

The questionnaire to evaluate students' familiarity with the SDGs is inspired by the one conducted by Lull-Noguera et al. (2021). Our questionnaire contains nine questions, two true-false questions, to discern whether students could identify SDG 5 and SDG 7, and the other seven are multiple-choice questions. These multiple-choice questions were like those from the previously mentioned questionnaire, and each question contained four possible answers, only one of which was correct. These questions were:

- Question 1: What does SDGs mean? (multiple-choice).
- Question 2: What is the target date for achieving these goals? (multiple-choice).
- Question 3: How many goals are there (SDGs)? (multiple-choice).
- Question 4: What do the SDGs seek to achieve? (multiple-choice).
- Question 5: Who are the SDGs for? (multiple-choice).
- Question 6: True or false: SDG 5 aims to achieve gender equality and empower all women and girls.

- Question 7: True or false: SDG 7 aims to ensure inclusive and equitable education and to promote lifelong learning opportunities for all.
- Question 8: Can we contribute to the achievement of the SDGS? (multiple-choice).
- Question 9: Who is responsible for achieving the SDGs? (multiple-choice)

The questionnaire was conducted during a face-to-face class in October 2022, and 55 students participated (24 female and 31 male students). To determine whether the degree studied influenced on students' knowledge of the SDGs (Lull-Noguera et al., 2021; Zamora-Polo et al., 2019), the same questionnaire was also given to 43 students (12 male and 31 female students) from the Biotechnology degree.

2.1.2. Teaching experience

The teaching experience described here corresponds to the first semester of the 2022-23 academic year, mainly within the Thermodynamics topic, a subject closely related to SDG 7 (Valero & Calvo, 2020). In recent years, thermodynamics has been taught through the flipped classroom model, which provides more room for practical work in the classroom (Alba et al., 2016). At the same time, it aims for students to take a more active role in all learning activities, including lectures. Students work autonomously in the classroom with the teacher's help, whose role is to encourage critical thinking and social and environmental responsibility (Peña et al., 2020). Below, we explain how activities related to SDGs 5 and 7 can be introduced both in face-to-face and online learning.

Classroom activities:

The general objective is for students to see that they can help solve environmental and socioeconomic problems daily by applying physics laws. Students should understand that, as pointed out by Tagüeña and Pollitzer (2021), science and technology are necessary tools to comply with the 2030 Agenda, «but the key is to include gender perspective to achieve effective sustainable development for both women and men» (p. 3). Although gender is not included in the specific SDG7 targets, energy policy «is not gender

neutral» (Odera & Mulusa, 2020, p. 99) and «insights into the gendered inequalities of energy needs, use, and access could contribute to designing energy transition policies that acknowledge and address current injustices» (Feenstra, 2022, p. 57).

Energy scarcity has been one of the most relevant issues in 2022 for European citizens and has starred in numerous press headlines. The analysis of current events can be used in class to promote sustainability-related competencies (Chuliá-Jordan et al., 2022). Similarly:

> There is a clear presence of gender issues in our daily lives (media, political movements, audiovisual production). For a large part of the teaching staff, this constant exposure facilitates a natural sensitization. Similar is the case of other topics such as sustainability, and the joint treatment of these issues can generate positive synergies (Marco-Simó et al., 2022, p. 53).

For example, when mentioning energy-saving programs, a classroom discussion could be centred on how these programs can impact women's lives, increasing time spent on household chores (Korsvik & Rustad, 2021). Women take on more domestic chores in the household, including putting the washing machine on, and Carlsson-Kanyama and Lindén (2007) showed that «when electricity rates varied, women's workload increased as they washed clothes and dishes at night and on weekends when electricity was cheaper. Women also refrained from using the clothes dryer, thus spending more time on this task» (p. 2163).

In addition, to raise students' awareness about the energy poverty suffered by millions of people on our planet and which mainly affects women, we showed an excerpt from a TED talk by scientist Rose Mutiso (TED, 2020) about energy inequality. At the heart of the video is the idea that «the core of our problems is ethical-political, in essence: limiting ourselves so that the other can exist» (Riechman, 2021, p. 23).

Virtual classroom:

Women have a more significant presence in the renewable energy sector than in traditional energy, such as oil or gas (International Renewable Energy Agency [IRENA], 2019), which must be highlight. To this end, within the topic of Thermodynamics, we included a brief biography of Maria Telkes, inventor and solar energy pioneer who, along with Eleanor Raymond and

Amelia Peabody, designed and created the first house to run entirely on solar energy (González & Pérez, 2022). In addition, the class's virtual classroom included a link to the biography of Donella Meadows, an environmental scientist and one of the authors of *The Limits to Growth*. This report warned 50 years ago of the dangers of unlimited growth, environmental pollution, and the uncontrolled consumption of resources.

Unfortunately, the warnings of the Meadows report were ignored. Today, we find ourselves in a situation of planetary emergency (Vilches & Gil, 2009), and to get out of it, it is necessary to «carefully analyse the proposed techno-scientific measures and their possible risks so that what may appear to be a solution does not generate more serious problems than those it is trying to solve, as has happened so many times before» (Vilches & Gil, 2010, p. 2). The war in Ukraine has brought to light the great importance of renewable energy sources to ensure maximum energy independence. However, when implementing these energy sources, it is necessary to analyze the impact they will have on communities, ecosystems and living beings. As Herrero (2021) points out:

> What is being called the green transition is not, as energy companies advertise, moving to live off the breeze, the power of the waves or sunlight. It is living off what is in the ground. It is more of a cowboy strategy (p. 61).

Therefore, it is necessary to raise awareness among students about the problems inherent in the energy transition, train their minds in critical thinking about the use of technology, and help «overcome the barriers to change associated with our cultural stereotypes (overconfidence in technological solutions or denialism)» (García et al., 2019, p. 1101), because as Peirano (2022, p. 11) asserts, «It is the oldest story in the book: that of an environmental disaster and technology that saves us all». Today, as Riechman (2021) stresses, «using much less energy means much less production and consumption (because eco-efficiency has its limits), and that means the material impoverishment of our societies. That is why we need barefoot eco-socialism and subsistence eco-feminism (Maria Mies & Vandana Shiva)» (p. 23).

As a continuation of the experience from the previous academic year (Calvo-Iglesias, 2022), a voluntary activity, within the topic of Thermodynamics, was proposed to students in the academic year 2022-23.

This time it was worth an extra 0.25 points in their final grade. The task consisted of watching a lecture by Alicia Valero (2017) and reading the chapter «Why there is no free energy» from *Petrocalipsis* (Turiel, 2020). Valero's lecture analyzes the circular economy and talks about the importance of lithium, cobalt, and nickel, which are present in most electronic devices and essential for manufacturing renewable energy technologies. At the same time, the reading warns of the false technological promises that abound on the internet. Afterwards, in class, the students were prompted to take a test comprised of eight true-or-false questions related to the lecture and the reading and to answer two questions: one about their opinion on recycling and one asking for their evaluation of the activity. For the latter two questions, which did not affect students' marks on the test, a maximum of 5 lines was provided for their answers. The remaining eight questions were weighted equally in the calculation of the results of the test (0-10). The maximum time allowed to complete the ten questions was 20 minutes.

3. RESULTS

The survey results, presented in Figure 1, show that engineering students are aware of the SDGs, although they need to figure out how many there are and need help to identify SDGs 5 and 7. As shown in this figure, male and female students show the same or similar levels of knowledge about the meaning of the acronym SDGs, the purpose of these goals, whom they are aimed at, and students' potential contributions to achieving them. However, female students showed a greater awareness of the other questions concerning the number of SDGs and the date by which they should be achieved; above all, they demonstrated a greater awareness of SDG 5. Concerning to SDG 7, we observed a low level of awareness in both sexes, although it was higher among male students.

Figure 1. Percentage of correct answers on SDGs

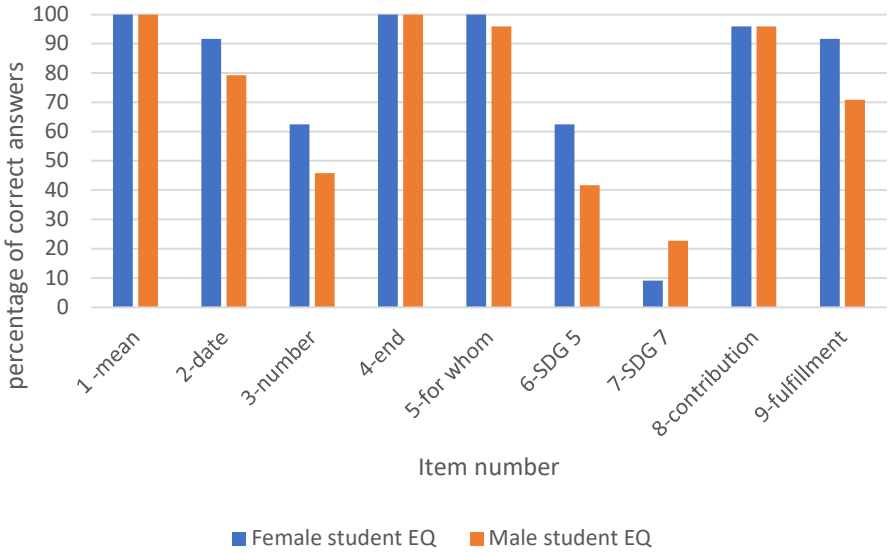

Table 1 shows the student's knowledge of the two different degrees is similar. However, first-year students in the Biotechnology (Bio) degree program are more adept at identifying SDG 5 than SDG 7, which may be due to their study's field. It can be appreciated that in this degree program (Bio) male students exceeded 50% correct answers on almost all questions except for the question about SDG 7. There was hardly any difference between men and women in the percentage of the correct answers, except for on the question about the date by which the SDGs should be achieved.

Table 1. Percentage of correct answers for each question according to degree and gender

	1 Mean	2 Date	3 Number	4 End	5 For whom	6 SDG 5	7 SDG 7	8 Contribution	9 Fulfillment
F EQ	100%	92%	63%	100%	100%	63%	9%	96%	92%
M EQ	100%	79%	46%	100%	96%	42%	23%	96%	71%
F Bio	97%	81%	55%	94%	100%	81%	3%	100%	84%
M Bio	92%	100%	58%	100%	92%	75%	0%	100%	83%

F: female student; M: male student

Concerning the proposed task, video and reading, the first thing to highlight is that most students enrolled in this subject participated: 70 out of 73 (96%). The average score on the true or false test, a typical ten-point scale, was high: 8.7 with a standard deviation of 1.4 a higher score than in the previous year (Calvo-Iglesias, 2022). Moreover, the students valued the task positively, both in terms of the subject matter itself and the resources used (video and reading). Based on some of the comments received in the evaluation of the activity it can be deduced that it did indeed serve to familiarize students with the reality of the current energy situation:

> *I think this reading is necessary. We all need to know and be well informed about what could happen if we do not remedy this situation. I learned the importance of being informed and basing my opinions on scientific facts rather than believing anything that I might find on the internet. Besides, I was unaware of the current situation, which I consider to be critical.*
>
> *This activity was interesting. Through it I learned that we must stop being consumerists and that we must take advantage of the products we have as much as possible. I recommend this activity to consumers and to people who still believe that our resources are infinite.*
>
> *I found this activity very interesting since it is a topic which requires all of our collaboration and awareness about the energy problems surrounding us. I would recommend watching the whole Alicia Valero video, as she explains the topic very well.*

4. DISCUSSION

The survey's results, presented in Table 1, show, first of all, that Chemical Engineering students program demonstrate a more excellent knowledge about the SDGs than students enrolled in other degree programs (Lull-Noguera et al., 2021); the exception being their ability to identify SDG 7. This last result is in contrast with that of the previous year, where the scores on SDG 7 were also higher for women than for men (Calvo-Iglesias, 2022). Likewise, Table 1 shows differences in students' knowledge of SDGs 5 and 7 depending on their degree of study. These results are in line with previous research and could be since a student's area of study determines his or her perception of the relevance of the SDGs in terms of career path, and therefore affects his or her prior training (Lull-Noguera et al., 2021; Zamora-Polo et al., 2019). The lack of awareness of SDG 5 shown by male students in the engineering degree is troubling since their presence is a majority in this degree; therefore, to advance in equality it is necessary that they understand the importance of achieving this goal. Also, in future cohorts, it would be interesting to include, as Ferrando et al. (2022) did, questions about students' possible contribution to any of the SDGs, both from the point of view of their profession and as individual citizens.

The activity allowed us to teach the topic of thermodynamics differently, showing practical life implications and connecting it with current issues such as sustainability and energy transition, as well as raising awareness about the relevant contributions of women in this field. In the answers to the questionnaire, Alicia Valero's name was mentioned several times by students of both sexes, perhaps because she is a scientist in the field of chemical engineering and for this reason may be deemed particularly relevant by students from this degree program. In addition, one of the students won a prize in sustainability with a proposal mentioning Rose Mutiso. Therefore, we have contributed to providing female references in the field of chemical engineering. In short, these activities can stimulate students' critical thinking abilities and help them contemplate the world through the lens of a different paradigm and project «horizons of desire compatible with the fabric of life» (Herrero, 2022, p. 158).

In future academic years, we will continue with these activities and seek to include reading in the curriculum that will open a discussion about «matters that are thus far invisible in the scientific field, such as care, the value of that which is unpaid, and the processes of empowerment» (Martínez et al., 2022, p. 10). We will also explore the potential of cinema, with the viewing of films such as *Alcarrás*, directed by Carla Simón and winner of the Golden Bear in Berlin in 2022, to analyze the impact that renewable energy can have on the environment, agriculture, and rural lifestyles as well as the risks involved in accelerating energy transition.

5. CONCLUSIONS

The experience detailed in this article shows that undergraduate students in the first-year Physics subjects of the Chemical Engineering and Biotechnology degrees generally have a good understanding of the SDGs. However, they need help to identify SDGs 5 and 7, and there are differences between the two-degree programs. New activities have been incorporated in the face-to-face and virtual classrooms to increase the awareness of Chemical Engineering students about these SDGs. At the same time, it is helpful to invite students to develop their critical thinking skills in the context of energy use and environmental concerns, gaining perspective about gender. To this end, it is crucial to begin by recognizing the critical role of scientists such as Maria Telkes in solar energy development and Donella Meadows in anticipating the dangers of unlimited growth. In addition, we must highlight the role that scientists from our society, such as Alicia Valero and Rose Mutiso, continue to play in our environment: Valero alerts us about the lack of mineral resources, while Mutiso depicts the energy poverty in Africa when compared to the Western world and expounds upon the paradox of the great demands on the continent of Africa.

In these times of global crisis, and to face these dangers in the most equitable way possible, we must ensure that the training students receive contributes to their understanding of the reality surrounding them, including our current energy crisis, gender inequalities, and the problems that renewable energies pose. For this reason, in future courses, we will continue with the activities proposed in this article and raise new ones that will enable us to acquire the necessary skills to face this planetary emergency.

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