

Boosting the sustainable development goals in a civil engineering bachelor degree program

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Abstract

Purpose – The purpose of this paper is to analyze the potential for implementing Sustainable Development Goals (SDGs) into the civil engineering bachelor degree in the School of Civil Engineering at Universitat Politècnica de València (Spain).

Design/methodology/approach – All the 2019/2020 course syllabi were analyzed to diagnose at which extent each subject within the program curriculum contributes to achieving the different SDGs.

Findings – The results show a promising starting point as 75% of the courses address or have potential to address targets covering the 2030 Agenda. This paper also presents actions launched by the School of Civil Engineering to boost the SDGs into the civil engineering curriculum.

Originality/value – This paper presents a rigorous and systematic method that can be carried out in different bachelor degrees to find the subjects that have the potential to incorporate the SDGs into their program. This paper also presents actions launched by the Civil Engineering School to boost the SDGs into the civil engineering curriculum.

Keywords Sustainable development goals, Civil engineering, 2030 Agenda, Syllabus, Outcomes, Program curriculum, Professional skill

Paper type Case study

1. Introduction

1.1 Context

In 2015, the United Nations approved one of the most ambitious and transcendent global agreements of our time, the 2030 Agenda for Sustainable Development (United Nations,

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2015). The Agenda adopted 17 Sustainable Development Goals (SDGs) as a new framework for sustainable development, based on five pillars: people, prosperity, peace, partnership and planet. The program calls all countries to end poverty, protect our environment and ensure global prosperity.

That same year, the Spanish Network for Sustainable Development (REDS) was created, as the Spanish spin-off of the Sustainable Development Solutions Network (SDSN). Its mission is to mobilize and raise awareness among society, public institutions and the corporate world in Spain, such that they become more aware of the SDGs in a more rigorous and committed way, as well as to promote their incorporation into future policies, the business world and societal behavior. In September 2020, this association published a guide (SDSN, 2020) to assist in implementing and incorporating education relating to the SDGs in universities and higher education institutions around the world. This document updated and expanded on the “Education” section of the publication “Getting Started with the SDG in Universities” (SDSN, 2017), which provides practical guidance on how to begin deepening the contributions of Universities in reaching the SDGs.

In 2018, the Government of Spain approved the “Action Plan for the Implementation of the 2030 Agenda” (Gobierno de España, 2019). This document recognizes Universities as essential actors that must commit to the implementation of the Agenda and explicitly indicates the contributions that must be reached. Based on this document, CRUE (an organization consisting of 76 universities in Spain) created the CRUE *Universidades España* commission for the 2030 Agenda, which defined its position on and commitment to implementing the SDGs in universities (CRUE, 2019).

In this context, the governing board of the *Universitat Politècnica de València* (UPV) adhered to the CRUE document and launched several actions to incorporate the SDGs into the learning outcomes of all UPV graduates. One of the strategic actions promoted by UPV was funding a call for projects on innovation and educational improvement, specifically to drive the incorporation of the SDGs into the curricula of different programs. Within this context, the School of Civil Engineering has developed, since September 2019, the innovative educational project “Incorporating the Sustainable Development Goals into the Civil Engineering Degree bachelor program.”

1.2 Universities and sustainable development goals

The need to incorporate sustainable development into higher education predates the 2030 Agenda. In December 2002, the United Nations General Assembly, through its Resolution 57/254, declared the Decade of Education for Sustainable Development (2005–2014). The resolution designated UNESCO as the lead agency for the promotion of this Decade (UNESCO, 2005) and invited all educational institutions to contribute toward promoting education for sustainability. It is necessary to highlight the important position that universities occupy in society. Universities play a key role in education, having the confidence of society and, through their research and development capacity, have a critical role in providing knowledge, testing, solutions and innovations to sustain and support the success of the SDGs (GUNI, 2019). Moreover, the SDGs provide a unique opportunity for Universities, allowing them to demonstrate their willingness and ability to play an active and meaningful role in the development of society and their contribution to global sustainable development (Bhowmik *et al.*, 2018).

Many universities are currently reviewing their contributions to achieving the various goals of the 17 SDGs. This contribution has been developed from different perspectives, including policies at the university level (Huyse and Pollet, 2019; Korhonen-Kurki *et al.*, 2020; Shiel *et al.*, 2020), complementary training for staff and students (Biasutti *et al.*, 2018;

Expósito and Granados Sánchez, 2020; Korhonen-Kurki *et al.*, 2020; Pallant *et al.*, 2020; Zamora-Polo *et al.*, 2019), other actions at the college level (Brandli *et al.*, 2020; Gough and Longhurst, 2018; Korhonen-Kurki *et al.*, 2020; Kupika *et al.*, 2020; Mawonde and Togo, 2019) and, finally, actions in the context of different degrees (Mawonde and Togo, 2019; Pandey and Kumar, 2018; Strachan *et al.*, 2019).

In Spain, all the work developed by universities to contribute to the achievement of the SDGs has been collected in the REDS website. This association has published a dossier (Miñano and García Haro, 2020) presenting the actions carried out in several universities. The document is organized into three chapters: Teaching (initiatives aimed at university students within the framework of official degrees), University Community (training and management initiatives involving the entire university community) and Society (initiatives involving and affecting other social sectors).

1.3 Engineering and sustainable development goals

Five years after the publication of the 2030 Agenda, Romero *et al.*, 2020 reviewed the status of its implementation in engineering schools around the world. They concluded that curricula, outcomes and teaching–learning strategies, as well as the assessment of engineering degrees, should be oriented to the SDGs. Today’s students are tomorrow’s professionals and society requires socially responsible engineers who have perfectly internalized sustainability criteria at the time of decision-making (Pellicer *et al.*, 2016).

Engineering is society’s best tool to change and shape the world. Future engineers need to be prepared to solve complex, multidisciplinary problems and to develop new sustainable technologies. In particular, civil engineering has a great responsibility, as an engine that transforms the built environment. The American Society of Civil Engineers of the United States has adopted a clear and inspiring definition: “civil engineers design, build and maintain the foundation for our modern society – our roads and bridges, drinking water and energy systems, sea ports and airports and the infrastructure for a cleaner environment.” Within this context, there is a mandatory need to incorporating the SDGs into the training of future civil engineers.

Major associations related to engineering education are aware of the importance of incorporating the 2030 Agenda into engineering education. The American Society of Engineering Educators adopted the “Declaration on Education for Sustainable Development” (ASEE, 1999). At the international level, the Barcelona Declaration (“International journal of sustainability in high[. . .],” 2005) – an outcome from the 2004 Conference on Engineering Education in Sustainable Development – states that “today’s engineers must be able to participate actively in the discussion and definition of economic, social and technological policies, to help redirect society toward more sustainable development,” among other principles.

The American Society of Civil Engineers has adopted a policy statement in support of the United Nations SDGs (ASCE, 2017) and, based on the summit on the Future of Civil Engineering held in June 2006, it published “The Vision for Civil Engineering in 2025,” a global vision on the aspirations of civil engineering for the 21st century (ASCE, 2007). The document establishes that (p. 2) “in 2025, civil engineers serve competently, collaboratively and ethically as master planners, designers, constructors and operators of society’s economic and social engine – the built environment; stewards of the natural environment and its resources; innovators and integrators of ideas and technology across the public, private and academic sectors; managers of risk and uncertainty caused by natural events, accidents and other threats; and leaders in discussions and decisions shaping public environmental and infrastructure policy.” Civil engineering associations worldwide have taken these

considerations as their own, to update the goals of the profession. This renewed paradigm acknowledges civil engineering as playing key roles in the transformation of the environment, thus representing a great responsibility and a direct influence on the achievement of the 2030 Agenda. On the occasion of the 75th anniversary of the United Nations, the Institution of Civil Engineers published the book “UN75 Sustainable Engineering in Action” (ICE, 2020), highlighting the role of civil engineering in the new agenda.

Given this international context toward sustainability, civil engineering schools must promote and instruct students to achieve the SDGs. Many universities have put effort to integrating the SDGs into their civil engineering curricula (Holmberg *et al.*, 2008; Lozano and Lozano, 2014; Sánchez-Carracedo *et al.*, 2019; Watson *et al.*, 2013), such that students acquire the outcomes and knowledge that the 2030 Agenda addresses in a holistic way. The main objective of this work is to analyze how the SDGs can be incorporated into the Civil Engineering Bachelor Degree program curriculum at UPV. To achieve this end, the authors reviewed all subjects within the curriculum, to identify the current or potential incorporation of the SDGs into their specific outcomes. Once the diagnosis was carried out, actions could be defined to boost the influence of the SDGs in the civil engineering curriculum.

2. Materials and methods

Different methodologies are usually used for the analysis of academic programs: Surveying of students, detailed curriculum analysis, interviews with academic staff or with other actors involved in the curriculum and so on. The analysis performed herein was based on the methodology established by the Sustainability Tool for Auditing Universities Curricula in Higher Education (STAUNCH) tool (Glover *et al.*, 2011; Lozano, 2010). Following the main steps of this methodology, the authors identify the potential for integrating the SDGs into the Bachelor’s Degree in Civil Engineering program at UPV. These steps were:

- selection of the criteria to be analyzed;
- information gathering;
- information classification; and
- program analysis and proposals.

Following the principles of the STAUNCH method, it was adapted and simplified to assess the extent to which each subject within the program curriculum contributed to the different SDGs. Thus, the “criteria” to be analyzed for our work were the 17 SDGs. Data was collected from the aims and descriptions of each course syllabus. All course syllabi were analyzed, focusing on objectives, outcomes and assessment methods. Thus, for each course, the contributions to each SDG (i.e. the criteria) were graded, at four levels:

- (1) The SDG topic is not considered and has null or very poor potential to be addressed.
- (2) The SDG topic is not considered but, according to the course syllabus, it has potential to be addressed.
- (3) The SDG topic is considered but there is no evidence on how it is addressed.
- (4) The SDG topic is considered and there is evidence on how it is addressed.

For this purpose, it was necessary to identify the SDG-related topics that were already being taught and to identify to which SDG target they contribute (Gimenez-Carbo *et al.*, 2019). Courses that could also potentially contribute were identified, as well as new needed topics. The 59 courses within the academic program are summarized in Table 1, in which the code

Code	Subject	ECTS ¹	Courses	Year
MAT	Mathematics for civil engineering (CE)	19.5	Mathematical fundamentals of CE	1
			Mathematical methods of CE	1
			Mathematics – Extension course	2
MMO	Mathematical modeling	10.5	Basic programming and numerical methods	1
			Basic statistics	1
REP	Representation systems	12.0	Drawing	1
			Representation systems	1
PHY	Physics for CE	19.5	Fundamentals of physics in CE	1
			Mechanics	1
			Physics – Extension course	2
ECO	Economics and business	4.5	Economics, legislation and business management	1
GEO	Geology	6.0	Geology applied to civil works	3
TOP	Topography and cartography	4.5	Surveying	2
FBU	Fundamentals of building engineering	25.5	Chemistry for civil engineering	1
			Construction materials and their application to CE	2
			Construction procedures (I) and (II)	2
			Electrical engineering	2
FST	Fundamentals of structural engineering	21.0	Mechanics of deformable solids	2
			Structural analysis	2
			Structural concrete	3
			Structural steel (I)	3
GTC	Geotechnics	6.0	Geotechnics and foundations	3
HHY	Hydraulics and hydrology	7.5	Hydraulics and hydrology	3
FEN	Fundamentals of environmental impact	4.5	Science and environmental impact of CE	2
BUS	Business management	4.5	Business management	4
RIN	Road infrastructures	10.5	Highways and airports	3
			Railways	3
TRA	Transportation and land development	4.5	Transportation and land development	3
BEN	Building engineering	15.0	Industrialized construction	3
			Maritime works	3
			Risk prevention and work organization	3
HYD	Hydraulic infrastructures	6.0	Hydraulic infrastructures	4
BDG	Building	6.0	Building	3
LAN	Land engineering	6.0	Geotechnical engineering techniques and methods	4
PRO	Projects	4.5	Projects	3
COM	Training complements for civil engineering	31.5	Building Information Modeling (BIM)	4
			Civil engineering and society	4
			Conceptual design of bridges	4
			Concrete structural elements	4
			Construction management and organization	4
			English	4
			Ethics in CE	4
			Geotechnical design of foundations and ret. walls	4
			Hydraulic and energy facilities	4
			Infrastructure maintenance management	4
			Introduction to water quality	4
			Management of construction and consulting	4
			Mobility and urban transport	4
			Philosophy of structures	4

(continued)

Table 1.
Bachelor's degree in
civil engineering:
program curriculum

Code	Subject	ECTS ¹	Courses	Year
			Port facilities	4
			River basin management, water resources and river engineering	4
			Road safety	4
			Structural design of foundations and ret. walls	4
			Structural steel (II)	4
			Surface and groundwater hydrology	4
			Technology of concrete structures	4
			Urban history and planning	4
			Urban hydraulic facilities	4
THE	Bachelor's thesis	12.0	Bachelor's thesis	4

Notes: ¹ European Credit Transfer System; 1 ECTS is about 25–30 h of student work, including 10 h of face-to-face learning

Table 1.

used for each course is specified. The following modules compose the curriculum: Basic training (MAT, MMO, REP, PHY, ECO, GEO), civil engineering fundamentals (GEO, TOP, FBU, FST, GTC, HHY, FEN, BUS), civil works technology (RIN, TRA, BEN, HYD, BDG, LAN, PRO), training complements for civil engineering (COM) and the bachelor's thesis (THE). All subjects and courses within each module are compulsory, except those included within the COM subject, where students can choose among several elective courses.

To complete the systematic information classification and analysis of the course syllabi, interviews with academic staff responsible for potential courses to include SGD-oriented topics were also held, to receive their input. First, 11 face-to-face interviews were held to clarify ambiguous aspects of some course syllabi. Then, after the first screening of all course syllabi, a workshop was organized for the whole teaching staff community of the school, to share our first diagnosis and adjust our analysis. A total of 73 lecturers from different knowledge areas participated in this workshop: statistics; graphical expression in engineering; English philology; applied physics; cartography and photogrammetry engineering; construction engineering; geotechnical engineering; transportation engineering; hydraulic engineering; applied mathematics; fluid mechanics; continuum mechanics and theory of structures; engineering projects; environmental technologies; urban and land planning. The workshop helped to make final adjustments to our analysis.

Besides the analysis of the program curriculum, general activities developed in the School of Civil Engineering were analyzed from the perspective of the SDGs. The general training needs of students were assessed, in terms of the 2030 Agenda. At the beginning of the academic year 2019/2020, we surveyed all our new Bachelor students asking them the following questions:

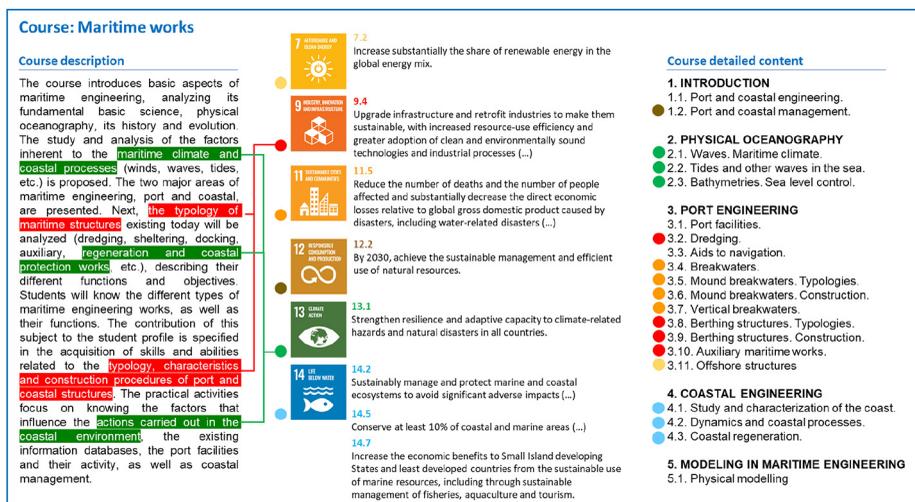
- Do you know what the 2030 Agenda is?
- Do you know what SDGs are?
- Have you ever done some activities to understand what sustainable development is?

A total of 64% of the students did not know the 2030 Agenda, whereas 43% did not know at all the SDGs. 70% of the students never did before any scholar activity to work and understand what sustainable development is. Thus, the school aimed to provide them with an extra-academic background to improve their skills and knowledge on the Agenda, from an integral and holistic perspective.

3. Diagnosis

Our analysis corresponded to the program for the academic year 2019–2020, considering each of the course syllabi composing the program. Figures 1–5 show the results of the diagnosis. For each course, the authors identified whether the 169 targets defined within any of the 17 SDGs were somehow addressed. In the Figures 2–5, each cell contains the targets addressed, crossing each course with each SDG. In addition, and according to the four-level grading adopted, each contribution was scored. If no targets were addressed and there was no room for it, the cell is left blank. Grades 1 (SDG topic not considered but with potential to be addressed), 2 (SDG topic considered but without evidence on how it is addressed) and 3 (SDG topic considered and with evidence on how it is addressed) correspond, respectively, to orange, blue and green cells. Each course–SDG crossing was assigned a grade. A course was assigned the higher grade of any of its crossings and, finally, the subject was assigned the higher grade of any of its courses. Figure 1 shows an example of how each syllabus analysis was performed. The analysis focused on the course description and course detailed content sections. If the course description mentioned explicitly issues related to ODS targets, the course was graded “2.” If no explicit mention appears in the course description but there is some potential to relate contents to ODS targets, the course was graded “1.” The course showed in Figure 1 (Maritime works) has both, explicit and potential relations, so it is finally graded “2.”

The diagnosis did not find evidence of any Grade 3 course, explicitly highlighting the need for actions to boost SDG incorporation within the curriculum. Nevertheless, 19 courses had addressed some of the SDG targets although without evidence on how (Grade 2). These targets covered 11 of the 17 SDGs. If we consider courses where, at present, any SDG target was addressed but, according to the syllabus, they had potential to be considered (Grade 1), the diagnose improves: 15 of the 19 courses graded 2 had potential to include other targets. In addition, 26 other courses were graded 1 as they had potential to consider some targets,



Notes: Relationships between explicit topics within the course description and ODS targets are showed by colored lines (leading to grade = 2). Potential relations between ODS targets and some course contents are indicated by colored dots (leading to grade = 1)

Figure 1.
Example of syllabus
analysis of the
“Maritime works”
course

Module	Subject	Courses	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Basic training	MAT	Mathematical fundamentals of CE																	
		Mathematical methods of CE																	
		Mathematics - Extension course																	
	MMO	Basic programming and numerical methods																	
		Basic statistics																	
	REP	Drawing																	
		Representation systems																	
	PHY	Fundamentals of physics in CE																	
		Mechanics Physics - Extension course																	
	ECO	Economics, legislation and business management					5.5				8.2 8.4 8.8	10.4		12.6					
GEO	Geology applied to civil works						6.6								13.3		15.3		

Figure 2.
Diagnosis for the module “Basic training”

Notes: Numbers in each cell refer to the SDG target addressed in each course. Contribution grading: white = 0; orange = 1; blue = 2; green = 3

Module	Subject	Courses	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Fundamentals of CE	TOP	Surveying																	
	FBU	Chemistry for civil engineering			3.9			6.3											
		Construction materials and their application to CE													12.4 12.5				
		Construction procedures (I)										9.4							
		Construction procedures (II)										9.4							
		Electrical engineering							7.3										
	FST	Mechanics of deformable solids																	
		Structural analysis										9.4			12.2				
		Structural concrete Structural steel (I)										9.4			12.2				
	GTC	Geotechnics and foundations																15.3	
	HHY	Hydraulics and hydrology						6.4			9.4		11.5 11.b	12.2	13.1			15.1	
	FEN	Science and environmental impact of CE		1.5				5.5	6.6		8.4 8.5			11.3 11.4 11.6		13.3		15.1 15.3 15.5	15.2 15.4 15.9
											8.3 8.8	9.4			12.2 12.6				
	BUS	Business management					5.5				8.3 8.8	9.4			12.2 12.6				17.7

Figure 3.
Diagnosis for the module “Fundamentals of CE”

Notes: Numbers in each cell refer to the SDG target addressed in each course. Contribution grading: white = 0; orange = 1; blue = 2; green = 3

Module	Subject	Courses	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	
Civil works technology	RIN	Highways and airports									9.1 9.4		11.2	12.2						
		Railways									9.4									
	TRA	Transportation and land development			3.6			6.6			9.1 9.4		11.4 11.6 11.7		13.1					
		Industrialized construction									9.4		11.b	12.2						
	BEN	Maritime works							7.2		9.4		11.5 11.b	12.2	13.1	14.2 14.5 14.7				
		Risk prevention and work organization									8.8			12.2						
	HYD	Hydraulic infrastructures		2.4					6.1 6.2	7.2					12.2	13.1				
	BDG	Building												11.1 11.c	12.2					
	LAN	Geotechnical engineering techniques and methods													12.2					
	PRO	Projects										9.4		11.b	12.2	13.1 13.3				

Notes: Numbers in each cell refer to the SDG target addressed in each course. Contribution grading: white = 0; orange = 1; blue = 2; green = 3

Figure 4.
Diagnosis for the
module “Civil works
technology”

although they did not consider them at the time of the diagnosis. In total, 45 courses (75%) addressed or had the potential to address targets covering the 17 SDG. In terms of subjects, seven subjects were graded 2, whereas eight were graded 1. The subject COM could be graded 1 or 2, given that its courses are elective and the selection depends on the student.

The “Basic training” module (Figure 2) included the most courses graded 0: 10 courses corresponding to four subjects – MAT, MMO, REP and PHY. Two other courses were graded 0 in the “Fundamentals of CE” module. This situation corresponds to basic courses on mathematics, drawing, physics and basic pre-technological fields.

The diagnosis highlighted the most addressed (Grade 2) SDGs within the curriculum. Clean water and sanitation (SDG 6) was developed into six courses within years 1, 3 and 4. Industry, innovation and infrastructure (SDG 9) was developed into five courses within years 2 and 4. Sustainable cities and communities (SDG 11) was developed into five courses within years 3 and 4. Finally, climate action (SDG 13) and life on land (SDG 15) were developed into three courses within years 2, 3 and 4.

Considering courses that addressed some SDGs (Grade 2) and those that did not but had evident potential (Grade 1), the civil engineering curriculum was strongly related to 5 of the 17 SDG:

- (1) SDG 6 “Clean water and sanitation”: 10 courses.
- (2) SDG 9 “Industry, innovation and infrastructure”: 27 courses.
- (3) SDG 11 “Sustainable cities and communities”: 17 courses.
- (4) SDG 12 “Responsible production and consumption”: 16 courses.
- (5) SDG 13 “Climate action”: 12 courses.

The remaining SDGs could be addressed in different courses (between 1 and 9) with different depth and scope, depending on the specific case. In addition, students could

Module	Subject	Courses	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17		
COM	COM	Building Information Modelling (BIM)									9.4										
		Civil engineering and society					5.5 5.c							11.3 11.b					16.7	17.1	
		Conceptual design of bridges										9.1									
		Concrete structural elements										9.1									
		Construction management and organization						5.5			8.3 8.8										
		English	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
		Ethics in CE				4.7	5.5					8.3 8.8	9.1 9.2	10.2		12.6 12.7					
		Geotechnical design of foundations and retention walls										9.1									
		Hydraulic and energy facilities								7.2		9.1				13.1					
		Infrastructure maintenance management										9.1		11.1							
		Introduction to water quality	1.5		3.9				6.3									14.1	15.1		
		Management of construction and consulting						5.5				8.3 8.8	9.4			12.2 12.6					17.7
		Mobility and urban transport													11.2						
		Philosophy of structures										9.1		11.c							
		Port facilities										9.1						14.4			17.1
		River basin management, water resources and river engineering		2.4					6.4 6.5							13.1			15.1		
		Road safety			3.6								9.1		11.2						
		Structural design of foundations and retention walls											9.1								
		Structural steel (II)											9.1								
		Surface and groundwater hydrology	1.5						6.4 6.6						11.5		13.1				
Technology of concrete structures											9.1										
Urban history and planning													11.3 11.4								
Urban hydraulic facilities							6.1 6.2						11.1		13.1	14.1					

Figure 5. Diagnosis for the module “Training complements for CE”

Notes: Numbers in each cell refer to the SDG target addressed in each course. Contribution grading: white = 0; orange = 1; blue = 2; green = 3. (*) the English course contributes from a general perspective and is not related to specific targets

develop other activities within their curriculum related to the SDGs (e.g. internships, sport activities, student representation and so on).

The diagnosis highlighted that the possibility to address the SDGs within the program curriculum was high. Compulsory courses with the greatest potential to include the SDGs,

considering the number of SDGs that were already integrated (Grade 2) or had the potential to be (Grade 1), were as follows:

- Science and environmental impact of CE (year 2): 7 SDGs.
- Hydraulics and hydrology (year 3): 6 SDGs.
- Maritime works (year 3): 6 SDGs.
- Hydraulic infrastructures (year 4): 6 SDGs.
- Transportation and land development (year 2): 5 SDGs.
- Business management (year 4): 5 SDGs.

Within the COM module, the elective courses that better addressed or could address the SDGs were:

- Ethics in civil engineering (year 4): 8 SDGs.
- Management of construction and consulting (year 4): 5 SDGs.
- Introduction to water quality (year 4): 5 SDGs.

The course “English” was identified as a particular case as, from the general perspective of linguistics, it can address all SDGs. Indeed, SDGs 9, 11 and 15 were graded 2, as these topics were addressed within the course. The course “Civil engineering for society” is of relevant importance, as it was the only subject of the curriculum linked to SDG 16 “Peace, justice and strong institutions.” In the same way, “Ethics in civil engineering” was the only course that developed SDG 4 explicitly. However, SDG 4 “Quality Education” must be seen as transversal to the whole curriculum. Indeed, target 4.7 aims to ensure that *all learners acquire the knowledge and skills needed to promote sustainable development*. In addition, target 4.4 aims to *substantially increase the number of youth and adults who have relevant skills, including technical and vocational skills, for employment, decent jobs and entrepreneurship*. Both targets are inherent to the whole program curriculum.

4. Actions to boost the presence of the SDGs in the civil engineering curriculum

The implementation of improvements in a degree program at UPV includes, according to the UPV’s Quality Manual, changes in two spheres: Improvements in the processes of the UPV or the School of Civil Engineering and improvements in the design of the academic program degree itself. Within this context, actions should be proposed at three different levels, for the incorporation of the SDGs into the learning outcomes and professional profile of the Bachelor Degree in Civil Engineering graduates. Thus, the actions to boost the SDGs in the civil engineering curriculum were classified in the following three specific levels:

- (1) The first level consists of introducing content related to the 2030 Agenda in a transversal way, such that all students understand its extent. In this phase, the transversal and compulsory training activities for students of different courses should be conceived and defined, to introduce improvements to the processes of the School.
- (2) The second level introduces changes to the courses and/or subjects, to incorporate the SDGs into student learning outcomes. With the results obtained from the diagnosis of the current situation of the curriculum, a re-definition of the aims and descriptions of each course syllabus should be proposed by the Program Academic Committee, such that activities related to the SDGs are included. This level

corresponds to proposals for improvement that do not involve a modification of the program verification by the national quality agency. In this case, after the evaluation by the UPV Quality Service, the implementation is immediate and is the responsibility of the school.

- (3) Finally, the third level corresponds to raising potential improvements to the curriculum, which may lead to more integrated and articulated changes regarding the implementation of the SDGs across the curriculum. The third level corresponds to proposals for improvement that involve a deep modification of the program and that require a new verification by the national quality agency. The scope for action and immediacy in the implementation of these proposals is more limited, but it is advisable to study their need and viability. In addition, these modifications must fulfill the ABET and EUR-ACE requirements, as this degree program is accredited by both of these (American and European) agencies.

To achieve the goals of this project, several specific tasks were implemented during the academic years 2019–2020 and 2020–2021. At the first level, since September 2019, different transversal activities targeting students and academic staff of the school have been developed, among which the following are highlighted:

- The conference “The SDG in Civil Engineering.” This activity was aimed at explaining the objectives pursued by the 2030 Agenda, the 17 SDG and the 169 targets. The activity was aimed at all 1st year students, although it has been incorporated as one of the mandatory meetings for students and tutors involved in the University Tutorial Action Plan (Gimenez-Carbo *et al.*, 2017). The task aims to ensure that, during their first year, all students acquire a homogeneous level of knowledge of the Agenda and the SDGs.
- MOOC course at edX (Calabuig Tormo *et al.*, 2021): “SDG in the United Nations 2030 Agenda: Challenges of the Sustainable Development Goals,” which has been included as an activity for students to add elective credits into their curriculum since the 2019–2020 academic year.
- Round tables and workshops relating to the SDGs in public and private entities in the civil engineering sector. This activity was aimed at presenting the experiences of actions carried out by different actors in society to achieve the SDGs. Attendance of these activities also let bachelor’s degree students add elective credits into their curriculum. The following workshops stood out, regarding the participation of students and academic staff: “Opening Day of the 2019-2020 Academic Year: Engineering in emergency situations,” “Strategies for adaptation to climate change: from the COP to the Valencian space,” “Scientists responsible for the 2030 Agenda,” “The SDG in business management,” and “Good practices for incorporating the SDG in UPV degrees.”

At the second level, changes in the course syllabi have been proposed. Following the analysis presented in Section 3, all subjects and courses related to the SDGs are now known. The Governing Board of the School of Civil Engineering established the inclusion of SDG-related contents in the aims and description of each course syllabus of the program curriculum, as part of the learning outcomes acquired in the different subjects. Given this, meetings were held with the academic course coordinators, to address the changes intended to effectively include the SDGs into student learning outcomes. The School approved the guidelines for course syllabi review for the academic year 2020–2021 on April 30, 2020. The

document included the following point regarding the SDGs: “When defining the syllabus, it is necessary to consider sustainability and respect for the environment, adding explicit reference to any of the Sustainable Development Goals.” All the potential possibilities identified in the diagnosis can be now addressed with actions at the second level, through including specific actions in the different course syllabi.

In addition, within level 2, from the 2020–2021 academic year, the UPV School of Civil Engineering requires its students to incorporate a critical reflection into their bachelor’s thesis, describing the contribution or relationship of their thesis with the 2030 Agenda and the SDGs. To achieve this requirement, students must include an annex to their bachelor’s thesis report, according to the model shown in [Figure 6](#). This action is aligned with the first action that UPV developed to integrate the SDGs into bachelor and master degrees. Through the UPV training portal, the course “2030 Agenda and the Sustainable Development Goals” has been promoted between students, to train and educate them about the need to comply with the United Nations 2030 Agenda, as citizens and future professionals. The course is online and remains open throughout the academic year; in successive editions, it has provided enough information for students to reflect on how their bachelor’s thesis contributes to the achievement of the SDGs.

Finally, the third level corresponds to improvement proposals that imply a modification of the program verification. The room for change and the immediacy in the implementation of these proposals is very limited, as previously mentioned. However, it is also important to consider actions at this level, as they are the ones that can lead to more integrated and articulated changes throughout the program curriculum. According to the diagnosis of Section 3, the course “Civil engineering for society” has a relevant importance, as it was the only subject of the curriculum linked to SDG 16 “Peace, justice and strong institutions.” In the same way, “Ethics in civil engineering” was the only course that developed SDG 4 explicitly. In this sense, future revisions of the curriculum that would lead to modifications in program verification should analyze the convenience of including these courses, which are elective at present, as compulsory courses within the program curriculum.

Besides studying how to introduce the SDGs into the Civil Engineering bachelor degree program curriculum, the authors also had to consider how to assess whether students achieve these learning outcomes. All students must pass exams to verify that they have reached the learning outcomes; so, topics related to the SDGs that were introduced in each course were relatively easy to assess (of course, assessment activities must be adequately defined, such that this statement is valid). In addition, it is also very important to realize that the integration of these contents in the program curriculum will make them present in every work that the future civil engineers develop in their professional activity.

Once the students leave the school, it is very difficult to track them, from a professional perspective (this will be the responsibility of the professional associations). The last academic chance to assess them, regarding to what extent their learning outcomes were aligned with the SDGs, is through their Bachelor’s Thesis. At this point, they develop the most similar activity to the technical work that they will carry out during their professional career.

Therefore, a rubric (a sustainable holistic rubric) was developed, to analyze the ability of students to incorporate the SDGs into their work ([Figure 7](#)). This rubric was based on that presented by [Crespo *et al.*, 2017](#). The rubric was designed by considering the five parts in which the SDGs are grouped and four levels of achievement (A, B, C and D) to assess the integration of SDG. Two scopes – potential and assigned – were considered. The adaptation of the rubric to four levels was made to maintain the same assessment system that is considered at UPV, to evaluate the generic outcomes ([Gimenez-Carbo *et al.*, 2020](#)).

Annex to the bachelor's thesis

Relationship of the bachelor's thesis with the Sustainable Development Goals of the 2030 Agenda

Degree of relationship of the thesis with the Sustainable Development Goals (SDGs).

Sustainable Development Goals	High	Medium	Low	Not applicable
SDG 1. No poverty				
SDG 2. Zero hunger				
SDG 3. Good health and well-being.				
SDG 4. Quality education				
SDG 5. Gender equality.				
SDG 6. Clean water and sanitation				
SDG 7. Affordable and clean energy				
SDG 8. Decent work and economic growth				
SDG 9. Industry, innovation and infrastructure				
SDG 10. Reduced inequalities				
SDG 11. Sustainable cities and communities				
SDG 12. Responsible consumption and production				
SDG 13. Climate action				
SDG 14. Life below water				
SDG 15. Life on land.				
SDG 16. Peace, justice and strong institutions				
SDG 17. Partnerships for the goals				

Description of the alignment of the bachelor's thesis with the SDGs with a higher degree of relationship.

*Please use as many pages as necessary

Figure 6.
Compulsory annex to
the bachelor's thesis
at the UPV

The potential score of the thesis was used to indicate whether the bachelor's thesis has the potential to include some of the SDGs. In this case, 0 means "not applicable," and the SDGs are not linked to the work; 1 means "low potential," where the SDGs can be present within the work, although they are not necessary; 2 means "medium potential," where it is evident that the SDGs are present within the work; and, finally, 3 means "high potential," for which the SDGs must be present and their presence is critical for the development of the thesis.

Rubric Incorporation of the SDGs in the bachelor's thesis

Relationship of the bachelor's thesis " _____ " with the Sustainable Development Goals of the 2030 Agenda.

The supervisor must assess the relationship and incorporation of the SDGs in the bachelor's thesis in two scopes: **POTENTIAL:** Assessment of the degree of potential relationship of the bachelor's thesis with the SDGs at 4 levels: Not applicable = 0, Low = 1, Medium = 2 and High = 3.

ASSIGNED TO THE STUDENT: As supervisor assesses the degree of achievement of integration of the SDGs that the student has achieved during the completion of the bachelor's thesis in 4 levels (A, B, C, D). In the event that some of the ODS do not apply to this thesis, the student must be assigned "NA".

Rating scale SDGs	Assigned*
A	Excellent
B	Adequate
C	Developing
D	Not reached
NA	Not applicable

Factors to consider	Potential	Assigned
People		
SDG #1 No poverty		
SDG #2 Zero hunger		
SDG #3 Good health and well-being		
SDG #4 Quality education		
SDG #5 Gender equality		
Planet		
SDG #6 Clean water and sanitation		
SDG #12 Responsible consumption and production		
SDG #13 Climate action		
SDG #14 Life below water		
SDG #15 Life on land		
Prosperity		
SDG #7 Affordable and clean energy		
SDG #8 Decent work an economic growth		
SDG #9 Industry, innovation and infrastructure		
SDG #10 Reduced inequalities		
SDG #11 Sustainable cities and communities		
Peace		
SDG #16 Peace, justice and strong institutions		
Partnerships		
SDG #17 Partnerships for the goals		

* NOTE: A thesis can have a degree of potential relationship with a SDG low (1) or medium (2), but the student will have developed it in an excellent way and therefore will have an assigned value of A. On the contrary, a thesis can have a degree of potential relationship with a SDG high (3), but the student has not developed it adequately and therefore will have an assigned value of C or D.

Figure 7.

Rubric to analyze the ability of a student to incorporate the SDGs into their bachelor's thesis

The score assigned to the student shows the development level of each SDG in the bachelor's thesis. In this case, A means "excellent," such that there is evidence that the SDGs are present in the work and that their inclusion conditioned the final result; B means "adequate," such that the SDGs were mentioned and applied throughout the work; C means "developing," such that the SDGs were mentioned, but were not applied or applied in an unclear or incorrect way; and, finally, D means "not reached," such that the SDGs were not included within the work. In the event that some of the SDGs did not apply to the thesis, the student must be assigned the value "NA."

5. Discussion

The need to incorporate SDGs or sustainability-related topics into higher education has been a recurring theme over the past decade. Swedish higher education institutions recently

adopted the 2030 Agenda as a key framework for introducing sustainability in the curricula of engineering degrees. The results show that sustainable development is successfully integrated into these institutions (Finnveden *et al.*, 2020). This work indicates that 77% of these institutions have courses or programs that integrate sustainable development, but only 42% can show with clear examples how this is done. The study does not provide evidence on how to integrate the SDGs in each bachelor degree. Another Swedish analysis (Leifler and Dahlin, 2020) addresses the key role of the Bachelor's Academic Coordinators on addressing sustainability within engineering education at Swedish universities and engineering colleges. Strachan *et al.* (Strachan *et al.*, 2019) describe how vertically integrated projects can be used to introduce the SDGs into students' education. In this case, each student undertakes one or two projects throughout the Bachelor program, with the limitation that these projects are only related to one SDG. The National University of Kaohsiun (Taiwan) (Chang and Lien, 2020) is making a great effort to show evidence in each course syllabus about the links to each SDG. The analysis will let to detail the contribution of each Bachelor program to the specific SDGs addressed. Within this context, our study adds evidence on how considering sustainability and SDGs into the Civil Engineering bachelor degree.

The diagnosis and analysis developed within the context of the Civil Engineering bachelor degree allowed us to perform an analysis of the strengths, weaknesses, opportunities and threats (SWOT) of the proposal presented in this work. According to Romero-Gutierrez *et al.*, 2016, strengths refer to the things that the participants perceived to work. To identify the strengths, the authors considered the areas where others viewed the organization as doing well. Weaknesses refer to the things the organization needs to improve, such as weaknesses in resources or capabilities that hinder the organization from achieving the goals. By understanding the weaknesses, the authors can focus on specific areas that need improvement. Opportunities and threats are external existing factors or situations that may affect the organization in a positive way (or negative way, in the case of threats) in achieving the desired goals, as well as trends that the organization could take advantage of. The examination of trends is helpful in identifying opportunities. Table 2 shows the SWOT analysis related to boosting the SDGs in the Civil Engineering bachelor degree.

Despite the weaknesses and threats that were detected, the actions carried out to integrate the SDGs into the curriculum have been highly valued by the students and instructors of the School. The training workshops on the SDGs for instructors and students have provided extra motivation, allowing for the revision of the course syllabi for all subjects for the 2021–2022 academic year, to incorporate content related to the SDGs, as established in the diagnosis. In addition, this motivation serves to improve the ability of students to reflect on the contributions or relationships of the SDGs in their bachelor's thesis, as well as in their professional work, once they have completed their studies. However, it is necessary to complete the analysis by surveying students on the degree of knowledge of the 2030 Agenda and the SDGs throughout the academic years, to be able to assess their increase in knowledge on the subject. Moreover, it is important to maintain an attractive offer of transversal activities that allows for the generation and maintenance of interest in the 2030 Agenda and the SDGs.

6. Conclusions

The adoption of the 2030 Agenda and the SDGs by UN member states aims to promote prosperity while protecting the planet. The SDGs recognize that reaching such prosperity must be developed in parallel with strategies addressing economic growth and social needs, while facing climate change effects and environmental protection. Civil engineering is at the core of this transition toward sustainability. Universities, as the prime institution

Table 2.
SWOT of boosting
the SDGs in the civil
engineering bachelor
degree

Weaknesses	Threats
When class attendance is not compulsory, student absenteeism increases	Students may come to perceive the proposals as an increase in their study load
The teaching staff degree of involvement is very uneven	Instructors can make the mistake of introducing these innovations without giving up other traditional teaching methods and activities (student overload)
The current schedule of teaching activities (calendar and schedule) has very few degrees of freedom	Demotivation and abandonment by instructors if dedication to the initiative involves a significant increase in effort without teaching recognition
Students do not actively participate in surveys	
There is a certain immobility on the part of the teaching staff	
Strengths	Opportunities
The instructors involved have done so very actively	Instructors recognize the need to consider the evolution of current curriculum programs to new contexts
The context of Civil Engineering is very suitable for the development of the SDGs	The project values multidisciplinary and team work
The Governing Board of the School of Civil Engineering is firmly committed to promoting the initiative	The development of these initiatives promotes teaching coordination between subjects
The UPV Centre for Development Cooperation has been actively involved	The development of these initiatives will involve the improvement and updating of the course syllabi
The University Tutorial Action Plan admits the necessary flexibility to incorporate the training proposals for the SDGs	The project can increase student motivation and performance

responsible for the education of future professionals, must ensure the alignment of their curricula with the 2030 Agenda and the SDGs.

The School of Civil Engineering at UPV has analyzed to which extent the Civil Engineering Bachelor Degree has addressed the SDGs within its subjects and courses. Our diagnosis showed that 45 courses (75%) addressed or had the potential to address targets covering the 17 SDGs. In terms of subjects, seven subjects were graded 2 (the SDG topic was considered but there was no evidence on how it will be addressed), whereas eight were graded 1 (the SDG topic was not considered but, according to the course syllabus, it had potential to be addressed). SDGs 6, 9, 11, 13 and 15 were the most addressed within the curriculum, which highlights the areas that civil engineering affects the most.

Several actions have been promoted by the Civil Engineering School, to boost the effective implementation of the SDGs in their Civil Engineering Bachelor Degree. Besides transversal actions (mainly focusing on training and dissemination activities), two main initiatives have been developed. First, making explicit reference to the SDGs in the course syllabi of the program, according to the diagnosis. Further, students must include a mandatory annex to their bachelor's thesis, including their critical reflections on the contribution of their work to achieving the SDGs and the 2030 Agenda objectives.

Some barriers have still to be overcome; the degree of involvement of the teaching staff is very unequal and there is a risk of demotivation if there is no recognition to the additional tasks. Nevertheless, the opportunities to adapt our curricula to new societal contexts are also acknowledged by instructors and the Civil Engineering professional context arises as an excellent opportunity to do so.

Future work is now required, to ensure that students achieve knowledge on these topics and to focus their future professional skills toward sustainability principles. The foundations for the effective implementation of the SDGs into the Civil Engineering Bachelor Degree have been set. Future modifications of the curriculum program must

ensure alignment between Civil Engineering and the challenges addressed by the SDGs and the 2030 Agenda.

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