A study on the interpretation of sustainability by ESP engineering learners

Joaquín Santiago López & Ana Roldán-Riejos
Universidad Politécnica de Madrid (Spain)
joaquin.santiago@upm.es, ana.roldan.riejos@upm.es

Abstract

Sustainability is a complex concept that students in the fields of engineering must understand, interpret, and apply. The implications arising from the degree of understanding of the concept constitute a topic that deserves attention due to the impact that this can have on students' academic roles and professional development. In this regard, there is hardly any research on the views and awareness of engineering learners on their knowledge progress about sustainability. Likewise, the scope of ESP practice has been widening during the last decades from teaching language skills and the use of genres in specialized language towards delving into relevant interdisciplinary areas of specialized knowledge for students' professional practice. The present paper carries out an analytical and qualitative exploration into the awareness of ESP construction engineering students on their knowledge about sustainability during their studies. Firstly, a specific questionnaire was designed with the main aim to encourage students' awareness of their own knowledge and to promote transversal competences included in their curricular programs. Additionally, an examination into the curricular subjects of construction engineering degrees focused on syllabuses content, learning objectives and transversal competences was done. The results of the questionnaire show that although engineering students recognize gaps when learning about sustainability issues, they are able to identify ways to cover these deficiencies. In conclusion, ESP practitioners can play an important role when promoting learning awareness strategies, such as self-monitoring and self-assessment, as well as the practice of transversal competences. This procedure can contribute to develop more autonomous and productive ways of learning and to strengthen interdisciplinary action.

Keywords: Sustainability, interdisciplinary action, metacognitive strategies, transversal competences, construction engineering.

Resumen

Un estudio sobre la interpretación de la sostenibilidad por alumnos de inglés para fines específicos de ingeniería

La sostenibilidad es un concepto complejo que los estudiantes de ingeniería deben comprender, interpretar y aplicar. Las implicaciones derivadas del grado de comprensión de este concepto merecen atención debido a su repercusión en los roles académicos y en el desarrollo profesional de los alumnos. Se ha observado, además, una laguna en la investigación acerca de las reflexiones de los estudiantes de ingeniería respecto a sus conocimientos sobre sostenibilidad. Por otra parte, la trayectoria de los estudios de Inglés para Fines Específicos (IFE) ha experimentado un gran avance en las últimas décadas: ya no solo abarca la enseñanza de las destrezas lingüísticas y los géneros más comunes en campos especializados, sino que también profundiza en aquellas áreas de conocimiento interdisciplinar con mayor repercusión en la práctica profesional. El presente artículo realiza una investigación analítica y cualitativa sobre la interpretación de alumnos de IFE de ingeniería de la construcción sobre el tema de la sostenibilidad durante sus estudios. En primer lugar, se diseñó un cuestionario con el objetivo principal de impulsar la reflexión de los estudiantes sobre su propio aprendizaje y el fomento de competencias transversales. Asimismo, se realizó un estudio sobre el papel de la sostenibilidad en los cursos de ingeniería de la construcción centrado en el contenido de los programas, los objetivos de aprendizaje y las competencias transversales. Los resultados del cuestionario muestran que, si bien los alumnos reconocen lagunas en su formación sobre sostenibilidad, también son capaces de identificar formas de cubrir estas carencias. Se concluye que el desarrollo de estrategias de aprendizaje consciente como la monitorización, la autoevaluación y la práctica de competencias transversales puede contribuir a desarrollar un aprendizaje más autónomo y productivo y a fomentar la interdisciplinariedad entre alumnos de IFE.

Palabras clave: Sostenibilidad, interdisciplinariedad, estrategias metacognitivas, competencias transversales, ingeniería de la construcción.

1. Introduction

1.1. Literature review

A search for the term "sustainability" in Google yields a large list of results, which proves its relevance across different disciplines and contexts. According to Brüggemeier (2019, p. 2): "Both large corporate groups and small companies, political alliances and religious communities use this term,

demonstrating the extent to which the topic permeates our world and showing just how important the debates and activities associated with it are". Due to their alikeness, sustainability and sustainable development (SC) are used as synonyms in this paper.

The concept 'sustainable development' dates back to 1713, when the Head of the Saxon Mining Office in Freiberg advocated for a "sustainable use" of forests. At that time, the use of the term was restricted to specialized domains only to open the range for wider use much later, when the Brundtland Commission published *the dossier* "Our Common Future" in 1987, on behalf of the United Nations (WCED, 1987, p. 41). The report stated that: "Sustainable development is development that meets the needs of the present generation without compromising the ability of future generations to meet their needs" (WCED, 1987, p. 40). Since then, both concepts "sustainability" and "sustainable development" have been used interchangeably (Dernbach & Cheever, 2015; Lippert, 2010; Mensah & Ricart Casadevall, 2019; Thürer et al., 2018). Dernbach and Cheever (2015) point out that sustainability is now a prevailing concept that has been growing over decades of discussion.

The Brundtland Commission stresses the influence of development on environmental issues: "Environment and development are not separate challenges; they are inextricably linked. Development cannot subsist upon a deteriorating environmental resource base (…). They are linked in a complex system of cause and effect" (WCED, 1987, p. 13). Dernbach and Cheever (2015) claim that sustainable development provides an overall framework that should allow humans to live in harmony with nature, instead of living at its expense. Generally, the concept of development implies growth, as noted by the *Cambridge Dictionary Online*. Seemingly, growth appears linked both to human needs and to environmental impact in sustainable development.

In summary, the concept of sustainable development encompasses a complex web of semantic associations that entail the compatibility of growth and balance in economic, social, and environmental terms (Dernbach & Cheever, 2015, p. 29).

Few studies have been conducted so far about the role of engineering students as interpreters of sustainability that shed light on its academic and professional repercussions. In one example, Thürer et al. (2018) examine engineering articles addressing sustainability in construction engineering academic curricula and conclude that more research focused on educational

settings is still needed. In turn, Gunarathne et al. (2020) propose a framework to merge sustainable construction with value engineering in construction projects in order to encompass academic and professional factors. Msengi et al. (2019) explore students' knowledge and awareness of sustainability in their college campus by means of a questionnaire about sustainability initiatives, such as recycling or being printing conscious. The study underlines that most students lack awareness of and knowledge on sustainable matters although acknowledging its importance. Birdsall (2013) deals with the interpretation of sustainability and the level of self-awareness by a group of pre-service teachers' students and remarks that learners showed simplistic interpretations of the concept. Birdsall (2013) also points out the importance of education to understand this specific concept.

Despite the importance of environmental matters in construction nowadays, practically no research exists concerning engineering students' views and knowledge awareness about sustainability. As ESP (English for Specific Purposes) scholars, we agree with Hyland's (2012) statement: "How students experience their lives, their studies and their disciplines often remain unexplored yet may generate critical insights into issues which are meaningful for learners and to our professional activities" (Hyland & Jiang, 2021, p. 40). In this respect, this paper tries to cover a gap by bringing a group of ESP construction engineering students' voices to the fore and examining their engagement with a concept that affects their studies. The scope of ESP studies has been extended over the last decades from teaching language skills and the use of common genres in specialized fields towards delving into interdisciplinary areas of specialized knowledge that are relevant for students' professional practice (Bhatia, 2002; Candlin & Crichton, 2011; Engberg & Petersen, 2011). In this respect, the present work attempts to go beyond the study of ESP textual and discursive features in order to analyze engineering students' views and awareness of this important curricular topic. When dealing with new approaches in LSP, Candlin and Crichton (2011, pp. 294-296) highlight the need for researchers to understand the world of participants in the learning process because "that is referenced to their subjective experience" and claim that (ESP) research ought to focus "not only on professional and discursive practices in one or more domains and sites but on the interdisciplinary and interprofessional significance of focal themes". For this type of analysis, a deep connection with the specialized learning community is necessary as well as "a close and sustained involvement of the researcher with the community of practice" (Candlin &

Crichton, 2011. p. 279). Polyakova and Galstyan-Sargsyan (2020, p. 19) claim that "non-linguistic instruction requires a strong focus on communicative and professional competences embedded in curricular programs and teaching materials of specialised language subjects". ESP practitioners ought to be familiar with the relevant specializations they are involved with (Bocanegra-Valle, 2010; Dudley-Evans & St. John, 1998; Hutchinson & Waters, 1987; Lesiak-Bielawska, 2015). Following Hyland (2012), this work entails an emphasis on practice above text. Needs analysis is an essential part of ESP studies to guide practitioners about relevant features in the students' field of expertise (Dudley-Evans & St. John, 1998; Hutchinson & Waters, 1987; Hyland & Jiang, 2021). To achieve this, a close collaboration with the construction engineering community is mandatory to identify the main requirements of the engineering professional world and to keep updated with the construction engineering market's requirements. In fact, it has been confirmed that sustainability is a pervasive feature of construction engineering nowadays. Moreover, sustainability is a focal theme for students to know about, and it is also part of a transversal competence encompassed in these studies[1]. Consequently, the design of a questionnaire that could encourage students to reflect on their own learning about this concept was deemed pertinent. As Anthony (2011, p. 12) points out, it is worth making students reflect on their learning, on how they learn. The different questions in the survey were carefully planned to obtain deeper nuances of interpretation that students might have. ESP action thus opens a motivating interdisciplinary scenario where relevant curricular themes should be foregrounded to increase students' learning awareness.

1.2. Research purpose of this paper

The present paper aims to carry out a study about the understanding of sustainability by a group of students pursuing construction degrees in UPM (Universidad Politécnica de Madrid). The students who participate in this study are required to pass the B2 CEFR (Common European Framework of Languages) level in English before enrolling in ESP courses, so they should be upper-intermediate students. Specifically, respondents come from the schools of building engineering and civil engineering. To conduct the analysis, a questionnaire was designed to explore the students' interpretation and awareness of their knowledge of sustainability. The main research questions under scrutiny were:

(i) How do students perceive their own knowledge about sustainability during their studies? In what courses and subjects do students perceive that they can better develop their knowledge of sustainability during their training?

(ii) What academic activities are perceived by students to be more suitable to help them accomplish their knowledge about sustainability? What are the main ideas they evoke when talking about sustainability?

(iii) What steps do they propose to take in order to further their knowledge about sustainability in the future?

In summary, the first part of this paper deals with a theoretical approach to sustainability, with special emphasis on lexical and semantic aspects, and its repercussions on construction engineering. The impact of sustainability in the course descriptors and transversal competences of the degrees under study is then examined. This analysis tries to provide an overview of how sustainability is academically managed and how diverse aspects of the concept are addressed in the course syllabuses. The following sections present the ESP learning context of the study, a description of the methodological approach adopted in data collection and a thorough explanation of the survey. Subsequently, the results obtained from the survey are discussed as well as the strategies promoted to help students monitor and self-regulate lifelong learning skills. Finally, the paper suggests further analysis and forthcoming lines of research.

2. A theoretical approach to sustainability

The notion of sustainability has become widespread in the construction domain over the last decades. Blockley (2005, p. vii), author of the *New Dictionary of Civil Engineering*, argues that sustainable practice must be kept

> in the forefront of our minds. To do so requires practical rigor based on an appropriate use of science and practical experience with clear values to deliver quality for all stakeholders, including the natural environment (Blockley 2005, p. vii).

The next section looks at sustainability as a complex and multifaceted concept pertaining to different theoretical and experiential domains.

2.1. Semantic intricacies of the term

Despite its prevailing use, many scholars maintain that the concept of sustainability lacks clarity and precision (Brüggemeier, 2019; Dernbach & Cheever, 2015; Du Pisani, 2006; Glavi & Lukman, 2007; Lippert, 2010). Farley and Smith (2020, p. 2) claim that "Sustainability began as a promising, inspirational and hope-filled worldwide endeavor but has become a buzzword, often with little more behind it than rhetoric". Glavi and Lukman (2007, p. 1875) assert that "semantics and content analysis enable the researcher to better describe and understand sustainable development concepts". Therefore, it is important to refer to sustainable development in a more precise and articulate manner. These authors also claim that the problem is intensified because of easy access to sources that approach the topic in dissimilar ways. Further, it seems that more critical attention to the definitions and their meaning is required. The broad nature of the term "sustainability" permeates many areas, including academia. Direct observation and previous ESP analysis indicate that it is appropriate to explore this concept thoroughly.

Since sustainability is a term that resonates in many different areas, it frequently appears combined with a descriptor that restricts its meaning. For instance, the definition found in *Sustainability Journal* (n.d.) refers to the concept as: "the environmental, cultural, economic, and social sustainability of human beings". Additionally, the *Cambridge Dictionary Online* defines it as "the quality of causing little or no damage to the environment and therefore able to continue for a long time".

It is apparent that the term encapsulates concepts as growth and balance that seem difficult to reconcile. From the etymological point of view, sustainability comes from the verb "sustineo" meaning "to hold up, hold upright, uphold, bear up, keep up, support, sustain" (*Perseus Dictionary of Latin*, n.d.). Originally, sustainability is connected to physical equilibrium and refers to the balance between an upward and a downward force. A balance of forces is also required in the concept of sustainable development that encapsulates the need for growth but also some limitations. In this respect, sustainable development has been considered an oxymoron because economic growth can affect environmental care (Dernbach & Cheever, 2015, p. 29).

2.2. Sustainability in the construction area

Interestingly, Brennan (2015) notes that, even though sustainable development (SD) has garnered significant attention over the past 30 years, its progress within the construction industry has been slower compared to other sectors. Some authors advocate for promoting activities that lead to enhance the correct understanding of the concept in construction (Msengi et al., 2019). More particularly, it is argued that the hazards of uncontrolled building in the construction industry could be prevented by keeping the balance between the three main pillars of sustainability, namely the environment, society and economy. These columns are also known as the 3 Ps: planet, people and profit (Smythe, 2014).

3. Methodology

3.1. Preliminary stage

As a previous stage to administering the questionnaire, the content of the syllabuses that our students follow in their respective degrees was examined in order to determine to what extent sustainability is prioritized in their studies. The core subjects from different construction engineering degrees were perused to identify the courses that included sustainability issues in their course descriptors. One undergraduate syllabus and two master's degree syllabuses offered at the Building Engineering School (Table 1), along with two undergraduate syllabuses of civil engineering studies (Table 2), were analyzed. Another central issue of the research was to determine the role and relevance of transversal competences regarding sustainability in students' curricular subjects. This was done in order to verify the approach to sustainability in the students' technical environment.

As a rule, most mentions of sustainability were found in the competencies section of the syllabuses. However, a full description of how training in this concept was practically implemented was lacking in the course descriptors[2]. The absence of such information can be linked to insufficient academic training on sustainability. Nonetheless, more data to support this statement would be needed.

Particularly, in the case of the building engineering undergraduate degree, 23 subjects out of 49 within the syllabus included references to sustainability (46.9%). A deeper analysis of this specific syllabus revealed that most

sustainability content was concentrated in the 3rd and 4th academic years. This could be due to the fact that students can mainly opt for specialized subjects at the end of their studies. As to postgraduate syllabuses in building engineering, 8 and 3 subjects out of 15 included mentions of the concept (53.3% and 20% respectively). The syllabus of the master's program in project management comparatively shows a greater number of sustainability mentions than the technological innovation one, as Table 1 shows. The reasons for this difference would require more extensive research.

Degrees	Total subject count	Subject with mentions	%
Building Engineering undergraduate syllabus	49	23	46.9%
Master in Project Management syllabus	15	8	53.3%
Master in Technological Innovation syllabus	15	3	20%

Table 1. Sustainability mentions in the syllabuses of Building Engineering Degrees.

Data from both civil engineering syllabuses corroborate a higher degree of sustainability content during the last years of study. It is important to note that the civil engineering and business administration degree consists of a dual program, and therefore it offers a wider range of subjects and contents than the civil and territorial engineering degree. Taking this into account, sustainability mentions are proportionally similar in the syllabuses of both degrees. In particular, 15 curricular subjects out of 48 and 12 out of 76 (dual degree) showed references to sustainability (31.2% and 15.8% respectively, see Table 2).

Degrees	Total subject count	Subject with mentions	%
Civil and Territorial Undergraduate Engineering Degree	48	15	31.2%
Civil Engineering & Business Administration (Dual) Undergraduate Degree	76	12	15.8%

Table 2. Sustainability mentions in the syllabuses of Civil Engineering Degrees.

These figures indicate that students do not seem to receive consistent training about sustainability, especially in their first years of study. It was also found that a high number of sustainability mentions in the syllabuses corresponded to mere designations of didactic chapters or units. Alternatively, mentions were also found in descriptors of subjects' competences and in bibliographical references.

In an academic technical environment, a thorough analysis of curricular subjects entails scrutinizing the role of transversal competences

(Karapetjana et al., 2017). From the transversal competences (CT, *competencias transversales* in Spanish) that are harnessed in construction engineering education, the following ones were selected for the survey administered to students:

- CT1) Commitment and capacity to apply sustainability principles in professional practice.
- CT5) Versatility and capacity for autonomous learning.
- CT9) Capacity to design, analyze, and interpret key experiments in construction engineering.

CT1 directly addresses the practice of sustainability. CT5 encourages the use of metacognitive strategies such as self-monitoring and self-assessment as a means to foster autonomous learning. CT9 enhances cognitive abilities that are needed to promote learning awareness.

The next section discusses the ESP learning context of the engineering students under study.

3.2. The ESP learning context

The students who participated in this survey were 61 ESP learners from the building and civil engineering degrees. In these ESP courses, a communicative approach is followed to enhance students' linguistic skills by means of targeted strategies. The main aim is educating autonomous learners who are capable of processing and developing core concepts autonomously. In this context, learning strategies are oriented to favor students' autonomy in managing their own learning and taking responsibility for it. Understanding a concept involves a process rather than a single operation. Gibbs (1999, pp. 38-39) distinguishes three "moments" or stages in understanding: *comprehension*, defined as the instantaneous process of finding meaning, mostly unconscious; *recognition*, described as consciously identifying the product of comprehension; and *interpretation* that involves analysis of the product of comprehension and conscious reflection about what something means. In an ESP context, when engineering students try to understand and interpret a concept such as sustainability, at least two operations are needed: (1) recruiting previous knowledge about it and (2) assessing the level of familiarity with it. It also involves activating the different nuances of the concept within the construction area.

The use of cognitive strategies has a direct bearing on students' preferred ways of learning. This can be seen in the completion of tasks such as summarizing texts, translating, identifying keywords, and using diagrams. On the other hand, promoting the use of metacognitive strategies, especially those dealing with planning and managing learning, is useful not only during the academic stage, but also in the long term. Metacognition has been defined as "the third person point of view of one's own knowledge and thoughts that one possesses, to different degrees of clarity, accuracy and control" (Masatoshi, 2022, pp. 95-96). By metacognition, learners can think about and discern their learning process and thus design strategies that compensate for possible knowledge gaps. The main focus lies in "what the learner has to do in order to learn" (Ajideh, 2009, p. 165). According to Masatoshi (2022, pp. 95-96), metacognition represents "a higher-order thinking process" and is "a strong predictor of learning successes". Tran and Hasegawa (2022) argue that learners make concurrent use of cognitive and metacognitive strategies and perform feedback and interaction between them. Thus, when learning technical terms, students may use association and visualization as cognitive strategies, and they also can evaluate whether their knowledge follows the progress planned for a task or if they need to use other strategies to fulfil this goal.

Our ESP students follow a combination of on-site and distance learning instantiated in a blended model that fosters students' independence and self-management (Ajideh, 2009; Khezrlou, 2012; Ortega-Ruipérez, 2022; Theobald, 2021). It can also be described as self-regulated learning or, in other words, as "an active, constructive process whereby learners set goals for their learning and then attempt to monitor, regulate, and control their cognition, motivation, and behavior" (Pintrich, 2000, p. 453). Most students identified the type of learning activities that were more useful to understand and interpret this concept; this ability proved that they could make use of planning and monitoring strategies to improve their progress. Furthermore, the use of self-assessment skills can also be valuable to lifelong learning (LL) in the professional future. Figure 1 illustrates this process.

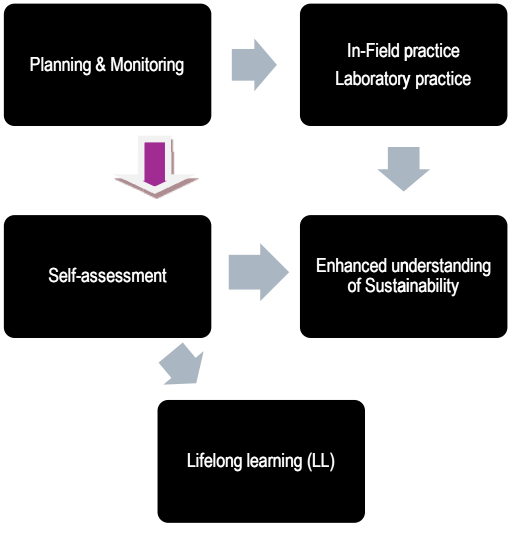

Figure. 1. Process of self-regulated learning.

By focusing on their knowledge of key curricular concepts, students can successfully monitor their progress and detect deficiencies. Students can cope better in the professional world if acquainted with ways to measure their own learning. Our contribution as ESP educators in this context is to provide tools that promote reflection and facilitate students' self-assessment, critical thinking and learner autonomy. Developing critical thinking competence can be useful to understand topics such as sustainability.

3.3. Data collection

The experimental section of this paper deals with a survey about students' knowledge, understanding, and confidence in sustainability topics. Students enrolled in ESP courses for building construction and civil engineering were asked to fill out a questionnaire designed to test the preliminary aspects described above. The sample population included 61 respondents, who were all building construction and civil engineering students at undergraduate and postgraduate levels. Participants were asked to answer different types of questions based on Ortega-Ruipérez's approach (2022, p. 223), namely, "what I know, how well I know it (...), what I want to know, and how I can learn it". The questions were also intended to elicit information about the strategies that the students used to learn about sustainability. The use of questionnaires is a very common instrument in applied linguistics research to

gather relevant data from participants. They are useful because they save time, effort and financial resources (Dörnyei & Dewaele, 2023). In turn, Fairclough and Thelmal (2021) point out that sometimes the validity of questionnaires can be disputed, especially if they make use of very general questions, which can result in sample bias. To provide optimal validation, the questionnaire used in the present paper consisted of targeted specific items, it was anonymous and voluntary (see Tables 3, 4 and 5 to learn about the rationale behind the different sections and questions in the survey). The students were previously informed about how the results of their answers would be treated for ongoing research and pedagogical purposes. They were also asked to provide their agreement to participate. Therefore, ethical standards were met regarding information as well as motivation. In addition, previous consultations with an expert on questionnaire design and implementation were conducted in order to pilot closed and open-ended questions as well as how to process them. The aim of the questions was to obtain reliable data and to provide insights into the views and considerations of a group of engineering students; therefore, qualitative and quantitative data can be derived since the number of participants is homogeneous and represents a specific field of engineering. Creswell (2012, p. 229) claimed that in "purposeful qualitative sampling" a careful selection of respondents to elicit relevant information is needed.

3.4. Survey design and implementation

Following the approach described in section 3.3 above, the questionnaire was designed to determine (1) the extent of students' knowledge about sustainability; (2) students' interpretation of the concept; (3) the strategies that were used to cover potential gaps and (4) the implications at a professional level. For methodological reasons, the questions were structured into 3 major sections[3]. The first section deals with the demography (D-questions) of participants and served to establish (1) age, (2) sex, and (3) type of degree. Section 2 focuses on cognitive (knowledge or content-based) aspects; more specifically, these questions deal with cognition factors associated with the concept of sustainability, use of background information and students' learning attitudes (Qs 1-5). The main purpose of this section was to analyze the learning interpretative process itself (cognitive level) rather than the students' knowledge awareness (metacognitive level). Questions in section 3 (Qs 6-10) refer to students' use of strategies according to their knowledge, their learning awareness and their progress in

conceptualizing sustainability. The list below shows the abbreviations used in the analysis according to the type of aspect assessed:

- S: Sustainable Construction
- SD: Student Data
- CS: Cognitive Strategies
- MS: Metacognitive Strategies
- SU: Strategy Use
- LL: Lifelong Learning

Tables 3, 4 and 5 illustrate the rationale behind every question in relation to the goals pursued as well as the main traits covered.

Question	Rationale	Aspect assessed
Age	To find students' degree of knowledge, fluency in SC	SD
Sex	To ascertain differences/similarities in students' interpretation and learning of SC	SD
Degree/studies	To elucidate whether the title and syllabuses content of construction degree studies are influencing factors in learning about sustainability	SD

Table 3. Quantitative/formal aspects of section 1 Demographics.

Question	Rationale	Aspect assessed
1	To find out whether students had previous knowledge of SC	CS
2	To pinpoint what factors students consider + relevant in SC and their scale of relevance	CS
3	To identify those academic subjects that increase students' understanding of SC	CS
4	To identify which academic subjects are more useful to learn about sustainability and their degree of effectiveness	CS
5	To find out the scale of practical application of SC of students in class	SU

Table 4. Qualitative/Conceptual aspects of section 2 Cognition.

Question	Rationale	Aspect assessed
6	To find out students' awareness of their knowledge on SC	MS
7	To verify the students' self-assessment on SC concerning their knowledge and confidence	MS
8	To find inferences about SC interpretation when formulated as metaphors	MS
9	To elucidate students' self-assessment of their professional capability with SC	MS/SU
10	To elucidate students' attitudes towards LL (Lifelong learning) on SC	MS/LL

Table 5. Qualitative/Conceptual aspects of section 3 Metacognition.

In order to test the validity of the questionnaire, various information sources, including a close examination of the role of sustainability in the different syllabuses, courses and degrees were consulted; the information

received from these sources corroborated the curricular status of sustainability in the engineering studies and permitted a triangulation of the data (Creswell, 2012). A further step taken was to ask an external colleague to review the pertinence of the questions and the data obtained in order to check for credibility, objectivity or subjectivity in them.

All in all, ESP surveys can be effective tools to inform and provide reliable data about students' use of transversal competences in relatively small-scaled communities that would otherwise go unnoticed (Braun et al., 2021).

4. Results and discussion

In this section the results from the questionnaire are discussed. Most of the answers have been transferred to image format using Google docs Tools and then converted to table layout for clarity reasons. Where further data were required, the Pearson product-moment correlation coefficient model was used to detect potential correlations between different variables. The questionnaire was administered to 61 students in total.

As for demographics, nearly half of the respondents (46%) were between 20-22 years of age. This suggests that they are halfway through their studies, as most UPM students start their 4-year degrees at 18. The remaining 54% include students over 23, mostly in the range 23-29, who are completing their last year as undergraduates or are enrolled in a master's program.

Results showed a total of 53.4% male and 46.6% female. The slightly higher proportion of male students reflects the current university students' population, although the trend is gradually getting fully balanced.

Regarding construction engineering specialization, 41% of students pursued a building engineering degree and 59% a civil engineering one. The questionnaire was targeted at both groups (see Table 6). Most participants (78.3 %) were undergraduates, while 21.7% were taking a master's program in building engineering contents.

Degree		Educational level	
Civil Engineering	59%	Undergraduate	78.3%
Building Engineering	41%	Postgraduate	21.7%

Table 6. Students' distribution according to degree and level.

The next group of questions was centered on determining students' awareness of their own learning progress about sustainability. Question 1 sought information about students' perception of sustainability knowledge before university studies. 50% of the students believed that they lacked sufficient knowledge on sustainability. The other 50% considered that they already had enough knowledge. As a matter of fact, the first years of academic training consist of core subjects (e.g., physics, calculus, chemistry, technical drawing) and sustainability is gradually incorporated in subsequent years of study.

Results from question 2 showed students´ choice of different engineering methods that they considered more suitable for sustainable construction. Most participants opted for optimizing water use and recycling materials (80%), reducing waste (75%) and increasing research in new sustainable materials (63%). Aspects such as reducing the impact of construction (61%), aiming at zero carbon emissions (56%) and complying with environmental legislation were regarded as secondary (56%).

In question 3, the 61 participants gave their opinion about the most relevant curricular subjects for learning sustainability. Table 7 shows the number of students (N.) along with their corresponding percentages based on the Likert-type scale: 1 being the most relevant and 5 being the least relevant in the learning process. Students responded that the most valuable subjects in learning about sustainability were materials and construction, whereas structures, physics and maths were considered less relevant along the scale. Interestingly, the subjects chosen by the students match the syllabuses with more content on sustainability (see section 3.1).

	Maths		Physics		Construction		Materials		Structures		Others	
	N.	%	N.	%	N.	%	N.	%	N.	%	N.	%
1	12	19.68	9	14.75	18	29.50	21	34.42	8	13.13	11	18.04
2	5	8.20	12	19.68	14	22.95	15	24.59	13	21.31	9	14.75
3	9	14.75	16	26.22	11	18.04	2	3.27	20	32.78	16	26.22
4	9	14.75	5	8.20	11	18.04	10	16.39	10	16.39	12	19.68
5	26	42.62	19	31.15	7	11.47	13	21.31	10	16.39	13	21.31

Table 7. Validation for curricular subjects on a scale of relevance from 1 (the most relevant) to 5 (the least relevant).

In Question 4, students were asked to rate the usefulness of various learning activities in helping them understand the role of sustainability in the

construction domain. They were given three response options: 1. *Very useful, 2. Useful and 3. Of little use*. The majority of respondents rated field trips as either *very useful* or *useful*. Lectures were rated second, followed by lab work and websites, with a slightly lower impact. Table 8 shows the number of students (N.) along with their corresponding percentages.

	Field Trips		Lectures		Lab Work		Websites	
	N.	%	N.	%	N.	%	N.	%
1	41	67.21	19	31.14	24	39.34	21	34.42
2	15	24.59	33	54.1	26	42.62	28	45.90
3	5	8.20	9	14.60	11	18.04	12	19.68

Table 8. Validation of training activities on a scale of usefulness from 1 (very useful) to 3 (of little use).

Furthermore, to explore the relationship between students' age (understood here as years spent in college), their self-reported knowledge, and their engagement in sustainability-related practices (as reflected in Questions 5–7), a Pearson product-moment correlation coefficient analysis was conducted. While optimal correlation is considered significant at the 0.5 level in this model, the analysis revealed a weak positive correlation at the 0.1 level between age and sustainability engagement, [$r = .10$, $n = 60$, $p < .0005$], suggesting that length of time in college does not strongly predict students' sustainability-related attitudes. In contrast, a strong and statistically significant positive correlation was found between students' familiarity with texts and websites on environmental legislation and their self-perceived knowledge of sustainable construction, [$r = .58$, $n = 60$, $p < .0001$]. This indicates that students who actively consult legal sources tend to report higher levels of understanding sustainability principles, considering the relevance of administrative and institutional frameworks in these matters (as European Union guidelines, for instance). These significant correlations are reflected in Table 9, which provides a full summary of the correlation coefficients across the survey variables.

Correlations				
		I have sufficient knowledge on sustainable construction to prepare class activities	I do not feel confident enough when applying my knowledge of sustainability in a practical way	I believe that it is important in my profession, but I still need to improve my knowledge about it
Age	Pearson Correlation Sig. (2-tailed) N.	.053 .685 60	-.173 .186 60	.002 .990 60
I can easily understand texts and explanations about sustainable construction	Pearson Correlation Sig. (2-tailed) N.	.345** .007 60	-.136 .301 60	-.081 .538 60
I am confident in my ability to integrate sustainability with multiple technologies	Pearson Correlation Sig. (2-tailed) N.	.466** <.001 60	-.319* .013 60	-.190 .145 60
I am familiar with texts and websites about legislation and sustainability	Pearson Correlation Sig. (2-tailed) N.	.581** <.001 60	-.093 .480 60	-.016 .903 60
I have sufficient knowledge on sustainable construction to prepare class activities	Pearson Correlation Sig. (2-tailed) N.	1 60	-.121 .356 60	-.109 .406 60
I do not feel confident enough when applying my knowledge of sustainability in a practical way	Pearson Correlation Sig. (2-tailed) N.	-.121 .356 60	1 60	.251 .053 60
I believe that it is important in my profession but I still need to improve my knowledge about it	Pearson Correlation Sig. (2-tailed) N.	-.109 .406 60	.251 .053 60	1 60

lote:

*Note: **Correlation is significant at the 0.01 level (2-tailed). *Correlation is significant at the 0.05 level (2-tailed).*

Table 9. Correlations using the Pearson correlation coefficient model.

As far as metacognitive strategies are concerned, the survey also explored the degree of students' awareness about using their knowledge on sustainability in class (question 5). In this respect, 48.3% of them stated that sometimes they applied their knowledge on sustainability in class activities, whereas 26.7% did this very rarely. Likewise, 21.7% used it frequently and only 3.3% responded very often.

On the other hand, responses to question 6 about learning progress, 76.7% of students said that they were progressing in sustainability learning, whereas 13.3% declared that they had very little knowledge. Likewise, 10% felt confident about their current knowledge.

The results of question 7, shown in Table 10 (where N. stands for number of students), provide insights into students' self-assessed knowledge and confidence concerning sustainable construction. The responses indicate a

generally positive perception, with the majority of participants strongly agreeing (1) or agreeing (2) about their understanding of texts on sustainable construction. Similarly, a lower percentage expressed confidence in integrating sustainability knowledge with various technologies (1 and 2). However, areas such as familiarity with legislation and the ability to prepare class activities showed greater variation, with roughly half of students selecting "disagree" or moderate agreement. Importantly, a considerable number strongly agreed (1) that, although sustainability is essential in their professional field, they still need to enhance their knowledge. These findings highlight both recognition of the topic's importance and a perceived need for further learning, emphasizing the relevance of targeted educational support.

	I can easily understand texts and explanations about sustainable construction.		I am confident in my ability to integrate sustainability with multiple technologies.		I am familiar with texts and websites about legislation and sustainability		I have sufficient knowledge of sustainable construction to prepare class activities.		I do not feel confident enough when applying my knowledge of sustainability in a practical way.		I believe that it is important in my profession, but I still need to improve my knowledge about it	
	N.	%	N.	%	N.	%	N.	%	N.	%	N.	%
1	10	16.39	3	4.92	4	6.56	1	1.64	10	16.39	37	60.66
2	46	75.41	35	57.38	17	27.87	17	27.87	24	39.34	21	34.43
3	5	8.2	18	29.51	31	50.82	32	52.46	23	37.7	1	1.64
4	0	0	5	8.2	9	14.75	11	18.03	4	6.56	2	3.28

Table 10. Students' validation for self-perceived knowledge corresponding to 1 (Strongly agree), 2 (Agree), 3 (Disagree), 4 (Strongly disagree).

The purpose of question 8 was to explore students' interpretations of sustainability. The question was formulated by means of common metaphorical associations related to environmental topics. These associations were based on the basic conceptual schemas of *force*, *nurture*, *growth and development*. The reason for exploring students' interpretations by means of metaphor is based on the assumption that metaphors can transfer complex ideas into more accessible concepts; in fact, conceptual metaphors are frequently used in the technical domain as a useful tool that can help grasp abstract concepts (Roldán-Riejos & Úbeda-Mansilla, 2013; Santiago & Roldán Riejos, 2009). In this respect, the schema of force (fighting against elements) and the nurturing (taking care) schema were chosen to illustrate this question.

The FORCE (fighting) and NURTURE metaphors have been addressed by Lakoff and Johnson (1980) and the *growth* and *development* schemas have been

studied by Johnson as recurrent in human mental representations (Johnson, 1987, 2005). On a scale from "strongly match" to "does not match", students were asked to label statements (metaphors) commonly associated with *sustainability*. Table 11 shows students' answers to interpretations of sustainability.

Sustainability is	Strongly agree/agree
MANAGING natural resources	83.3%
TAKING CARE of the environment	80%
DEVELOPING better housing and structures	73.3%
FIGHTING against degradation	70%
IMPROVING economic growth	55%

Table 11. Metaphorical associations in question 8.

Question 8 was designed to identify possible differences in the choice of metaphoric mappings about sustainability between male and female students. Results, however, did not reveal significant variations in the responses: 36% of males showed slightly more interest in the metaphor SUSTAINABILITY IS FIGHTING AGAINST DEGRADATION compared to 33% of females. However, 40% of males proved to be more interested in the metaphor TAKING CARE OF THE ENVIRONMENT as opposed to 36% of females. Minor variations also indicated more interest in managerial action by males, whereas females opted for sustainable construction as "improving economic growth". In turn, males chose sustainable construction as "managing natural and local resources and developing better housing and structures" (Tables 12 and 13). All in all, data fluctuations are too low to claim significant differences according to sex.

Sustainable Construction Is	Strongly Match/Match
FIGHTING against land degradation	36%
TAKING CARE of the environment	40%
IMPROVING economic growth	28.3%
MANAGING natural and local resources	40%
DEVELOPING better housing & structures	38.3%

Table 12. Metaphorical associations about question 8 MALE population (32 respondents).

Sustainable Construction Is	Strongly Match/Match
FIGHTING against land degradation	**33.3%**
TAKING CARE of the environment	40%
IMPROVING economic growth	31.6%
MANAGING natural and local resources	36.6%
DEVELOPING better housing & structures	**33.3%**

Table 13. Metaphorical associations about question 8 FEMALE population (28 respondents).

The results of questions 9 and 10 shed light on the adoption of sustainability strategies by students. This could have effects on their future careers and reveal effective ways for ongoing learning. Although a slight majority (48.4%) responded that they felt 'prepared' to put their knowledge into practice, 43.3% of them stated that they felt 'barely prepared' and only 8,3% stated to be 'well prepared' (see Table 14).

How prepared do you think you are to work with sustainability issues in the near future?	%
Well prepared	8.3%
Prepared	48.4%
Barely prepared	43.3%

Table 14. Metacognition: Students 'awareness of their knowledge about sustainability.

As for further actions after graduation, 36.6 % replied that they intended to learn by themselves, specifically by applying their knowledge practically, "as they develop professionally". This result essentially confirms students' preference for a practical approach in getting to know about sustainability. Additionally, 35% stated that they wanted to learn by reading specialized materials, and the remaining 16.7 % said they would enroll in a master's program or resort to other methods, 11.7% (see Table 15).

What steps are you going to take to further your knowledge about sustainability?	%
Learning on the spot as I develop myself professionally	36.6%
Learning by myself by reading websites, journals, etc.	35%
Enrolling in a master's program	16.7%
Others	11.7%

Table 15. Metacognition: Preferred ways to continue learning about sustainability.

In view of the results shown above, it can be claimed that students are aware that they lack enough knowledge about sustainability until they reach the last academic years (3rd and 4th). They also prefer practical activities rather than lectures or theoretical approaches as more effective learning methods to address sustainability. In view of this, a more extensive approach in further academic subjects, including core and specialized ones, is recommended in order to increase and facilitate students' understanding of this concept throughout their studies.

Regarding the research questions formulated at the beginning of this paper, the main results show the following points:

(i) Students' answers verify that they are capable of harnessing their knowledge by means of cognitive and metacognitive strategies of interpretation, monitoring and evaluation. Furthermore, students are able to identify courses and subjects that help them understand and leverage their learning about sustainability, for example, they recognize that in advanced courses they are able to acquire more knowledge. This result is in agreement with the study done on the courses and subjects that more extensively dealt with sustainability in academic syllabuses.

(ii) Students also name specific activities that help them to develop their knowledge and awareness of sustainability more easily, for example laboratory work and in-field activities. Likewise, students point out among the most useful learning activities looking at regulations and legal aspects related to sustainable construction or consulting electronic sources about them. In addition, students are able to use metaphors as a vehicle for conveying their ideas about sustainable construction, for example fighting against land degradation ("fight" metaphor) and taking care of the environment ("nurture" metaphor).

(iii) As to the steps proposed to continue further learning, students designate professional activities done on site. This choice underlines the need for autonomous and practical learning in long-term knowledge. Becoming autonomous learners is also in line with the practice of some curricular and transversal competences mentioned before and entails the ability to self-regulate learning.

5. Conclusions

This paper has explored from an interdisciplinary stance the interpretations and awareness of a group of ESP construction engineering students about their knowledge of the subject of sustainability. The main goal was to hone the practice of three transversal competences that the students should be able to implement. Competences embody, apart from sustainability knowledge, autonomous learning, and are also meant to enhance students' analysis and interpretation abilities. The pertinence of practicing these competences in ESP learning has far-reaching effects because their formulation responds to international academic quality standards, and to engineering companies' requirements. In fact, students need to infer social, scientific and ethical repercussions from the role of sustainability in engineering and therefore they will benefit from addressing these transversal competences. Similarly, autonomous learning can be fostered by evidencing

students' capacity to self-regulate and monitor their own learning. Consequently, the ESP context provides an ideal scenario for the implementation of these skills which in turn contributes to reinforcing basic competences in engineering studies. The study was done by means of a specific questionnaire aimed to encourage engineering students to reflect on their learning process and to promote transversal competences such as learning autonomy and the ability to interpret key concepts in their studies. The use of questionnaires is a common tool used in applied linguistics to gather direct and reliable data from participants.

The sample included does not represent a large number of students and the results of the analysis are not expected to be generalized, yet the authors are confident that studies of this kind could help instill self-monitoring skills as well as provide much needed practice in ESP transversal competences. Likewise, adopting a similar interdisciplinary approach is recommended in other academic domains and also to extend the number and profile of students involved. Further ways to motivate students in this respect can be the use of subject-specific debates and group projects, which in turn can stimulate critical thinking and discussion skills. In sum, addressing specialized focal themes in ESP training emerges as a compelling challenge to study and practice students' transversal competences and to raise learning awareness. This is a fertile area that could lead to interesting results in the ESP field.

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Dr Joaquín Santiago López has been working as an Associate Professor since 2000 at the Department of Linguistics Applied to Science and Technology (UPM) teaching English for architecture and building construction and English for Academic and Professional Communication both to undergraduate and postgraduate students. He has specialized in discourse analysis and cognitive linguistics, with special focus on the analysis of conceptual mechanisms from the perspective of gender studies. He has recently contributed to the development of ArchiTermFinder, a multimodal database in association with the Macquarie University of Sydney.

Dr Ana Roldán-Riejos has been lecturing ESP as an Associate Professor at the School of Civil Engineering (UPM) for several decades. Most of her publications explore the role of metaphors in technical discourse from a cognitive viewpoint by means of corpus-based studies. Her research interests also include the study of technical phraseology, translation, contrastive linguistics and critical discourse analysis. She has been working as an external evaluator for the European Union since 2016.

NOTES

[1] (CT1) Commitment and capacity to apply sustainability principles in professional practice in accordance with UPM regulations.

[2] Titles of subjects have been translated for practical reasons. Full details about the courses included in this section can be found at:

https://www.edificacion.upm.es/grado_en_edificacion

https://www.edificacion.upm.es/master-universitario-en-innovacion-tecnologica-en-edificacion-mite

https://www.edificacion.upm.es/master-universitario-en-gestion-en-edificacion-mage

https://caminos.upm.es/grado-de-ingenieria-civil-y-territorial/#1632483400270-0d133641-cddc

[3] Full details of the survey can be found at: https://docs.google.com/forms/d/e/1FAIpQLSdUBDkArsthVYa8oh1dwJ7J22o—WcfOn26Bc6VUDU9yKxCFA/viewform