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TRANSFORMATIVE PRACTICES: FOSTERING EFFECTIVE COMMUNICATION IN ENGINEERING EDUCATION THROUGH CHALLENGE-BASED LEARNING IN ESP CONTEXTS

Abstract

This study explores the implementation of a Challenge-Based Learning (CBL) methodology that integrates communication pedagogy through the Communication in the Disciplines (CID) model within the context of English for Specific Purposes (ESP). The objective is to assess the effectiveness of CBL in enhancing learning outcomes and developing soft skills, with a particular emphasis on acquiring effective communication skills, which are regarded as the most critical among soft skills. Conducted during the 2022-2023 academic year, the intervention involved 60 computer engineering students tasked with designing advanced AI products for a globally operating software company. After completing the project, students evaluated the CBL-based ESP course, highlighting their overall satisfaction and perceived benefits of developing ESP soft skills, particularly communication. The results demonstrated that students acquired practical knowledge valuable for both professional and educational settings. The findings contribute to the existing literature advocating for the adoption of challenge-based methodologies in teaching language within the engineering curriculum. This study also adds to the broader debate on innovative teaching approaches that better prepare students for globalised, interdisciplinary workplaces.

Key words

challenge-based teaching and learning, ESP, engineering, CID model, effective communication skills.

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1. INTRODUCTION

Engineers must be prepared not only for technical challenges but also for the interpersonal and professional aspects of their careers (de Campos et al., 2020). The engineering industry is rapidly evolving, demanding professionals with a well-defined skill set, geographical mobility, and the ability to collaborate in international and interdisciplinary teams. These teams often use professional and academic English as their *lingua franca* (Dudley-Evans & St John, 1998). Recognising the critical role of communication in engineering success, Darling and Dannels (2003) emphasise that most engineering work occurs in an oral environment where communication skills are the "lifeblood of a practising engineer." The ABET Engineering Criteria (ABET, 2022) highlight "the ability to communicate effectively with a range of audiences" as one of the seven essential outcomes for undergraduate engineering programmes. Research demonstrates that inadequate communication skills can negatively impact the careers of engineering students (Kovac & Sirkovic, 2017; Veis, 2017).

In alignment with ABET's accreditation criteria, Schulz (2008) emphasises that, in addition to communication, soft skills such as teamwork, collaboration, problem-solving, ethical and professional conduct, leadership, adaptability, lifelong learning, interpersonal skills, and global and cultural awareness are essential for proficiency beyond academic and technical knowledge. While communication is a fundamental soft skill, the ability to work effectively in teams, adapt to changing environments, and demonstrate ethical and culturally aware practices is equally important. These soft skills complement technical abilities and are crucial for developing well-rounded professionals equipped to meet the diverse challenges of the modern workplace.

Despite the well-documented need to enhance communication and other soft skills, significant deficiencies persist, particularly among engineering graduates compared to those in the Humanities and Arts (Arnó-Macià et al., 2020; Bobkina et al., 2019, 2020, 2023; Kovac & Sirkovic, 2017). While universities are making efforts to develop communication programmes specifically for engineers (Nisbet & Markowitz, 2015), integrating discipline-specific communication skills within English for Specific Purposes (ESP) contexts remains a challenge (Hyland, 2022; Linvill et al., 2019). Although there has been progress in curriculum and assessment-focused research on ESP communication practices (Bazhutina & Tsepilova, 2024; Hyland, 2022), classroom methods for ESP are still underexplored and require further development (Anđelković et al., 2022; Bell, 2022; Hyland & Jiang, 2021; Tasić & Stamenković, 2024).

To address this need, the present study explores the implementation of a Challenge-Based Learning (CBL) methodology to integrate communication pedagogy within the ESP context, specifically focusing on the Communication in the Disciplines (CID) model (Dannels, 2001). The study aims to assess the effectiveness of challenge-based methods in developing soft skills, with a particular emphasis on

acquiring effective communication skills, which are considered the most crucial among soft skills. To achieve this, we will first analyse communication skills by examining specific subskills relevant to the ESP field. Following this, a comprehensive assessment of overall soft skills, including communication, will be conducted. Finally, we will evaluate students' perceptions of the CBL experience. This three-tiered approach seeks to provide a detailed understanding of the impact of challenge-based methods on communication skills within the ESP context and their broader influence on students' soft skills and overall learning experience.

Given these objectives, this study aims to answer the following research questions:

- RQ1: What are the students' perspectives on the usefulness of the challenge-based methodology for acquiring ESP-related communication skills?
- RQ2: What are the students' perspectives on the usefulness of the challenge-based methodology for acquiring overall soft skills?
- RQ3: What are the students' general perspectives regarding the challenge-based ESP course based on the CID model?

2. THEORETICAL BACKGROUND

2.1. Communication pedagogy in the engineering disciplines

Communication across the Curriculum (CXC) is an area of scholarship and practice that focuses on addressing the teaching and learning of communication in engineering and science education. Building on CXC research, Dannels (2001) introduced an additional model called the CID model, which shifts the teaching perspective from merely presenting disciplinary content to focusing on how that content is shared. This model assumes that student learning in a general classroom is enhanced when content and instruction are tailored to the specific discipline, ensuring that students engage in situations similar to those they will encounter in their future professional lives. The delineation of this model encompasses the following theoretical principles (Dannels, 2001, pp. 147–153):

1) Oral genres are sites for disciplinary learning: Oral communication genres are seen as spaces where disciplinary learning takes place. Students engage in and learn from oral communication within the context of their specific academic disciplines.
2) Oral argument is a situated practice: Oral argumentation is recognised as situated practice, giving importance to the way arguments are situated within the specific context of the discipline.
3) Communication competence is locally negotiated: Communication competence is acknowledged as negotiated locally within the context of a

specific academic discipline. Different disciplines may have unique expectations for effective communication.

4) Learning to communicate is a context-driven activity: Communication is closely related to the context in which communication occurs. The communication context of each discipline should be taken into account when designing communication instruction.

These four principles emphasise the importance of integrating communication skills within the specific contexts of each discipline, ensuring that students can effectively communicate in their future professional or academic endeavours (Dannels & Gaffney, 2009).

According to Sullivan and Kedrowicz (2011), the model "provides a chance for different disciplines to collaborate with the purpose of enhancing and aligning student communication competence with perceived needs of their disciplines and future professions" (p. 389). Following these authors, we will analyse communication skills as part of a more generic set of soft skills or interpersonal skills. Furthermore, we will pause to scrutinise communication skills in detail, paying attention to a list of subskills commonly required in ESP (as presented in section 3).

2.2. Integrating Challenge-Based Learning in ESP contexts

In recent times, the idea of 'grand challenges' (also known as societal challenges), that is, issues that society must address to solve the key problems of global health and development, has had a great influence on defining the direction and scope of national research and innovation programmes (European Commission, 2020; NAE, 2008). The importance of these challenges can hardly be overestimated. Thus, in Europe, Horizon 2020, the biggest EU research and innovation programme, is entirely structured around global societal challenges, such as health and demographic change, climate and energy transition, food security and sustainable agriculture, among others (European Commission, 2020). According to Rådberg et al. (2020), Challenge-Based Learning "takes place through the identification, analysis and design of a solution to a socio-technical problem. The learning experience is typically multidisciplinary, involves different stakeholder perspectives, and aims to find a collaboratively developed solution that is environmentally, socially, and economically sustainable" (p. 22).

Challenge-based education is rooted in experiential learning, which posits that students' learning is significantly enhanced through active involvement in unstructured educational encounters (Kohonen, 1992; Kolb, 1984). This approach emphasises learning through direct experience, reflection, and the application of knowledge and skills in real-world contexts. Closely related to other experiential methodologies, such as problem-based, inquiry-based, and design thinking, CBL

stands out by aiming to address real-world issues rather than merely using global problems as classroom scenarios (Gaskins et al., 2015). Previous research has demonstrated the effectiveness of various experiential learning approaches in engineering contexts, further validating this method (Tatzl, 2015, 2019).

CBL emphasizes real-world, active, self-directed, and contextual learning experiences (van den Beemt et al., 2023). It closely aligns with other active learning methodologies, such as Content-Based Instruction (CBI), which uses subject-specific content to teach language and underscores the importance of context in learning (Brinton et al., 1989; Snow & Brinton, 2017). Both CBL and CBI strive to make learning active and relevant to students' lives. CBL achieves this by fostering practical application through collaboration and hands-on problem-solving, while CBI enhances contextual understanding by integrating subject-specific content into language instruction.

The advantageous outcomes linked to CBL experiences are widely recognised. By facing challenges, students address authentic, real-world problems that exist within their environments and require solutions directly related to their learning context (Pérez-Sánchez et al., 2020). This offers a student-centred learning framework, enabling learners to apply their knowledge and skills in real situations (Gallagher & Savage, 2020; Lin, 2015). Thus, CBL practices represent an additional step towards enhancing students' learning process as 'learning through' rather than 'learning to' (Bernard et al., 2016).

CBL is especially well-suited for engineering studies due to its emphasis on addressing current problems that require practical solutions. This approach encourages students to work collaboratively in teams to develop innovative solutions (Doulougeri et al., 2024; Rådberg et al., 2020). Faculties act as moderators monitoring individual learning processes and clarifying possible doubts from different groups of students (Pisoni et al., 2020). Students acquire specialised knowledge within their field of study while developing soft skills such as problem-solving, creativity, and teamwork. These skills are crucial for both personal and professional success, as they enhance the socioemotional development of each student, making them more effective in any productive activity (Leijon et al., 2021).

Johnson et al. (2009) outline a CBL framework that comprises three key phases: involvement, investigation, and implementation (see Figure 1). The involvement phase begins with the formulation of a challenge, initiated by an essential question that leads to the exploration of a broad topic with significant societal relevance. During the investigation phase, students engage in inquiry and exploration to establish a foundation for developing practical solutions. This phase involves formulating research questions, conducting activities, and utilising resources to acquire the necessary knowledge for creating viable solutions. In the implementation phase, students present evidence-based solutions for class discussion and validation by experts (Nichols et al., 2016). Finally, the documentation of their work is shared and published to disseminate the findings.

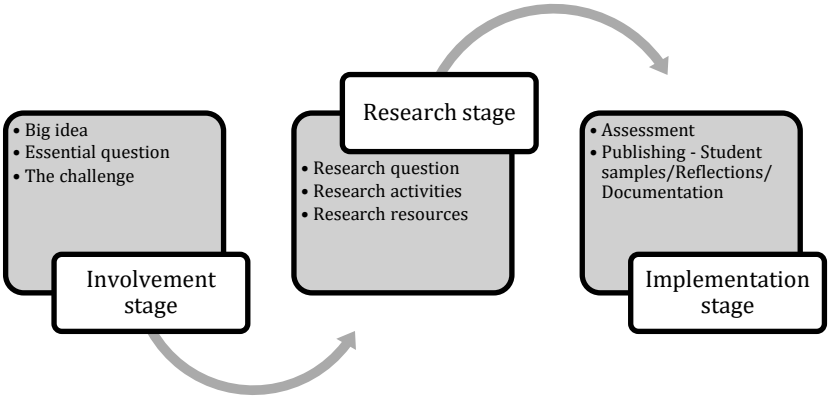

Figure 1. CBL general teaching-learning framework (adapted from Johnson et al., 2009)

Despite the growing body of research on CBL in engineering courses (Azeiteiro et al., 2015; Malmqvist et al., 2015; Mesutoglu et al., 2022; Racovita-Szilagyi et al., 2018; Rådberg et al., 2020; Sidhu et al., 2021), its impact on language learning within ESP contexts remains significantly underexplored (Bobkina & Domínguez Romero, 2022). This gap highlights the need to integrate communication pedagogy that focuses on competencies and skills into engineering education (Linvill et al., 2019). Furthermore, there appears to be a decline in discussions about classroom practices (Hyland, 2022). To address this deficiency, the current study aims to develop, implement, and evaluate an ESP communication course based on the CID model (Dannels, 2001; Dannels & Gaffney, 2009; Dannels et al., 2014).

3. METHOD

The overall research design of the study was descriptive, exploratory, and non-interventionist. We followed a quantitative approach, utilising a Likert-scale 5-point questionnaire to assess our students' opinions on the use of CBL in the ESP classroom. The focus was on evaluating the perceived effectiveness of this methodology in enhancing both their communication skills in English and overall soft skills through active, real-world challenge-based activities.

3.1. Participants

The educational intervention was carried out during the 2022-2023 academic year with 85 students enrolled in Computer Engineering at a Spanish university as part of the course "English for Professional and Academic Communication" (EPAC). Of these students, 25 opted for the final assessment without attending classes. Therefore, data for the study were collected from 60 participants: 53 male and 7 female in their fourth year of the programme, aged between 21 and 26 years. Their

English proficiency levels ranged from B2 to C1 according to the CEFR classification (Council of Europe, 2020), as B2 was *sine qua non* for enrolment in the course. All participants voluntarily and anonymously agreed to participate in the study, and participation or non-participation had no effect on their grades.

3.2. Course design

The EPAC course was developed by the Department of Linguistics Applied to Science and Technology in collaboration with the Department of Computer Systems Architecture and Technology at the School of Computer Engineering. Although the course is taught exclusively in English by the Linguistics Department, collaboration with the Computer Engineering Department was essential for addressing course challenges.

The technical components of the course are integrated into the existing EPAC curriculum, which is mandatory for all engineering schools at the university of research. This dual approach includes foundational concepts covered in ESP communication classes, focusing on both written and oral communication. For written communication, students learn about various academic writing genres, such as research papers, abstracts, and posters. They develop research skills, learn to structure papers, organise paragraphs, use citation styles, acquire academic vocabulary and style, avoid plagiarism, and engage in collaborative writing and peer review. The oral communication component focuses on presentation structure, communication skills, non-verbal communication, and audience interaction. These skills are taught using examples and scenarios specific to computer engineering, ensuring alignment with students' academic pursuits.

Methodologically, the course employs a CBL framework (see Figure 1), centred around tasks within the realm of computer engineering. This aims to connect tasks directed towards resolving the challenges with the overarching goals set for students as future engineers.

To support students' learning through the CBL framework, the Linguistics Department developed RUBRIK (Bobkina & Montiel Ponsoda, 2022), an interactive assessment platform (see Figure 2).[1] Using RUBRIK, students submit self and peer evaluations of their group members in addition to receiving teacher evaluations. The course evaluation criteria require students to prepare two written documents – a poster and a research proposal – and to deliver a final public presentation of each team's solution.

[1] *Rubrik* is an advanced interactive assessment tool designed to generate personalized PDF reports on students' developed posters and research proposals immediately upon completion of the assessment. The platform offers a quiz mode to facilitate understanding of the structural elements of these genres, alongside peer assessment and self-assessment modes, thereby enhancing the evaluative and reflective capabilities of students. https://rubrik.onrender.com/

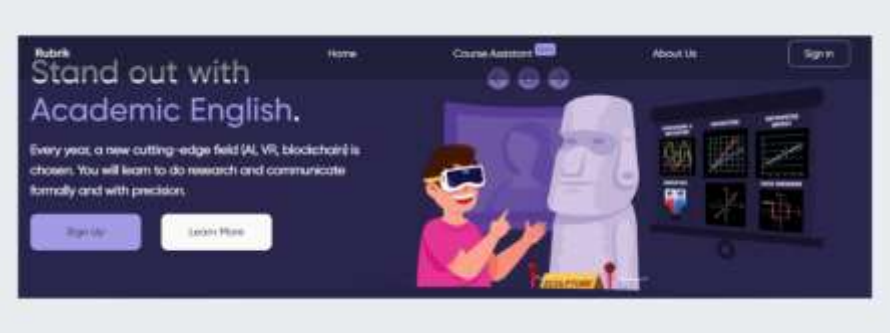

Figure 2. RUBRIK interactive assessment platform (Bobkina & Montiel Ponsoda, 2022)

3.3. Implementation procedures

To implement the CBL methodology with Computer Engineering students in the ESP class, we decided to integrate it into the TELANTO community.[2] This interactive and inspiring online platform is designed to engage students from over 650 universities worldwide in solving real-world business challenges (see Figure 3). By using TELANTO (Science2Society, 2016), we were able to present two authentic challenges to our students, simulating a real working environment. Among the international companies offering challenges, we selected BasementLab (www.thebasement.io), an international technological innovation firm specialising in advanced AI product design, as it aligned best with the objectives of our course.

Figure 3. TELANTO call for challenges notice board

[2] TELANTO is an online platform that connects academia and business through its Academic Business Network and Cloud solution. It enhances challenge-based education, providing students with industry-relevant skills and offering companies modern recruiting practices. http://science2society.eu/content/telanto

As shown in Figure 4, the two challenges proposed involved the development of advanced mobile applications.

Degree	Computer Engineering Degree (4th year students)
Subject	English for Professional and Academic Communication
CHALLENGE 1	
General idea	Access to large communal garages with the help of a mobile phone
Essential question	How can we create a more specific application for large communal garages that addresses individualised hashing?
Challenge to solve	Design a mobile application to access large communal garages using a mobile phone with individualised hashing. The application must include features for users to share parking spaces, utilise an authorised fingerprint system, and provide navigation to parking spots without GPS functionality.
CHALLENGE 2	
General idea	Facilitating the understanding of technical texts
Essential question	How can we create a specific application that would facilitate the understanding of a technical text?
Challenge to solve	Design a mobile application to enhance comprehension of technical texts. The application should analyse content automatically and offer actions and supplementary information to aid understanding. Additionally, propose an objective evaluation technique to measure performance.

Figure 4. Challenges for developing advanced mobile apps

In the case of the first challenge, students were tasked with designing an application that enabled access to large communal garages through a mobile phone (Figure 5). The objective of this challenge was to create a more specific application tailored for large communal garages, emphasising individualised hashing. Regarding the second challenge, the focus was on creating a mobile application that facilitates comprehension of various types of technical texts. This application would serve as an effective tool for enhancing readers' technical knowledge and skills.

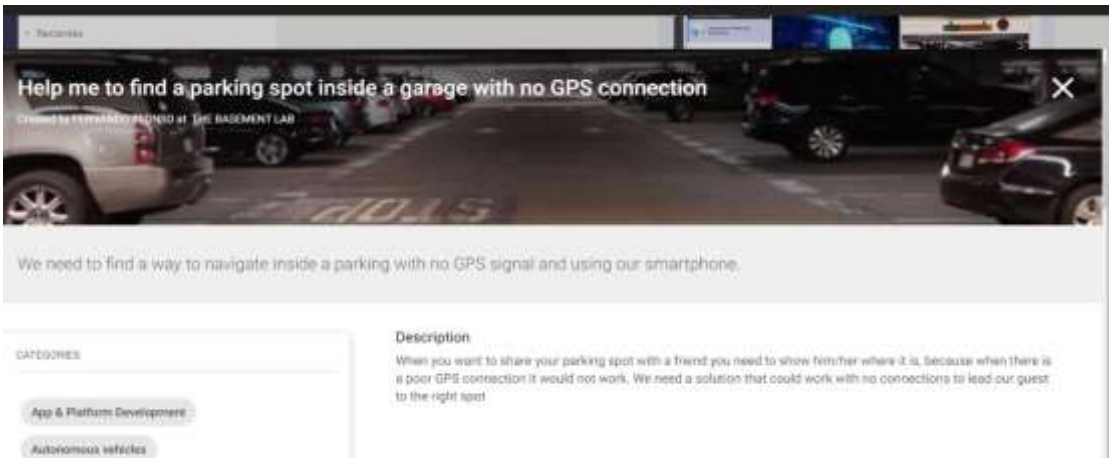

Figure 5. TELANTO platform screenshot: *Help me to find a parking spot inside a garage with no GPS connection* challenge

The collaborating company took on the responsibility of providing technical support and participating with us in several online and face-to-face sessions throughout the semester: launching the challenge and kicking the project off, resolving doubts, as well as providing final feedback and evaluation. Additionally, students had the opportunity to receive personalised support from them, raising their doubts and questions through the TELANTO platform. Figures 6 and 7 illustrate a typical online session and present a schematic overview of the collaborative process, respectively.

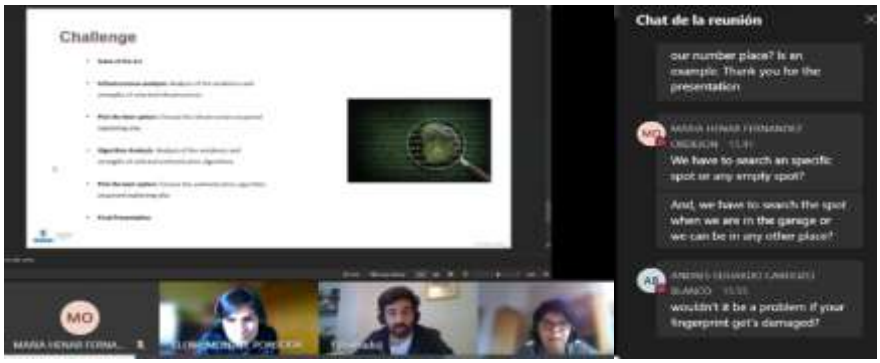

Figure 6. A screenshot of an online kick-off session

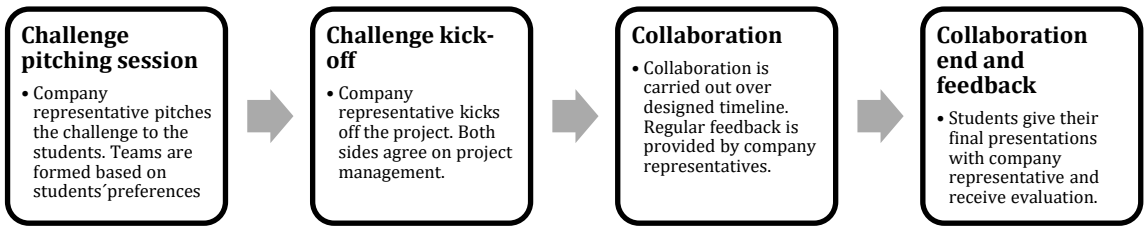

Figure 7. Collaborative process scheme

To pursue the objectives of the course, the proposed solution to the challenge had to be presented in four different formats: 1) a short video (Elevator Pitch) presenting the initial idea; 2) a poster or pentachart (scientific poster template consisting of five parts that allows a concise and graphic representation of a research proposal); 3) a research proposal itself; and 4) an oral presentation of the research proposal. Upon the completion of the project, the best solutions were selected and finally presented to the collaborating company in a face-to-face session. The two best proposals were awarded a diploma. The Appendix presents examples of two of the best pentacharts developed by the students.

Both challenges served as excellent pretexts for students to enhance their oral and written academic communication skills in real-world contexts, as well as to develop other essential soft skills such as teamwork, critical thinking or creativity, among others.

The challenge experience spanned approximately 15 weeks, during which students worked in stable groups of 3 to 4 members – 12 groups of 4 members each and 4 groups of 3 members each. The groups were formed voluntarily to enable students to collaborate with team members they felt most comfortable with.

3.4. Data gathering instruments

To evaluate students' satisfaction with the methodology and gather their perspectives on the effectiveness of CBL for acquiring ESP communication skills and soft skills, we administered an evaluation questionnaire at the end of the course.[3] The questionnaire, outlined in Table 1, consisted of four parts. Sections 1 to 3 aimed to assess students' views on the usefulness of CBL in an ESP classroom setting. These sections contained 31 items designed to measure agreement levels using a five-point Likert scale (ranging from 1 = strongly disagree to 5 = strongly agree). Section 4 focused on collecting sociodemographic information such as age, gender, and degree of the participants.

The initial structure of the questionnaire adhered to Fowler's (2002) reliability principles, focusing on clear language, unbiased structures, and explicit instructions. To refine its clarity, six university students tested the questionnaire, and subsequent revisions were made to eliminate ambiguities and minimise language interpretation errors. Following these adjustments, the questionnaire achieved a Cronbach's alpha reliability coefficient of 0.971, indicating a robust level of internal consistency.

	PART 1. Students' opinions on the usefulness of CBL methodology for acquiring ESP-related communication skills
1.1	Using productive English language skills (e.g., writing and speaking) in academic/professional environment
1.2	Using receptive English language skills (e.g., listening and reading) in academic/professional environment
1.3	Understanding the structure of a poster/pentachart
1.4	Understanding the structure of a research proposal
1.5	Using academic language in formal communication
1.6	Constructing a well-written paragraph
1.7	Quoting and referencing the information sources
1.8	Using writing editors and assistants
1.9	Understanding the structure of a good oral presentation
1.10	Understanding how to develop efficient visual support for oral presentation
1.11	Using an efficient structure and literary devices (metaphor, simile)
1.12	Using efficient non-verbal language
1.13	Answering the audience questions effectively
1.14	Handling stress

[3] The research did not require ethics committee approval because it involved standard classroom activities with minimal risk, voluntary and anonymous participation, and no sensitive data collection.

PART 2. Students' opinions on the usefulness of CBL methodology for acquiring overall soft skills (including communication)	
2.1	Communication: sharing ideas
2.2	Collaboration: working together, learning together
2.3	Information literacy: untangling the web (to solve the challenge)
2.4	Invention: creating solutions
2.5	Critical thinking: thinking deep, thinking differently
2.6	Self-direction: owning your learning
PART 3. Students' general opinions on the challenge-based experience	
3.1	The challenge met my expectations
3.2	The challenge was exciting and motivating
3.3	The working/learning environment was pleasant
3.4	The duration of the challenge was adequate
3.5	I gained some professional knowledge during the challenge that will be helpful for my future career
3.6	I appreciated working with an authentic challenge
3.7	I enjoyed taking part in the oral presentation sessions and interacting with other groups
3.8	I found it helpful to exchange my group's proposal with the rest of the teams
3.9	I found it helpful to peer-evaluate my classmates' proposals and vote for the best ones
3.10	I found it interesting to conclude the challenge by presenting the best solutions to the whole group
3.11	I would recommend the challenge-based methodology as an ESP teaching/learning method

Table 1. Evaluation questionnaire on CBL effectiveness in ESP communication and soft skills

4. ANALYSIS OF THE RESULTS

This section analyses the survey results regarding the effectiveness of the CBL methodology in enhancing ESP communication skills and overall soft skills among university students. The analysis is organised into three main areas: students' opinions on the usefulness of CBL for acquiring ESP communication skills, their views on the impact of CBL on soft skills, and their overall perceptions of the challenge-based ESP course. To thoroughly evaluate the data, we employed various statistical techniques using SPSS (IBM, 2020). Descriptive statistics – including mean, median, mode, and standard deviation – were computed to summarise central tendencies and variability in the responses. We conducted frequency analysis to assess how students rated different aspects of CBL, focusing on the proportion of students who found each skill "very/extremely useful" or "moderately useful." Additionally, we performed a reliability analysis using Cronbach's alpha to ensure the internal consistency of the survey items. Finally, we used visual representations, such as bar and pie charts, to clearly illustrate the findings and facilitate interpretation.

4.1. The usefulness of a challenge-based methodology for acquiring ESP-related communication skills

Findings revealed that students generally find CBL beneficial across various academic competencies (see Table 2). In particular, there was strong consensus among students on the effectiveness of CBL in enhancing specific communication

skills, such as understanding the structure of research articles, using academic language, and structuring effective oral presentations. These aspects received the highest mean scores – 4.15, 4.15 and 4.20, respectively – indicating a robust endorsement of CBL's impact in these areas. Additionally, students expressed positive feedback on acquiring both productive and receptive English language skills, constructing coherent paragraphs, and developing compelling visual aids for presentations, with mean scores ranging from 3.83 to 4.08. However, there was moderate agreement on the usefulness of CBL for tasks such as quoting and referencing, employing literary devices effectively, utilising non-verbal communication, and responding to audience questions, with mean scores ranging from 3.57 to 3.77. The lowest agreement was noted in areas concerning the use of writing editors and assistants, as well as managing stress, with mean scores of 3.32 and 3.45, respectively. These results suggest a varied perception among students regarding the applicability of CBL in certain aspects of ESP communication skills.

	Using productive English language skills	Using receptive English language skills	Understanding the structure of a poster	Understanding the structure of the research	Using academic language in formal communication	Constructing a paragraph	Quoting and referencing	Using writing editors and assistants	Understanding the structure of the oral	Developing a good visual support	Using an efficient structure and literary devices	Using efficient non-verbal language	Answering the audience questions	Handling stress
N valid	60	60	60	60	60	60	60	60	60	60	60	60	60	60
Mean	4.03	3.83	3.60	4.15	4.15	3.93	3.77	3.32	4.20	4.08	3.57	3.73	3.67	3.45
Median	4.00	4.00	4.00	4.00	4.00	4.00	4.00	3.00	4.00	4.00	4.00	4.00	4.00	4.00
Mode	4	4	5	5	5	5	4	4	5	5	4	4	4	4
Deviation	0.94	0.97	1.36	.094	0.97	1.13	1.08	1.13	1.02	1.08	1.13	1.10	1.16	1.40

Table 2. Students' ratings of ESP communications skills acquisition through CBL methodology: Mean ratings and distribution

Further evaluation involved transforming raw data into a descriptive scale ranging from 'not useful at all' to 'extremely useful.' Figure 8 illustrates that an overwhelming majority of respondents (86.7%) considered CBL extremely or very useful for acquiring ESP-related communication skills. In contrast, only 10% found it moderately useful, and 3.3% described it as slightly useful, demonstrating widespread agreement on CBL's effectiveness in enhancing ESP competencies.

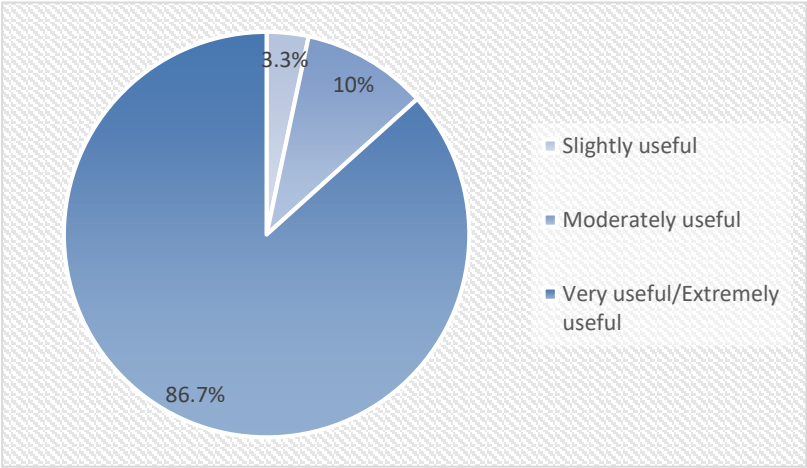

Figure 8. Students' general opinions regarding the usefulness of CBL methodology for acquiring ESP-related communication skills

A detailed examination of communication subskills within ESP contexts encompassed written and oral proficiencies (see Table 3). Regarding written communication, CBL was particularly effective in employing academic language in formal contexts (81.7%), improving understanding of research document structures (78.3%), and constructing well-articulated paragraphs (70%). However, skills related to comprehending poster structures and using writing editors were deemed less beneficial, with only 55% and 46.3% of respondents, respectively, perceiving CBL as very or extremely useful in these areas. In oral communication, CBL excelled in the development of visually compelling support materials (81.7%) and in enhancing comprehension of presentation structures (83.3%). Conversely, students indicated that CBL was less effective in addressing stress management (58.3%), using non-verbal communication effectively (65%), and employing literary devices such as metaphor and simile (65%). These findings highlight specific areas where refinement of CBL methodologies could enhance overall efficacy in preparing students for real-world communication challenges.

	Useless/ Slightly useful	Moderately useful	Very/ extremely useful
Using productive English language skills (e.g., writing and speaking) in academic/professional environment	6.7%	16.7%	76.7%
Using receptive English language skills (e.g., listening and reading) in academic/professional environment	10%	21.7%	68.3%
Understanding the structure of a poster	21.7%	23.3%	55%
Understanding the structure of a research proposal	5%	16.7%	78.3%
Using academic language in formal communication	8.3%	10%	81.7%
Constructing a well-written paragraph	13.3%	16.7%	70%
Quoting and referencing the information sources	11.7%	26.7%	61.7%
Using writing editors and assistants	21.7%	30%	46.3%
Understanding the structure of a good oral presentation	8.3%	8.3%	83.3%

Understanding how to develop efficient visual support for oral presentation	10%	8.3%	81.7%
Using an efficient structure and literary devices (metaphor, simile)	16.7%	18.3%	65%
Using efficient non-verbal language	13.3%	21.7%	65%
Answering the audience questions effectively	16.7%	18.3%	65%
Handling stress	23.3%	18.3%	58.3%

Table 3. Students' opinions on the usefulness of CBL methodology for acquiring ESP-related communication skills

4.2. The usefulness of a challenge-based methodology for acquiring overall soft skills (including communication skills)

Findings revealed that students generally perceive the CBL approach as beneficial for developing a range of soft skills (see Table 4). Notably, there was strong consensus on the effectiveness of CBL in enhancing specific soft skills, with communication skills receiving the highest mean score of 3.90. Other areas of positive impact included collaboration (3.75), critical thinking (3.72), self-direction (3.70), creativity (3.57), and information literacy (3.45). Median and mode values of 4 across the board reflect a general agreement on CBL's positive impact. Standard deviations ranged from 0.95 to 1.22 indicating that self-direction skills had the most consistent responses, while collaboration skills showed the most variability. In general, the data suggest that students find CBL effective in enhancing various soft skills relevant to ESP.

	Collaboration skills	Communication skills	Information literacy	Creativity	Critical thinking skills	Self –direction skills
N valid	60	60	60	60	60	60
Mean	3.75	3.90	3.45	3.57	3.72	3.70
Median	4.00	4.00	4.00	4.00	4.00	4.00
Mode	4	4	4	4	4	4
Deviation	1.22	0.99	1.13	1.11	1.01	0.95

Table 4. Students' ratings of ESP soft skills acquisition through CBL methodology: Mean ratings and distribution

To gain deeper insights, raw data from items 2.1 to 2.6 (see Table 1) were categorised using verbal descriptors: 'not useful at all,' 'slightly useful,' 'moderately useful,' 'very useful,' and 'extremely useful.' As shown in Figure 9, 85% of students rated the CBL methodology as very or extremely useful, 12% as moderately useful, and 3% as slightly useful.

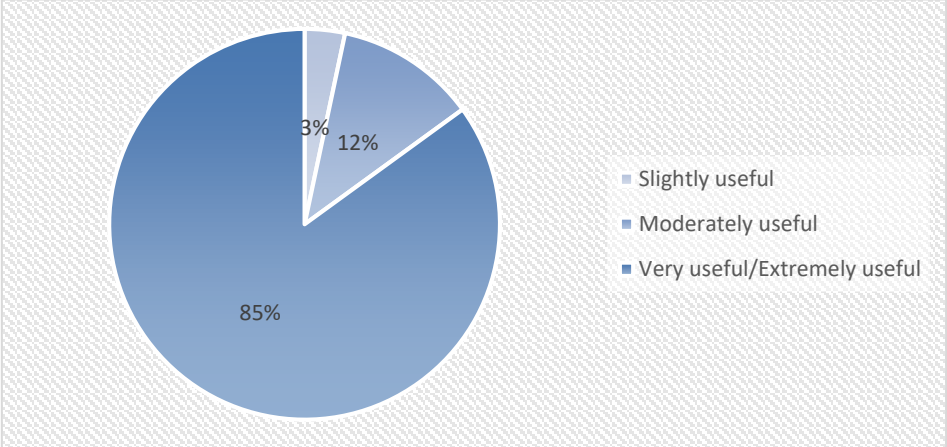

Figure 9. Students' general opinions regarding the usefulness of CBL methodology for acquiring soft skills

An examination of the effectiveness of the CBL methodology in developing various soft skills revealed varied perceptions among students (see Table 5). Communication skills were highly valued, with 80% of respondents acknowledging CBL's effectiveness in improving interpersonal communication. Collaboration skills, which encompass working and learning together, were recognised as beneficial by 66.7% of students. Critical thinking and self-direction both showed similar levels of appreciation, with 66.7% of participants finding CBL to be very or extremely useful in fostering these skills. Conversely, information literacy skills were perceived as the least beneficial, with only 56.7% recognising CBL's value in this area. The responses on creativity skills were mixed: 20% considered CBL to be slightly useful or useless for fostering creativity, while a significant majority of 63.3% found it effective in generating new solutions and enhancing creative thinking.

	Useless/ Slightly useful	Moderately useful	Very/ extremely useful
Communication: sharing ideas	11.7%	8.3%	80%
Collaboration: working together, learning together	15%	18.3%	66.7%
Information literacy: untangling the web	18.3%	25%	56.7%
Invention: creating solutions	20%	16.7%	63.3%
Critical thinking: thinking deep, thinking differently	10%	23.3%	66.7%
Self-direction: owning your learning	10%	23.3%	66.7%

Table 5. Students' opinions regarding the effectiveness of the CBL methodology for acquiring overall soft skills

4.3. Students' overall opinions about the challenge-based ESP course based on the CID model

Findings reveal that students generally had positive evaluations of the challenge-based ESP communication course based on the CID model, as shown in Table 6. The working/learning environment received the highest mean score of 3.85, indicating that students found it pleasant. However, the challenge's excitement and motivation aspect scored the lowest with a mean of 3.25, suggesting areas for improvement. Mean scores for other aspects ranged from 3.27 to 3.73, with medians and modes of 4 for most items, reflecting a positive consensus. Standard deviations ranged from 0.92 to 1.35 indicating different levels of agreement among responses. Overall, students appreciated the practical knowledge gained and the authenticity of the challenges, with a mean recommendation score of 3.70, though aspects related to excitement and motivation could be enhanced.

	The challenge met my expectations	The challenge was exciting and motivating	The working environment was pleasant	The duration was adequate	I gained professional knowledge	I appreciated working with an authentic challenge	I enjoyed taking part in the oral presentations	I found it helpful to exchange my proposals with other teams	I found it helpful to peer evaluate my classmates proposals	I found it interesting to conclude by presenting the best solutions	I would recommend the CBL method for ESP courses
N valid	60	60	60	60	60	60	60	60	60	60	60
Mean	3.52	3.25	3.85	3.73	3.27	3.62	3.47	3.43	3.38	3.57	3.70
Median	3.50	3.00	4.00	4.00	3.00	4.00	4.00	4.00	4.00	4.00	4.00
Mode	3	3	4	4	4	4	4	4	4	4	4
Deviation	0.98	1.00	0.92	1.10	1.18	1.20	1.33	1.35	1.20	1.25	1.18

Table 6. Students' ratings of overall opinions regarding the challenge-based ESP course: Mean ratings and distribution

For further analysis, data from items 3.1 to 3.11 (see Table 1) of the questionnaire were recoded into a new variable reflecting differences in attitude, categorised into five levels: 'strongly negative,' 'mostly negative,' 'neutral,' 'mostly positive,' and 'strongly positive.' Figure 10 shows that over 71.7% of the respondents had a strongly or moderately positive attitude towards challenge-based activities, followed by about 20% of neutral respondents and 8.3% with mostly negative perceptions.

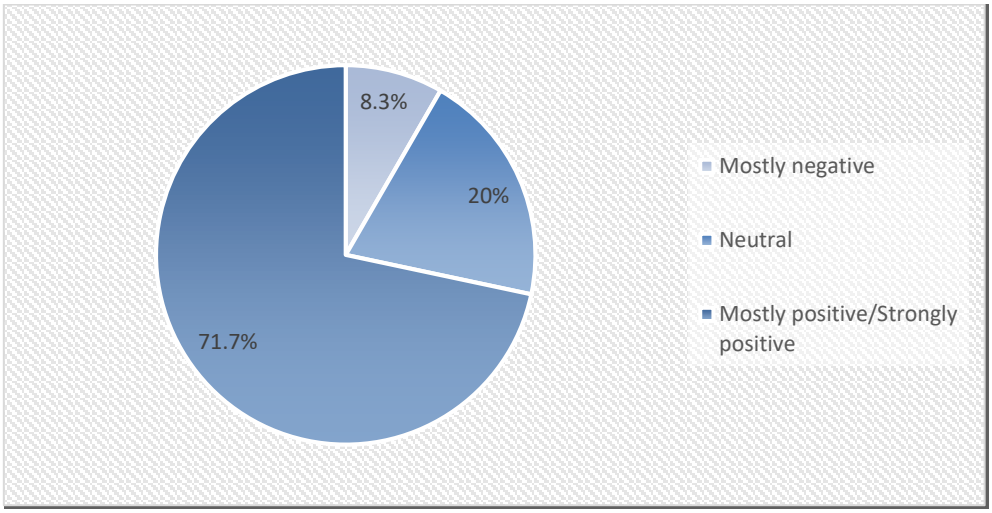

Figure 10. Students' general perception about the CBL methodology for language learning in the ESP context

Regarding the analysis of specific items (Table 7), the highest-rated aspects were the working/learning environment and the challenge duration, with 66.7% and 65% positive responses, respectively. Almost 62% of participants appreciated working with an authentic challenge. Furthermore, 57.4% perceived it as exciting and motivating. Generally, 60% of respondents felt the challenge met their expectations, and 63.3% agreed on its usefulness for their future careers. Oral presentations were also perceived positively, with 60% of respondents enjoying participation and 66.7% appreciating the presentation of the best solutions. More than 63% of respondents would recommend the CBL methodology as a suitable ESP teaching/learning method. However, aspects related to teamwork and peer evaluation were more contentious, with approximately one-fifth of respondents disliking peer evaluation. Further research is needed in this regard.

	Strongly disagree/ disagree	Undecided	Agree/ strongly agree
The challenge met my expectations	10.7%	33.3%	60%
The challenge was exciting and motivating	12.6%	30%	57.4%
The working/learning environment was pleasant	8,3%	25%	66.7%
The duration of the challenge was adequate	13.3%	21.7%	65%
I gained some professional knowledge during the challenge that will be helpful for my future career	15%	21.7%	63.3%
I appreciated working with an authentic challenge	16.6%	21.7%	61.7%
I enjoyed taking part in the oral presentation sessions and interacting with other groups	21.7%	18.3%	60%
I found it helpful to exchange my group's proposal with the rest of the teams	25%	18.3%	56.7%
I found it helpful to peer-evaluate my classmates' proposals and vote for the best ones	21.7%	26.7%	51.6%

I found it interesting to conclude the challenge by presenting the best solutions to the whole group	20%	13.3%	66.7%
I would recommend the challenge-based methodology as an ESP teaching/learning method	13.3%	23.3%	63.3%

Table 7. Students' general perception about the CBL methodology for language learning in the ESP context

5. DISCUSSION

The present research aimed to provide further insights into the application of the CBL methodology within situated communication pedagogy, incorporating the CID model, for foreign language acquisition in ESP computer engineering contexts. The findings reveal that students exhibited a strongly positive attitude towards the CBL methodology based on the CID model, indicating their readiness to endorse CBL methodology as an effective approach to teaching and learning ESP. Students particularly valued the opportunity to address real challenges posed by leading tech companies that use English mediated communication. Engaging with these challenges was not only motivating but also provided valuable professional experience in AI product design. Many respondents also reported feeling more prepared to work in an international environment, as they had not previously used English for professional communication. While most students evaluated teamwork and collaboration positively, peer-assessment practices were largely criticised. Consistent with prior research, assessment remains a challenging aspect of CBL and deserves further attention from educators (Membrillo-Hernández et al., 2021).

Regarding ESP-related communication skills, the CBL methodology was notably effective in developing productive communicative abilities, both written and oral, especially when it came to designing and defending technical-scientific projects. Students appreciated the opportunity to use English in formal academic and professional situations closely resembling real-life contexts and involving external stakeholders. These findings align with previous research, emphasising the effectiveness of CBL as an active learning and employment-oriented pedagogy, promoting skill development among students in various disciplines, including learning sciences, cognitive psychology, and educational psychology (Espey, 2018; Lee et al., 2021; Seman et al., 2018). Therefore, this educational approach proves highly relevant in exposing students to professional challenges, facilitating the development of both disciplinary and cross-disciplinary competencies. Additionally, several authors argue that CBL not only enhances understanding of challenging disciplinary concepts (López-Fernández et al., 2020; Pérez-Sánchez et al., 2020) but also serves as a valuable complement to traditional teaching methods (Seman et al., 2018).

Regarding the development of overall soft skills, the results of the study demonstrate that most of the students were highly positive when evaluating the effect of the CBL methodology on their interpersonal skills. Beyond communicative

skills, students emphasised its effectiveness in promoting collaborative skills and critical thinking, and creativity. These findings are consistent with previous research validating the benefits of CBL in cultivating cross-curricular skills across disciplines such as science, medicine, and engineering. Scholars like Espey (2018) and Olivares Olivares and López Cabrera (2017) assert that CBL can contribute significantly to developing critical and creative skills by encouraging students to propose and implement solutions to real-world problems. According to Kasch et al. (2023), active learning approaches like CBL are instrumental in supporting interdisciplinary learning and collaboration. Similarly, Yang et al. (2018) advocate for CBL as a method to enhance students' innovation and creativity, fostering curiosity, breaking patterns, and generating new ideas (p. 46). Additionally, Charosky et al. (2021) and Pérez-Sánchez et al. (2020) emphasise CBL's role in developing teamwork and networking skills.

Unexpectedly, information literacy skills were rated as the least beneficial. This could be attributed to most senior students' proficiency in finding, evaluating, and organising information. Another unexpected finding was the variation in students' opinions regarding the usefulness of CBL in developing creativity, with one-fifth of the students expressing no perceived value in this aspect. This result is somewhat perplexing and warrants further research.

6. CONCLUSIONS

The findings underscore the educational implications of incorporating challenge-based methodologies into language teaching practices, particularly within ESP engineering contexts. Educators are encouraged to integrate real-life challenges posed by engineering companies as a framework for foreign language curricula. Addressing authentic problems not only enhances communication skills but also develops critical soft skills necessary for professional success. Pedagogically, CBL engages students deeply, fostering better retention and practical application of language skills. To maximise CBL's effectiveness, educators should design relevant and adaptable CBL activities, implement diverse assessment methods, and provide continuous feedback. Adequate resources and comprehensive educator training are also essential. However, the study's limitations must be acknowledged. The sample size was limited, and reliance on self-reported quantitative data may impact the study's reliability and validity. Future research should incorporate additional qualitative inquiries to explore student decision-making processes and preferences when engaging with challenges. Expanding the sample size to include students from diverse engineering disciplines would further validate the outcomes and provide deeper insights into the effective implementation of CBL in ESP contexts.

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Appendix

Examples of two of the best pentacharts developed by the students