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Promoting soft skills in higher engineering education: Assessment of the impact of a teaching methodology based on flipped learning, cooperative work and gamification

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Abstract

In the dynamic and complex environment of industrial engineering, soft skills have become fundamental elements to achieve professional success. This work analyzes (i) how industrial engineering students at the University of Valladolid in Spain perceive the effect of a teaching methodology (characterized by a sound and systematic integration of Information and Communication Technologies (ICT) in all phases of the teaching–learning process and based on the combination of Flipped Learning, cooperative work and gamification), on the development of their soft skills, and (ii) the relationship between this development of soft skills and academic performance. Voluntary surveys were applied to students of seven engineering degrees during four academic years. Data collected have been analyzed by means of graphical and statistical techniques to obtain a deep and rigorous understanding of the impact of teaching methodology. The results show a positive perception by students of the effect of teaching methodology. It is not only a motivating element that improves participation but, moreover, students perceive that it significantly contributes to the development and enhancement of skills such as communication, teamwork, problem solving, critical thinking and the effective use of ICT. In addition, the positive influence of these competencies on academic performance was evidenced. This work identifies several key aspects related to the results obtained: (i) the synergies achieved by combining Flipped Learning with cooperative work and gamification; (ii) the importance of face-to-face activities and encouraging students' active participation; (iii) the outstanding effect of the appropriate integration of ICT on the results; (iv) the adaptation of teaching to the needs of each group of students; and (v) the fundamental role of monitoring and continuous improvement of methodology as pillars to guarantee its long-term effectiveness and to overcome any challenges that may arise.

Keywords Flipped learning · Cooperative work · Gamification · Soft skills · Academic performance · Information and communication technologies

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1 Introduction

Within the framework of the European Higher Education Area (EHEA), generic competencies or soft skills have become an essential component in the comprehensive training of university students, which seeks to prepare them as future professionals and citizens (Crespí & García-Ramos, 2020; González & Wagennar, 2006; United Nations Educational Scientific and Cultural Organization (UNESCO), 2015). Social, emotional and interpersonal skills, such as effective communication, adaptability, time management, teamwork, critical thinking, problem solving, etc., are fundamental skills in the twenty-first century (Chan et al., 2017). They not only have a positive impact on students' academic and social performance (Aryani et al., 2021), but are also essential to ensure their employability and professional development, as shown by numerous works (Aryani et al., 2021; Barhoumi, 2023; Caggiano et al., 2020; Cinque, 2016; Diez et al., 2020; Gibb, 2014; Ibrahim et al., 2017; Majid et al., 2012; Mwita et al., 2023; Shehu Lokaj et al., 2021; Srivastava & Kuri, 2021; Vera, 2021).

In the specific context of engineering, research on soft skills development has been growing over the years in number and relevance (Caggiano et al., 2020) because companies are looking for engineers who, in addition to possessing technical skills (hard skills), also possess the soft skills needed in today's Industry 4.0 context (Jamila, 2020; Sakran & Prescott, 2013). Employers are aware of the importance of these skills to improve the efficiency and organization of different tasks and work groups (Barhoumi, 2023). To be successful in their profession, engineers must possess a balanced combination of hard and soft skills, allowing them not only to efficiently address the technical and economic aspects of their work, but also to fulfill their responsibility to solve problems and meet the needs of society (De Campos et al., 2020). Some authors even consider that the importance of the soft skills required for current and future engineers exceeds the importance of technical skills (Lowden et al., 2011; Ten Caten et al., 2019).

Companies are looking for engineers who are creative, innovative, critical thinkers, self-learners, proactive, etc., and who can work cooperatively to meet the many challenges of increasingly dynamic and changing environments (Andrews & Higson, 2008; Diez et al., 2020). There is no doubt that this demand will increase as companies adopt the paradigms of Industry 5.0, an enhanced version of Industry 4.0 that recognizes the importance of the human factor and seeks to harness creativity, intelligence and human qualities to increase the efficiency of processes (Poláková et al., 2023).

Numerous organizations, aware of this fact, have focused their efforts to respond to the importance of soft skills in engineering (De Campos et al., 2020), trying to combine business needs with university education. In this sense, the EUR-ACE label, defined by the European Network for Accreditation of Engineering Education (European Network for Accreditation of Engineering Education (ENAEE), 2021) for degree and master's degree programs (Haro et al., 2023), plays a crucial role at the European level by establishing standards that go beyond technical competences. EUR-ACE promotes an integrated approach in engineering education, recognizing the importance of soft skills and their development for future graduates to be able to face diverse and continuously evolving professional environments.

However, even though universities encourage the development of knowledge that can be measured in terms of hard skills and soft skills (Betti et al., 2022), the integration of the latter in higher education programs is still insufficient, especially when compared to the extent to which technical skills are integrated into higher education programs (Diez et al., 2020; K. N. Tang, 2018). Moreover, these programs are generally based on the use of "traditional" or "passive" learning methods (Arasti et al., 2012) that are teacher-centered (Barhoumi, 2023), characterized by a unidirectional transmission of knowledge (Gatica-Saavedra & Rubí-González, 2020) and by a lack of interactivity, and in which the development of soft skills is not adequately addressed. Addressing this problem requires the use of "innovative" or "active" pedagogical approaches (Arasti et al., 2012), more interactive and student-centered, to help students cultivate skills beyond the mere acquisition of technical knowledge and prepare them for success in an increasingly diverse and dynamic world (Ten Caten et al., 2019).

In the last few decades, experimentation with active learning methodologies, both inside and outside the classroom, has grown significantly in response to the demands of an interconnected XXI century (Troncoso Lobos, 2023). This has given rise to many teaching methodologies (Arasti et al., 2012) that try to extend the possibilities of the lecture method so widely used in higher education, allowing students to develop both their soft skills and technical skills (Diez et al., 2020). It is in this context that Flipped Learning[1] (FL) has burst onto the scene (Lage et al., 2000). Although it is not new (Al Mamun et al., 2022), FL is a methodological approach that is gaining more and more presence and importance in the most diverse educational scenarios (Ovcharuk et al., 2023) due to advances in new technologies and the large number of resources currently available on the internet (Cheng et al., 2019). Thanks to FL, students can transform information into knowledge in a process facilitated by the teacher, allowing them to improve their academic performance, their understanding and the development of their soft skills (Birgili et al., 2021).

To achieve this goal, FL actively flips the traditional teaching (Martínez-Jiménez & Ruiz-Jiménez, 2020) by reorganizing the learning processes of the traditional approach (Galindo & Badilla Quintana, 2016). Specifically, the teacher makes some or all the direct instruction available to students through audiovisual resources and contents that they can consult at any time (Bergmann & Sams, 2012), and class time is used to engage them in hands-on and collaborative activities (Flipped Learning Network Hub, 2014), thus reformulating the link between teachers and students (Troncoso Lobos, 2023). It is a methodology recommended to increase student engagement and capture their attention during classes (Elmaadaway, 2018), in which

[1] In 2016, numerous teachers, scholars, researchers, and practitioners in FL formed the Flipped Learning Global Initiative (FLGI) with the intention of identifying best practices in FL (Flipped Learning Global Initiative (FLGI), 2024) and thus supporting the adoption of this methodology worldwide (McCarthy, 2016). FLGI's work is helping to replace the term "flipped classroom" with "flipped learning," which reflects a broader understanding of this approach, as it facilitates teaching independently of the environment, rather than simply as a way of organizing classes (Birgili et al., 2021).

the teacher merely provides the appropriate materials and supports the activities of students (Stöhr et al., 2020), who interact with each other peer-to-peer in a hands-on, collaborative and critical way (Troncoso Lobos, 2023).

But FL not only changes classroom dynamics or the roles of teachers and students (Troncoso Lobos, 2023), but also flips the pyramid of Bloom's Taxonomy (Bloom, 1956) by placing the elements "understanding" and "remembering" as the bases for work outside the classroom, while analysis, evaluation and creation take place inside the classroom (Zainuddin & Halili, 2016). Consequently, thanks to FL, students achieve more meaningful learning and are able to think about the subject matter at higher levels of Bloom's taxonomy, while exercising multiple soft skills in the activities they perform, both inside and outside the classroom. In addition, this methodology allows them to manage and advance at their own pace, with the teacher's guidance, something promoted by UNESCO, especially in situations as complex as the one recently experienced with the COVID-19 pandemic (United Nations Educational Scientific and Cultural Organization (UNESCO), 2020).

The combination of FL with other methodologies, such as cooperative work and gamification, is a dynamic and effective strategy to enhance the development of soft skills among students, especially in the university environment (Ekici, 2021; Pozo Sánchez et al., 2020; Sailer & Sailer, 2021; Segura-Robles et al., 2020). FL fosters the capacity for autonomous learning, critical thinking, self-regulation, time management, decision making, reflection capacity, continuous improvement, etc. The integration of cooperative work and gamification adds a playful and motivating aspect to the learning experience. In this way, student participation is increased, while promoting skills related to teamwork and communication, problem solving, decision making under pressure, creativity, etc., all of which are highly valued skills in the professional environment.

After several academic years applying this methodological approach in several subjects taught at the School of Industrial Engineering of the University of Valladolid (UVa), we have proposed to study the results of its implementation. In particular, and after having analyzed in a previous work the impact on academic results (Galindo-Melero et al., 2024), this work aims to analyze the opinion of our students on how the combined use, by means of the transversal application of Information and Communication Technologies (ICT) tools, of FL approach, cooperative work and digital gamification tools has contributed to the development of their soft skills. We also analyze the relationship between this assessment and the academic results achieved. This is a longitudinal study based on data collected through student surveys during the last four academic years.

This work is organized as follows. First, the main aspects of the methodology employed in the study are described, including the context, motivation, research questions (RQ), data collection, the soft skills involved in the study, and a brief description of the analysis performed. Next, the results of the evaluation of the responses provided by the students, regarding the two RQ raised in the study, are shown. The discussion section analyzes the results obtained, by relating them to the RQ, and discusses aspects of the study itself, such as its strengths, limitations, implications, recommendations, etc. Finally, the main conclusions of the study are drawn.

2 Methodology

2.1 Context and motivation

The study focuses on the subject in which the teaching methodology began to be applied, Production and Manufacturing Systems (PMS), a subject taught in seven of the nine degrees in industrial engineering offered by the UVa. With a load of 4.5 ECTS credits and a multidisciplinary approach, PMS covers a wide range of topics related to production systems in industrial environments, so its teaching is divided into three thematic blocks given by three different departments of the UVa.

Initially, the educational methodology used in the three thematic blocks was based on the use of master lectures, while the evaluation was centered on written exams and laboratory practices. Over the years, a significant problem was identified in the third thematic block of the subject, in which two key tools for decision making related to production systems, simulation and costs, were addressed. Specifically, students showed a markedly lower academic performance compared to the other two thematic blocks, and the trend was clearly negative.

Although several causes were identified (Galindo-Melero et al., 2024), it was noteworthy that students only achieved a very superficial understanding of the concepts and related tools. Despite high class attendance rates and the fact that students claimed in the surveys to understand the subject matter, it was evident that the learning model implemented was not working. Many students did not practice problem solving, either in the classroom or at home, nor did they acquire the skills needed to solve the problems, such as the ability to analyze and synthesize, critical thinking, creativity, pressure tolerance, etc.

To address this challenge, a methodology focused on FL, cooperative work and gamification, and on a transversal application of ICT tools, was implemented in the third thematic block. This methodology was designed to encourage the students' active participation, promote teamwork and develop the necessary skills for solving the aforementioned problems. In line with the FL, before each class, students review the online didactic material to prepare for the face-to-face activities; specifically, they interact with the content available in several formats, including presentations (both static in pdf and dynamic in Genially) and videos (both in-house and external), in addition, they assess their level of understanding through quizzes on the LMS platform, which include interactive H5P quizzes. During classes, time is devoted to hands-on, collaborative activities, where students work in teams to solve problems and participate in gamification quizzes with Socrative (Pryke, 2020); in addition, students strengthen their knowledge in practical laboratories where, following a learning-by-doing approach, they address real challenges and experiment with various simulation tools. After class, they complete digital homework assignments and quizzes autonomously to reinforce the knowledge acquired and identify doubts and questions.

The implementation of this methodology has been carried out gradually (Hao, 2016), although from the beginning it was already possible to appreciate a remarkable improvement in academic results, which was accompanied by a better satisfaction level of the students. After several years of implementation, we are now at an appropriate time to evaluate in depth the extent to which the aforementioned methodology has allowed to address the RQ. In particular, in this study we assess the extent to which the methodology is contributing to the development of students' soft skills and whether there is a correlation between these skills and academic results.

Although active learning methodologies and the tools that are part of the proposed educational methodology have already been widely used in higher engineering education, these methodologies have generally been used separately, i.e., by studying the application of a certain methodology independently from the others. On the contrary, this study is characterized by an integrated approach that combines FL, cooperative work and gamification, using ICT as a transversal and unifying thread, which not only facilitates the acquisition of theoretical knowledge, but also contributes to the development of soft skills and digital skills, essential in today's labor market.

2.2 Research questions

The first RQ (RQ1) is the following: *What is the students' perception about the degree to which the methodology used has allowed them to develop their soft skills?* Specifically, the study has been conducted among students of seven degrees in industrial engineering over the last four academic years and considers a total of 25 soft skills. A longitudinal design has been chosen as it allows to observe changes and trends in the students' perception over time, providing valuable information on the effectiveness of the new methodology.

However, we think it is important to consider a more comprehensive perspective. As mentioned in (Betti et al., 2022), most of the studies that evaluate the impact of active learning techniques usually analyze technical and soft skills separately. For this reason, we also set a second RQ (RQ2): *What is the relationship between the development of soft skills and academic performance (hard skills)?*

This study will not only allow a better understanding of the influence of the new educational methodology on the comprehensive education of industrial engineering students but will also provide valuable insights to continuously improve and adapt the methodology. In this way, we will be able to focus our activities more effectively in the future, ensuring a comprehensive and effective development of the students' soft skills.

2.3 Data collection

For this study, data were obtained from the surveys that students voluntarily completed through the virtual classroom of the subject once the teaching of the thematic block had concluded. In addition, student academic information has been collected through SIGMA (the application for the management of academic procedures at the UVa) and the virtual classroom of the subject, to better characterize the study population.

This population is constituted by students of the seven degrees in industrial engineering at the UVa in which the subject is taught. The study covers a period of four academic years, from 2020–2021 to 2023–2024. The engineering degrees analyzed are: Industrial Organization Engineering (IOE), Mechanical Engineering (ME), Industrial Technology Engineering (ITE), Chemical Engineering (CE), Electrical Engineering (EE), Industrial Electronics and Automation Engineering (IEAE) and Energy Engineering (ENE).

Throughout the study period, a total of 622 students of the 1920 enrolled completed the survey, which means a participation rate of 32.39%. Using Slovin's formula (Tejada et al., 2012), it is found that this sample is statistically significant, since it provides a confidence level of 95% with a margin of sampling error of 3%, ensuring the representativeness of the results. However, due to the voluntary nature of the survey, participation varied over time, as can be seen in Fig. 1, which shows the percentage of students who completed the survey satisfactorily in each academic year, both in general and segmented by gender (male vs. female) and by the students' enrollment status (non-repeater vs. repeater).

A notable decrease in participation is observed during the 2022–2023 academic year, although this participation has increased during the last period studied. In addition, a fairly balanced distribution between the participation of males and females is identified. It should be highlighted that, despite their lower number, females have maintained a slightly higher participation rate in all academic years. There is also a significantly higher participation rate among students enrolling for the first time in the subject compared to those repeating the subject.

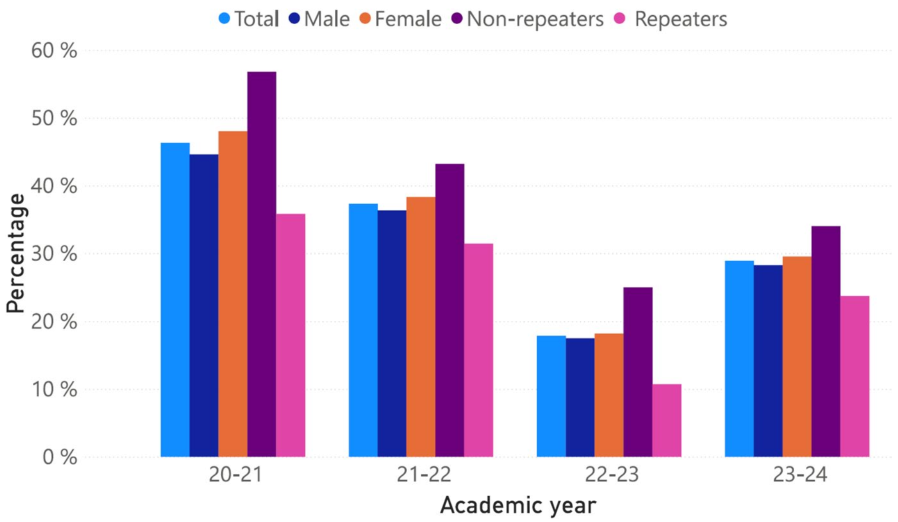

Fig. 1 Variation in the percentage of students who completed the survey in the last four academic years, by gender and enrollment status of the student

2.4 The softs skills analyzed in the study

At the end of the teaching of the third thematic block, a survey is carried out with the students to collect their assessment and opinion on different aspects related to this teaching. The survey includes a specific section where students evaluate the extent to which they consider that the methodology used in the block has enabled them to develop 25 soft skills (see Appendix). A Likert-type rating scale has been used with values from 1 to 7, where 1 means that the student considers that the methodology has not helped at all to develop the soft skills, while 7 means that the student perceives that the methodology has been extremely effective in helping to develop and apply the soft skills, and that the student has no significant criticisms or suggestions for improvement. Regarding the RQ2, the fact that the survey was not anonymous made it possible to study, after collecting the marks of the ordinary exam, the relationship between the development of soft skills and academic performance.

A wide variety of terms are used in the literature to refer to soft skills, such as twenty-first century skills, employability skills, generic skills, people skills, key competences, core skills, personal skills, socioemotional competencies, etc. (Chan et al., 2017; Gibbons-Wood & Lange, 2000; Ibrahim et al., 2017; Organisation for Economic Cooperation and Development (OECD) & The World Bank, 2016; Srivastava & Kuri, 2021; Vera, 2021). This terminological diversity, together with the multiplicity of existing definitions, reflects the complexity of the concept and the variety of skills that it encompasses. There are different perspectives depending on the context, the researcher, the specific aims of each study, etc., which is also shown in the different ways of classifying and grouping these skills (Cinque, 2016). For instance, the Tuning Project (González & Wagenaar, 2006) emphasizes instrumental, interpersonal, and systemic skills; Boyatzis (2008) focuses on cognitive, emotional, and social intelligence; the ModEs project (Haselberger et al., 2012; Succi & Wieandt, 2019) identifies personal, social, and methodological skills; Caggiano et al. (2020) categorize soft skills into intrapersonal, interpersonal, activity development, and impression management; and De Campos et al. (2020) classify skills into six categories: (i) problem solving and critical thinking, (ii) communication, (iii) teamwork, (iv) ethical perspective, (v) emotional intelligence and (vi) creative thinking.

Table 1 shows the soft skills that form part of the survey, grouped into the six skill categories proposed in (De Campos et al., 2020). It also includes references in which all or some of the soft skills from each of these skill categories are identified.

2.5 Integrated development of soft skills by applying the teaching methodology

The teaching methodology, by integrating the flexibility of autonomous learning characteristic of FL with cooperative dynamics and gamification techniques, and making a transversal use of ICT tools for this purpose, provides a favorable

Table 1 Soft skills assessed in the survey, grouped into skill categories, and references in which all or some of the soft skills from each of these skill categories are identified

Skill categories	References	Soft skills	
R Problem solving and critical thinking	(Aksoy & Pasli Gurdogan, 2022; Bosch-Farré et al., 2024; Caggiano et al., 2020; Canelas et al., 2017; Craft & Linask, 2020; De Cassia Nakano et al., 2019; Fuentes et al., 2021; Guerra-Báez, 2019; Leal Paredes, 2020; Lozano et al., 2022; Maheshwari & Seth, 2019; Michavila et al., 2018; Poláková et al., 2023; Quijada Lovatón, 2019; Vera, 2021)	R1	Problem solving
		R2	Analysis and synthesis
		R3	Critical thinking
		R4	Pressure tolerance
C Communication	(Caggiano et al., 2020; Guerra-Báez, 2019; Hernández Herrera & Neri Torres, 2020; Leal Paredes, 2020; Lopez-Agudo et al., 2021; Lozano et al., 2022; Maheshwari & Seth, 2019; Michavila et al., 2018; Poláková et al., 2023; Quijada Lovatón, 2019; Robles, 2012; Vera, 2021)	C1	Communication skills
		C2	Assertiveness
		C3	Listening skills (active listening)
T Teamwork	(Bosch-Farré et al., 2024; Cabı, 2018; Caggiano et al., 2020; Canelas et al., 2017; De Cassia Nakano et al., 2019; Fuentes et al., 2021; Funes, 2018; Guerra-Báez, 2019; Hernández Herrera & Neri Torres, 2020; Leal Paredes, 2020; Lozano et al., 2022; Maheshwari & Seth, 2019; Michavila et al., 2018; Poláková et al., 2023; Quijada Lovatón, 2019; Robles, 2012; Saglam & Arslan, 2018; Srivastava & Kuri, 2021; Sun & Wu, 2016; Vera, 2021)	T1	Cooperative work
		T2	Leadership
		T3	Delegation skills
		T4	Negotiation skills
		T5	Responsibility
		T6	Adaptability
		T7	Organization and planning
E Ethical perspective	(Guillén Cordero & Astorga Aguilar, 2020; Hernández Herrera & Neri Torres, 2020; Hyder et al., 2020; Ibarra, 2021; Michavila et al., 2018; Robles, 2012; Vera, 2021)	E1	Honesty
		E2	Respect
		E3	Solidarity
		E4	Spirit of service
I Emotional intelligence	(Afzal & Masroor, 2019; Bosch-Farré et al., 2024; Fuentes et al., 2021; Guerra-Báez, 2019; Hernández Herrera & Neri Torres, 2020; Lozano et al., 2022; Maheshwari & Seth, 2019; Morgan Asch, 2020; Poláková et al., 2023; Quijada Lovatón, 2019; Robles, 2012; Sun & Wu, 2016; X. Tang et al., 2019; Webb & Doman, 2016)	I1	Perseverance
		I2	Resilience
		I3	Positive attitude
		I4	Empathy

Table 1 (continued)

Skill categories	References	Soft skills	
P Creative thinking	(Fuentes et al., 2021; Guerra-Báez, 2019; Hernández Herrera & Neri Torres, 2020; Leal Paredes, 2020; Lozano et al., 2022; Michavila et al., 2018; Poláková et al., 2023; Quijada Lovatón, 2019; Vera, 2021)	P1	Creativity
		P2	Proactivity
		P3	Efficient use of ICT (Information and Communication Technologies)

environment for students to develop multiple soft skills in different learning scenarios that are interconnected and complement each other, promoting the emergence of positive educational synergies.

The preparation and autonomous learning activities, such as the review and analysis of the multiple available didactic resources and the completion of interactive quizzes through the educational platform, encourage the development of skills such as responsibility (T5), organization and planning (T7), perseverance (I1), critical thinking (R3) and the effective use of ICT (P3). On the other hand, autonomous problem solving in digital environments allows stimulating the capacity for analysis and synthesis (R2), critical thinking (R3) and problem solving skills (R1), while also contributes to the development of skills such as pressure tolerance (R4) and the ability to adapt to change (T6), as students are faced with challenges and deadlines, allowing them to acquire a positive (I3) and proactive (P2) mindset.

Face-to-face cooperative work activities promote the development of skills such as communication (C1), assertiveness (C2), active listening (C3), teamwork (T1), leadership (T2), delegation (T3), negotiation (T4), responsibility (T5), adaptability (T6), empathy (I4), honesty (E1), respect (E2), solidarity (E3) and spirit of service (E4). Moreover, team problem solving, in particular, makes it possible for students to put into practice skills such as analysis-synthesis (R2), problem solving (R1) and creativity (P1), while gamification in teams, in addition to fostering motivation, makes it possible to develop resilience (I2) and positive attitude (I3), and achieves this through the use of mobile devices, thus promoting a creative (P1) and efficient use of ICT (P3). In addition, constant feedback from teachers throughout the process enhances critical reflection (R3) and continuous improvement.

Laboratory practices are another scenario in which students are required to apply theoretical knowledge in a limited time, which fosters responsibility (T5), proactivity (P2), organization and time management (T7). By facing practical challenges individually, students develop problem-solving (R1), creativity (P1) and critical thinking (R3) skills, as they must search for innovative solutions and adapt their knowledge to concrete situations. At the same time, the possibility of asking questions to their peers stimulates effective communication (C1), the ability to explain concepts clearly and concisely, and collaboration (T1). On the other hand, the intensive use of different simulation software, in addition to the LMS platform, allows them to deepen the proper use of these tools (P3).

2.6 Brief description of the conducted analysis

The analysis has been divided into two clearly differentiated sections, in line with the proposed RQ.

To understand students' perceptions of the impact of the methodology on the development of their soft skills (RQ1), a comprehensive descriptive analysis of the responses collected has been carried out. This analysis considers four key variables that may influence students' perceptions: academic year, gender, students' enrollment status (non-repeater vs. repeater) and the engineering degree to which the students belong.

For each soft skill, and within each segmented group of students, measures of central tendency (mean, mode and median) and measures of dispersion (standard deviation) were calculated in order to provide a general idea of the distribution and variability of the responses within each group. An ANOVA analysis of variance was also performed to determine whether there are statistically significant differences in the ratings of soft skills as a function of the key variables studied.

The descriptive analysis includes many illustrative graphs to visualize the responses and their evolution over time (academic years) and for each group of students (gender, students' enrollment status and engineering degree). These graphs serve to identify trends and patterns in the soft skills ratings, facilitating the understanding of how the methodology affects different groups of students and different skills.

To address the RQ2, which aims to understand the possible relationship between soft skills development and academic performance, several statistical and graphical analyses have been performed. These analyses focus on assessing the correlation between students' responses about their soft skills and their academic performance, with the aim of identifying the soft skills (independent or explanatory variables) that have the greatest impact on students' marks (dependent variable).

Specifically, Pearson's correlation coefficient was calculated to quantify the linear association between the variables and to determine the strength and direction of the relationship between soft skills and academic performance. In addition, a statistical regression was performed to identify the variables that best explain the variations in students' marks. Finally, Power BI has been used to create interactive visualizations to explore in detail the relationships between variables and improve the understanding of the data.

3 Results

3.1 RQ1: Students' perception about their soft skills development

To understand the most relevant aspects of the students' perception about the impact of the educational methodology on the development of their soft skills, we will start by showing the results of the survey in a global way. From this overview, we will be able to delve into specific details and explore trends and patterns that emerge from the longitudinal study of the data.

Table 2 provides an initial summary statistic of the students' ratings. This table includes the mean, mode and median rating for each skill. It also shows the mean ratings as a function of engineering degree, gender, student status and academic year. This information provides an overview of the distribution of responses, allowing an understanding of how students' perceptions vary according to the different key variables.

Figure 2 shows the variation of the average percentage of each of the ratings over the period studied. Each line is associated with an academic year, which allows to observe how the average perception of students has changed over time.

Table 2 Summary statistic of student ratings, including means, modes, medians and mean ratings by engineering degree (ME, IOE, CE, IEAE, ENE, ITE and EE) gender (male (M) and female (F)), students' enrollment status (non-repeater (NR) vs. repeater (R)) and academic year (20–21, 21–22, 22–23 and 23–24)

Soft skill	Mean	Mode	Median	ME	IOE	CE	IEAE	ENE	ITE
C1	6.3	6	6.25	6.5	6.46	6.42	6.36	6.34	6.25
C2	5.1	5	5.05	5.18	5.23	5.16	5.12	5.08	5.1
C3	5.9	6	5.85	6	5.98	5.96	5.92	5.9	5.8
E1	5.86	6	5.82	5.9	5.88	5.87	5.87	5.82	5.82
E2	5.3	5	5.42	5.42	5.38	5.34	5.32	5.3	5.22
E3	6.2	6	6.18	6.42	6.38	6.28	6.24	6.22	6.15
E4	5	5	4.98	5.12	5.08	5.04	5.02	4.97	4.96
I1	6.39	6	6.34	6.42	6.39	6.37	6.4	6.35	6.36
I2	5.7	6	5.64	5.8	5.76	5.74	5.72	5.67	5.64
I3	6.5	7	6.3	6.68	6.7	6.64	6.58	6.54	6.38
I4	5.5	5	5.4	5.7	5.62	5.56	5.52	5.5	5.5
P1	6.7	7	5.24	6.71	6.68	6.12	6	6.00	5.92
P2	5.35	5	5.32	5.45	5.42	5.39	5.37	5.32	5.33
P3	6.8	7	6.7	6.88	6.84	6.83	6.81	6.76	6.78
R1	6.6	7	6.54	6.75	6.68	6.65	6.63	6.59	6.6
R2	6.48	7	6.46	6.58	6.55	6.52	6.5	6.46	6.48
R3	6.4	6	6.32	6.57	6.49	6.45	6.43	6.39	6.38
R4	6.65	7	6.62	6.7	6.67	6.65	6.63	6.59	6.58
T1	6.58	7	6.54	6.7	6.64	6.59	6.58	6.56	6.5
T2	5.2	5	5.15	5.4	5.32	5.28	5.23	5.18	5.16
T3	6	6	5.94	6.2	6.16	6.12	6.06	6.01	5.94
T4	6.28	6	6.24	6.34	6.3	6.28	6.29	6.24	6.26
T5	6.4	6	6.32	6.56	6.58	6.5	6.46	6.42	6.39
T6	5.39	5	5.28	5.5	5.6	5.45	5.42	5.38	5.36
T7	5.8	6	5.76	6.1	6.16	6.02	5.9	5.88	5.71
Total	**6.02**	**6.03**	**5.91**	**6.14**	**6.12**	**6.05**	**6.02**	**5.98**	**5.94**

Soft skill	EE	M	F	NR	R	20–21	21–22	22–23	23–24
C1	5.81	5.78	6.82	6.42	6.18	6	6.2	6.58	6.42
C2	4.81	5.74	4.46	5.28	4.92	4.95	5	5.18	5.27
C3	5.74	5.76	6.04	6.36	5.44	5.77	5.87	6	5.96
E1	5.82	5.64	6.08	5.98	5.74	5.8	5.86	5.88	5.9
E2	5.12	5.61	4.99	5.45	5.15	5.06	5.28	5.39	5.47
E3	5.73	5.60	6.8	6.45	5.95	5.9	6.15	6.28	6.47
E4	4.78	5.60	4.4	5.35	4.65	4.92	4.99	5.02	5.07
I1	6.4	6.10	6.68	6.52	6.26	6.32	6.38	6.41	6.45
I2	5.54	6.05	5.35	5.83	5.57	5.61	5.69	5.75	5.75
I3	6.02	6.38	6.62	6.78	6.22	6.47	6.49	6.5	6.54
I4	5.1	6	5	5.8	5.2	5.23	5.3	5.6	5.88
P1	5.32	6.61	6.79	6.78	6.62	6.61	6.68	6.73	6.78

Table 2 (continued)

Soft skill	EE	M	F	NR	R	20–21	21–22	22–23	23–24
P2	5.14	6.28	4.42	5.48	5.22	5.28	5.32	5.43	5.37
P3	6.66	6.8	6.8	6.8	6.8	6.7	6.76	6.8	6.94
R1	6.29	6.58	6.62	6.69	6.51	6.52	6.58	6.62	6.68
R2	6.25	6.54	6.42	6.53	6.43	6.41	6.44	6.55	6.52
R3	6.08	6.52	6.28	6.56	6.24	6.33	6.38	6.44	6.45
R4	6.67	6.54	6.76	6.72	6.58	6.59	6.64	6.67	6.7
T1	6.47	6.53	6.63	6.64	6.52	6.5	6.56	6.62	6.64
T2	4.81	5.97	4.43	5.37	5.03	5.15	5.2	5.25	5.2
T3	5.52	5.94	6.06	6.42	5.58	5.94	5.98	6.2	5.88
T4	6.21	5.95	6.61	6.36	6.2	6.24	6.27	6.3	6.31
T5	5.91	5.96	6.84	6.56	6.24	6.31	6.38	6.45	6.46
T6	5.01	5.93	4.85	5.49	5.29	5.34	5.36	5.41	5.45
T7	4.91	5.97	5.63	6	5.6	5.7	5.78	5.83	5.89
Total	**5.68**	**6.1**	**5.94**	**6.18**	**5.85**	**5.91**	**5.98**	**6.08**	**6.1**

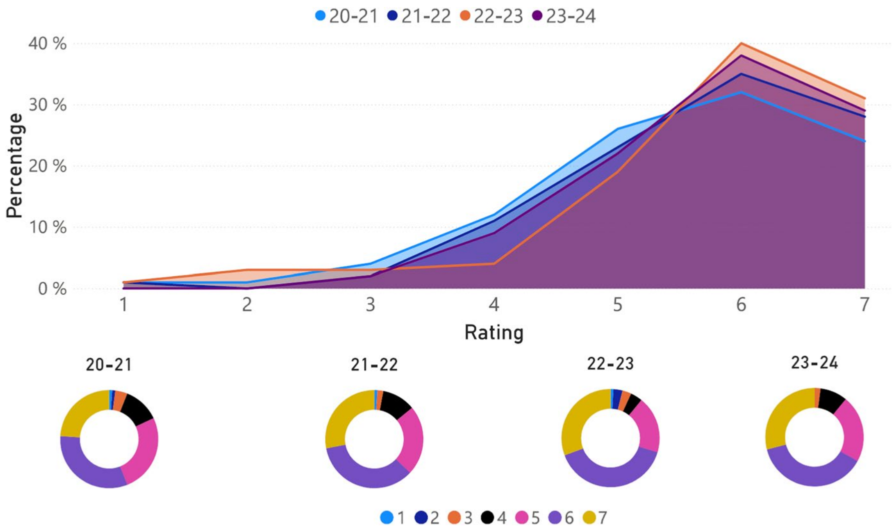

Fig. 2 Variation of the average percentage of soft skills ratings over the period studied

There is a clear trend towards higher ratings, which suggests a favorable perception by students of the impact of the methodology on the development of their soft skills. In order to explore the behavior of these high ratings, Fig. 3 shows the variation of the percentage of soft skills that have obtained a highest rating (i.e., a rating of 6 or 7) by at least 60% of the students in the sample, disaggregated by each of the engineering degrees studied. As can be seen, this percentage has

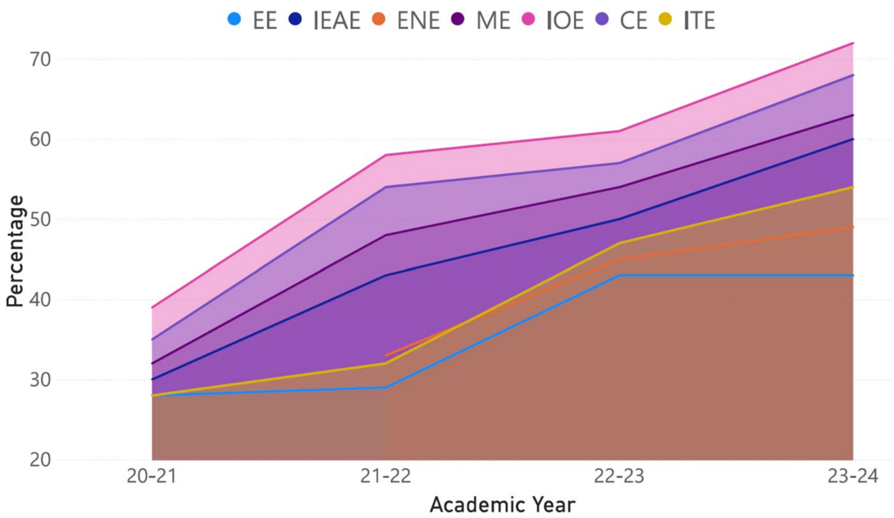

Fig. 3 Variation of the percentage of soft skills that have obtained a highest rating (6 or 7) by at least 60% of the students, disaggregated by each of the engineering degrees. No survey results were obtained for ENE degree in the 2020–2021 academic year

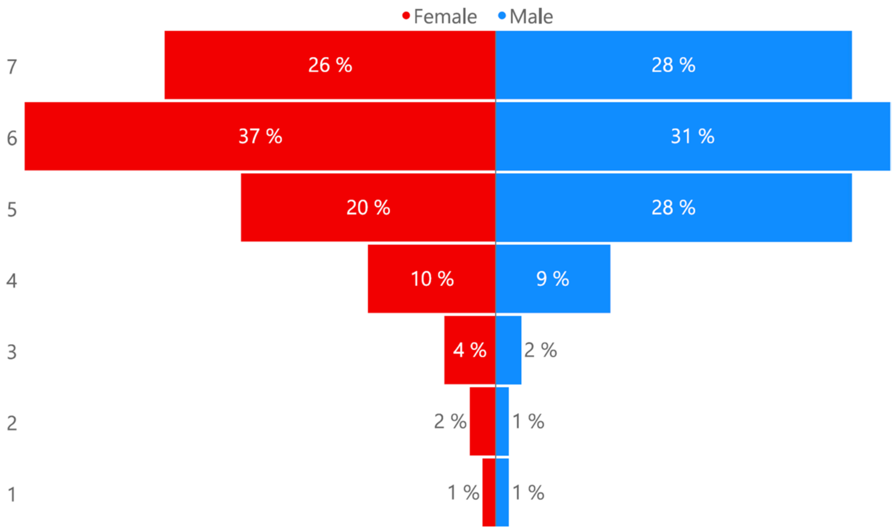

Fig. 4 Distribution of the average percentage of each rating as a function of gender

grown significantly over the academic years. This progress is especially notable in several degrees, where the percentage has even doubled.

For a deeper understanding of the results, an analysis of the average percentage of each rating is shown as a function of the rest of the segmentation variables considered: gender, students' enrollment status and engineering degree. Figure 4

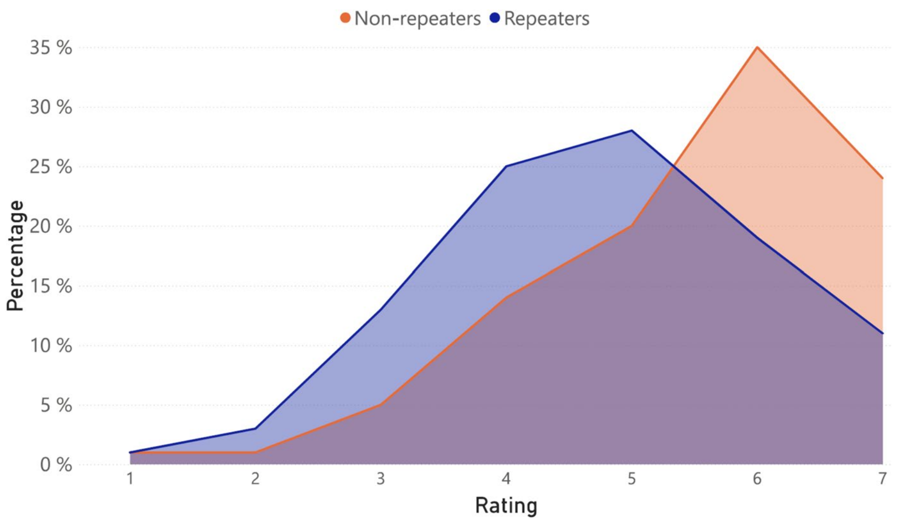

Fig. 5 Distribution of the average percentage of each rating as a function of students' enrollment status

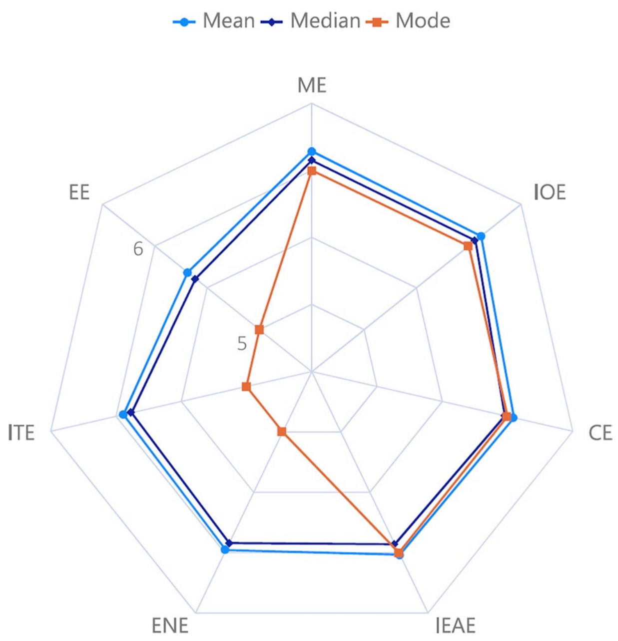

Fig. 6 Measures of central tendency (mean, mode and median) for each engineering degree

shows the distribution of the average percentage of each rating as a function of gender, while Fig. 5 shows it as a function of students' enrollment status. Figure 6 shows the mean, mode and median for each of the engineering degrees included in the study.

Several ANOVA analyses were also performed to assess whether there are statistically significant differences in the mean rating depending on the academic year, gender, students' enrollment status and engineering degree. The null hypothesis (H_0) states that there is no significant difference in the mean ratings among students of different academic year, gender, students' enrollment status or engineering degree, while the alternative hypothesis (H_1) states that there is a significant difference. As an example, Fig. 7 shows the results of the ANOVA analysis, performed by using the Microsoft Excel Analysis ToolPak add-in, for engineering degree, gender, students' enrollment status and academic year.

As can be seen in Fig. 7, the F-statistic, which compares inter-group variability with intra-group variability, yields values considerably higher than the critical values in all cases and, consistent with this, the associated p-values are extremely low. These results show that it is very unlikely that the differences between groups are due to chance, which reinforces the hypothesis that there are statistically significant differences in the ratings of soft skills between different groups for the four key variables studied.

Figure 8 shows the mean ratings for each of the soft skills, ranked from highest to lowest rating, while Fig. 9 shows the average percentage of each rating for each of the six skill categories evaluated (Problem solving and critical thinking (R), Communication (C), Teamwork (T), Ethical perspective (E), Emotional intelligence (I), Creative thinking (P)). These graphical representations make it possible to visualize the students' perception of the importance and development of each of the skills and skill categories, clearly identifying those in which the methodology has a greater overall impact.

After obtaining an overview of the ratings given by the students, we will begin to show the results of the longitudinal study to further understand the data. This

ANALYSIS OF VARIANCE

(a) Engineering degree

Origin of variations	*Sum of squares*	*Degrees of freedom*	*Mean squares*	*F*	*p-value*	*Critical value for F*
Between groups	328.58	6	65.566	729.254479	1.010E-13	2.19369873
Within the groups	329.6594212	3728	0.089386302			
Total	658.23	3734				

(b) Gender

Origin of variations	*Sum of squares*	*Degrees of freedom*	*Mean squares*	*F*	*p-value*	*Critical value for F*
Between groups	12.02354502	1	12.02354502	56.62547828	1.009E-13	3.848956878
Within the groups	263.7195016	1242	0.212334542			
Total	275.7430466	1243				

(c) Students' enrollment status

Origin of variations	*Sum of squares*	*Degrees of freedom*	*Mean squares*	*F*	*p-value*	*Critical value for F*
Between groups	140.0772939	1	140.0772939	933.1582045	2.546E-153	3.848956878
Within the groups	186.4378389	1242	0.150110981			
Total	326.5151328	1243				

(d) Academic year

Origin of variations	*Sum of squares*	*Degrees of freedom*	*Mean squares*	*F*	*p-value*	*Critical value for F*
Between groups	77.40209944	3	25.80069981	119.105494	4.545E-72	2.6084855
Within the groups	538.085492	2484	0.216620568			
Total	615.4875914	2487				

Fig. 7 ANOVA analysis performed for (**a**) engineering degree, **b** gender, **c** students' enrollment status and (**d**) academic year

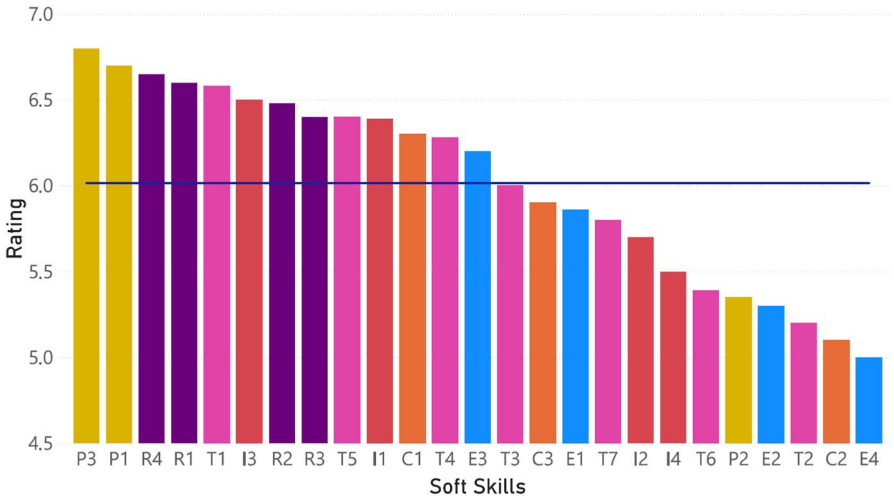

Fig. 8 Mean ratings for each of the soft skills, ranked from highest to lowest rating. The horizontal line indicates the mean rating of all soft skills for the period considered

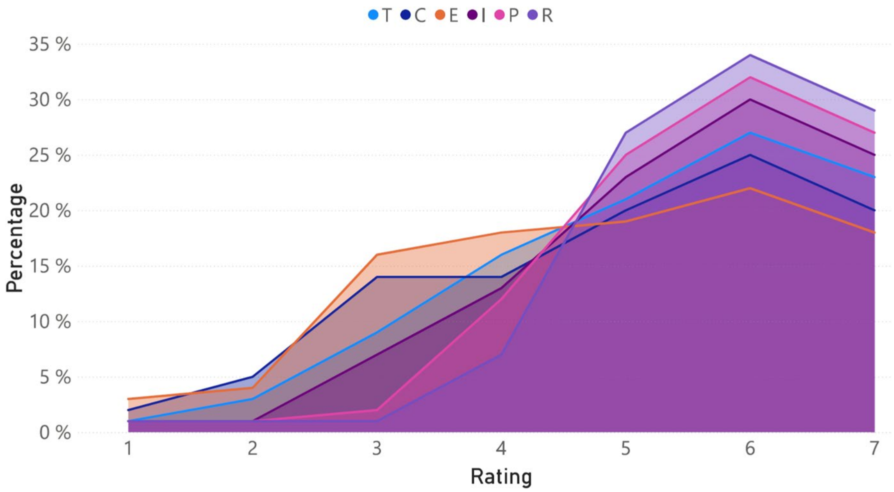

Fig. 9 Average percentage of each rating for each of the six skill categories evaluated (Problem solving and critical thinking (R), Communication (C), Teamwork (T), Ethical perspective (E), Emotional intelligence (I), Creative thinking (P))

analysis will allow to explore the variation of the ratings over time and also as a function of the other key variables. Figures 10 and 11 show the starting point of the longitudinal analysis, offering an initial perspective about the variation of the average percentage of each rating as a function of gender (Fig. 10) and students' enrollment status (Fig. 11).

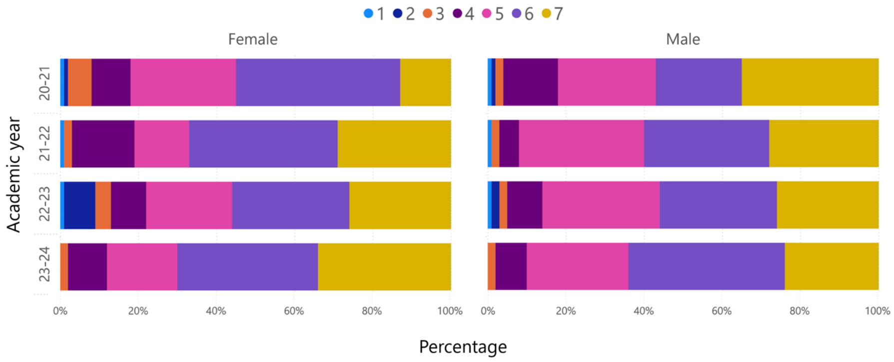

Fig. 10 Variation of the average percentage of each rating as a function of gender

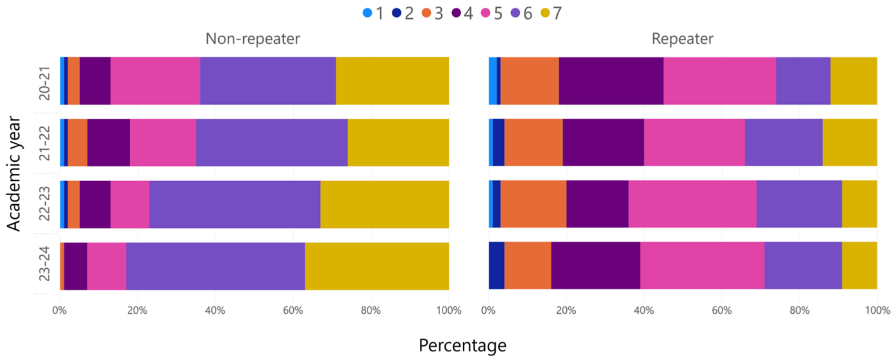

Fig. 11 Variation of the average percentage of each rating as a function of students' enrollment status

Figure 12 uses a radial diagram to illustrate, in a compact way, the variation, over the period studied, of the mean rating for each of the engineering degrees.

Figures 13 and 14 further develop the longitudinal analysis. Figure 13 shows the variation, over the period studied, of the ranking of the mean ratings that students have given to the impact of the educational methodology on the development of each of the soft skills. On the other hand, Fig. 14 shows the variation, over the period studied, of the mean rating for each of the skill categories.

With the aim of identifying which soft skills have undergone a more significant change or evolution in the students' perception over time, the percentage variation between the mean ratings of the first and last year for each soft skill was calculated. The formula used is shown in Eq. (1).

$$Percentage\ variation = \frac{(Mean\ Rating\ Academic\ Year\ 23/24) - (Mean\ Rating\ Academic\ Year\ 20/21)}{(Mean\ Rating\ Academic\ Year\ 20/21)} \cdot 100 \tag{1}$$

The results are graphically presented in Fig. 15, which shows the percentage variation of the mean ratings for each soft skill, ranked from the greatest to the

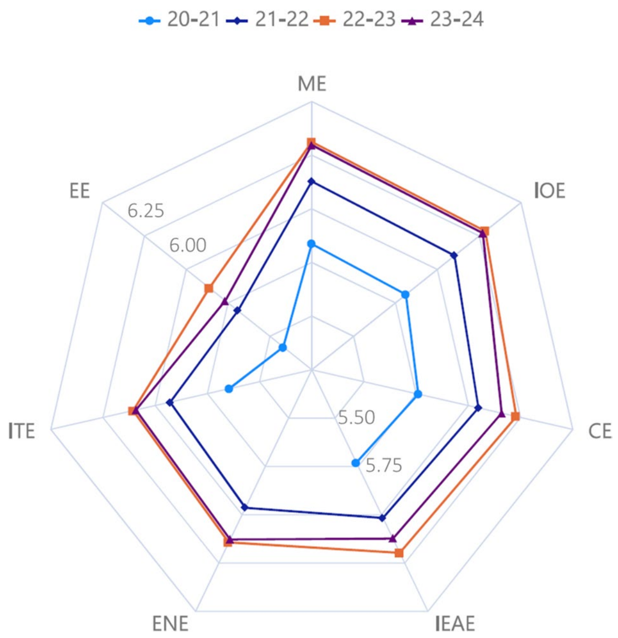

Fig. 12 Variation, over the period studied, of the mean rating for each of the engineering degrees. No survey results were obtained for ENE degree in the 2020–2021 academic year

smallest change. Figure 16 extends the previous information, showing the percentage variation of the mean ratings of each soft skill, disaggregating the results by gender and students' enrollment status. This segmentation makes it possible to identify possible disparities in the perception of students as a function of these variables.

Figure 17 highlights the difference in rating as a function of the students' enrollment status. Specifically, it shows the variation over the four academic years in the mean ratings of each of the skill categories for repeat and non-repeat students.

3.2 RQ2: Relationship between academic performance and soft skills development

3.2.1 Pearson's correlation coefficient

Pearson's correlation coefficient, r, developed by Karl Pearson in 1895 (Lee Rodgers & Nicewander, 1988), is a dimensionless statistical measure that allows quantifying the strength and direction of the linear relationship between two quantitative variables. Its mathematical formula is shown in Eq. (2), where r is the Pearson Correlation Coefficient, X_i/Y_i are the values of the variable X/Y, and $\overline{X}$ /$\overline{Y}$ are their respective means.

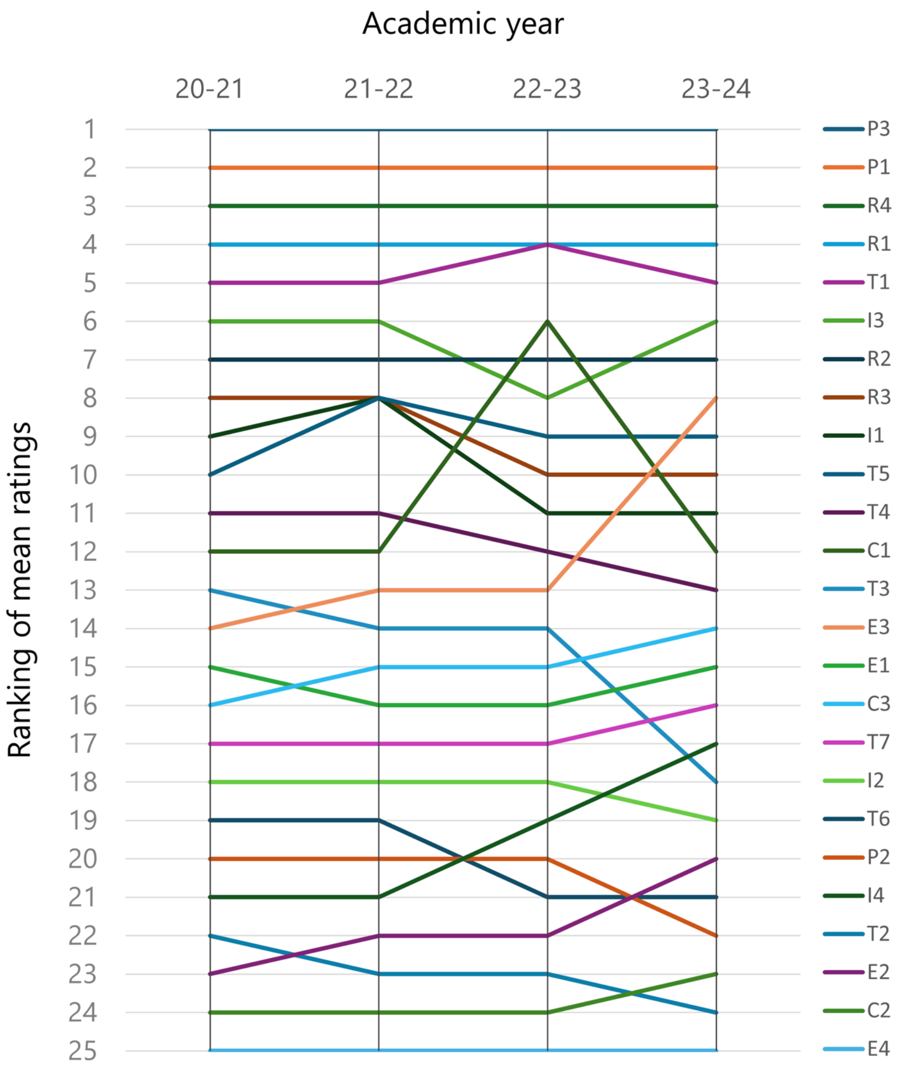

Fig. 13 Variation, over the four academic years of the ranking of the mean ratings for each of the soft skills

$$r = \frac{\sum\left(X_i - \overline{X}\right)\left(Y_i - \overline{Y}\right)}{\left[\sum\left(X_i - \overline{X}\right)^2 \sum\left(Y_i - \overline{Y}\right)^2\right]^{1/2}} \tag{2}$$

The value of r ranges from -1 to $+1$. The magnitude of this value indicates the strength of the linear relationship between the variables. In this sense, a correlation of $+1$ is as strong as -1: in the first case there is a perfect positive linear relationship

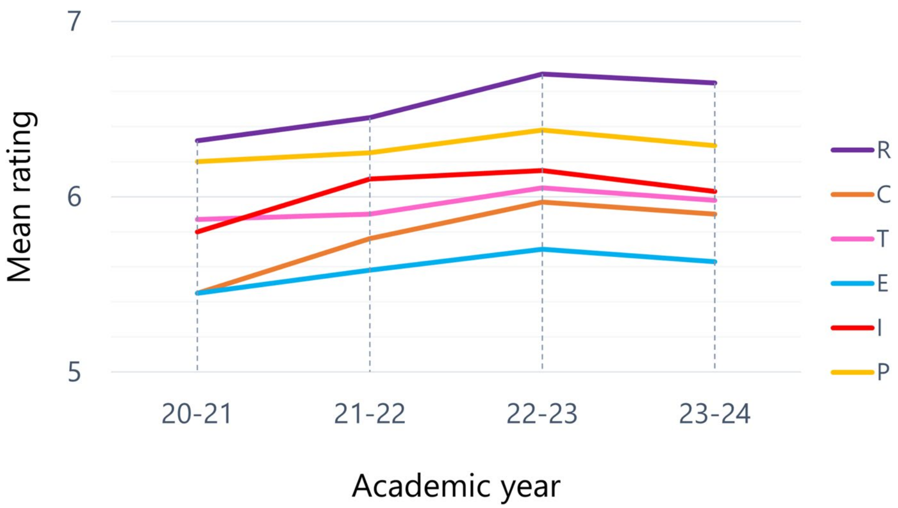

Fig. 14 Variation, over the period studied, of the mean rating for each of the skill categories

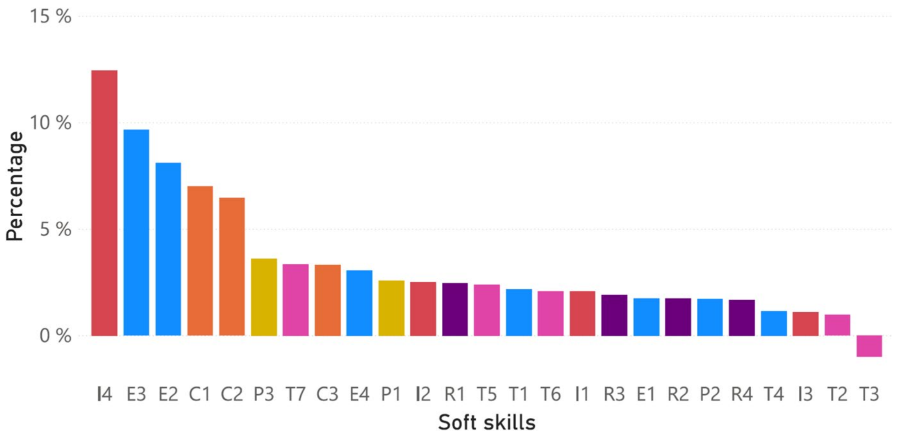

Fig. 15 Percentage variation of the mean ratings for each soft skill, ranked from the greatest to the smallest change

while in the second case this relationship is perfect but negative. On the contrary, a value of 0 indicates that the variables are not linearly correlated (Benesty et al., 2009); i.e., there is no linear relationship between the variables of interest, although there may be some other type of dependence or association.

Using the open-source programming language R (R Core Team, 2021), considering the mark in the ordinary exam as the dependent variable, and the 25 soft skills analyzed as independent variables, the Pearson's correlation coefficient, *r*, was calculated for each soft skill. Table 3 shows the r value of the eight independent variables that have the greatest influence on the final mark.

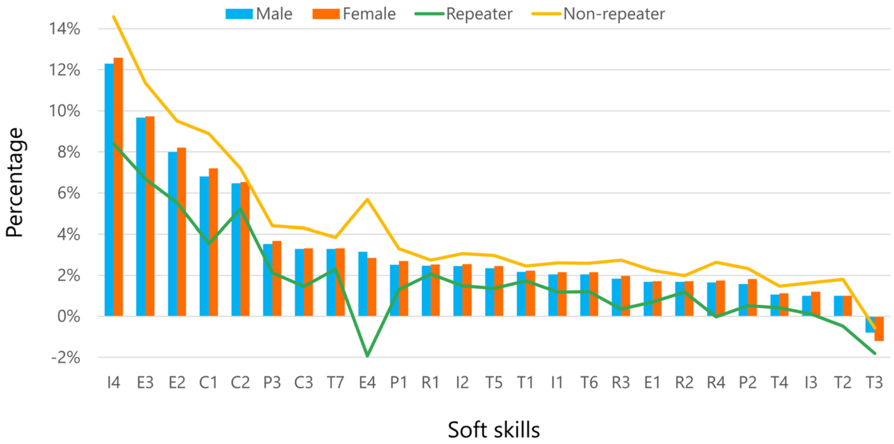

Fig. 16 Percentage variation of the mean ratings of each soft skill, disaggregated by gender and students' enrollment status

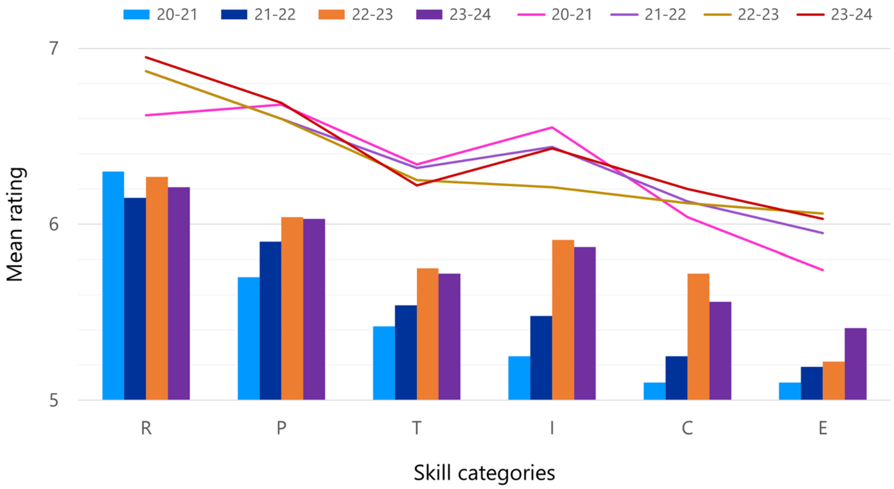

Fig. 17 Variation over the four academic years in the mean ratings of each of the six skill categories for repeat (column chart) and non-repeat students (line chart)

3.2.2 Linear regression model

To further explore the relationship between academic performance and soft skills, a linear regression model was developed using the partial least squares method (Abdi, 2003). This allows finding the values of the coefficients of the linear regression equation that best describe the relationship between the variables (Eq. (3)):

$$Y = \beta_0 + \beta_1 \cdot X_1 + \beta_2 \cdot X_2 + \cdots + \beta_n \cdot X_n + \varepsilon \tag{3}$$

where:

Table 3 Pearson's correlation coefficients (r) of the independent variables (soft skills) with greater influence in the dependent variable

Soft skill	r
Efficient use of ICT (P3)	0.68
Problem solving (R1)	0.56
Cooperative work (T1)	0.54
Communication skills (C1)	0.28
Organization and planning (T7)	0.27
Leadership (T2)	0.25
Respect (E2)	0.24
Positive attitude (I3)	0.23

Y Response or dependent variable; in this case, the academic performance achieved by the student in the exam of the ordinary call.

β_0 Constant coefficient.

β_i Beta coefficients that represent the influence of each independent variable (X_i) on the dependent variable (Y).

X_i Independent variables or predictors, i.e., the rating given by the student for each of the soft skills analyzed in this study.

ε Error term.

The regression coefficients β_i (estimated values) indicate the individual influence of each independent variable on the dependent variable, i.e., how much the latter changes on average for each unit of change in the corresponding independent variable. The magnitude of the absolute value of βi reflects the strength of the relationship, while the sign indicates the direction of the relationship: a positive value indicates that a higher soft skill rating is associated with higher academic performance, while a negative value indicates the opposite. On the other hand, each regression coefficient has a p-value associated with it that helps to determine whether the observed effect is statistically significant and, therefore, not due to chance. If this value is less than the established significance level (in this case, 0.05), the null hypothesis that there is no relationship between the variables is rejected.

In this study, to select the most relevant explanatory variables in the multiple linear regression model, we used the stepwise method (Kokaly & Clark, 1999), which is based on the gradual incorporation of regressors (X_i) into the regression equation, considering both their logical relevance and their statistical significance. The final purpose is to obtain a model with a reduced set of variables that accurately explains the relationship between soft skills and academic performance, avoiding overloading the model with irrelevant or redundant variables.

Table 4 shows the results of the regression analysis by considering the final mark in the ordinary exam as the dependent variable. As can be seen, the table includes the estimated regression coefficients β_i and the associated p-values for each of the soft skills considered in the study.

3.2.3 Power BI tool

To supplement the results obtained in the linear regression and in the analysis by means of Pearson's correlation coefficient, and to strengthen the understanding of the relationship between soft skills and academic performance (mark obtained in the ordinary exam), Power BI key influencers visualization was used to explore how the soft skill ratings, and in particular the highest soft skill ratings (6 and 7), influence the achievement of a mark of 5 or above (pass mark) in the ordinary exam.

As can be seen in Fig. 18, Effective use of ICT (P3) emerges as the main factor that contributes to achieving a pass mark. Specifically, 87.71% of students who rated the soft skill Effective use of ICT (P3) highly (6 or 7) passed the ordinary exam,

Table 4 Results of the linear regression, considering as dependent variable the final mark in the ordinary exam and soft skills as independent variables (sample size is 622 students)

Soft skill	β_i	Standard error	*p*-value
Efficient use of ICT (P3)	0.075	0.001947864	1.02E-05
Problem solving (R1)	0.072	0.001894748	1.10E-05
Cooperative work (T1)	0.069	0.000368974	1.03E-05
Leadership (T2)	0.065	0.001945678	2.86E-05
Positive attitude (I3)	0.062	0.004258795	5.60E-05
Communication skills (C1)	0.058	0.001315246	1.45E-05
Pressure tolerance (R4)	0.057	0.000362546	2.70E-05
Proactivity (P2)	0.055	0.002839879	3.90E-05
Resilience (I2)	0.05	0.005628379	3.90E-05
Perseverance (I1)	0.047	0.001524569	4.48E-05
Delegation skills (T3)	0.042	0.002854679	1.89E-05
Organization and planning (T7)	0.037	0.001527812	2.60E-05
Listening skills (C3)	0.036	0.002584157	1.20E-05
Respect (E2)	0.03	0.003839846	3.60E-05
Negotiation skills (T4)	0.024	0.002548745	4.36E-05
Solidarity (E3)	0.024	0.001626341	5.04E-05
Responsibility (T5)	0.023	0.002541123	1.48E-05
Adaptability (T6)	0.02	0.003945879	3.85E-05
Assertiveness (C2)	0.02	0.004868741	2.80E-06
Empathy (I4)	0.018	0.001415085	6.08E-05
Honesty (E1)	0.015	0.002846789	3.98E-05
Creativity (P1)	0.014	0.002615678	1.80E-05
Analysis and synthesis (R2)	0.012	0.004796547	8.40E-05
Critical thinking (R3)	0.006	0.003649754	4.28E-05
Spirit of service (E4)	0.003	0.001924724	4.76E-05

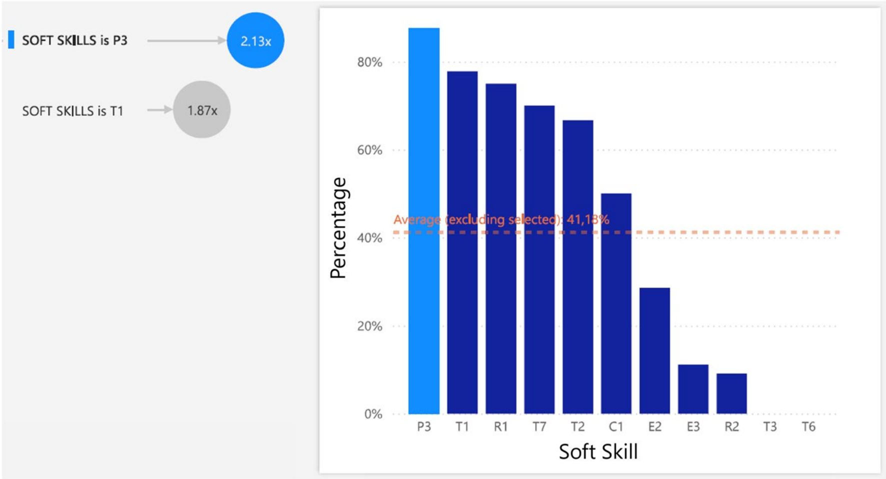

Fig. 18 Effective use of ICT (P3) is the main factor that contributes to achieving a pass mark: 87.71% of students who rated the soft skill Effective use of ICT (P3) highly (6 or 7) passed the ordinary exam, while this percentage drops to an average of 41.18% for the rest of the soft skills

while this percentage drops to an average of 41.18% for the rest of the soft skills that the software considers as influencers (excluding Effective use of ICT (P3)). Consequently, there is a 2.13 (=87.71/41.18) times higher probability, with respect to the average excluding Effective use of ICT (P3), that students will pass if they have rated Effective use of ICT (P3) highly (6 or 7). Figure 18 also shows that the results are consistent with those obtained in the linear regression and in the analysis by means of Pearson's correlation coefficient, where the three soft skills with the highest correlation with academic performance were also Efficient use of ICT (P3), Problem solving (R1) and Cooperative work (T1).

4 Discussion

The results of this study show that students perceive that the teaching methodology used has a positive influence on the development of their soft skills (RQ1), influence discussed in detail in Section 4.1. However, some differences are also observed in the perception of students depending on the academic year, gender, students' enrollment status and the engineering degree in which the subject is taught (Sections 4.2, 4.3, 4.4, and 4.5). The study also shows that ICT tools act as a driving force in the development of soft skills, promoting their acquisition and application in several scenarios (Section 4.6). On the other hand, a positive correlation has been found between the development of soft skills and academic performance (RQ2), suggesting that the acquisition of these skills can contribute significantly to improving academic outcomes, as detailed in Section 4.7. Therefore, the results of the study allow adequately addressing the RQ raised.

Finally, the discussion is completed by highlighting the need for continuous improvement and adaptation of the methodology (Section 4.8), identifying the strengths (Section 4.9) and limitations (Section 4.10) of the study, and raising some implications and educational recommendations that emerge from it (Section 4.11).

4.1 Positive students' perception about the impact of methodology on soft skills

Analysis of the surveys reveals clear evidence of the positive students' perception about the degree to which the methodology used has allowed them to develop their soft skills. These results are consistent with those of previous studies that show that the implementation of educational methodologies, such as FL, cooperative work or gamification, improves the development of soft skills by students (Barhoumi, 2023; Birgili et al., 2021; Bosch-Farré et al., 2024; Jamila, 2020; Khlaisang & Teo, 2024; McGowan et al., 2023; Mohamed-Amar & Mohamed-Amar, 2024; Sharma et al., 2023). Furthermore, the success achieved by the proposed methodology can be attributed to its integrated approach, developed through the transversal and effective use of ICT. This fact shows that, since the development of soft skills is a highly complex process in which multiple factors interact, integrated methodologies that combine multiple approaches can lead to good results when addressing the development of soft skills (Betti et al., 2022).

The overall mean rating is just above 6 (Fig. 8), with a notable variation among the different skills evaluated, ranging from 5.0 for the Spirit of service (E4) to 6.8 for the Effective use of ICT (P3). This wide range in the ratings shows the variety of soft skills addressed and the subjective nature of the students' individual perception about their own development.

A more in-depth analysis of the soft skills shows that the mean and median are very close to each other (Fig. 6), although the mean tends to be slightly higher than the median, indicating a slight positive skewness. This suggests that most ratings are clustered in the medium–high range, reflecting a positive perception of the impact of the methodology on the development of the soft skills. In fact, an examination of the percentages reveals a distribution of ratings that is clearly skewed towards the most positive evaluations in most soft skills (Figs. 2 and 3). The highest ratings are highly clustered, with 61% if only the two highest ratings (6 and 7) are considered and 85% if the three highest ratings (5 to 7) are included (these percentages of 61% and 85% are average percentages for the four academic years under study).

The students think that, thanks to the methodology used, they have been able to develop to a greater extent skills related to problem solving and creative thinking. Specifically, at the top of the ranking (Fig. 8) we find "Effective use of ICT (P3)" (6.8), followed by "Creativity (P1)" (6.7), "Pressure tolerance (R4)" (6.65), "Problem solving (R1)" (6.6), "Cooperative work (T1)" (6.58) and "Positive attitude (I3)" (6.5). However, the contribution of the methodology seems to be lower in other skills such as "Spirit of service (E4)" (5.0), "Assertiveness (C2)" (5.1) and "Leadership (T2)" (5.2), so more emphasis should be placed on these interpersonal skills.

It is noteworthy that the skill categories related to communication and teamwork, despite the fact that they are fostered in the classroom through specific activities, obtain lower ratings than expected (Fig. 9). Although their overall ratings are positive, they do not reach the level expected for the educational approach implemented. A possible explanation for this fact could lie in the low participation of repeat students, whose behavior could be skewing the ratings downward.

On the other hand, ANOVA analysis revealed significant differences in the ratings of soft skills as a function of academic year, gender, students' enrollment status (Fig. 7) and engineering degree. These findings suggest that the methodology may have a differential impact on different groups of students, which requires further analysis to better understand the underlying reasons.

4.2 Longitudinal analysis

The students' perception of the effectiveness of the methodology in developing their soft skills shows a positive trend over the academic years studied, as evidenced by the gradual increase in the mean rating and the percentage of high ratings, as well as the decrease in the percentage associated with low ratings (Figs. 2 and 3).

Specifically, the mean rating has risen from 5.91 in the first academic year (2020–2021) to 6.10 in the last academic year (2023–2024). The percentage of the highest ratings (6 and 7) has risen from 56 to 67%, and when considering ratings from 5 to 7, the percentage has increased from 82 to 89% (Fig. 2). The lowest ratings (1 and 2) have been decreasing over time, although with some fluctuations in certain years (Fig. 2). This positive variation in ratings by students suggests that the methodology, due to continuous improvement, has become more effective in helping students develop their soft skills.

The analysis by skills reveals a heterogeneous scenario, with some skills consistently standing out as the best rated (Fig. 13). Creativity, problem-solving skills, pressure tolerance and effective use of ICT are found within this group, suggesting that the methodology has a positive impact on the development of these skills. On the other hand, competencies such as empathy, respect, solidarity and active listening have undergone a remarkable progression over time, demonstrating the positive effect of the improvement actions implemented. As an example of this progression, Fig. 19 shows the variation in the percentages of each rating over the study period for the soft skill Empathy (I4); during the last academic year 70% of the students rated this soft skill with one of the two highest ratings (6 and 7), while in the first academic year this percentage was 40%.

The analysis by skill categories (Figs. 13 and 17) also reveals a generalized trend towards improvement. As noteworthy aspects, the greatest improvement was in the Communication category (C), which shows a significant increase in the mean rating of 0.45 points (above 8%), allowing it to leave the last place. Problem solving and critical thinking (R) has experienced the second largest increase, 0.33 points (above 5%), which allows it to consolidate its position in first place. In contrast, Creative thinking (P), despite maintaining its position as the second highest-rated category in all the academic years, has barely improved its rating over these academic years.

These results suggest that the methodology and continuous improvement actions are effectively contributing to the development of soft skills in students, such as

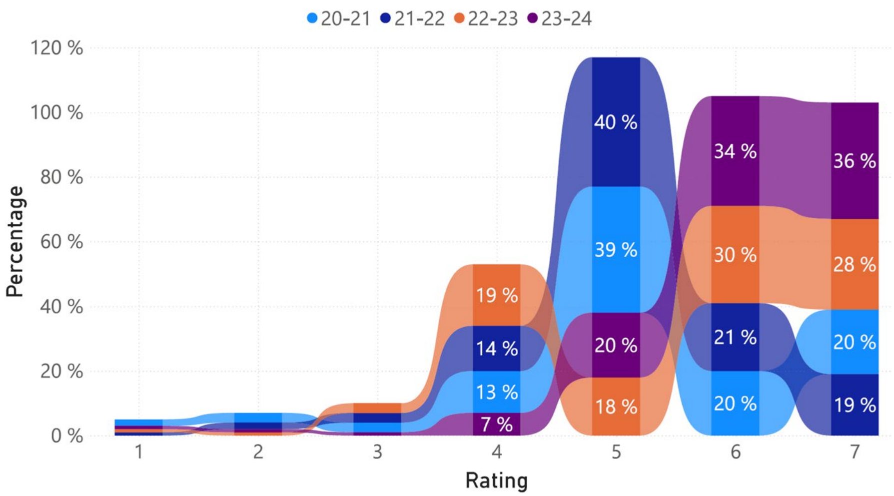

Fig. 19 Variation in the percentages of each rating over the study period for the soft skill Empathy (I4)

the effective use of ICT, rigorous analysis of problems, the critical thinking necessary for their resolution, creativity and cooperative work. But these results also encourage further reflection on the need to reinforce teaching and learning strategies focused on the development of the lowest rated soft skills. This is the case, for example, of leadership, respect and proactivity, fundamental skills required for success in the business world and in life in general.

4.3 Effect of gender on ratings provided by the students

The methodology is positively rated by both genders, with very similar mean ratings: 6.1 for males and 5.94 for females. This sameness is also observed in the percentage of higher ratings (6 and 7), which reaches 59% for males and 62% for females, indicating a generalized acceptance of the methodology regardless of the gender of the students.

On the other hand, the ratings of the methodology have shown an upward trend over the academic years, both in males and females (Fig. 10). However, it should be noted that the female ratings show greater variability over the years, since the ratings given by females have increased at a higher rate than those given by males. This difference reflects a progressive improvement in female perception of the methodology.

In the first academic year, the mean ratings given by males were considerably higher than those given by females. However, this difference has gradually narrowed in subsequent academic years, evidencing a trend towards more similar ratings by both genders (Fig. 10). In fact, in the last academic year, the mean ratings given by females have surpassed those given by males. This trend is also reflected in the percentage of higher ratings (6 and 7), which experienced a notable increase for both genders: from 57 to 64% for males and from 55 to 70% for females.

The results (Fig. 10) reveal an interesting dynamic in the differences between males and females in terms of skill categories. While in the first two academic years, male ratings exceeded those of females in all areas, from the third academic year onwards, a reversal of this trend is observed in the skill categories of Communication (C), Creative thinking (P), Problem solving (R) and Teamwork (T). These skill categories are closely related to classroom activities, which may mean that the attendance and participation of females has been increasing compared to that of males.

In contrast, in the skill categories of Ethical perspective (E) and Emotional intelligence (I), females give lower ratings than males over all academic years. While these differences have remained stable, it is important to highlight the persistent gender gap in these skill categories, suggesting the need for further analysis of the factors that may be contributing to this difference.

4.4 Effect of students' enrollment status on ratings

Non-repeat students perceive the methodology to be more effective in developing their soft skills to a greater extent than repeat students. This difference in rating can be clearly seen when comparing the mean rating: while non-repeat students rated the impact with a 6.18, repeat students only gave a 5.85 rating. It is also seen in the shape of the distribution of ratings, which shows a pronounced skewness towards high ratings for non-repeat students, while the distribution of repeaters is closer to a normal curve (Fig. 5). Finally, the percentage of the highest ratings (6 and 7) confirms this difference, with a value for non-repeaters (59%) significantly higher than for repeaters (30%).

It is noteworthy that the gap in the perception of the effectiveness of the methodology between non-repeat and repeat students widens over the academic years. For example, the percentage of the highest ratings (6 and 7) for non-repeaters increases significantly from 64% in the first academic year under study (2020–21) to 83% in the last academic year under study (Fig. 11). In contrast, this increase is markedly lower for repeaters (from 26% in the first academic year to 29% in the last academic year). This disparity in ratings suggests that the methodology is less effective for the development of soft skills in repeat students. Their lower attendance in face-to-face classes limits their participation in classroom activities, which could be a determining factor in this difference in perception.

As expected, the gap in ratings of skills between non-repeat and repeat students is evident in all skill categories (Fig. 17). However, it is worth noting that there is an improvement over time in repeaters' ratings in almost all categories, with the exception of Problem solving (R). In the case of non-repeat students, the improvement is very significant precisely in this skill category, as well as in Communication (C) and Ethical perspective (E); in the rest, there is no improvement and even a slight drop.

Undoubtedly, the lower participation in face-to-face classes by repeat students is a determining factor in the difference in perception of the effectiveness of the methodology. Not attending class limits their participation in the activities programmed in the classroom, which hinders the development of soft skills in comparison with non-repeat students, who tend to attend class more regularly.

4.5 Effect of engineering degree

The overall perception of the methodology among engineering students is positive, irrespective of their degree program (Fig. 6). Most students give high ratings in all degrees, indicating that they perceive the methodology as an effective instrument for developing their soft skills. Except for the degree in EE, the rest of the degrees give a mean rating higher than or very close to 6.

Nevertheless, while the overall trend is positive, there are some variations in students' perceptions among the different engineering degrees. For example, students of ME and IOE degrees tend to give slightly higher ratings compared to the rest of the engineering degrees. Studies are needed to help understand these differences, as they could be due to various causes: the affinity of the methodology with the skills inherent to these degrees, the expectations and previous experiences of the students, the characteristics of the teaching staff, etc.

Although there are differences among engineering degrees, there is a certain consistency in regard to the highest-rated soft skills. Efficient use of ICT (P3), Problem solving (R1), Cooperative work (T1), etc. are consistently rated highly throughout all engineering degrees and academic years. This suggests that the methodology may be particularly effective in promoting these fundamental soft skills, which are highly valued in the professional field of engineering.

In contrast, soft skills such as the Spirit of service (E4), Assertiveness (C2) or Leadership (T2), among others, receive the lowest ratings in all engineering degrees. This fact could be related to the nature of the tasks and activities performed in the classroom, which tend to focus on the development of cognitive and technical skills, leaving less time for developing soft skills. It is particularly noteworthy that Leadership (T2), a fundamental skill for professional success in engineering, is among the least valued soft skills. This finding encourages us to reflect on the need to design and implement specific strategies and actions to foster the development of this Leadership soft skill in students.

4.6 Role of ICT as a soft skill and its integration into the educational methodology

The study shows the close interrelationship among ICT, learning and development of soft skills. Due to the implementation of a methodology that combines different pedagogical approaches and a wide range of digital tools, it has been possible to foster meaningful learning and the active development of numerous soft skills. But this integration of ICT into the methodology goes beyond the simple use of digital tools. These tools have become pedagogical mediators that have allowed students to personalize their learning, giving them the ability to autonomously explore concepts at their own pace and to self-assess the level of learning acquired. In addition, these digital tools have also helped to stimulate creativity and critical thinking, to foster analytical skills and decision-making, to develop problem solving, collaboration among students, etc., this is the case, for example, of the tools used in the resolution of laboratory challenges.

It is noteworthy the fundamental role played by gamification tools in improving students' motivation. By transforming learning into a playful activity, participation has been promoted and a more attractive learning environment has been developed.

On the other hand, it is important to highlight that the effective use of ICT (i) has become the soft skill most highly rated by students, in terms of their perception about the degree to which the methodology employed has allowed them to develop a specific soft skill (Fig. 8), and (ii) contributes the most to academic performance (Table 3, Table 4 and Fig. 18). By working with multiple digital tools and platforms, students have been acquiring digital competencies essential for their academic and professional future. This is reflected in the fact that students perceive effective use of ICT as the competence they have developed the most.

Therefore, the results of the study suggest that the integration of ICT in an innovative educational model has a significant impact on the development of soft skills, especially with regard to digital competencies. Therefore, these findings support the need to continue exploring and promoting the pedagogical use of ICT in education.

4.7 Relationship between soft skills development and academic performance

In relation to the RQ2, the results of the linear regression analysis (Table 4) show that a large number of independent variables (predictors) have statistically significant estimated coefficients, as evidenced by their p-values, which are well below the established significance level (0.05). This suggests that these variables maintain a statistically significant association with the academic performance of the students. Furthermore, the linear regression analysis has a coefficient of determination R^2 of 0.9682, which shows an excellent goodness of fit and confirms its ability to accurately estimate the values of the dependent variable, in this case, the final mark of the ordinary exam. These results are aligned with those of Keng (2023), which show that soft skills are significantly associated with students' marks.

Within the set of independent variables analyzed, there are notable differences in their impact on students' academic performance. Some soft skills have significantly higher estimated coefficients than others, indicating a more pronounced effect on academic performance. It should be noted that the positive coefficients reflect a direct association between the independent variable and academic performance, i.e. an increase in the value of the independent variable is associated with an improvement in academic performance.

According to the linear regression analysis (Table 4), the soft skills that have the greatest influence on students' academic performance are the Effective use of ICT (P3) ($\beta = 0.075$), the ability to solve problems efficiently (R1) ($\beta = 0.072$), Cooperative work (T1) ($\beta = 0.069$), Leadership (T2) ($\beta = 0.065$) and Positive attitude (I3) ($\beta = 0.062$). These soft skills, together with others such as Communication skills (C1), Pressure tolerance (R4), Proactivity (P2) or Resilience (I2), stand out as critical factors for academic success, as suggested by the results of the study.

These results are consistent with those obtained in the analysis with Power BI (Fig. 18) and when calculating the Pearson correlation coefficient, which showed (Table 3) that the soft skills with the strongest correlation with the mark in the ordinary exam were the Efficient use of ICT (P3) ($r=0.68$), Problem solving (R1) ($r=0.56$), Cooperative work (T1) ($r=0.54$) and Communication skills (C1) ($r=0.28$). This agreement among the three analyses reinforces the hypothesis that suggests that these soft skills are key factors that positively influence the academic performance of engineering students. In addition, these results can contribute to the insights provided by previous studies that, by using a similar approach, aim to assess students' perceptions of the importance of soft skills for academic performance and career development (Ngo, 2024).

4.8 The importance of continuous improvement and adaptation

This study also reveals that adaptation and continuous improvement are crucial aspects for improving results and achieving educational goals. The methodology used has shown a positive impact on the development of soft skills in engineering students, and its effectiveness has improved over time, precisely due to this continuous improvement and adaptation to the specific needs of the students. However, there are still interesting actions to be taken in this respect.

Perceptions regarding the methodology and its impact on soft skills development vary according to academic year, gender, students' enrollment status and engineering degree. This fact suggests the need for an adaptive approach that considers the specific needs of each group in order to adjust strategies. For example, differentiated activities or resources could be implemented to reinforce the development of soft skills in students who value these skills less or to increase the participation of repeat students.

Indeed, the active participation of all students, especially repeaters, is essential to improve the impact of the methodology. In this sense, activities can be implemented to increase the motivation and engagement of all students, such as further diversifying activities, using more visual and interactive teaching resources, or providing individualized support.

The study identifies soft skills that have a greater influence on academic performance, such as Efficient use of ICT (P3), Problem solving (R1) or Cooperative work (T1). Focusing on the development of these skills through educational methodology can have a more significant impact on learning outcomes. Obviously, it is also necessary to incorporate specific strategies to foster the development of those soft skills that are less valued.

On the other hand, continuous improvement requires a process of constant monitoring and assessment. Different tools, such as surveys, interviews or data analysis, can be used to collect information about students' perceptions, soft skills development and academic performance. This information will allow identifying areas for improvement and making adjustments to the methodology in order to optimize its results.

4.9 Strengths and positive aspects of the study

The study is based on a sound and exhaustive methodology that combines different research techniques to obtain a comprehensive analysis of the impact of the methodology on the development of students' soft skills. The use of surveys allows the collection of quantitative data on students' perceptions, while statistical analysis facilitates the processing and interpretation of these data. The graphical representation of the data not only facilitates the understanding of the results, but also enhances the identification of patterns and trends that might go unnoticed in a purely numerical analysis.

The longitudinal design of the study allows observing the variation in students' perceptions over time, which provides key information about the effectiveness of the methodology over time. This longitudinal perspective is particularly relevant for assessing the sustained impact of the methodology on students' soft skills development, as it allows going beyond a one-time evaluation and capturing changes that occur over a longer period of time.

Another strength is that the study goes beyond analyzing a limited set of soft skills and covers a wide range of soft skills relevant to the personal and professional development of engineering students. This breadth of the study allows for a more comprehensive view of the impact of the methodology on students' comprehensive development.

Furthermore, the study does not merely provide general results, but deepens the analysis by identifying differences in the perception of the methodology as a function of academic year, gender, students' enrollment status and engineering degree. This detailed information allows to better understand the specific needs of different groups of students and to adapt the methodology accordingly.

On the other hand, the study not only identifies the soft skills that are most influenced by the methodology, but also highlights those that have the greatest impact on academic performance. This information is crucial to understand which soft skills are most relevant for success in this subject and to focus educational efforts on their development.

The study does not simply present positive results, but also recognizes the need for continuous improvement of the methodology. This proactive attitude towards improvement demonstrates the authors' commitment to the development of effective educational strategies for the promotion of soft skills in engineering education.

Finally, the study can contribute to raising awareness of the importance of soft skills development in engineering education among teachers, university managers, politicians, etc. By demonstrating the positive impact of soft skills on academic performance, the study can encourage the integration of soft skills development into teaching projects and educational programs.

4.10 Limitations and biases of the study

The study has some limitations and biases that must be considered when interpreting its results. It should be noted that the study was conducted in a specific context, with a sample of engineering students from a single university, the UVa, so the results cannot be generalized to other populations, i.e. other degrees, other universities or even other countries.

On the other hand, while the study is based on students' perceptions of the impact of the methodology on the development of their soft skills, it is important to consider that this may be subject to certain biases. For example, students may tend to overestimate or underestimate their own skills, or their responses may be influenced by factors external to the study, such as their personal motivation, their relationship with the teacher, peer pressure, or even the mood of the day on which they completed the survey.

In this regard, other variables that could influence students' soft skills development and academic performance were not taken into account. For example, students' socio-economic status, prior academic history and exposure to previous educational experiences were not monitored.

Furthermore, while the sample size is considerable, it may not be fully representative of the entire population of students in the different engineering degrees. If the students who participated in the surveys are those more likely to have a positive view of the methodology or to be more motivated to develop their soft skills, the results could be biased. An overall positive perception of the methodology could influence individual ratings for soft skills (halo effect), biasing the responses towards higher ratings.

In addition, the relationship between soft skills development and academic performance is complex and multifactorial. Although the study provides evidence of a positive association, it does not establish causality. Therefore, further research is needed to better understand the mechanisms underlying this relationship.

In summary, and despite these limitations and biases, the study gives valuable information about the potential of the methodology to promote the development of soft skills in industrial engineering students. It also identifies the need for future research that considers the aforementioned limitations and expands the sample to more diverse populations in order to obtain more generalizable conclusions.

4.11 Educational implications and recommendations

The study offers valuable implications for engineering education, highlighting the importance of a holistic approach that fosters the development of both academic and socio-emotional skills of students.

Firstly, it is confirmed that the evaluated methodology has a positive impact on the development of engineering students' soft skills, which in turn leads to improved academic performance. These soft skills, increasingly in demand by employers, are key to the professional success of engineers.

The results show that the combined use of active methodologies such as FL, gamification and cooperative work can create a dynamic and stimulating learning environment that not only favours the development of soft skills and academic performance, but also prepares students to face the challenges of today's world in a collaborative and creative way.

In this regard, the incorporation of the methodology in teaching projects and educational programs can contribute to the education of professionals who are better prepared for today's challenges. In order to achieve an effective implementation of the methodology, it is important that teachers receive adequate training to apply the methodology effectively and adapt teaching to the needs of students.

The results also suggest that academic performance is not only limited to technical knowledge or hard skills; soft skills also play a crucial role in student achievement. Therefore, engineering education should adopt a holistic approach that addresses both the academic and socio-emotional development of students.

On the other hand, the study shows a significant positive correlation between the appropriate use of ICT and students' academic performance. This underlines the need to incorporate technological tools and resources in a creative and pedagogical way to enhance their impact on learning and to prepare students for an increasingly digitized and interconnected world.

It is worth noting that the perception of the effectiveness of the methodology has improved over time, reflecting a process of continuous improvement. It is essential that teachers, departments and educational institutions establish monitoring and evaluation mechanisms to identify areas for improvement and make appropriate adjustments in the implementation of teaching methodologies.

In this process of continuous improvement, it is important not to forget those soft skills that are most in demand by companies, in order to develop specific programs to work on them. Therefore, it is important to establish communication channels with companies to know the demands of the labour market and adapt the training of students accordingly.

The results of the study show that the perception of the methodology varies according to the academic year, gender, students' enrollment status and engineering degree. This suggests the need for an adaptive approach that considers the specific needs of each group of students. It is necessary, whenever possible, to design and implement differentiated strategies to address the diversity of students and amplify the impact of the methodology.

On the other hand, there are skills for which the methodology is more effective, but there are others for which it is not so effective. Therefore, special attention should be paid to the development of the latter skills through specific activities, feedback and the creation of a collaborative learning environment.

The study also shows that the active participation of all students is crucial to the success of the methodology. Strategies must be implemented to encourage the engagement of all students, especially those who have difficulties in participating in learning activities. This implies that different active learning techniques may be needed, depending on what hard and soft skills are sought to be developed in students or what educational goals are desired to be achieved.

Classroom activities are a distinct advantage of face-to-face universities over online institutions. We must be able to strategically leverage this competitive advantage using active methodologies, such as the one evaluated in this study, to enhance the development of soft skills and the academic performance of engineering students.

5 Conclusions

This work describes a study that addresses a RQ1, i.e., *What is the students' perception about the degree to which the methodology used has allowed them to develop their soft skills?* The study also addresses a RQ2, i.e., *What is the relationship between the development of soft skills and academic performance (hard skills)?* The results obtained in the study allow adequately addressing both RQs raised.

The results show a positive effect of the methodology in relation to the aforementioned RQ. It has been found that not only students perceive that this methodology effectively fosters the development of many soft skills, but that these soft skills also contribute to a significant improvement in the academic performance of students, demonstrating its usefulness as a tool for the comprehensive development of students, which, on the one hand, shows that the promotion of soft skills is an essential investment that not only enriches the educational experience of industrial engineering students, but also provides them with a sound and holistic training to successfully face the professional challenges of the future, and, on the other hand, contributes to underpinning the insights from previous works.

In addition, the study highlights the importance of several key aspects for the success of the educational methodology:

- The use of different active methodologies as pedagogical tools transforms engineering education and contributes to the development of well-rounded professionals.
- The appropriate incorporation of ICT in the educational process plays a fundamental role in learning and in the development of soft skills.
- It is crucial to adapt teaching to the specific needs of each group of students through differentiated strategies, considering the multiple influencing factors.
- The active participation of all students in learning activities is essential for the success of the methodology. Therefore, specific strategies should be implemented to encourage such participation.
- Monitoring and continuous improvement of the methodology are key elements in achieving more efficient and effective engineering education. This improvement process ensures the sustainability of the benefits of the methodology over time and overcomes challenges that may arise in its implementation.

Appendix: Voluntary survey administered to students

In the following survey, students were asked to rate to what degree they considered that they had developed each of the mentioned soft skills as a result of the educational methodology employed in the third thematic block, using a scale of 1 to 7, where 1 means a minimum development and 7 a maximum development.

Soft skill	1	2	3	4	5	6	7
Problem solving							
Analysis and synthesis							
Critical thinking							
Pressure tolerance							
Communication skills							
Assertiveness							
Listening skills							
Cooperative work							
Leadership							
Delegation skills							
Negotiation skills							
Responsibility							
Adaptability							
Organization and planning							
Honesty							
Respect							
Solidarity							
Spirit of service							
Perseverance							
Resilience							
Positive attitude							
Empathy							
Creativity							
Proactivity							
Efficient use of ICT							

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Declarations

Competing Interests The authors declare that they have no competing interests.

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