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Assessing the impact of Teaching Innovation Projects on university quality indicators and employer expectations: a case study in the Spanish university

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ABSTRACT

This work analyses the influence of teaching innovation projects in the field of Chemical Engineering at the University of Oviedo (Spain) on both institutional quality indicators and employers' expectances. The projects were classified into three groups: related to the Chemical Engineering programs, those with scientific or technological relevance, and those focused on learning methodologies. Many projects focus on active methodologies and PBL, and assessment, and although a positive relationship was observed with teaching satisfaction and some quality indicators, we noted that several important aspects were not adequately reflected there. Likewise, little alignment was observed between the skills demanded by employers and those developed in the teaching innovation projects. A bibliometric analysis suggests that the proliferation of highly segmented teaching innovation projects in Spanish universities could be due to faculty promotion criteria. Efforts should focus on coordinated program-level actions, rigorous content, thoughtful AI integration, and effort-based learning.

Keywords: teaching innovation projects; gamification; quality indicators; engagement; teaching methodologies.

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1. Challenges of chemical engineering education

Chemical Engineering has been defined as the science of transformation, and processes through which the raw materials are transformed into valuable products are safe, efficient, and sustainable (IChemE, 2025a). In order to do so, chemical engineers need technical expertise in a wide range of disciplines, such as chemistry, biochemistry, engineering, materials science, and information technology and related disciplines that include economics, management, safety, and environmental protection (Feijoo et al., 2019). In addition to technical competence, the modern engineer has to possess various transversal and non-technical skills such as ethical awareness, effective communication, teamwork and accountability. Technological advances over the past decade have further transformed the discipline. The integration of digital technologies allowed enhance accessibility, safety, and engagement through virtual laboratories, simulation software, and augmented reality works (Chiu, 2021). Additionally, AI is potentially used in learning activities with the idea of obtaining a personalized education by tracking student progress, as well as to obtain feedback in real-time (Chiu, 2021; Keith et al., 2025; Ruiz Rodríguez et al., 2025). Another issue is the Industry 4.0 (dos Santos et al., 2018), which would also lead to curriculum adaptation by incorporation of data analytics, process automation, and digital twins to align with industry demands and improve graduates' employability.

The American Institute of Chemical Engineers (AIChE) (Alkaya et al., 2015), has emphasized the importance of aligning university curricula with current and future industrial needs (Alford & Edgar, 2017). Particular attention was paid to process safety, dynamics, control, and applied statistics. Furthermore, industry leaders have emphasized the importance of transversal skills, including communication, teamwork, and problem-solving abilities, alongside technical expertise.

The definition of educational benchmarks for engineering programs is mostly guided by accreditation bodies such as the IChemE and the Accreditation Board for Engineering and Technology (ABET, 2024). In 2021, IChemE, emphasized the importance of mathematics, science, and associated engineering disciplines, as well as general skills, including communication, time management, teamwork and digital skills (Bolton et al., 2023; IChemE, 2021). Similarly, the 2025-2026 ABET criteria specify that curricula should integrate advanced courses in mathematics, chemistry, and physics, as well as the engineering application of these sciences to the design, analysis, and control of processes, with particular attention to associated hazards (ABET, 2024).

Teaching methodologies must be adapted to meet the evolving needs of both industry and society. Methodologies such as problem-based and project-based learning (PBL) have been used as interconnected approaches in engineering education, this methodology offers some opportunities to engage students in problem-solving with real life engineering relevance (Mayer, 2007). The success of this initiative is strongly influenced on the application way, being the option of a department-wide chemical engineering reform a desirable and feasible option (Ragusa & Lee, 2012). Another methodology, widely tested in the last decade, is gamification. It is considered as an approach to motivate and engage students in their learning process. Its application in several subjects of both bachelor's and master's degrees resulted in very positive impressions from both students and teachers involved in the subjects (Díaz et al., 2024; Feijoo et al., 2018; Suárez-López et al., 2023). Augmented reality application on chemical engineering teaching includes the accessibility for representing complex concepts and safely visualizing industrial processes in the area, which is said to promote greater engagement among students, contributing to improved learning and the development of interpersonal, investigation, and autonomy skills (Rebello et al., 2024). And, even, the application of generative artificial intelligence was applied to chemical engineering context (Keith et al., 2025).

A central challenge is how these teaching methodologies ensure the acquisition of skills and knowledge specified by accreditation bodies for Chemical Engineering profession. The assessment and quality assurance processes should determine whether these methods genuinely enhance employability.

However, despite numerous studies and reports on industry expectations and individual pedagogical innovations, we are not aware of any work that examines the effects the different types of teaching innovation projects and how these might influence academic results, both within the student environment of the faculty, and from the point of view of employers. This study seeks to address that gap through a case study describing the impact of teaching innovation projects implemented in Chemical Engineering studies at the University of Oviedo (Spain), on internal quality indicators, and employers' expectations.

2. Innovation teaching projects at the University of Oviedo

This work compiled all teaching innovation projects funded by the Education Research Institute (INIE) at the University of Oviedo (Spain) from 2010 to 2025 (INIE, 2025) and selected those related to Chemical Engineering studies. Data was obtained exclusively from publicly accessible project records available on the INIE website, no individual level or identifiable data was used. Projects were included if they were formally recognized by the University within the specified period. Duplicated entries, incomplete records or projects lacking sufficient descriptive information to allow classification were excluded.

To ensure methodological transparency, the classification procedure was based on a structured codebook developed specifically for this study. The unit of analysis was the individual project entry. The codebook detailed the definition of each category, inclusion and exclusion criteria, and illustrative examples to support consistent decision-making. Before formal coding, both researchers jointly discuss sample projects and refine category boundaries.

After a dozen projects were analyzed jointly, the full dataset was independently coded by the two researchers. Each project was assigned to one of three predefined categories:

- Those directly related to the Chemical Engineering Bachelor's or Master's programs, or to individual subjects within them (see Table A1, Appendices).

Table 1. Classification of Teaching Innovation Projects Related to Chemical Engineering (University of Oviedo, 2010–2025).

Project category	Number of projects	Percentage	Topics (%)
I. Projects directly related to the Chemical Engineering Bachelor's or Master's programs, or to individual subjects (see Appendix 1)	16	6.4 %	- Basic formation in Chemical Engineering Bachelor (fundamental subjects: Mathematics, Physics, Graphical Expression) (38 %) - Core Chemical Engineering subjects (31 %) - Applied to laboratories of Chemical Engineering Bachelor (19 %) - Master's Subjects (6 %) - Others (6 %)
II. Projects addressing scientific or technological aspects applicable to Chemical Engineering (see Appendix 2)	66	26.5 %	- Aspects of technical subjects (52 %) - Methodology in technical subjects / Bachelors (29 %) - Related to the labour market (6 %) - Related to High School education and student recruitment (1 %) - Other aspects (12 %)
III. Projects focused on general learning methodologies (see Appendix 3)	167	67.1 %	- Active methodologies and PBL (31 %) - Assessment and self-assessment (17 %) - Use of technologies in teaching (16 %) - Development of transversal skills (12 %) - Innovation in the teaching of scientific skills (8 %) - Autonomous learning (5 %) - Gamification and ludic learning (4 %) - Final degree project (4 %) - Inclusion and educational accessibility (3 %)

- Those addressing scientific or technological aspects applicable to Chemical Engineering (see Table A2, Appendices).
- Those focused on general learning methodologies (see Table A3, Appendices).

Within the three groups, 249 projects have been selected, which can be broken down as follows: 6.5 % corresponding to projects directly involved in Chemical Engineering studies, 26.5 % related to technical teachings and 67 % related to teaching methodology. Two researchers performed the classification independently, with greater than 90 % agreement. Coding reliability was assessed by comparing the independent classifications; discrepancies were discussed and resolved by consensus to ensure consistency. All the information is summarized in Table 1.

The third group of projects, and the most numerous, is divided into 9 subgroups which deal with very general aspects that could be applied to university studies in any area. The four more relevant subgroups (assessment and self-assessment, active methodologies and PBL, development of transversal skills and use of technology in teaching) are plotted by year, from 2010 to 2025, in Figure 1. It is worth noting that in 2014, 2017, and 2020, a significant number of

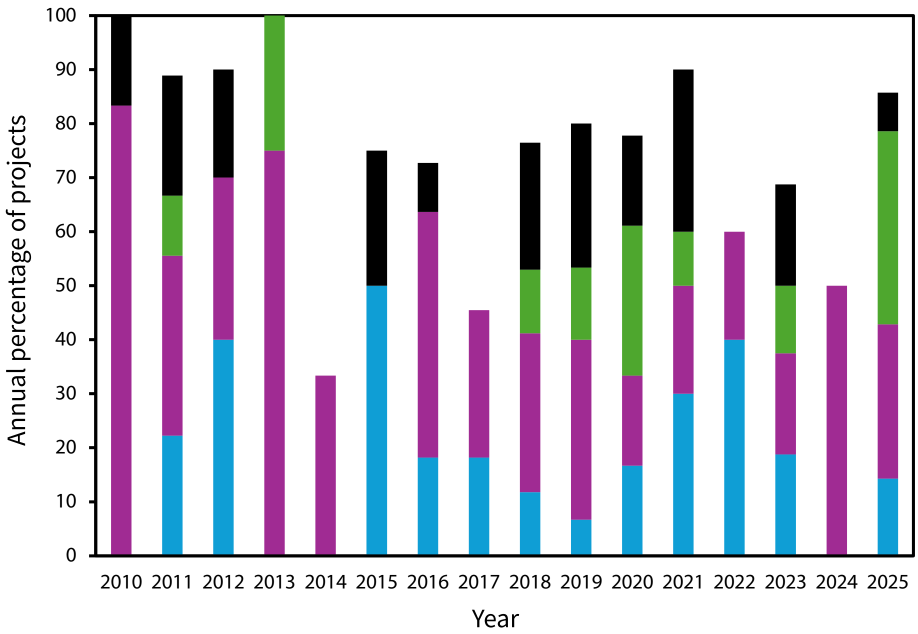

Figure 1. Evolution from 2010 to 2025, of the percentage of general teaching innovation projects related to the main subgroups: assessment and self-assessment (blue), active methodologies and PBL (purple), development of transversal skills (green) and use of technology in teaching (black).

teaching innovation projects were focused on gamification and ludic learning, as well as final degree projects. Furthermore, in 2020, due to the COVID-19 pandemic, the highest number of teaching innovation projects were developed.

The predominance of active methodologies and PBL in the early years (2010–2013) corresponds to periods in which the total height of the bars remains relatively stable, indicating that fluctuations in the global indicator are largely driven by this category.

3. Indicators on chemical engineering studies at University of Oviedo

The Students' Evaluation of Teaching (SET) is a tool for monitoring university quality and constitutes a primary indicator for teaching evaluation and quality degree accreditation. Table 2 presents the results of participation as well as the average values of the items of general satisfaction with teaching of both students and faculty staff.

Student participation in the SET -ranging from 250 to 500 answers each year- is observed to fluctuate greatly over the analyzed period, with a clear downward trend. However, the overall student satisfaction in the Chemical Engineering Bachelor's program is very similar to the faculty self-assessment satisfaction. Furthermore, it could be highlighted, based on the summary report provided by the Technical Quality Service, that among the questions about which the students were asked—what they have learned, material resources and physical conditions, as well as the professor's work—students particularly valued the professors' activity, and this has been more pronounced in the later years of the period.

Table 2. Summary of Students' Evaluation of Teaching (SET) results for the Chemical Engineering Bachelor's program at the University of Oviedo, from 2015/16 to 2023/24 academic years (latest published report). Scale for satisfaction varies in the range 0–10 (UTC, 2025a).

Year	Students' response percentage	Overall Student Satisfaction	Faculty self-assessment of satisfaction
2015/2016	41.4	6.5	7.2
2016/2017	38.5	6.7	7.5
2017/2018	29.5	7.2	7.1
2018/2019	25.5	7.5	7.6
2019/2020	20.8	8.1	7.7
2020/2021	30.4	7.5	8.0
2021/2022	30.8	7.4	7.8
2022/2023	30.6	7.9	8.0
2023/2024	24.6	8.1	8.3
Average	30.2	7.4	7.7

A second group of indicators include the Performance Rate, defined as the ratio between the number of credits passed by students (each credit refers to 1 ECTS, that is, 25 hours of student work) in an academic year and the total number of credits enrolled in this year; the Success Rate, defined as the ratio between the number of credits passed by students enrolled in the referenced academic year and the total number of credits they submitted for evaluation in that year; the Assessment Rate, defined as the ratio between the number of credits submitted for assessment by students enrolled in the referenced academic year and the total number of credits in which they were enrolled; and, finally, the Efficiency Rate, defined as the ratio between the total number of credits passed and the total number of credits enrolled by graduating students throughout their studies. From Figure 2 it is observed that across all academic years, these indicators show an upward trend, with the Success Rate presenting the least clear upward pattern.

Figure 3 shows the evolution between the 2018/19 and 2022/23 academic years (the latest figures available on the website), of both the first-year dropout rate and the total dropout rate, the latter covering the first three years of the degree. As can be seen, the first-year dropout rate is very high, exceeding 50% in the 2019/20 academic year. In the same year, the dropout rate for the first three years exceeded 95%. It is worth noting that Spanish public universities have open access, that is, free or very low-cost, which partly explains higher dropout rates.

Despite the limited historical data, it is reasonable to think that these figures are related to the situation experienced because of the COVID-19 pandemic, since an important decrease in dropout rates has been observed from that point. On the other hand, data on employment one year after graduation is very encouraging, showing full employability (although these figures correspond to only 3 to 5 students in each course, which limits the possibility

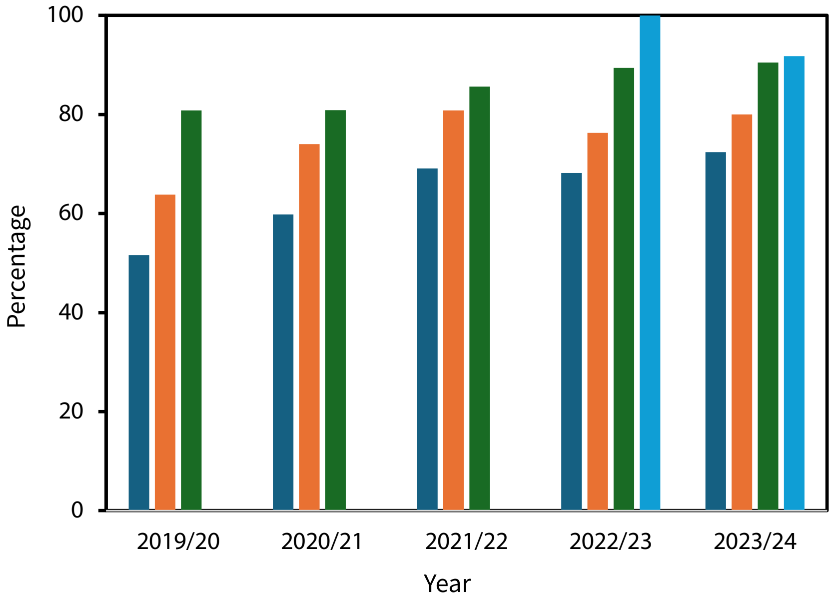

Figure 2. Percentage of performance rate (dark blue), success rate (orange), assessment rate (green) and efficiency rate (light blue) from 2019/20 to 2023/24 in Chemical Engineering Bachelor (UTC, 2025b).

of generalization). On the other hand, for graduates of the Chemical Engineering Bachelor's program in the 2021/22 academic year, the employment one year after graduation drops from 80% (Figure 3) to 62.5% according to the 2024 Annual Work Program (Canal & Cueto, 2024a).

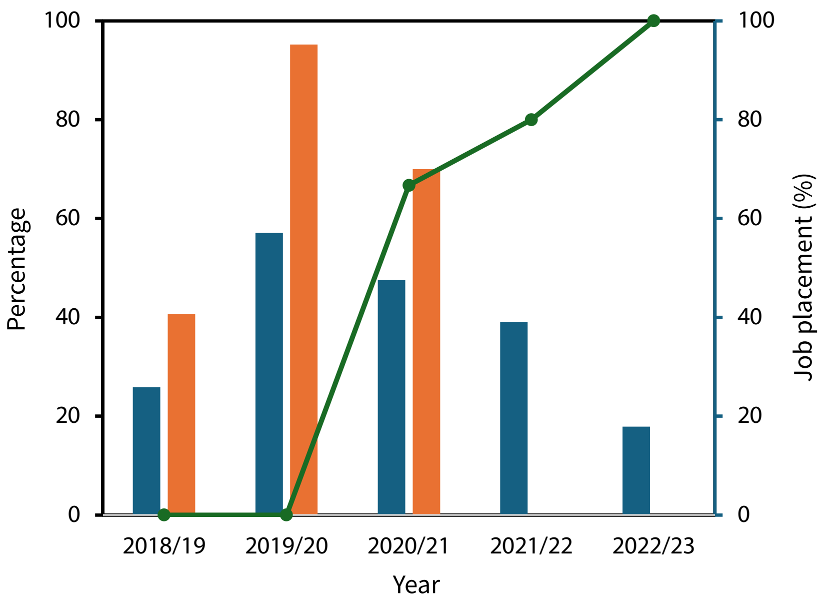

Figure 3. Percentage of the first-year dropout rate (blue) and the total dropout rate (orange) from 2018 /19 to 2022/23 in Chemical Engineering Bachelor. On the right axis, the employment one year after graduation (UTC, 2025b). There is no data on employment one year after graduation for the period 2018/19–2019/20.

In a more general way, and regarding employability, it has been observed that, although the demand for STEM (Science, Technology, Engineering, and Mathematics) professionals is high, the number of graduates is relatively low compared to other European countries. For example, Spain has the fourth lowest proportion of graduates in science and technology Bachelors within the EU-27, ahead only of Cyprus, Malta, and Belgium, and is far behind the leaders in this aspect: Germany and Romania (both with 35% of graduates in STEM studies) and Finland, Estonia and Croatia (between 28-29%) (CYD, 2023). In addition, this trend is increasing, since in 2023/24 the ratio of students enrolled in engineering studies decreased to 17 % compared with 8 years earlier (Canal & Cueto, 2024a).

Additionally, it is worth mentioning that Chemical Engineering Bachelor of the University of Oviedo is accredited by IChemE since 2012 (IChemE, 2025b). This is a mark of assurance that the program meets the high standards set by the Engineering Council, the regulatory body for the engineering profession in the UK, in collaboration with the discipline-specific UK professional engineering institutions (PEIs).

4. Analysis of innovation concerns

4.1. Analysis of the influence of teaching innovation projects on indicators

The Teaching Innovation Projects listed in Table 1 are analyzed jointly in this section. Before extracting information from the observed data, it is worth clarifying what we might expect from the different types of teaching innovation projects and how these might influence academic results. Projects implemented in second-year subjects— in which Chemical Engineering subjects begin to be taught —would require at least three years before to observe any effect on employment. Therefore, the empirical analyses should be interpreted within these temporal constraints.

Simply by applying logical reasoning, it could be supposed that the application of active methodologies, problem-based learning (PBL), assessment and self-assessment strategies, and transversal-skills training could enhance student engagement, autonomy, and metacognitive abilities. Likewise, these mechanisms should contribute to students' higher satisfaction, improved performance indicators, reduced dropout, and, in the long term, better employability. In addition, application of technologies in teaching, although could have different objectives, could reinforce these effects when used to support feedback, interactivity, or immersive learning.

As expected, the comparative analysis of satisfaction scores (Table 2) and the evolution of teaching innovation projects (Table 1, Figure 1) reveals a clear positive trend between the intensity of pedagogical innovation and improved perceptions of teaching quality. Between 2015 and 2017, student satisfaction levels were quite low (6.5–6.7), a period characterized by limited activity in projects related to active methodologies and assessment. In contrast, from 2018 to 2023, the expansion of initiatives—particularly PBL and the use of technology—corresponded with substantial increases in satisfaction (8.1 for students and 8.3 for faculty). In 2023/24, satisfaction indicators remained high although the response percentage was quite modest (24.6%), suggesting that the impact of innovative efforts is not immediate.

Similarly, the analysis of innovation projects in the Chemical Engineering Bachelor program between 2010 and 2025 reveals a significant alignment between theoretically grounded interventions and improvements in in key academic performance indicators (Figure 2 and 3). The proportion of projects focused on general learning methodologies—comprising active methodologies and PBL (31%) and assessment and self-assessment strategies (17%) (Table 1, Figure 1)—could influence the increases in performance, success, and efficiency rates observed from 2019/20 to 2023/24, Figure 2. Concerning the first year and total dropout rates, in the range 2018/19 and 2022/23, both decreased, being related to an increase in innovation projects focused on transversal skills and the use of technologies in teaching.

Nevertheless, some discrepancies emerge when contrasting theoretical expectations with empirical outcomes. Although a positive association appears between projects dedicated to active methodologies and PBL and internal performance indicators, establishing a causal relationship remains difficult. PBL was implemented in specific subjects, being recommended for a good use its application in a large part of the Bachelor (Ragusa & Lee, 2012); and, secondly, although its application has remained relatively stable over time, with interruptions in 2014, 2015, and 2022, these methodologies are not decisive in reducing either the first-year dropout rate or the overall dropout rate (Figure 3). A more accurate assessment of these active methodologies may require employer feedback, which could capture improvements that are not visible in internal indicators.

In the case of assessment and self-assessment projects, the theoretical rationale is clearer: self-assessment tools, consistent rubrics, and structured feedback should support metacognition and more accurate self-evaluation. As can be observed, a positive trend is observed between these projects and performance indicators and satisfaction levels. From the literature, it is emphasized the need for reliable tools and tutor feedback to ensure accuracy and learning effectiveness (Llopis-Albert & Rubio, 2021; Sáiz Manzanares et al., 2015; Sloan & Scharff, 2022). However, it's important to emphasize that the accuracy of both the self-assessment mechanisms and the rubrics is vital, and feedback from the tutor is especially beneficial (Karaman, 2024).

Projects involving the use of technologies in teaching form a diverse group (third subgroup of projects in Table 1), varying from virtual campus design and attendance control to the implementation of tools such as Kahoot or instructional videos. Despite the theoretical potential of technologies such as VR, AR, mixed reality, or AI to improve learning (Chiu, 2021; Keith et al., 2025), no clear empirical correlation appears between these initiatives and quality indicators in our dataset. This may reflect the heterogeneity of these projects and their variable alignment with pedagogical objectives.

Transversal-skills projects work competencies such as teamwork, communication, technical reading, and written expression, which enrich students' education, better preparing them to face the challenges of the workplace (Guerra-Macías & Tobón, 2025; Moliner et al., 2015). Integrating these transversal skills into university courses can enrich students' education, better preparing them to face the challenges of the workplace. Likewise, a higher level of transversal skills was associated with better academic averages among student (Guerra-Macías & Tobón, 2025). Since no relationship was observed between these aspects and the indicators described previously, transversal skills projects will be analyzed based on what employers and society, in general, expect from new graduates.

Finally, although gamification and ludic learning constitute a smaller subset of general methodology projects, they appear frequently across initiatives both in Bachelor's and Master's subjects, which suggests a positive reception from both students and faculty. The literature identifies theoretical benefits: development of critical thinking, reinforcement of student self-confidence, and increased interaction between students and instructors (Feijoo et al., 2019; Suárez-López et al., 2023); but also highlights risks such as stress, competition, misalignment with curricula, and insufficient depth for complex problem solving (Almeida et al., 2023; Díaz et al., 2024; Dichev & Dicheva, 2017; Lester et al., 2023). These limitations may explain why the positive mechanisms suggested by theory do not clearly translate into improvements in performance indicators (Table 2, Figure 2 and 3).

4.2. Analysis of the influence of innovation projects on the expectations of employers and society

Since the compilation of quality indicators relates to the satisfaction and performance of students and/or staff in the academia, we should go further to understand both employers and society's expectations. To fully understand the effectiveness and relevance of teaching innovation projects, it is necessary to integrate the expectations of employers and society. The theoretical assumption guiding this section is that engineering education must align not only with internal performance metrics but also with the competencies demanded by professional practice, defined by the accreditation bodies such as the IChemE and ABET, as well as societal changes.

In this way, from the curricula, it seems clear that a chemical engineer should be able to design specified units that include material transfer, heat transfer, and fluid flow processes, but also apply process safety, process dynamics, process control, and statistics (Alford & Edgar, 2017; Alkaya et al., 2015; Feijoo et al., 2019). Furthermore, industry leaders have emphasized the importance of transversal skills, including communication, teamwork, and problem-solving abilities, alongside technical expertise (Alford & Edgar, 2017; Alkaya et al., 2015). This presents a major challenge, because while four or five decades ago, separation processes focused on distillation and absorption, today's programs have expanded (at least, theoretically) to cover a broader range of separation processes (adsorption, filtration, crystallization, extraction, chromatography, membrane technologies, and centrifugation) (Bolton et al., 2023). But this doesn't mean that distillation isn't still very relevant. Therefore, it is clear the need to motivate students to continuous improvement and constantly learning and to develop capacity to deal with increased uncertainty and complexity. In this way, the acquisition of digital tools (in the context of Industry 4.0 (Pozzo & Al-Zoubi, 2025)), sustainability and circularity, and professional ethics are currently required by employers.

Recent employer surveys confirm the importance of transversal skills in current labor market, remarking, first, the importance of degree-specific competencies, and second, on transversal skills (Canal & Cueto, 2024b). The importance of the latter was especially relevant in the case of self-management and attitudes toward work, especially the willingness to learn and adapt, responsibility, teamwork, time management, problem-solving, emotional intelligence and proactivity, as well as communication skills. This is not an isolated problem in Spain; employers in other countries have also detected a gap between engineering training and the development of these skills (Chan & Luk, 2022), indicating that this is a structural challenge rather than a localized issue.

However, in the list of teaching innovation projects (see Tables A1, A2 and A3), beyond teamwork and communication skills, any other skill appeared. This disconnect suggests that current pedagogical innovations may not fully align with the mechanisms theoretically required to enhance graduates' employability and professional readiness, Figure 4.

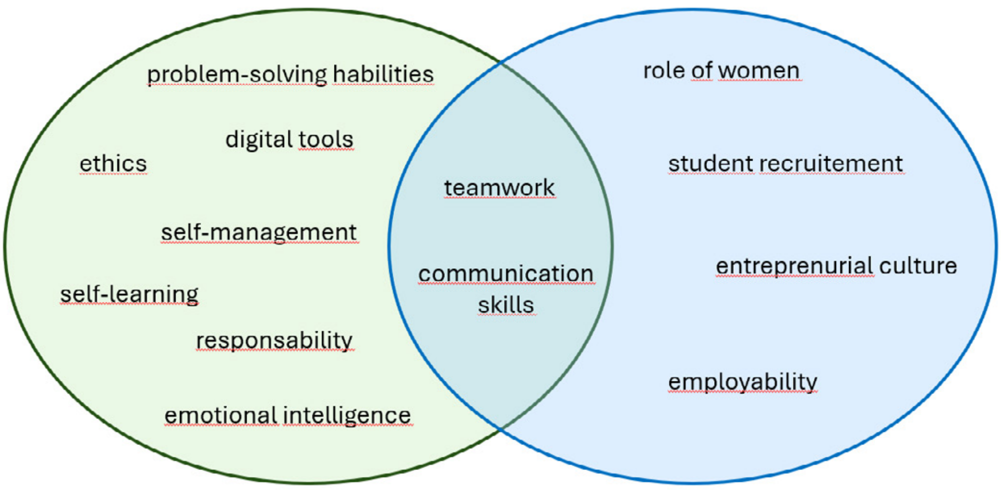

Figure 4. Venn Diagram for comparison of keywords of employer demands (green) and keywords of teaching innovation projects (blue).

Societal perceptions also influence these dynamics. Changes in how chemical engineering is viewed influence both student enrolment and employer expectations. A recent study attributes the declining enrolment in chemical engineering programs in Spain to the low recognition of the discipline in the Spanish society (Rodríguez-Gómez et al., 2025). This broader context implies that teaching innovation must not only enhance learning outcomes but also help to communicate the value and relevance of the discipline to prospective students and the general society.

4.3. Critical analysis and improvement actions

Universities face important challenges, because the changes that are taking place are constant and very fast. Curricula are increasingly broad, and at the same time, employers and society increasingly expect more (transversal skills). These pressures help explain why teaching innovation has become a central focus of educational policy. A common criticism, however, is the reluctance of university professors of technological disciplines to introduce changes in their teaching methodology. In response to this challenge, U.S. universities began several years ago to organize sessions and workshops to redefine the role of professors as instructors, with the aim to promote changes in university learning cultures, depending on the effective implementation of new teaching practices (Feixas & Zellweger, 2010).The unequivocal idea is clear: university teaching that integrates pedagogical skills and in-depth subject knowledge leads to better learning outcomes compared to traditional methods (Sloan & Scharff, 2022).

Yet the teaching methodology should not overlap the core knowledge of the discipline. In a highly critical paper on new university teaching methodologies in general and, gamification (Li & Liu, 2023), it was highlighted that instructional content remains the most influential determinant of student learning; methodology alone cannot compensate for weak conceptual foundations. Additionally, implementing techniques such as gamification or problem-based learning (PBL) in isolated subjects can raise engagement and motivation but may also restrict students' exposure to essential course material, especially when instructors experience difficulty completing the full syllabus (Ragusa & Lee, 2012). Students themselves have reported that such methodologies, when used in limited contexts, may reduce the depth of knowledge acquired (Suárez-López et al., 2023). These dynamics generate two unintended negative consequences: (1) student evaluation of teaching (SET) scores often rise because fewer conceptual barriers make courses appear easier, thus increasing grades (Berezvai et al., 2020), and (2) instructors teaching subsequent subjects encounter students with insufficient foundational knowledge.

From the above, it can be deduced that the value of SET is relative. While it is to be expected that a majority will respond consistently to objective questions, SET reliability is limited by complex scoring systems and inconsistent rating behaviors (Xiao et al., 2025). In fact, based on detailed analyses of repeatability and reproducibility in SET, it was concluded that they do not accurately measure teaching quality (Vanacore & Pellegrino, 2019). These limitations create a disconnect between measured satisfaction and actual learning.

Within this context, one hypothesis regarding the expansion of teaching innovation projects—particularly in Spain—is that they are a requirement for teaching assessment systems, such as the DOCENTIA program (Llopis-Albert et al., 2023) and accreditations for faculty promotion. Teaching innovation projects receive substantial weight in promotion criteria, although there is no real monitoring of the impact of these projects on student outcomes. In agreement, a bibliometric search in the Web of Science Core Collection further highlights the imbalance: Spain exhibits an excessively high proportion of publications on teaching innovation projects (Figure 5).

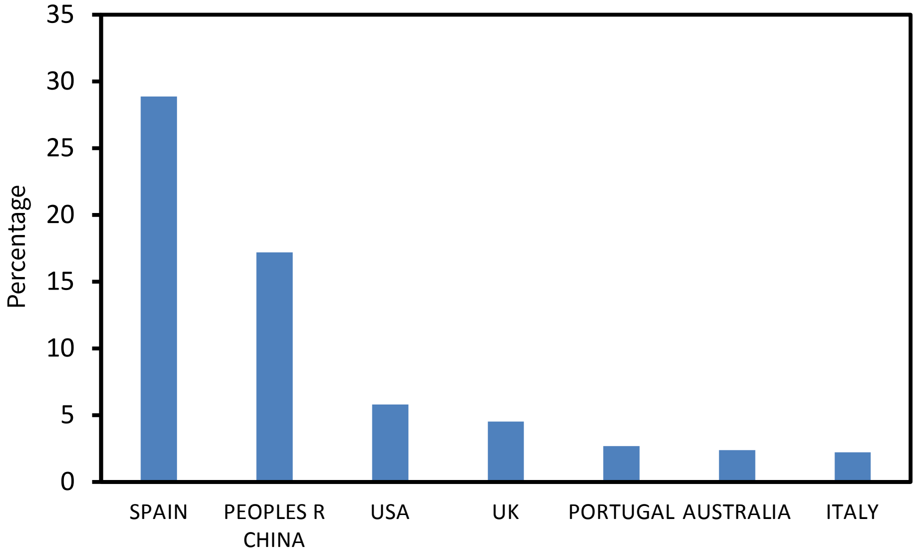

Figure 5. Plot of percentage of manuscripts in Web of Science Core Collection database according to the search term "teaching innovation project", total number of manuscripts: 9040. Date: 23/07/2025. Only countries with percentages higher than 2 % are represented.

Thematically, the dominant areas include self-regulated learning, science education, and educational technology. Citation patterns, however, are heavily skewed: a small number of papers receive substantial attention, while most receive very few citations (Velarde-Molina et al., 2023). This suggests that while interest in innovation is widespread, its scholarly impact is concentrated and uneven.

As improvement actions, it is proposed, first of all, joint actions within either Bachelor or Master, for which actual leadership in the university is necessary. Moreover, this leadership is crucial in the current context of incredible change where Chemical Engineering Departments have a lot of work to do to adapt to new challenges: very rapid changes in society or emergence of AI. This last one must be incorporated into the curricular program, but from analysis and reflection, in order to design learning experiences with structured AI integration points. What is more, AI could be used to enhance entrepreneurship education by pushing students out of their comfort zones through real or pseudo-real-world tasks.

Second, it is essential to recognize and reward student effort . An example could be the promotion of open-ended learning experiences delivered in authentic settings and that aim to solve real problems faced by industry. Although such experiences demand substantial effort from students, they reinforce the value of perseverance and deepen practical learning.

Finally, positive changes are now emerging. If the hypothesis that faculty promotion criteria have driven the proliferation of innovation projects is correct, then recent modifications in Spanish academic staff evaluation processes may redirect these incentives. Following the RD 678/2023, the Spanish agency for university staff qualification has shifted from quantitative metrics toward evaluating the quality, relevance, and impact of academic contributions.

While this move represents a progress toward a more holistic understanding of academic performance, it remains to be seen how these changes will translate into improved teaching quality from the students' perspective remains an open and important question for the coming years.

In any case, to encourage both in-depth knowledge of the discipline and innovative teaching techniques, it would be preferable not merely to grant accreditation for a faculty position, but to promote genuine competition among candidates.

4.4. Limitations of the study

In this study, we analyzed SETs results, quality indicators and employer expectations in relation to teaching innovation projects, providing valuable information on the projects' impact on academic outcomes. However, we must be aware that the results should be taken with caution, since these evaluations were collected after completion of the activities, when the students have no experience to really evaluate the subject in the context of the Bachelor. That is, the SETs show short-term perceptions. In addition, it compares academic performance in subjects with and without gamification, which introduces error factors.

In addition, the use of quality indicators (SET, performance, success, dropout and employability), in some cases, is limited by low response rates, which limits generalizability. Moreover, the structural shock introduced by COVID-19 affected teaching formats, student engagement and assessment conditions.

5. Conclusions

Teaching innovation projects in the Chemical Engineering studies at a Spanish University (Oviedo) show an association with improved teaching satisfaction and internal performance indicators, although the impact of innovative efforts is not immediate. Increases in active methodologies, PBL, assessment tools, and technology-enhanced learning align with higher satisfaction scores and better performance, success, and efficiency rates. However, the causal link remains uncertain because many innovations were applied only to specific subjects and inconsistently over time. Projects on transversal skills and gamification show positive perceptions but limited measurable impact on quality indicators.

Employers expect chemical engineering graduates to have a wide knowledge of both core technical competencies and of transversal skills such as communication, teamwork, adaptability, and problem-solving, while most teaching innovation projects address only a small part. These demands, add to demands for digitalization, sustainability, and professional ethics, highlight the need for continuous learning. All these employer demands have been found not to be reflected in the university's indicators.

Thus, although innovative techniques, especially PBL or gamification, can enhance motivation, they present the risk of limiting content and distorting SET. Many teaching innovation projects appear driven more by staff promotion concerns in the Spanish university, than by proven impact on learning. Improvement efforts should emphasize coordinated program-level actions, rigorous content delivery, thoughtful integration of AI, and authentic, effort-based learning experiences.

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APPENDIX 1

List of teaching innovation projects from the University of Oviedo directly related to the Chemical Engineering Bachelor or to subjects within it

Project title	Academic year
Didactic material based on interactive 3D visualization of objects for the development of spatial vision in the subject of Graphic Expression	2014
Intensification in the development of general skills in the subject “Chemical Engineering” through the analysis of chemicals process flow diagrams	2018
Using Kahoot! in “Linear Algebra” classes	2018
Methodological change in “Fundamentals Physics” subject to promote motivation and logical reasoning of the students of the Degree in Chemical Engineering	2018
Gamification applied to “Emulsion Technology and Suspensions”	2018
Project-based learning applied to Electrical Engineering	2018
Optimization of an absorption laboratory practice through use of sensors and the Labview application	2018
Teaching innovation perspective in Computer Fundamentals	2019
The flipped classroom as a methodology for problem-solving in Industrial Chemistry	2020
Gamifying Thermodynamics	2021
Tutorial videos: a tool for independent learning in chemistry and chemical engineering laboratories	2021
Integration of the Sustainable Development Goals (SDGs) into Industrial Chemistry	2022
Peer learning and assessment in the Chemical Engineering Laboratory	2023
Role-playing games as a tool for SDG implementation in Industrial Chemistry	2023
Optimizing the gamification methodology in the Graphic Expression course	2023
Exploring Chemical Engineering: Innovation and Sustainability for the Present and the Future	2025

APPENDIX 2

List of teaching innovation projects from the University of Oviedo related to scientific or technological aspects which could be applied to Chemical Engineering

Project title	Academic year
Implementation of an Integrated Quality and Occupational Safety System in practical classes laboratory	2010
New teaching methodologies in the acquisition of skills in engineering degrees	2011
Women in the History of Chemistry. An activity for the development of transversal skills in the year of Chemistry (UNESCO 2011)	2011
Opening of the Master's Degree to the Business and Institutional Employers	2013
Chemistry 2.0. Blogs and wikis to enhance the meaningful and collaborative learning in chemistry teaching	2013
Non-face-to-face practical work between different subjects and courses in technical degrees	2013
How to take an exam in the field of engineering: Method based on group tutorials and classroom practice	2014
Hydroelectric plants of Asturias in video clips with locution in English	2014
Improving the quality of TFGs in the field of engineering	2016
Design and scaling of a bioprocess: from the research article to the plant industrial.	2016
Project for the orientation of the professional career of students of engineering	2016
Application of statistical methods to the analysis of real data and preparation of technical reports	2016
Training in good practices in Engineering studies: how to avoid plagiarism academic.	2016
Adaptation of Environmental Engineering in Master's Degree Studies. Case Study of the Master's Degree in Mining Engineering	2016
Engineering students looking for their first job: the use of CE3X	2017
Design and development of an interactive learning experience using structural gamification and simulation to encourage student work in laboratory practices in the field of computer networks	2017
Implementing educational Gamification in the field of electronic technology	2017
Let's break with the sealed laboratory subjects: development of learning environments that facilitate the transversality of knowledge	2017
Learning and application of economic-business concepts for engineering students through press news and economic articles	2017
Innovative teaching methodologies from the specialized knowledge of the mathematics teacher	2017
Coordination between High School and University Mathematics Teachers, beyond the EBAU, to minimize the frequent "errors" that students make in the Calculus and Numerical Methods exams.	2017
Home exam in the subject of Optics	2017

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Project title	Academic year
Use of multimedia resources for teaching subjects related to electromagnetism	2017
Application of Labview to data collection in laboratory practices	2017
Implementation of the Flipped Learning methodology for autonomous learning in the laboratory: Application in the field of Analog Electronics	2017
Gamification of the subject “Waves and Electromagnetism” (bilingual degrees) of the Polytechnic School of Engineering of Gijón	2017
Green infrastructure and urban systems Sustainable drainage in undergraduate and graduate studies in engineering	2018
First stages aimed at the active search for employment in fields related to the subject “Techniques for the analysis of solids and surfaces”	2018
Gamification in the subject of Resistance Materials taught in different grades and schools engineers	2018
Strengthening basic mathematical concepts throughout engineering degrees. Detection of conceptual errors	2018
Innovation in learning fluid mechanics by using a mobile application questions and answers	2018
Reinforcement of Python learning through the use of a programming Gymkhana	2018
Cooperative learning techniques in “Materials Resistance”	2018
GAMING: Gamification for Engineers	2019
“Board game” applied to technical subjects	2019
Automatic generation of Moodle questionnaires and learning analytics strategies for the improvement and evaluation of learning in subjects of Control	2019
Combining gamification and the use of devices mobile phones to innovate in the studies of engineering	2019
Analysis of the Sustainable Development Goals through ICT: Objective 11 Cities and Sustainable Communities	2019
Study engineering at UNIOVI	2019
Generation of video tutorials for distance learning in two bilingual courses in the Bachelor’s Degree in Mechanical Engineering	2020
Applied industrial biotechnology process: cheesemaking practices	2020
Methodology for promoting participation and learning in the subject of Energy Systems and Hydraulic Development	2020
Using simulation-based tools to foster an entrepreneurial attitude in engineering students	2020
Adaptation of the Numerical Computing course to the format of a massive online MOOC	2020
Application of the flipped classroom method in electrical engineering studies	2020
Use of EVA rubber didactic models for teaching metal structures	2020

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Project title	Academic year
Using eXeLearning as a tool for developing laboratory and classroom practices in the area of Environmental Technologies	2021
Collaborative peer learning for the training of engineers	2021
Gamification of technical subjects with high regulatory content	2021
The inverted laboratory and its application to chemistry practicals in the Bachelor's Degree in Industrial Technology Engineering at the University of Oviedo	2021
CoopSolar: Cooperative Learning in the Design and Simulation of a Large Solar Photovoltaic Plant	2022
Gamification of the Graphic Expression subject in bilingual programs	2022
Monitoring the study and understanding of the Optics subject through questionnaires	2022
Strengthening knowledge in Environmental Engineering through a gamification methodology developed in Group Tutoring	2022
Collaborative learning methodology aimed at applying theoretical and practical knowledge to develop a prototype for an interuniversity competition within the framework of sustainable mobility	2022
Project-Based Learning (PBL) and Peer Assessment in Electrical Engineering Projects: Electrical Installation Design and Audits	2022
Peer-to-peer in electronic technology: Promoting collaborative learning	2022
Digital tools for teaching computational models	2022
Development of cognitive and instrumental skills in Electrical Engineering	2023
Introduction of a cross-curricular practice and gamification with ICT in Fluid Mechanics laboratory practices	2023
Teaching strategy in technical education using flipped learning and competency-based assessment	2023
Artificial Intelligence as a Resource to Enhance Learning: Implications for Chemistry Teaching	2023
Creation of a comic-game board using Genially in courses on "Solar Energy."	2024
Broadened Perspectives: Educational Hybridizations of Engineering and Philosophy at the University of Oviedo.	2024
DEVA - Development of video games oriented to learning in technical education	2025
Educational resources in mathematics for engineers: REMAI	2025

APPENDIX 3

List of teaching innovation projects from the University of Oviedo related to learning methodologies

Project title	Academic year
Design, implementation and evaluation of a blended-learning training ecosystem adapted to the European Higher Education Area	2010
Development of teaching material to promote the transversal competence "teamwork" in students of the University of Oviedo	2010
A change in university teaching: the use of active methodologies to promote competencies at the University of Oviedo.	2010
Blended-learning tools applied to group tutoring within the framework of the EHEA	2010
The teaching-learning process supported by the integration of Web 2.0 tools to Virtual Campus	2010
Audiovisual strategies and resources in WEB 2.0 as support for a better teacher	2010
Augmented reality on mobile devices: application to the field educational	2011
Personal Virtual Campus: A portable e-learning system with support for unconventional teaching and assessment activities	2011
Advancing in the use of active methodologies for the promotion of skills at the University of Oviedo	2011
Development and adaptation of teaching material to promote transversal competence "teamwork" throughout the Campus Virtual of the University of Oviedo	2011
Assessment of learning through self-assessment questionnaires on-line	2011
Low-cost adaptation to the European Higher Education Area (EHEA)	2011
Application of an automatic system to attendance control and its export to Virtual Campus	2011
Development of entrepreneurial culture with training ecosystems interdisciplinary	2011
The completion of the Final Year Project as an opportunity to enhance the ability and ability to speak in public	2011
Application of new information technologies, group work and new evaluation technologies	2012
Promotion of meaningful and collaborative learning through the use of WEB 2.0	2012
Design of e-rubrics for the assessment of transversal skills	2012
Platform for the integration and innovation of theoretical content and its applications in engineering degrees	2012

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Project title	Academic year
The effectiveness of group tutoring in the development of key skills for insertion into the labor market	2012
Expanding the boundaries of the classroom in the digital era for the development of autonomy and professional training	2012
Evaluation and development of ICT tools to improve teaching dynamics in classrooms	2012
Online self-assessment test: a motivating autonomous learning method	2012
Improvement of the evaluation process and implementation of group activities	2012
The use of continuous assessment in learning: comparative analysis of methods and results	2012
ECTS: correspondence between the ECTS credit and the student's actual work time	2013
Effective work groups: exploring collaborative Learning through Group Work Tutored	2013
Influence of integrated and individual blogs on the quality of written works	2013
A new vision of group work: blended group work	2013
Kuhn's didactic methodology in learning science: from the expository class to the flipped class.	2014
Dynamization of group tutorials and fixation of concepts key through board games	2014
The implementation of gamification elements in the teaching-learning process	2014
Project-Based Learning: Design, development and editing of videos didactics for initial teacher training	2015
B-learning and cooperative learning teaching strategies with digital peer assessment tools	2015
Classroom Assessment Techniques - Quality Assessment classroom learning	2015
Just in Time Teaching and flipped class as gamifying elements in the learning process	2015
Designing Virtual Campus. A professionalizing and mentoring experience between university students	2016
Improvement of the Teaching Methodology and the Continuous Evaluation System implemented in the subject "Computer Tools", through activities "workshop" evaluated with rubrics.	2016
Teaching innovation in laboratory practices through TFGs and TFMs	2016
Why do students prefer private academies to individual tutoring?	2016
Self-regulation of learning through the virtual campus in the first year of Degree	2016
Promotion and improvement of research, technological, legal, translation and communicative as a basis for access to the labor market	2016
Group tutoring: an opportunity to stimulate autonomous learning of the student.	2016
Teaching strategies to promote autonomous and collaborative learning	2016
The importance of interdisciplinarity in Final Degree Projects	2016

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Project title	Academic year
Application of the Chronozoom computer tool for the preparation collaborative online educational content in the classroom.	2016
E-orientation: online pre-university orientation project	2016
Autonomous e-assessment as an improvement strategy in the learning process in university contexts.	2016
Constructivism and cooperative learning in a changing environment and multidisciplinary	2016
Implementation of evaluation elements in a master's subject	2016
ONLINE tools to promote collaborative learning of students	2017
Gamification in the classroom: "Escape Room" activity-based experience	2017
Self-assessed online learning assistant	2017
Self-regulation tools to promote university permanence	2017
Teamwork at the University and its evaluation through rubrics	2017
Strategies to face and improve the TFG at the University with the use of ICT	2017
Enhancing student participation through gamification and collaboration tools	2017
Development of online self-assessment questionnaires through the Virtual Campus to improve the autonomous work of students	2017
Does the TFG help me improve my oral and written communication skills?	2017
Inclusive multidisciplinary training ecosystems for improving learning in higher education	2017
Improving learning and teaching based on student feedback	2017
From field practice to theory: the path inverse applied to the study of a case	2018
Improving the coordination of subjects through the automatic generation of minutes based on the communication via email	2018
Kahoot! tool as an innovation proposal educational in expository classes	2018
Advantages of online teaching: an approach multidisciplinary	2018
Exploration and intervention on reliability judgments of scientific information sources	2018
Cross-curricular training for writing reports and technical documents enhancing written language appropriate	2018
Towards a true evaluation of the acquisition of skills	2018
Improving understanding and expression in first year university students	2018
Audiovisual Knowledge and Learning Pills	2018
Personifying science: Use of new technologies to encourage critical reading and understanding of scientific publications	2018
Co-evaluation through the virtual campus: definition of indicators and feedback	2018

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Project title	**Academic year**
Science is wonderful. Share the wonder.	2018
Backchannel in expositive lessons	2018
Improved explanations of concepts and exercises through the use of subtitled videos	2018
Development of innovative methodologies through learning with mobile devices	2018
Peer learning as a success strategy	2018
Meet our scientists	2018
Lifelong learning: projects Service-Learning	2019
Audiovisual Pills of Knowledge and Learning. Expansion and improvement	2019
Kahoot! tool as a proposal educational innovation in expository classes	2019
Meta-cognitive variables and learning in university students	2019
Using videos for learning	2019
What's after university? Departures professionals of our degree	2019
Communication strategies in the field professional through the use of ICT	2019
Promotion of autonomous and team work through classroom practices	2019
Active participation monitoring techniques in lecture classes	2019
Collaborative Learning through Youtube	2019
Collaborative learning through a project milestone based	2019
Team Teaching: a teaching methodology innovative to improve customer engagement students in the classroom	2019
"Learn to know how to do." Synthesis and citation from different sources of information.	2019
Preparation of a Scientific Poster	2019
Teaching innovation to improve the context classroom learning	2019
Publication of provisional grades. As comparisons between students influence their motivation and academic results	2019
Training in planning academic tasks through the Virtual Campus	2020
Smartphone use in the classroom using Kahoot and Mentimeter	2020
Creation of educational videos to support flipped classroom sessions and self-correction of errors	2020
Improving written and oral communication skills in overcrowded classrooms	2020
Cooperative learning as a teaching model in in-person and distance learning university education	2020
The importance of game-based learning as a tool for promoting inclusive education	2020
Development of training programs and development of generic skills in undergraduate students.	2020
The opportunity to learn how to improve: online formative assessment	2020

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Project title	Academic year
Development of transversal skills through collaborative research on the Virtual Campus	2020
"True education consists of bringing out the best in oneself." How to foster student empowerment through written communication	2020
Creating online activities for student assessment	2020
Development of a learning methodology using gamification for the acquisition of transversal skills.	2020
Methodology for improving general and specific skills in the Final Degree Project	2020
Application of the design thinking methodology to promote the development of transversal skills and multidisciplinary work	2020
Kangaroo Community Facing the Leap to the Digital University: Human Interactions, Technological Silences, and Reflective Dialogues	2020
Use and creation of educational videos for online teaching	2020
Comparison of student reactions to online assessments versus in-person assessments	2020
Pre-Instructional Problem-Solving Approach Applied to University Teaching	2020
Using Smartphones in the Classroom Through Innovative Teaching Tools	2021
Dialogues with 18-year-olds	2021
Video tutorial applications in university teaching	2021
Improving written communication skills in overcrowded classrooms	2021
Kangaroo Community for Burnout: Peer Support and Shared Wellness Strategies	2021
Design and development of instruments for the authentic assessment of soft skills in undergraduate and master's degree courses	2021
Flipped learning through interactive collaborative work methods, problem-based learning, and project development	2021
Correction of laboratory practices and proposed exercises in real time	2021
Verification of theoretical concepts through the design of experiments	2021
Automated creation and grading of customized multiple-choice exams, valid for both in-person and online assessment.	2021
Transforming continuous assessment into a collaborative and motivating approach	2022
Using a Smartphone as a Learning Tool: Mentimeter and JigSpace	2022
Self-tracking system for a subject to facilitate study, content acquisition, and continuous assessment	2022
"Free problems" as a tool to encourage students' self-learning	2022
Constructive and cooperative learning as a strategy for recognizing, posing, and solving logical problems	2022
Scientific communication: a first look at common research formats	2022
Using avatars to create non-perishable multimedia teaching resources	2023

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Project title	Academic year
Artificial Intelligence in Higher Education: Promoting Positive and Critical Use by Students	2023
Digital resources and strategies for improving oral and written communication skills (with special attention to media language)	2023
Lab Sheets for an Effective Scientific Presentation	2023
Integration of Artificial Intelligence as a Self-Training Tool in a Master's Degree Subject	2023
The use of scientific articles as a learning methodology through reading comprehension and presentation	2023
Use of new information technologies for the creation of open educational materials and for the assessment of collaborative learning	2023
More with less: adapting methodologies and resources to changes in teaching demand	2023
Implementation of tests to reinforce subject knowledge	2023
Monitoring and analyzing participation and cooperation in teamwork	2023
Interuniversity Collaboration for Educational Innovation in Final Year Projects	2023
Proposal for interdepartmental coordination for Values Education	2023
Improving pass and learning rates: Introduction to study strategies for multiple-choice exams	2023
The summary as a tool for improving academic writing	2023
Traditional system vs. new technologies and reverse planning	2023
The generation of multilingual educational videos in university and school contexts	2023
Plant Research Conference	2024
Hearing Refresher Pills	2024
Guide to good practices for teaching effectiveness	2024
Self-Construction Material: Refining and Promoting a Pedagogical Model for SDG Development from an Interdisciplinary Perspective	2024
FinEduca360: Youth for Youth	2024
Toward a more inclusive university: accessibility and digitalization of teaching content and methodologies	2024
Enabling Next-Generation Network Infrastructures for Learning (HIRED)	2024
Get closer to your scientific future	2024
Professionals with impact: a boost to the labor market	2025
Effectiveness of using the Learning Outcomes Tool (LOT) in university students' autonomous learning for problem-solving in real-life contexts.	2025
Wooclap: Learn how to use it, energize your classes, and encourage student participation and self-regulation.	2025
Active breaks in university teaching to improve student and faculty satisfaction. ActivaDos Project	2025

(Table continued on next page)

Project title	Academic year
Promoting the responsible and thoughtful use of artificial intelligence in university learning: impact assessment and design of innovative guidelines with a gender perspective	2025
Building Bridges: Solidarity and Social Justice from the University Classroom	2025
Application of a methodology to improve general skills in the TFG and TFM	2025
Interactive Education with AI: Gamification, Digital Progress Boards, and Personalized Feedback for the Classroom of the Future	2025
Emotional Engineering: Development of Transversal Competencies in University Education	2025
Collaborative Infographics: Communicate, Innovate, Inspire	2025
Development and assessment of competencies through playful elements supported by Artificial Intelligence.	2025
Implementation of Thinking Routines in the university classroom to improve student attention and retention	2025
Transversality unites	2025
The university in the community: learning and service as a tool	2025
Methodological innovation through cooperative learning: Impact on motivation and performance in contexts of low initial collaboration	2025