



Practice Paper

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Engagement of 1st year engineering students through the interaction with 4th year Product Development Projects

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ABSTRACT

This paper presents the first intervention of the RESOLUT project, launched at ETSETB-TelecomBCN, the UPC School of Telecommunication Engineering to enhance student motivation and engagement through socially oriented, project and challenge-based learning. The initiative connects first-year engineering students with fourth-year students engaged in challenges proposed by companies and third-sector organizations. The intervention included a series of structured activities: presentations of the initial statements of the projects, collaborative design-thinking workshops, and final project showcases. The approach aimed to inspire early-year students, foster leadership among seniors, and strengthen interdisciplinary learning. Feedback from 68 out of 180 participants was very positive, with increasing satisfaction across the activities. The paper discusses the outcomes of this pilot and

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outlines plans to integrate these activities formally into the curriculum. RESOLUT serves as a replicable framework for aligning engineering education with societal needs and fostering early engagement in meaningful learning.

1 INTRODUCTION

On 2023, the Technical University of Catalonia (UPC) started a process to rethink the learning experience at the University with the aim to transform teaching at the UPC (Carrió et al., 2024) which is called Learning Galaxy. After promoting structured discussions on curricular content, teaching methodologies and learning spaces on every engineering school, participants identified key elements for rethinking the teaching model and proposed specific action plans in a call for projects funded by the University. ETSETB-TelecosBCN, the UPC School of Telecommunication Engineering, presented the project RESOLUT (Social Challenges and Leadership for Technological Universities), which was funded and is being implemented (September 2024-July 2027). The aim of this project is twofold. The first objective is fully aligned with UPC's mission and focusses on designing a new paradigm for project-based courses, more closely integrated with societal needs. This initiative requires service-oriented projects proposed by third-sector agents, fostering student engagement with real-world societal challenges. The second objective is to promote interaction between seniors and freshmen/freshwomen through these projects to enhance motivation and leadership skills, and seeks to increase interdisciplinary projects to involve a broader student body. By leveraging challenge-based learning methodologies, RESOLUT strives to boost student motivation, improve learning outcomes, and reduce dropout rates, particularly in early academic years. There are also specific actions on the teaching and learning methods in the first year. The project's outcomes are expected to have a long-term, wide-reaching impact across UPC, serving as a model for other institutions and strengthening the university's social commitment. What is described in this paper is the design and results of a first pilot intended to boost the engagement of 1st year students through the interaction with 4th year Product Development Project students.

2 CONTEXT AND PRACTICAL WORK

2.1 Student Motivation and Engagement in 1st year Engineering courses

Student motivation and engagement are key to prevent dropout in 1st year of Engineering programs. Experiential Learning methodologies, Peer-Learning and Peer-Mentoring have been identified as relevant strategies that would promote this motivation and engagement. Pantzos et al. (2022) explored engineering student motivation in challenge-driven project courses using Self-Determination Theory. They found that autonomy, competence, and relatedness are critical to motivation in first-years. Also Tembrevilla in the ASEE systematic review on experiential learning (2023) documents the integration of hands-on, real-world projects into first-year curricula and notes positive effects on retention and identity formation. This Engineering Identity develops early and remains stable across the first years, underscoring the importance of early interventions, according to Lockhart & Rambo-Hernandez (2023). Also Godwin et al. (2024) explored how engineering identity and belonging predict grit among first-generation students, demonstrating that identity development supports persistence.

Several studies describe empirically-backed evidences that peer learning and peer mentoring significantly contribute to reducing first-year student abandonment in engineering programs. Approaches like peer-led team learning (Muller et al., 2017), mandatory peer mentoring (Budny et al., 2010), (Agrawal et al., 2024) and peer-led study groups (Reisel et al., 2012) consistently improve retention by nurturing academic success, community inclusion and a sense of belonging.

The improvement of the Peer-Mentoring activities will also be included in the RESOLUT project, but are not described in this practice paper. The following sections describe the interaction between first and fourth year students around the project and challenge-based projects as a way to implement a sort of peer-learning and a first contact with the experiential courses.

2.2 ETSETB Project and Challenge-Based courses itinerary

The Bachelor's degree in Telecommunication Technologies and Services Engineering at ETSETB-TelecosBCN, includes three project-based courses in order to provide a framework to facilitate the learning of personal, interpersonal and professional skills. The CDIO model (Crawley et al., 2024) was used in the design of the program, which was completed 13 years ago. The three project-based courses are "Introduction to Engineering" (2nd year, 6 ECTS), "Basic Engineering Project" (3rd year, 6 ECTS) and "Advanced Engineering Project" (AEP, 4th year, 12 ECTS). In the first two subjects, students work in reduced teams (3-5 students) following a partially guided plan which also includes some disciplinary contents learning and in which the project topic is proposed by the supervisors. Although the goal of the three courses is to provide a context close to the practice of engineering, the first two use standard PBL methodology (Du et al., 2009), providing both context and contents through a known and guided sequence of activities. However, the AEP course follows the Product Development Project (PDP) model, which can also be assimilated to the New Product Development model (Cobb et al., 2016). In this course, larger working groups (8-12 students) carry out the design of a complete product or service, including its business model. The teams generate the requirements and specifications of the product or service from the initial interaction with the stakeholders, define the system block structure and the work packages, which are assigned to subgroups of 2-3 students. They must design, implement and test the subsystems, integrate them, define a business model based on the product or service and perform the sustainability and ethical analysis. In the first years (2011-2014) the challenges of the AEP projects were proposed by the teaching staff. Since then, external agents were gradually involved and currently, 8-9 out of 10 challenges are proposed mostly by companies but also by hospitals, foundations or NGOs. This subject is compulsory and 1780 students have passed through it and have worked in 177 different projects. Some examples of project challenges are: image processing software for rehabilitation of facial paralysis due to facial nerve injury, blockchain-based payment distribution system in the music industry, measurement of the content level of clothes recycling containers or a device for expressing the pain score of patients recovering at home. The AEP course is scheduled twice per academic year (Fall and Spring terms). In the Fall term, 10-15 students carry out the AEP course in a different way, following a Challenge-Based Learning (CBL) model (Malmqvist et al., 2015) in multidisciplinary teams. A study comparing both approaches was published (Charosky et al. 2021). In (Bragós et al., 2022) a study

about the performance of the students in the project-based and standard courses can be found.

Several of the AEP challenges are already set by third sector institutions, hospitals or government departments with a societal purpose. Also, some companies propose challenges with societal focus, according with their corporate social responsibility programs or focus on the sustainability aspects. In the framework of the RESOLUT project, we plan to increase the proportion of challenges coming from these sectors and approaches in AEP but also to build a vertical itinerary, having societally oriented challenges in the three project-based courses (2nd, 3^d and 4th year) and a first activity in the first year as a way of giving purpose to the engineering studies and raising the motivation and engagement of the students.

2.3 1st year students' engagement through exposure to the 4th year projects

While the framework of this vertical itinerary is still under construction, a pilot to improve the engagement of 1st year students through exposure to the 4th year projects was conducted in the Fall term of the current academic year. It consisted of three steps:

1st activity, performed on October 9th, 2024. The 4th year students were in the 4th week of their AEP projects, and the Preliminary Design Report was completed (Svensson & Krysanter, 2004). They were asked to perform a short presentation (10 min + Q&A) to the 1st year students about the challenge statement, their approach to the solution and the project plan. This requirement was set up from the beginning of the course. Eight different projects were presented in two parallel sessions (4 projects each one):

- Nanosatellite mission to the Moon (i2Cat and NanoSatLab)
- Pointclouds processing for a building plans tracer robot (Hewlett Packard)
- Pain scale score for remote children health monitoring (Sant Joan de Déu Hospital)
- Remote health check system for developing areas (Fractus)
- Anomaly detection in IT systems using Machine Learning (ITNow)
- Entry Inspection Unit for an automated warehouse (Mecalux)
- Low cost and robust device for visual health inspection (Fractus)
- Improvement of connectivity between moving rovers in an automated warehouse (Mecalux)

A total of 180 1st year students attended the sessions, 100 of them the first 4 projects and 80 of them the last 4 projects. Before the students' presentations, we introduced the RESOLUT project and the challenge-based courses itinerary of the bachelor's degree and its rationale to the 1st year students.

2nd activity, performed on November 13th, 2024. The 1st year students participated in a Design-Thinking activity (2-hours) in which they were asked to find answers to a design question following a structured-brainstorming process in teams.

At the end of the session, the teams presented a poster with their proposals. A week before the activity, they were asked about their preferences, expressing a prioritized order for three of the projects. The result was that 4 out of the 8 projects were present in this phase: Nanosatellite (33 students); Plans tracer robot (31 students);

Pain Scale Score (19 students) and Remote Health (16 students). After the activity, the students were asked to fill an anonymous questionnaire providing insights about the projects and feedback about the activity interest.

3^d activity, performed on January 20th and 21st, 2025. The 1st year students who had completed the first two activities were invited to attend the final presentation of one of the projects, which were performed by the 4th year students in front of their supervisors and representatives of the external institutions. These presentations, given in English, were an assessment activity for the 4th year students. Because of confidentiality issues, it was not possible to attend the Plans Tracer Robot presentation and the students chosen among the other three ones. The distribution was: Nanosatellite (43 students); Pain Scale Score (15 students) and Remote Health (24 students). The students were also asked to fill an anonymous questionnaire providing insights about the projects and feedback about the activity interest.



Fig. 1. Partial view of the room where the Pain Scale Score device was presented in front of the Hospital representatives and the project supervisors.

3 RESULTS AND INSIGHTS

About the attendance, from a total of 240 students enrolled in the first year of the ETSETB bachelor's degree, 180 attended the first activity, 99 the second one and 82 the third one, being the drop-out between the first two activities a lot bigger than the one between the last two activities. Our understanding is that the students attending the first two activities were the ones really interested on the experience and that the reason for not attending the third one was probably because it was out of the classes period, just after the exams.

The abridged results of the questions about the activities ("Assessment of the activity: Grade the activity from 1 (not at all useful) to 5 (very useful)" can be seen in the Table 1 and the histograms for the three activities in the Figure 2. Only the scores given by the students which attended the three activities are displayed.

Table 1. Grades given by the students to the three activities (mean score, scale 1 to 5)

Project (number of participants)	Activity 1 Presentation	Activity 2 Design Thinking	Activity 3 Final Presentation
Nanosatellite (37)	3,8	3,8	4,1
Pain Score (11)	4,2	4,5	4,8
Remote Health (20)	3,8	4,0	4,6
Total (68)	3,8	3,9	4,4

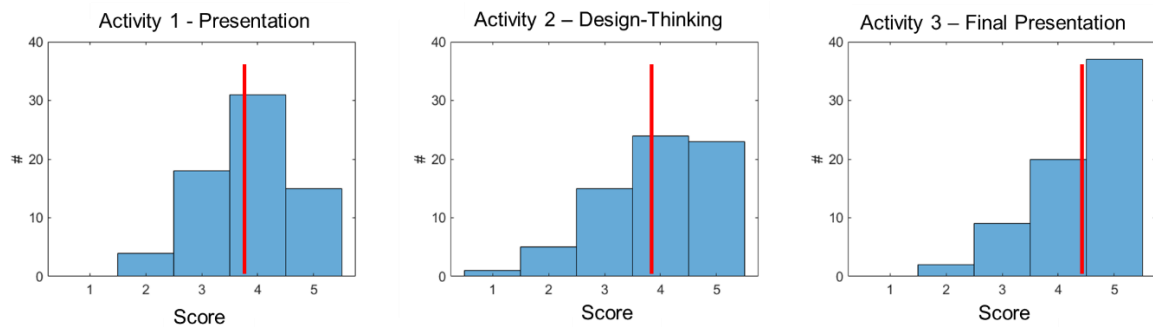


Fig. 2. Histograms and mean value (red line) of the grades given to the three activities

The feedback is good, above 3,8 in all cases, which is above the average value of the results of the courses at UPC. There are very few students that have provided a low or very low mark (3 in activity 1, 5 in activity 2, and 2 in activity 3). The proportion of grades in the good and very good columns increased as the activities progressed (68% in activity 1, 69% in activity 2 and 85% in activity 3).

The questionnaire also included open questions about different aspects of the activities. Some representative answers to the question "Do you think these activities may have helped you visualize the content of the bachelor?" are: "Yes, it has made me see the level that is reached upon finishing the degree". "Yes, it has helped me have a clearer vision of the purpose of the courses I am taking and those I will have to take". "It has made me see that our degree can be applied to create solutions in other areas that are useful for society". "It motivates you to continue, despite the difficulties". "It has helped me learn about fields in which I never thought I could work".

Although the students participating in the activities related with health (Pain Scale Score and Remote Health) provided higher marks, there were more students interested in the more technological projects. They had higher preferences to choose these projects in all polls and, as the Plans Tracer Robot was not available for the final presentation, most of the attendants to the first and second activity in this project moved to the nanosatellite project and not to the health-related projects.

4 CONCLUSIONS AND IMPLICATIONS

The overall assessment of this initiative by its promoters is positive. A significant number of 1st year students has followed it and has given a good score, mainly to the final presentations, which were more complex than the previous activities. We think that a relevant factor has been the opportunity of witnessing the feedback given by the companies or hospital representatives, which gives a sense of true reality.

We also consider that the participation of the 4th year students in the activities is positive for their learning outcomes. The task of presenting the project to an audience with low technological knowledge is definitely a good synthesis exercise, and mostly when the project definition is quite preliminary. Also, the pressure of having this kind of public mixed with the external experts in the final presentation is good for the development of communication skills.

The activities described in this conference communication were a pilot implementation of the kind of activities we are planning to establish in the RESOLUT project framework in order to enhance the motivation and engagement of the 1st year students, with the ultimate goal of reducing the withdrawal rate. We were initially hesitant about their acceptance but the results are encouraging. There is still a task to do to engage the students which only did the first activity and not the second and third ones. Next year, this set of activities will be included in a formal introductory subject, with regular enrollment and assessment, and will also be part of the formal requirements for the 4th year students. We will also study the correlation between the attendants and their academic results at the end of the academic year.

This intervention can be readily adapted to other institutions and educational contexts. Its modular design, relatively low cost, and strong alignment with institutional priorities make it practical for replication. Experiential courses in the later years of the curriculum—including capstone projects—can serve as showcases for first-year students, illustrating the kinds of work they will eventually be able to undertake. Moreover, inviting first-year students to contribute ideas for potential project improvements can enhance their motivation by providing a sense of early involvement and relevance.

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