

WIP: Shaping the Future of Engineering Education: Perspectives from the University Community on Innovative Teaching Practices

Mar Carrió Llach

*Institut de Ciències de l'Educació
Department of Optics and Optometry
Universitat Politècnica de Catalunya
Barcelona, Catalonia, Spain
mar.carrio@upc.edu*

Ramon Bragós Bardia

*Institut de Ciències de l'Educació
Department of Electronic Engineering
Universitat Politècnica de Catalunya
Barcelona, Catalonia, Spain
ramon.bragos@upc.edu*

Berta Bardí Milà

*Institut de Ciències de l'Educació
Department of Architectural Design
Universitat Politècnica de Catalunya
Barcelona, Catalonia, Spain
berta.bardi@upc.edu*

Joan Gispets Parcerissas

*Department of Optics and Optometry
Universitat Politècnica de Catalunya
Barcelona, Catalonia, Spain
joan.gispets@upc.edu*

Montserrat Alsina Aubach

*Institut de Ciències de l'Educació
Department of Mathematics
Universitat Politècnica de Catalunya
Barcelona, Catalonia, Spain
montserrat.alsina@upc.edu*

Oriol Buqueras Solsona

*Institut de Ciències de l'Educació
Universitat Politècnica de Catalunya
Barcelona, Catalonia, Spain
oriol.buqueras@upc.edu*

Antoni Hernández-Fernández

*Institut de Ciències de l'Educació
Universitat Politècnica de Catalunya
Barcelona, Catalonia, Spain
antonio.hernandez@upc.edu*

Abstract—This work in progress innovative practice paper presents a study conducted at Universitat Politècnica de Catalunya (UPC) to investigate the perspectives of the university community regarding the evolution of the institution's teaching model, particularly focusing on identifying the essential elements for engineering education. The study arises from the necessity for universities to adapt their educational approaches to meet the demands of contemporary society, emphasizing the cultivation of critical thinking, intellectual rigor, and social responsibility among students. This is part of the Learning Galaxy Initiative, which aims to enhance the students' learning experience and define a distinctive teaching model at UPC. Through structured discussions on curricular content, teaching methodologies and learning spaces, participants have identified key elements for rethinking the teaching model.

Keywords—engineering education, students, faculties and staff, focus groups, qualitative analysis

I. INTRODUCTION

Most Higher Education Institutions (HEIs) have modified their teaching models and curricula in the last years or are doing it in order to address contemporary challenges. The widely recognized need of adopting a student-centered and competence-based approach and also the need of including sustainability, ethics and innovation competences in the engineering curricula are drivers of this change. In addition, unexpected factors like the aftermath of the coronavirus pandemic or the emergence of generative artificial intelligence demand more agility to include innovative approaches to education.

The HEIs that already performed these changes usually made public their approaches to plan and manage the change, then allowing others to get inspiration. We would like to reference some good examples which include internal and external stakeholder involvement [1], gradual

development through pilots [2] or strong involvement of students [2], [3].

The Universitat Politècnica de Catalunya (UPC) recognizes this urgency and has embarked on a transformative journey through its project “Galàxia Aprenentatge” (Learning Galaxy, in English, LG from now on). The LG project seeks to engage the entire university community in a collective reflection on enhancing the learning experience, with the ultimate goal of defining a distinctive teaching model for the university. This process is structured into five phases, as illustrated in Figure 1. This paper focuses on a key action from phase 3, which involves collecting insights and perspectives from the internal stakeholders in the different Schools about the future teaching model.

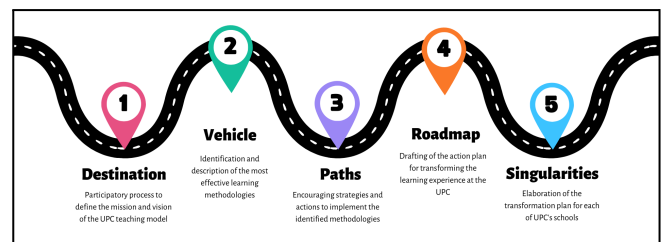


Figure 1: Learning Galaxy Initiative Phases.

II. THE LEARNING GALAXY INITIATIVE

The LG project at UPC aims to address three key objectives for enhancing university education. Firstly, it seeks to define the competencies students should acquire and educators should impart, aligning them with the overarching goals of education. Secondly, it aims to explore innovative methodologies to improve teaching and learning outcomes, striving for greater efficiency and effectiveness in the educational process. Finally, the project aims to

conceptualize and design conducive learning spaces, creating environments that inspire and facilitate learning for all stakeholders involved. The LG initiative places students, teachers and the rest of the university community at the center of a collective construction process for a novel teaching model. By rethinking traditional approaches, valuing and maintaining what works, but with a disruptive and transformative spirit in what does not, the project aims to identify more effective and efficient learning strategies. These strategies not only enhance academic outcomes but also foster critical thinking, sustainability, global justice, and interdisciplinary collaboration, in line with the so-called Sustainable Development Goals (SDGs).

As we delve into the current challenges facing society, we recognize their direct impact on STEAM education. Rapid technological advancements, environmental concerns, and shifting workforce demands require a pedagogical shift [4]. Our study aims to address these challenges head-on by proposing innovative teaching methodologies that empower students to thrive in a dynamic world [5].

The primary objective of this study is to explore the perspectives of the UPC university community regarding the evolution of the institution's teaching model. Specifically, we focus on identifying key didactic elements that can enhance education in engineering, architecture, science and the other disciplines taught at the UPC. By engaging with faculty, students, administration and services staff, and other stakeholders, we seek to uncover insights that will inform the ongoing transformation of teaching practices.

To inform our approach, first of all we conducted an extensive review of the literature on effective evidence-based teaching methodologies and made it available in a synthetic way to the university community on the website created for the project. We explored research on active learning, flipped classrooms, project-based learning, gamification, problem-based learning and other pedagogical innovations and methods. By synthesizing existing knowledge, we aim to build upon best practices and tailor them to the unique context of UPC. The methodologies highlighted in the UPC's transformative educational project LG are the following ones. The list, short explanation and relevant references are retrieved from the LG webpage:

<https://galaxiaprenentatge.upc.edu/ca/metodologies>

- Master Class. The teacher verbally explains the content to students [4], [5].
- Problem-based learning. Encourages independent learning among students with the support of peers and a teacher [6].
- Project-based learning. Structured around projects that address real-life issues, promoting active problem-solving [7], [8].
- Learning & Service. Integrates learning with community service in a coherent project [9].
- Challenge-based learning. Learning is centered around addressing real-world challenges [10], [11].
- Blended learning & flipped classroom. Utilizes both face-to-face and online learning components [12].
- Gamification. Applies game elements to educational contexts to enhance motivation and engagement, beyond game-based learning [13], [14].

- Cooperative learning. Students work in small groups to accomplish shared tasks [15].
- Case studies. Learning is centered around real cases relevant to students' future professions [4], [18].
- Clinical simulation. Simulates real-world scenarios for students to practice skills and knowledge in a safe environment [17].

Finally, we emphasize the importance of values such as critical thinking, intellectual rigor, and social responsibility in STEAM education. The project LG seeks to cultivate not only technical expertise but also ethical awareness and a commitment to sustainable development. Through this holistic approach, we envision a LG where students thrive as responsible global citizens.

III. METHODOLOGY

A. Data Collection

To capture the community's perspectives on LG and steer the transformation of various schools, discussion sessions and group interviewing were organized across the University's nine campuses. These sessions involved students (S), faculty (F), and administrative and service staff (AS). Facilitated through participatory dynamics, discussions were structured around three key themes: curricular content relevance, teaching methodologies, and learning spaces. Initially, individual representative groups shared their perspectives, followed by collaborative proposal development in mixed groups.

B. Participants

Thirteen sessions were conducted, involving 67 students, 178 faculty members, and 52 administrative staff from the nine campuses.

C. Data Analysis

All data collected has been transcribed and is currently subjected to an inductive qualitative content analysis, through a process of categorisation and codification to uncover insights into the desired teaching model and identify barriers and opportunities for its implementation.

IV. RESULTS

A. Vision of the Desired Teaching Model by Different Stakeholders

The discussions held separately with the three groups were analyzed, resulting in the identification of seven categories with their corresponding codes: curricular competencies (CC), learning methodologies (M), assessment (A), teachers' competencies (TC), learning resources (LR), learning spaces (LS) and study organization (SO). Here are the key findings:

- **Curricular competencies:** Students emphasize the necessity of transitioning towards a more practical teaching approach focused on developing specific competencies relevant to the workplace. Conversely, both faculty and administrative staff stress the need of enhancing transversal skills, with particular emphasis on improving reading comprehension, writing, critical thinking, media literacy and entrepreneurship. Additionally, there is widespread acknowledgment of the need to integrate sustainability into curricula, humanize engineering practices, incorporate

ethical considerations, and introduce gender perspectives. At the curricular level, community members advocate for better coordination and coherence between subjects, calling for increased transversality and interdisciplinarity.

“As a student, I would like to focus on the practice and have fewer exams” [S]

“Some students don’t have critical thinking skills” [F]

“There’s a lack of coordination between subjects, and we don’t really know which things we have in common” [S]

- **Learning methodologies:** all stakeholders express a need for more diversity in learning methods and a more practical approach, including in-situ demonstrations and laboratory practices, as well as active learning strategies such as cooperative learning, simulations, and project or challenge-based learning. Mentoring is also highlighted as a valuable strategy to engage and facilitate learning. Students emphasize the importance of connecting teaching to real-world applications through professional visits, practitioner seminars, or discussions with external experts. Some educators propose fostering reflective learning through portfolio assessments. Additionally, both students and teachers underscore the significance of fostering an inclusive classroom environment that encourages the participation of all students, ensuring a space where diversity is embraced.

“It works pretty well when we analyze real situations and debate about the news” [S]

“We should explain better the practical application of what we teach” [F]

“Using simulators helps students understand” [F]

- **Assessment:** assessment practices are predominantly mentioned by students, who advocate for the use of authentic assessment methods that support learning, emphasizing the importance of ongoing monitoring and feedback during the learning process.

“Multiple-choice exams don’t help me learning” [S]

“We should reduce the amount of exams and increase the use of continuous assessment” [S]

“Oral exams are a better way to test the students” [F]

- **Teachers’ competencies:** Several students express concerns about the learning process overly relying on teachers and emphasize the crucial role of teachers’ communication skills. Conversely, educators recognise the lack of effective tools to motivate students and stress the importance of teachers possessing curiosity, analytical skills, creativity, risk-taking abilities, ethical attitudes towards the profession, and interpersonal skills.

“Teachers behave in a very formal way that doesn’t make us feel close to them” [S]

“Some students say the way we teach is not attractive. They have a lack of motivation for learning” [F]

- **Learning resources:** all stakeholders suggest the university should provide more ICT resources, including audiovisual media, digital tools for more interactive lectures and AI tools to facilitate learning. Additionally, teachers and staff express concerns about having tools to prevent plagiarism.

“Digital resources are useful in classes” [S]

“Why aren’t we using AI? We have to” [S]

- **Learning spaces and study organization:** in terms of study organization, it is proposed to create spaces to work with smaller groups of students and to reconsider and improve the academic calendar.

“We lack spaces for students to work in groups” [AS]

“Adapt the academic calendar to facilitate the learning process” [AS]

B. Development of Proposals for improving the teaching model

Drawing upon the ideas generated by the different stakeholders, mixed groups involving all three stakeholders were formed. They were tasked with crafting proposals for a new teaching model and classifying them based on their impact and level of difficulty. In this subsequent phase of discussion, two additional categories emerged: human resources (HR) and university policies (UP). Results are provided in table 1.

	DI	EI
HI	<p>CC: coordination and integration of subjects, global vision of the curricula</p> <p>M: Use of real-world cases and societal challenges, Interdisciplinary projects, diversify learning methods, more practices, implementing AI properly, transversal workshops</p> <p>HR: renew the staff, more personnel and fewer applications</p> <p>UP: talent retention policies, reduce bureaucracy</p> <p>SO: reduce ratio students/teachers</p>	<p>M: interactive lessons, valuing the active participation of students, enhancing the participation of professionals in the classrooms, working with transversal projects from different subjects, promote the use of educational technologies at classroom, gamification, Integrate theory and practice</p> <p>A: combine different type of assessments, promote continuous assessment and Introduce oral exams</p> <p>TC: promote teachers’ training</p> <p>LR: use of technologies to monitor learning process</p> <p>SO: Intensive subjects, improve communication between all collectives and with other schools and departments</p> <p>UP: Recognition of teaching activity in the same way as research activity, senior teachers as mentors, increase the collaborations with companies and public administrations</p> <p>HR: More full-time professors</p>
LI	<p>M: Technology-based learning through experimentation</p>	<p>CC: Include a bridge course to balance students’ level of knowledge</p> <p>LS: availability of open laboratories for students, better coordination with teaching services (ICT, libraries, etc.)</p>

Table 1: Summary of the proposals emerged by the community, classified by High and Low impact (HI, LI) and difficult and easy to implement (DI, EI). They are grouped into the following categories: curricular competencies (CC), Methodologies (M).

C. Feelings about the change of educational model

[illegible]

D. Exploring the role of University spaces in transforming the learning experience

Facilities and Available Services

Category	Description
Infrastructure and Technical Resources	- Connections - Student space Chalkboard - Projector - Workspaces (labs, greenhouses, PC rooms, etc.) - Audiovisual equipment (sometimes unused)
Study Resources	- Natural light - Good views - Library and Digital Media
Amenities	- Coffee space - Multipurpose spaces
Student Life	- Big student/teacher ratio - Natural surroundings

Category	Description
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Educational Facilities	- Classrooms with more benches - Group work rooms - Very large classrooms for many students
Technical Resources	- Sufficient power outlets for PCs in every classroom - Better Wi-Fi coverage
Services	- More human and financial resources for students - Adequate bars and dining services - More sports facilities - Free parking
Student Representation	- Student delegation - More spaces for student associations and recreational activities (concerts, rehearsal rooms, etc.)
Specialized Resources	- More tools for practical work - Areas conditioned for specific fields of knowledge - New Museums and services related to especialities - New Sports facilities
Infrastructure and Logistics	- Good climate control - Sufficient and inclusive signage - Better connection with the city centre - Central campus information point

V. CONCLUSIONS

In this regard, several potential methodologies have been identified, such as problem, project and challenge-based learning, gamification and service-learning, among others. There is a consensus that an effective curriculum should combine various teaching methodologies adapted to different learning outcomes. On the other hand, there is a need to adopt new forms of evaluation, less focused on memorization and more centered on assessing skills relevant to professional and personal life. Emphasis is placed on the importance of continuous monitoring during the learning process and overall evaluation of the learning process, not only of the final result. Oral assessments are proposed in several schools.

Technology is perceived as a tool to enhance the teaching and learning process. Although the integration of artificial intelligence is seen as a challenge, its potential to positively impact student learning is also recognized. Physical spaces are identified as potential facilitators of the transformation of the teaching model. Classroom redesigns are proposed to include adequate spaces for small group work and extensive use of technology, as well as larger classrooms for lectures that allow for the adoption of different methodologies. The importance of spaces that foster student participation in university life is also emphasized. The proposed changes imply modifications to university policies, such as teacher training to adapt to

methodological changes and equitable recognition of teaching and research work.

Group interviewing within the university community, encompassing professors, students, and administrative staff, offers several advantages and challenges. As outlined by Watts and Ebbutt (1987), group interviews facilitate extensive discussions, fostering a diverse range of responses [18]. This approach proves particularly beneficial in settings where individuals share a common purpose or have been collaborating for an extended period. Furthermore, group interviews offer practical and organizational benefits, such as efficiency and minimal disruption compared to individual interviews [18,19]. They also enable the convergence of diverse opinions and perspectives, potentially enriching the data collection process. Additionally, group interviews may alleviate intimidation for participants, particularly students, compared to one-on-one interviews [19]. However, conducting group interviews presents various challenges. These include managing distractions, avoiding perceptions of authority, ensuring relevance, and eliciting genuine responses rather than mere compliance. Other challenges involve maintaining focus, mitigating dominant personalities, and addressing discomfort or insecurity among participants, especially in front of peers [19].

Considering these limitations, and although we have only been able to summarize it very briefly here, we have obtained in our study what we were looking for: a general and specific perspective of each campus of the UPC, both in terms of teaching-learning methodologies, from the student's, teacher's and staff's perspective, as well as an overview of the infrastructures, spaces and the general feeling of the university community, in their daily experience. This detailed understanding enables us to approach the next phase of the LG initiative more accurately: a call to pilot the transformation of some degree programs. The findings have been used to establish the basis and evaluation criteria for the call, steering the direction of the educational transformation. The call outlined several key objectives: to increase the use of active, participatory, and collaborative learning methodologies; to encourage the resolution of real-world challenges, both present and future; to strengthen the connection between student learning and society; to foster interdisciplinary integration and promote scientific and technological humanism; to enhance the value of face-to-face learning; to intensify the use of educational technologies; and to promote the development of transversal competencies. The call for proposals, which closed in June 2024, received 26 submissions from various degree programs, of which 8 were selected for pilot implementation. These pilots will be used to draw up the action plan to transform the UPC's teaching model and define the singularities of each school (Fig. 1).

There is still a lot of work to be done to process the information gathered, in order to be able to dedicate the efforts and resources available to concrete improvements, largely consensual, that will lead us to a modern and up-to-date university, appropriate to the 21st century, at all levels. As we move forward with the LG project, we aim to expand the range of stakeholders from whom we gather insights, including alumni and employers, to ensure a more comprehensive perspective on the transformations needed.

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