Title of the PBL challenge: **Problem-Based Learning in Plant Biotechnology**

Name of the responsible lecturer

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University / Department / Degree program

University of León / Department of Agricultural Engineering and Sciences / Bachelor's Degree in Biotechnology

Course / Subject in which implemented

3rd Course / Plant Biotechnology

Implementation period (dates)

February 9, 2026 – July 3, 2026

Total duration (weeks/hours)

14 weeks / 30 hours (10 hours in-class and 20 hours of autonomous work)

Number of students involved

56 students

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1. Project Design

1.1 Brief description of the project and the challenge proposed

This project is a Problem-Based Learning (PBL) experience implemented as part of the Bachelor's Degree in Biotechnology.

Students are presented with diverse, yet realistic, hypothetical scenarios and projects that mirror current problems in the plant biotechnology sector. Working in teams, students act as independent researchers, responsible for finding solutions to these challenges. To achieve this, they must conduct an exhaustive bibliographic search and correctly apply the molecular and biotechnological tools they have learned throughout their degree.

The ultimate goal is for students to apply their theoretical knowledge by proposing original ideas and innovative solutions to their projects.

1.2 Expected learning outcomes (academic and transversal competences)

The expected learning outcomes focus on integrating advanced biotechnological knowledge with the development of professional and sustainability-driven mindsets.

Academic Competences:

- To identify and apply the most suitable molecular and biotechnological tools to overcome specific hypothetical challenges in plant biotechnology.
- To conduct exhaustive bibliographic research and technical analysis to support the design and implementation of innovative solutions.
- To design experiments and understand the limitations of experimental approaches.

- To develop original and innovative technical proposals that demonstrate knowledge of biotechnological principles applied to real-world scenarios.
- To quantify and interpret scientific data to evaluate the feasibility and efficiency of the proposed solutions.

Transversal Competences:

- To apply critical thinking and scientific rigor to evaluate alternative biotechnological solutions and justify technical decisions based on scientific evidence.
- To develop the capacity for self-evaluation.
- To work effectively in collaborative research teams, assuming professional roles and managing project lifecycles.
- To develop professional communication and storytelling skills to present and defend project results effectively.
- To manage uncertainty and autonomy in decision-making processes, simulating the research environment.
- To integrate sustainability competences by reflecting on the environmental and social impact of biotechnological applications and their alignment with the Sustainable Development Goals (SDGs).

1.3 Targeted sustainability competences

In alignment with the ENVIHEI framework, this project aims to develop specific sustainability competences by requiring students to solve complex biotechnological problems with an ethical and environmental perspective.

- **Systems Thinking**: develop the capacity to "decode" the complex interactions between biotechnological situations and broader ecological and social systems. This involves understanding how molecular tools affect the entire agricultural value chain and resource cycles.

- **Critical Thinking and Ethical Responsibility**: the challenge requires students to evaluate the trade-offs between technical performance and environmental impact. They must demonstrate a critical mindset when selecting molecular tools, justifying their decisions based on their ability to minimize environmental footprints.
- **Anticipatory and Strategic Competence**: by proposing innovative solutions to hypothetical future scenarios, students learn to anticipate the long-term consequences of biotechnological applications. They are challenged to design strategies that are not only technically sound but also aligned with global sustainability mandates, such as the UN Sustainable Development Goals (SDGs).
- **Evidence-Based Decision Making**: Through exhaustive bibliographic research, students develop the competence to support technical decisions with scientific evidence that considers the physical and biological limits of our planet, framing biotechnology as an ethical commitment to responsible consumption and production (SDG 12).

1.4 Sustainability approach and how it is integrated into the project

Sustainability is integrated into this project as a transversal dimension rather than a separate module. The integration is achieved by framing technical biotechnological challenges as essential components of global sustainability solutions.

- **Integrated Technical Framework**: Students are taught that biotechnological tools (e.g., CRISPR, molecular markers, or plant tissue culture) are not merely laboratory techniques but instruments for environmental and social responsibility. For instance, increasing a crop's water-use efficiency is framed as a direct contribution to climate adaptation and resource conservation.

- **Challenge-Based Integration**: Each hypothetical project is designed around a core sustainability issue, such as reducing the environmental footprint of agriculture or enhancing food security under changing climate conditions. Students must "decode" these complex biological systems to propose solutions that are technically viable and ecologically sound.
- **Evaluative Reflection**: Sustainability is explicitly incorporated into the evaluation process. Students are required to justify their technical decisions by analysing the long-term impacts of their proposals. This includes evaluating the trade-offs between yield and biodiversity, or the reduction of chemical inputs through the development of naturally resistant varieties.
- **Alignment with Global Goals**: The project is rooted in the United Nations Sustainable Development Goals (SDGs), particularly SDG 2 (Zero Hunger), SDG 12 (Responsible Consumption and Production), and SDG 13 (Climate Action). By linking molecular results to these targets, students understand that biotechnological innovation is an ethical commitment to the planet's future.

This approach ensures that students do not view datasets or molecular biology tools merely as abstract concepts, but as actionable insights for building a more sustainable world.

1.5 Methodologies and tools used (PBL structure, facilitation techniques, etc.)

- **Facilitation**: The lecturer acts as a technical guide and facilitator, moving away from traditional instruction to support autonomous inquiry. This is done through regular follow-up sessions where the teacher helps teams evaluate the feasibility of their proposed biotechnological strategies.

- **Collaborative Work**: Students work in teams, simulating a professional research environment where they must manage group dynamics and task distribution.
- **Tools**: Students utilize bibliographic databases to identify existing solutions for similar problems. They also apply the molecular and biotechnological toolkit covered in the course to design their innovative proposals.

1.6 Organization of the project (group formation, timeline, milestones)

The project is organized into several distinct phases to ensure continuous monitoring and iterative improvement:

- **Phase 1: Initiation and Research**: The challenge is presented, and teams are formed. Each team is assigned a different project by drawing lots. Students conduct an exhaustive bibliographical search to identify viable scientific precedents for the proposed problem.
- **Phase 2: Strategy Selection**: Teams submit their preliminary research to the lecturer (see template here). A session is held to discuss and select the most viable or attractive technical path for each group.
- **Phase 3: Development and Intermediate Follow-up**: An intermediate tutorial is conducted to monitor progress, evaluate group dynamics, and address any internal teamwork challenges (see template here).
- **Phase 4: Feedback and Refinement**: Students perform a pre-exposition (rehearsal) of their work, receiving critical feedback from the lecturer and peers to refine their technical solution and communication style.

- **Phase 5: Submission of Written Reports**: This means that teachers already have them at their disposal before the final presentations.
- **Phase 6: Final Event**: A public final presentation is held where students defend their projects before their classmates and professors. This is timed to coincide (if possible) with the "Fascination of Plants Day" (https://plantday18may.org/category/europe/spain/).

1.7 Deliverables requested from students (type, format, deadlines)

To ensure a continuous evaluation of both technical progress and transversal competences, students are required to submit the following deliverables at different stages of the project:

- **Bibliographic Search Summary (Initial Phase)**: A structured summary detailing the literature review conducted to identify viable solutions for the proposed challenge to justify the selected biotechnological strategy (see template here).
- **Follow-up and Participation Questionnaire (Intermediate Phase)**: An individual questionnaire during the intermediate tutorial to monitor the progress of the activity and assess the individual participation and contribution of each group member to the collective work (see template here).
- **Final Project Report (Final Phase)**: A comprehensive written document containing all project information, technical justifications, and results. It is delivered following the format of the *AmbioCiencias* journal to produce professional-grade documentation. By way of example, attached supporting materials are four PBL final reports carried out during the 2025-2026 academic year.

- **Final Presentation Materials (Final Phase)**: Supporting visual materials for the oral defence of the project used to communicate and defend the innovative solution before the class and the teaching staff. Attached as supporting materials are four presentation materials carried out during the 2025–2026 academic year.

1.8 External collaborators involved (mentors, companies, experts...) and their role

While this implementation primarily utilizes internal academic expertise, the project is structured to simulate a professional research environment, where lecturers act as mentors. Each lecturer in this course is assigned to guide specific groups throughout the entire project. They act as facilitators, providing continuous feedback and guidance at every stage of the challenge. Their mentorship ensures that students effectively navigate the bibliographic research and select the most technically viable biotechnological tools for their hypothetical scenarios.

For the final presentation, the entire teaching staff of the subject is convened to form a specialized jury. Their role is to provide a peer-review of the projects, specifically commenting on and assessing the scientific viability and innovative interest of the proposed solutions. This mirrors the expert panel or jury evaluation format used in other implementations to validate project results.

By assuming these roles, the professors provide a professional-grade supervision and feedback that prepares students for independent research and professional practice in the biotechnology sector.

2. Project Evaluation

2.1 Assessment criteria and methods used

The assessment for the Problem-Based Learning (PBL) follows a continuous and formative model designed to evaluate both the technical quality of the solution and the students' professional development throughout the project lifecycle.

The evaluation is structured around three core pillars, with the following weighted criteria:

- **Written Project Report (40%)**: The final document, following the professional standards of the *AmbioCiencias* journal, is assessed based on:
    - The general structure and organization of the proposal.
    - The quality and depth of the bibliographic research.
    - Technical quality and precision in the use of scientific terminology.
- **Oral Presentation and Defence (55%)**: This phase involves a public defence in front of a panel of professors and is evaluated using a structured rubric (attached as supporting material) that considers:
    - Scientific Aspects: The suitability of the introduction, the clarity of the objectives and hypotheses, the formal correctness in representing results, and the scientific rigor of the discussion.
    - Formal Aspects: Communication style, clarity of exposition, and quality of visual aids.
- **Follow-up Tutorials and Participation (5%)**: This component is used for process tracking and monitoring team dynamics. It evaluates:
    - The individual participation and implication of each student in the group work.

- The effective distribution of tasks and coordination within the team.
- The progress made during the intermediate tutorials and the pre-exposition rehearsal.

As defined in the official teaching strategy, the PBL component accounts for 25% of the total final rating for the subject. To pass the course, students must obtain a minimum rating of 5 out of 10 in this specific section. This comprehensive method ensures that students are not only rated on their final output but also on their ability to act as independent researchers and effective team members.

2.2 Evidence of student learning (examples, outputs, results)

The evidence of student learning in the Problem-Based Learning in Plant Biotechnology course is demonstrated through the high quality of the technical outputs produced and the successful achievement of both academic and transversal competencies.

Key evidence of learning includes:

- **Professional Technical Documentation**: Students produced comprehensive project reports following the formal standards of the *AmbioCiencias* journal. These documents provided tangible evidence of their ability to use specific technical terminology and their proficiency in localizing, synthesizing, and managing scientific information.
- **Innovative Biotechnological Solutions**: All participating teams successfully designed viable strategies for crop improvement or "molecular farming". The projects demonstrated an integrated way of thinking by applying advanced tools to solve complex hypothetical challenges reflecting real-world agricultural and environmental issues.

- **Scientific Rigor in Communication**: During the final presentations and defences, students showed a high level of communication skill and the ability to transmit complex scientific ideas to both specialized and non-specialized audiences. The use of structured rubrics confirmed that students could clearly define hypotheses and objectives, represent results formally, and engage in rigorous scientific discussion.
- **Process Tracking and Accountability**: Evidence of effective teamwork and professional coordination was captured through intermediate follow-up questionnaires and meetings. These records showed that students assumed distinct roles and managed the project lifecycle autonomously, simulating a professional research environment.
- **Sustainability Reflection**: A significant result was the students' ability to link their technical proposals to ethical, social, and environmental implications. The outputs included critical reflections on how their biotechnological solutions contribute to the Sustainable Development Goals (SDGs).

Quantitative Results: The evaluation reflected a generally high level of performance across all groups. The distribution of grades showed consistent achievement in the different assessed dimensions, with students excelling in the technical justification of their proposals and the quality of their bibliographic research. No groups failed to meet the minimum requirements, demonstrating a strong acquisition of the intended learning outcomes.

3. Reflections and Recommendations

3.1 Main achievements and strengths of the project

- **Integration of Technical and Sustainability Competences**: The project successfully transcended traditional biotechnology teaching by connecting molecular biology tools to current global challenges. By linking principles of plant biology with SDGs, students understood that biotechnological innovation is an ethical and environmental imperative.

- **Professional Simulation and Authenticity**: A key strength of the experience is its high degree of professional simulation. Requiring students to deliver a final document following the standard format of the *AmbioCiencias* journal provided an authentic context for developing scientific dissemination skills, moving beyond simple classroom assignments.
- **Robust Feedback and Scaffolding**: The project structure ensured continuous student support through progressive scaffolding. The intermediate follow-up tutorials and the pre-exposition rehearsal created a strong feedback loop, allowing students to refine their technical strategies and communication styles before the final defence.
- **Fostering Autonomy and Critical Thinking**: The PBL methodology transformed the students' role from passive recipients to independent researchers. Students demonstrated a remarkable capacity for autonomous problem-solving, moving from initial bibliographic search to the design of novel biotechnological solutions that they had to justify technically and ethically.
- **Collaborative Dynamics**: The organization into independent research teams encouraged a professional-grade collaborative environment. Students learned to manage group dynamics, assume specific roles (such as project leads), and coordinate tasks to meet the rigorous demands of a complex biotechnological project.
- **Engagement with Real-World Scenarios**: By "decoding" hypothetical yet realistic biological systems, students moved away from viewing

datasets or molecular tools merely as abstract concepts and instead saw them as actionable insights for building a sustainable world.

3.2 Challenges faced and how they were addressed

- **Management of Teamwork Dynamics and Accountability**: A common challenge in project/problem-based learning environments relates to group dynamics and coordination. Although no interpersonal conflicts arose that required direct intervention from the lecturers, managing self-led research teams was a new experience for many students. To address this proactively, the collaboration of each team member was continuously monitored. Specifically, the intermediate follow-up surveys and participation questionnaires were used to track individual contributions (see template here), and this data was taken into account during the final evaluation to ensure fairness and engagement across all groups.
- **Overcoming Initial Inertia through Phased Scaffolding**: Another significant challenge was the initial lack of momentum in the project's early stages. Some students experienced difficulty transitioning from passive learning to autonomous inquiry, which occasionally led to inefficiencies and uncertainty. This was addressed by implementing a progressive scaffolding approach, breaking the project down into several manageable phases and intermediate milestones. By introducing specific intermediate deliverables, the overall workload was "de-constructed" into smaller tasks. This strategy effectively alleviated the cognitive load, provided students with a clearer roadmap, and ensured a more consistent work pace throughout the semester.

3.3 Lessons learned for future implementations

- **Expanding Topic Diversity**: A key lesson for future editions is the potential to increase student engagement by offering a wider and more varied catalog of project topics. Allowing teams to choose a challenge based on their specific professional interests would foster a stronger sense of ownership for the work. This approach aims to prevent students from feeling "forced" into scenarios that do not align with their expectations, thereby ensuring higher commitment and avoiding the low motivation that can arise from working on a topic of limited personal interest.
- **Refining Scaffolding for Early Engagement**: A primary lesson is that student autonomy in PBL environments is directly proportional to the robustness of the initial procedural support. To address the "initial lack of impulse" observed, future iterations could include a more explicit methodological induction at the start of the term. This may help align expectations regarding self-directed learning and ensure students feel comfortable with the project's requirements as early as possible.
- **Strengthening Accountability Mechanisms**: While intermediate follow-up questionnaires were effective for monitoring group dynamics, future implementations could further strengthen the tracking of individual contributions. Similar to other ENVIHEI pilots, the use of timesheets or work logs could be reinforced, requiring regular validation by both team members and the project manager to ensure a transparent and accurate record of individual effort.
- **Iterative Feedback Loops**: The success of the pre-exposition rehearsal highlighted the value of formative assessment. Future implementations will consider incorporating more in-class presentation milestones to

ensure that technical feedback is continuous and not limited to final deliverables, allowing for more substantial iterative improvements.

4. Supporting Material

4.1 Lecturers' materials and project documentation

Lecturers' materials and project documentation are available in the following link:

https://drive.google.com/drive/folders/1W5E5_EfSv_-P_lGyxnTUci15ZbnfbiD4?usp=drive_link

4.2 Deliverables produced by students, final presentations or pitch materials

An example of deliverables produced by students is available in the following link:

https://drive.google.com/drive/folders/1nIcu1YmLYq6m93jkaSOmxqfzGQZVXHGy?usp=drive_link

Students' final presentations used during the final defence sessions are available in the following link:

https://drive.google.com/drive/folders/1aR4hoEOFRKuGC2bNbNz2i4_ccK4aLNsr?usp=drive_link

4.3 Images/videos (with consent)

Photographic and video records were captured with the explicit consent of the participating students, and are available in the following link:

https://drive.google.com/drive/folders/1Dpa2s2BA-fjPDhCA8bMuvPYvzytJwz0N?usp=drive_link

4.4 Any other relevant material

All the materials, including this report, are available in the following link: https://drive.google.com/drive/folders/1P2ddAPlCjWG-5li79171hkufilhXjFh5?usp=drive_link

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Enriching lives, opening minds.
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