BIOTE(A)CH

BRIDGING THE GAP BETWEEN BIOTECHNOLOGY AND INDUSTRY: INTEGRATING DESIGN THINKING AND FLIPPED LEARNING

2022-1-TR01-KA220-HED-000085597

Co-funded by the European Union

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Acknowledgement

The development of this higher education curriculum, titled "Bridging the Gap Between Biotechnology and Industry: Integrating Design Thinking and Flipped Learning," has been a collaborative effort that owes its success to the dedication, expertise, and commitment of numerous individuals and organizations in the BIOTE(A)CH project consortium.

The project supported by the European Commission and funded through the Erasmus+ KA220 HED program has been possible with the Turkish National Agency's confirmation of the importance of this innovative initiative.

We wish to express our special thanks to all the partner institutions involved in this project and to the faculty members, educators, and experts who dedicated their time, knowledge, and experience to designing and refining this curriculum, and appreciate the support and collaboration of industry partners who shared their insights and real-world perspectives on the current trends and requirements of the biotechnology sector.

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Abbreviations

- EU: European Union
- EC: European Commission
- OECD: Organization of Economic Cooperation and Development
- NA: National Agency
- KA: Key Action
- HED: Higher Education
- NBT: New Breeding Techniques
- DNA: Deoxyribonucleic acid
- NGS: Next Generation Sequencing

About project

The field of biotechnology, with its vast applications in health, agriculture, food production, machinery, engineering, and environmental sciences, has emerged as a significant industrial sector, especially since the turn of the millennium. It not only presents a realm of innovative possibilities but also offers substantial employment opportunities for the next generation of biotechnology graduates. In Europe, the industrial biotechnology sector is expected to employ over 1 million individuals by 2030, marking a significant increase from 486,000 in 2016 (source: Europabio, 2016).

However, traditional undergraduate programs in biotechnology have predominantly focused on imparting scientific knowledge and laboratory skills, often lacking a dynamic connection between academia and industry. The evolving European business landscape calls for a more promising approach, one that equips graduates with the knowledge and professional pathways to thrive in an increasingly competitive job market. It is with this imperative in mind that the "BIOTE(A)CH" project places importance on enhancing the employability prospects of biotechnology undergraduates.

On the other hand, the European Commission's Digital Education Action Plan (2021-2027) envisions a future of high-quality, inclusive, and accessible digital education across Europe. It recognizes the transformative role of technology in education, especially in light of its extensive use during the COVID-19 pandemic. This plan serves as an immediate call for collaborative efforts at the European level to adapt education and training systems for the digital age.

Within this context, BIOTE(A)CH embraces the principles of digitalization and the application of blended learning. Blended learning, including the sub-type known as "flipped learning," represents a pedagogical approach that aligns with the digitalization of education. Flipped learning, a method where students are exposed to preparatory information, primarily in the form of video content, before the traditional classroom instruction, is particularly advantageous for advanced-level students. Their accumulated knowledge enables them to transition into self-directed learning effectively, fostering higher-order thinking skills and active engagement.

BIOTE(A)CH" seeks to integrate the principles of "design thinking" and "flipped learning" to ensure ongoing student engagement and participation in the learning process. Design thinking emphasizes the development of innovative solutions with reduced risks and costs, fostering employee buy-in. By actively involving students in the innovation development process, design thinking becomes a practical approach to fostering innovation. This approach allows students to seamlessly transfer knowledge and skills from academia to industry, a crucial aspect of both innovation and academic excellence.

In recent years, the roles of research institutions and industries have significantly evolved (OECD, 2007). As students embark on their career journeys, it has become evident that the transition from university to the workplace is more complex than ever before. Building on the literature review, this transition is seen as a critical step in graduates' future careers, requiring specific skill sets (Santisi et al., 2018). However, there remains a misalignment between university learning and workplace practices (Jackson, Fleming, and Rowe, 2019). Reports from employers indicate a notable gap between the skills expected and those possessed by recent graduates (Talgar and Goodey, 2015).

Furthermore, VET (Vocational Education and Training) providers face challenges in upskilling and reskilling their workforce to bridge the gap between higher education knowledge and practical application effectively. Hence, the enhancement of universities' course delivery methods and techniques plays a vital role in supporting graduates in the successful transfer of knowledge into practice.

The Objectives of the BIOTEACH Project

The Bioeconomy Strategy & Action Plan (2018) by the EC underscores the necessity for enhanced training and skills development across the bioeconomy sector, which promises substantial employment potential. The "BIOTE(A)CH" project partners concentrate on agricultural biotechnology, aiming to equip students with real-world skills upon graduation. This focus extends to various sectors, including agriculture, chemicals, energy, biochemical industries, research centers, and universities.

The project's objectives are multi-faceted:

1. To empower undergraduate students to explicitly connect data and information with the knowledge, skills, and approaches required for professional work.
2. To prepare students for a world where technological innovations are the norm, ensuring they remain adaptable and capable in their future careers.
3. To enhance students' self-awareness, improving their transversal skills such as self-directed learning, communication, and teamwork.
4. To foster dynamic collaborations between universities and industry representatives, promoting a culture of innovation and innovative thinking.
5. To integrate "design thinking" and "flipped learning" as novel course delivery approaches.

Expected Outcomes

BIOTE(A)CH aims to achieve several notable outcomes:

1. Equipping graduates with up-to-date knowledge and in-depth insights, enhancing their prospects in the job market, where knowledge is the primary economic resource (Drucker, 1994).
2. Delivering project results, including a comprehensive course curriculum titled "Knowledge to Practice through Design Thinking," a lecturer's guide, a success stories booklet, and video tutorials.
3. Establishing a robust network, both nationally and internationally, fostering the exchange of ideas and long-term relationships.
4. Serving as a scientific-based model for integrating "design thinking" and "flipped learning" into course delivery processes, providing a reference point for academicians and researchers in the field of Educational Sciences.

BIOTE(A)CH endeavors to create a forward-thinking curriculum that not only bridges the gap between academia and industry but also equips students with the knowledge, skills, and innovative mindset required for success in the evolving biotechnology sector.

Bridging the Gap between University and Industry

The "BIOTE(A)CH" project aspires to inject dynamism into undergraduate-level teaching by forging a robust connection between university instruction and the demands of the biotechnology industry. This strategic alignment seeks to empower students with the invaluable ability to transfer their knowledge and skills into their respective industry domains, even before they formally enter the workforce. By doing so, we endeavor to eliminate the redundancy of time spent on additional training activities and the financial burden of pursuing further education to attain proficiency. Furthermore, it underscores our commitment to equipping our students with the finest knowledge and competencies necessary to embark on successful career paths.

BIOTEACH Course Curriculum

Target Groups

The "BIOTE(A)CH" project addresses a diverse range of target groups. Our primary beneficiaries are undergraduate students pursuing biotechnology-related fields. They stand to gain immensely from the innovative curriculum, which bridges the gap between academia and industry, imparting practical skills and a problem-solving mindset. Additionally, faculty members and educators within higher education institutions constitute another target group. They will actively engage in implementing and refining the project's pedagogical approaches, fostering an environment that nurtures innovation and knowledge transfer. The developed teaching materials will support their future course delivery processes. Furthermore, BIOTE(A)CH extends its reach to industry stakeholders, including professionals and organizations within the biotechnology sector, who will play an integral role in guiding and collaborating with students during the piloting phase. By targeting those stakeholders—students, educators, and industry experts—BIOTE(A)CH aims to effect transformative change in biotechnology education and workforce development, benefitting both aspiring professionals and the biotechnology industry at large.

Modular Structure

The "BIOTE(A)CH" curriculum is organized into a modular structure, ensuring flexibility and adaptability to varying learning needs and contexts. Each module is designed to address specific aspects of biotechnology, innovation, and industry integration. This modular approach allows educators to customize the curriculum, selecting and sequencing modules based on the unique requirements of their students and academic programs. Whether focusing on design thinking principles, flipped learning methodologies, or practical problem-solving in the biotechnology sector, each module serves as a building block in the overall learning process. This modular structure enhances the curriculum's accessibility and relevance and empowers educators to tailor their teaching to the evolving demands of the biotechnology industry. Students benefit from a dynamic and interactive learning experience, engaging with modules that align with their career aspirations and interests. As the curriculum evolves, new modules can be seamlessly integrated to reflect emerging trends and technologies in the biotechnology domain, ensuring that graduates are well-prepared to thrive in the ever-evolving industry landscape.

Pedagogical Approach

The pedagogical approach in "BIOTE(A)CH" prioritizes active, experiential learning, real-world problem-solving, and collaboration with industry partners, preparing students to excel in the dynamic field of biotechnology and bridge the gap between academia and industry effectively as follows.

Design Thinking

Design thinking is, at its core, a problem-solving approach that empowers teams to comprehend and redefine complex challenges, question existing assumptions, and craft innovative solutions for prototyping and testing. It follows a structured process consisting of five stages: empathize, define, ideate, prototype, and test.

One aspect of the "BIOTE(A)CH" project is the integration of "design thinking" and "flipped learning" within biotechnology. Throughout the piloting phase, academicians and industry experts will collaborate closely with trained students. Real-world challenges will be laid on the table, with students having the unique opportunity to anticipate these issues through their observations in industrial applications. Subsequently, students will channel their observations and insights into the generation of novel biotechnological solutions. The "BIOTE(A)CH" project's course delivery process unfolds in five stages:

1. **Empathize:** In this initial stage, students will engage with video presentations that provide insights into the challenges prevalent in the biotechnology industry. This stage, together with studying lecture materials, involves flipped learning approach, enabling students to embark on independent learning practices before each classroom session.

2. **Define:** Building on the knowledge accumulated during the empathize stage, students will pool their insights and collaborate in teams to crystallize the identified challenges. Teamwork will strengthen collective data analysis, thereby concretizing the problem at hand.

3. **Ideate:** This stage catalyzes the generation of creative and logical ideas. Teams will embark on brainstorming, pushing the boundaries of thinking to propose innovative solutions. All ideas will be encouraged at this juncture, ensuring a rich pool from which to select in subsequent stages.

4. **Prototype:** As the curriculum application process progresses, teams will advance to the prototyping stage. Here, laboratory work will be initiated, providing students with hands-on experience. Collaborations with industry representatives will be useful in the selection and refinement of specific prototypes.

5. **Test:** The final stage involves testing of the developed prototypes to evaluate their efficiency in addressing the analyzed problem. Students will have the opportunity to present their product outlines to experts, with the potential for collaboration to enhance their prototypes for market readiness.

Flipped Learning

Flipped learning is an effective pedagogical approach in the "BIOTE(A)CH" practice as it encourages students to prepare independently, allowing for active engagement during face-to-face sessions. In the biotechnology field, where complex concepts exist, this method promotes a deeper understanding of foundational knowledge. Moreover, it accommodates different learning paces, fosters autonomy, and emphasizes practical application—essential in biotechnology, where theory must translate into real-world solutions. This approach also facilitates interaction with industry professionals, enabling students to gain insights into current practices. Overall, flipped learning aligns with the dynamic nature of biotechnology education, empowering students to bridge the gap between academia and industry through active, self-directed learning.

MODULE 1 Sustainability in Biotechnology

Problem 1 - Limitations in Whey Utilization

Objectives:

Students will be able to;

- Understand the whey content and its composition.
- Understand the process of cheese production and its associated byproducts.
- Understand the diverse applications of whey across various industries.
- Evaluate the advantages and disadvantages of utilizing whey in biotechnological methodologies.
- Analyze the environmental impact of whey.
- Analyze its limitations in efficient utilization.
- Create potential new areas with biotechnology to use whey with innovative approaches.
- Knows the legislation on the use of whey as a waste material

Content:

- Cheese production
- Whey as a waste
- Environmental Impact of Whey

Learning resources:

- Video on the cheese production process. Video content and accompanying documents provide information about whey processing and its composition, production, and utilization quantities.
- Articles, books, lecture notes

Week 1. Introduction (For All Modules)

In-Class Activity

Duration: 3x45 minutes

- The lecturer will provide information to the students regarding the modules planned for the semester.
- The tasks expected from the students throughout the semester will be defined within the scope of the course.
- Students will also receive information on how to access additional resources on the subject (university library, online resources, etc.).
- The topic of each module will be introduced to the students.
- The students will be divided into groups of 4 or 5.

- Each group will decide on the problem they will work on.

Teaching-Learning Methods

- Question-Answer
- Discussion

Week 2. Empathize

Out-Class Activity

- Prepared video and the resources are shared with students.
- Students will be required to comprehend the process of whey production in cheese and its byproducts, understand the various applications of whey, recognize the advantages and disadvantages of utilizing whey in biotechnological approaches, assess the environmental impact of whey, and acknowledge the limitations in its effective utilization. Additionally, they will need to be familiar with the legislation pertaining to the use of whey as a waste material.
- Students will be required to investigate the literature on whey process through using the resources available.

In-Class Activity

Duration: 3x45 minutes

- Students share the articles and books, etc. with their group members.
- Students discuss the problem based on literature.
- Students are instructed to envision themselves working in a cheese production company, where a significant quantity of whey is generated during the cheese-making process.
- As a group, they are expected to discuss the issue and provide a comprehensive description, considering all its dimensions (Worksheet 1).

Teaching-Learning Methods

- Brainstorming
- Discussion

Week 3. Define

Out-Class Activity:

- Students will be required to comprehend the process of whey production in cheese and its byproducts, understand the various applications of whey, recognize the advantages and disadvantages of utilizing whey in biotechnological approaches, assess the environmental impact of whey, and acknowledge the limitations in its effective utilization. Additionally, they will need to be familiar with the legislation pertaining to the use of whey as a waste material.

- Students will be required to investigate the literature on whey process through using the resources available.
- Each group will be tasked with creating a digital infographic or poster addressing the issue of whey as a waste material (to be presented in the classroom by Week 3).

In-class Activity

Duration: 3 x45 minutes

- Students will be required to present the infographics/posters and explain the problem about whey as a waste material.
- Students will find an opportunity to discuss and identify the problem with their classmates.

Teaching-Learning Methods:

- Presentation
- Discussion
- Question-Answer

Week 4. Ideate

Out-Class Activity

- At this stage, each student is asked to form ideas about how whey can be used more effectively. Students are asked to come up with many ideas. Unconventional ideas can also be produced.

In-Class Activity

Duration: 3 x45 minutes

- Each student will be asked to present and discuss her/his idea to the group.
- Students can be guided by the lecturer when necessary.
- For example, students' attention can be drawn to the following issues: fighting against hunger in the world, using long-lasting foods in times of disaster, using whey as a protein powder, the need for functional foods, reducing the damage of whey to nature, cost, etc.
- For each group, one or two of the ideas most suitable for implementation are identified amongst the ideas put forward.

Teaching-Learning Methods:

- Discussion
- Question-Answer

Week 5-6-7. Ideate

Out-Class Activity

- At this stage, in line with the ideas, students are asked to prepare a project proposal, including research aims, methods, data analysis and budget to be used to solve the problem. (Annex: Research Outline for all modules)
- Expert Opinion– communicate with experts working in the field about the project proposal.
- In this stage, opinions of the experts from associate partners will also be required (Suggested for Week 6).

In-class Activity

Duration: 3 x (3x45) minutes

- In the Week 5 and 6- Each group will inform the lecturer and the classmates about the progress in their research proposal
- Week 7. Each group will present their final proposal to their classmates.

Teaching-Learning Methods:

- Discussion
- Question-Answer
- Presentation

Week 8-9-10-11-12-13. Prototype & Testing

Out-Class Activity

- At this stage, students make preparations to conduct the project: supplying necessary materials and consumables, planning the project activities, etc.
- Associate partners will be contacted to support wet lab activities.

In-class Activity (Wet Lab)

Duration: 6 x (3x45) minutes

- Optimizing and performing experiments, obtaining results, analyzing and prototyping
- Testing the prototype

Teaching-Learning Methods

- Experiment Techniques
- Data Collection
- Data Analysis

Week 14. Assessment

Out-Class Activity

- Workshop-Students will present project results or products to the experts and receive feedback.
- Experts from industry (including associate partners) and academia.

In-class Activity

Duration: 3 x45 minutes

- Students will assess their own work based on the experiments they carried out as well as the experts' opinions.

Teaching-Learning Methods

- Discussion

Problem 2 - Barriers to Enhance Plant Resilience

Objectives:

Students will be able to;

- Understand the fundamental science behind climate change and its correlation with increasing heat and drought events.
- Recognize the physiological and genetic adaptations of plants that allow them to cope with drought and heat stresses.

- Learn about various biotechnological approaches, such as plant tissue culture and gene editing, to develop drought and heat-resistant plant varieties.
- Evaluate the pros and cons of using biotechnological solutions to address drought and heat-related challenges in agriculture.
- Analyze the environmental and socio-economic consequences of implementing biotechnologically enhanced crops in various ecosystems.
- Understand the global perspective and challenges related to water scarcity, food security, and the pivotal role of biotechnology in addressing these challenges.
- Identify potential innovative biotechnological applications to improve water use efficiency and heat tolerance in plants.
- Apply their knowledge of gene editing, tissue culture, and other biotechnologies to brainstorm and design potential solutions for the real-world challenge of climate-induced agricultural stresses.
- Delve into the legal, ethical, and societal issues associated with the use of biotechnology in developing drought and heat-resistant crops.

Content:

- Drought and Heat Resistance in Plants
- Biotechnological Approaches for Enhancing Plant Resilience
- Ethical, Legal, and Environmental Considerations of Biotechnological Interventions.

Learning resources:

- Video content and accompanying documents provide information about Plant Resilience and biotechnological techniques and applications.
- Articles, books, lecture notes

Week 1. Introduction (For All Modules)

In-Class Activity

Duration: 3x45 minutes

- The lecturer will provide information to the students regarding the modules planned for the semester.
- The tasks expected from the students throughout the semester will be defined within the scope of the course.
- Students will also receive information on how to access additional resources on the subject (university library, online resources, etc.).
- The topic of each module will be introduced to the students.

- The students will be divided into groups of 4 or 5.
- Each group will decide on the problem they will work on.

Teaching-Learning Methods

- Question-Answer
- Discussion

Week 2. Empathize

Out-Class Activity

- In this lecture students will be provided a prepared video and accompanying resources.
- Students will need to grasp plant adaptations to drought and heat, comprehend diverse biotechnological methods for bolstering plant resilience, discern the pros and cons of employing gene editing and tissue culture in mitigating climate-related issues, evaluate the environmental consequences of biotechnologically altered crops, and acknowledge the constraints in their practical application. Furthermore, they should be acquainted with the regulations governing the use of biotechnological techniques in agriculture.
- Students will need to research available resources on gene editing, tissue culture, and other biotechnological approaches for enhancing drought and heat resistance in plants.

In-Class Activity

Duration: 3x45 minutes

- Students are expected to distribute articles, books, and other relevant materials to their fellow group members.
- Within their groups, students engage in discussions centered around the issues raised in the literature.
- Students are given guidance to imagine themselves as employees in a company specializing in plant breeding and propagation, focusing on the development and propagation of novel plant genotypes.
- As a collective, they are tasked with thoroughly examining the problem and offering a comprehensive description that takes into account all aspects of the issue.

Teaching-Learning Methods

- Brainstorming
- Discussion

Week 3. Define

Out-Class Activity

- Students will need to delve into the intricacies of biotechnological strategies for enhancing drought and heat resistance in plants, grasp the applications and challenges of these techniques, weigh the ecological consequences of bio-engineered crops, and recognize the potential barriers in their widespread adoption. They should also become adept with the regulatory landscape surrounding biotechnological interventions in agriculture.

- Students are encouraged to explore research articles and resources on biotechnological solutions and methodologies for producing drought and heat-resistant crops.

- Each team will design a compelling digital infographic or poster highlighting the challenges and promises of biotechnology in tackling climate-induced agricultural stresses (to be presented in the classroom by Week 3).

In-class Activity

Duration: 3 x45 minutes

- Students will deliver presentations featuring professionally crafted infographics and posters that elucidate the challenges pertaining to climate change, drought, and plant resilience, accompanied by thorough explanations.
- Students will have the opportunity to engage in discussions with their peers to collectively address the identified issue.

Teaching-Learning Methods

- Presentation
- Discussion
- Question-Answer

Week 4. Ideate

Out-Class Activity

- Each student is encouraged to generate innovative concepts regarding the more effective utilization of biotechnological approaches. They are tasked with generating a multitude of ideas, including those that may be considered unconventional.

In-Class Activity

Duration: 3 x45 minutes

- Each student will be required to present and deliberate upon their respective ideas within the group.
- As an illustration, students may be directed towards key topics, such as engineering crops for drought and extreme heat resilience to safeguard food security, formulating sustainable cultivation techniques for evolving climates, cultivating enhanced plants without genetic modification through advanced breeding methods or plant tissue culture, accentuating the significance of ecologically sound agricultural practices,

mitigating agriculture's ecological footprint with biotechnologically-modified crops, evaluating the financial considerations associated with the adoption of biotechnological solutions, and so forth.

- Within each group, one or two ideas most amenable to implementation will be identified from the array of proposals.

Teaching-Learning Methods

- Discussion
- Question-Answer

Week 5-6-7. Ideate

Out-Class Activity

- Students will formulate a comprehensive project proposal aligned with their generated ideas. This proposal should encompass research objectives, methodologies, data analysis, and budget allocation, all geared towards effectively addressing the identified issue.
- Expert Opinion: Initiate dialogue with professionals actively involved in the relevant field regarding the project proposal.
- Furthermore, it is advised to solicit insights and opinions from experts affiliated with associate partners. This step is particularly recommended for Week 6 of the program.

In-class Activity

Duration: 3 x (3x45) minutes

- During Week 5 and 6, each group is responsible for providing a status update on the progress of their research proposal. This update will be shared with both the lecturer and classmates. It should include details on the evolving ideas, refined methodologies, and any challenges or adjustments encountered thus far.

- In Week 7, each group will have the opportunity to present their finalized research proposal to their fellow classmates. This presentation should encompass all pertinent aspects, including the research aims, chosen methods, anticipated data analysis, and the allocated budget. It is a culmination of the diligent work and collaborative efforts put forth by each group throughout the preceding weeks.

Teaching-Learning Methods

- Discussion
- Question-Answer
- Presentation

Week 8-9-10-11-12-13. Prototype & Testing

Out-Class Activity

- Preparation for Project Execution: At this stage, students engage in the necessary preparations to initiate and carry out their projects. This includes tasks such as procuring essential materials and consumables, planning project activities, etc. Students will focus on setting up the groundwork for a productive execution of their projects.

- Collaboration with Associate Partners for Wet Lab Activities: To bolster wet lab activities, the project teams will establish communication with associate partners. These partners, possessing specialized expertise and resources, will provide valuable support in facilitating the wet lab components of the projects. This collaborative effort aims to enhance the quality and effectiveness of the experimental work conducted in the laboratory setting.

In-class Activity (Wet Lab)

Duration: 6 x (3x45) minutes

- Optimizing and Performing Experiments, Obtaining Results, Analyzing and Prototyping: During this phase, students will focus on the hands-on execution of their experiments. This involves fine-tuning experimental procedures for optimal results, conducting the experiments, and meticulously recording data. Once the data is collected, students will engage in a rigorous process of analysis, where they scrutinize the results to draw meaningful conclusions. Additionally, based on the findings, students may develop prototypes to further validate their research.

- Testing the Prototype: Following the development of the prototype, it is subjected to a series of tests and evaluations. This phase is critical in assessing the functionality, efficiency, and effectiveness of the prototype. Testing may involve simulations, controlled experiments, or real-world trials, depending on the nature of the project. The goal is to ensure that the prototype meets the intended objectives and performs as expected. Feedback from these tests will inform any necessary adjustments to the prototype.

Teaching-Learning Methods

- Experiment Techniques
- Data Collection
- Data Analysis

Week 14. Assessment

Out-Class Activity

In this workshop session, students will have the opportunity to present the results of their projects or any developed products. This presentation is a key step in the research process, as it allows students to communicate their findings and innovations effectively with the experts from industry (including associate partners and academia). The objective is to receive constructive feedback from a panel of experts, which will further refine and enhance the quality of the work.

In-class Activity

Duration: 3 x45 minutes

Students will evaluate their own work, drawing from the experiments they conducted and taking into account the feedback provided by experts.

Teaching-Learning Methods

- Discussion

MODULE 2
Enzymes in Biotechnology

Problem 1 - Challenges in Recombinant Enzyme Production

Objectives:

- Students will be able to;
- Have knowledge about the usage areas of enzymes.
- Have knowledge about the production techniques of recombinant enzymes.
- Uses the production techniques of recombinant enzymes.
- Have knowledge about the establishment of a laboratory-scale enzyme production system.
- Apply enzyme quantification methods.
- Have knowledge about controlling the purity of enzymes produced.
- Makes activity measurements of enzymes.
- Apply the enzymes produced.

Content:

- Recombinant DNA technology
- Enzyme production and purification
- Enzyme purity control
- Enzyme Activity characterization
- Enzyme application

Learning resources:

- Video on applications of enzymes in biotechnology. Video content and accompanying resources provide information on enzyme production, purification and activity control. Applications of enzymes in related industries.
- Articles, books, lecture notes etc.

Week 1. Introduction (For All Modules)

In-Class Activity

Duration: 3x45 minutes

- The instructor informs the students about the modules.
- The tasks expected from the students during the semester are defined within the course.

- Students also receive information on how to access additional resources on the topic (university library, online resources, etc.).
- The topic of each module is introduced to the students.
- Students are divided into groups.
- Each group decides on the problem they will work on.

Teaching-Learning Methods

- Question - Answer
- Discussion

Week 2-3. Empathize

Out-Class Activity

- Prepared videos and resources are shared with the students.
- Students are asked to learn about the usage areas of enzymes, production techniques, establishment of a laboratory-scale enzyme production system, enzyme quantification methods and purity of enzymes produced.
- Students are asked to learn about enzyme production and applications using available resources.

In-Class Activity

Duration: 2x(3x45) minutes

- Students share articles, books, etc. with group members.
- Students discuss the problem based on the literature.
- Then, students are asked to demonstrate the difference in the quality of products with and without enzymes.
- Students are expected to discuss the issue in all its dimensions and explain it comprehensively, taking into account the examples they give as a group.

Teaching-Learning Methods:

- Brainstorming
- Discussion
- Question and answer

Week 4. Define

Out-Class Activity

- Students are asked to learn about the usage areas of enzymes, production techniques, establishment of a laboratory-scale enzyme production system, enzyme quantification methods and purity of enzymes produced.
- Students are asked to conduct research on enzyme production and applications using available resources.
- Each group is tasked with creating a mind map on the topic of enzyme production and applications (to be presented in class in Week 4).

In-class Activity

Duration: 3 x 45 minutes

- Students are asked to present a mind map and explain the problems in enzyme production and applications.
- Students have the opportunity to discuss and define the problem with their classmates.

Teaching-Learning Methods:

- Brainstorming
- Discussion

Week 5. Ideate

Out-Class Activity

- At this stage, each student is asked to generate ideas for choosing the most appropriate method for enzyme production, checking the purity of the enzyme produced and characterizing its activation in the most appropriate way.
- Students are asked to come up with many ideas on the topic. Unusual ideas can also be generated.

In-Class Activity

Duration: 3 x 45 minutes

- Each student is asked to present his/her idea to the group and discuss it.
- Students can be guided by the instructor when necessary.
- For example, students' attention can be drawn to the following topics: The importance of enzymes to produce high-value products, the importance of the enzyme production method to be used for each enzyme, the importance of determining the purity of enzymes after they are produced in order to obtain high yields, the activity parameters of the enzyme produced.

- For each group, one or two ideas that are most suitable for implementation are determined among the ideas put forward.

Teaching-Learning Methods:

- Discussion
- Question-Answer

Week 6-7. Ideate

Out-Class Activity

- At this stage, students are asked to prepare a project proposal that includes research objectives, methods, data analysis and budget to be used in solving the problem in line with the ideas. (Annex: Research Draft for all modules)
- Expert Opinion - communication with experts working in the field about the project proposal.
- At this stage, the opinions of experts from the silent partners of the project will also be needed (recommended for Week 6).

In-class Activity

Duration: 2 x (3x45) minutes

- **Week 6:** Each group will inform the instructor and classmates about the progress of their research proposal
- **Week 7:** Each group will present their final proposal to their classmates.

Teaching-Learning Methods:

- Discussion
- Question and answer
- Presentation

Week 8-9-10-11. Prototype

Out-Class Activity

- At this stage, students make the necessary preparations to carry out the project: Procuring the necessary materials and consumables, planning the project activities, etc.
- Associated partners of the project will be contacted to support the laboratory work.

In-class Activity (Wet Lab)

Duration: 4 x (3x45) minutes

- Optimizing and performing experiments, obtaining and analyzing results and prototyping

Teaching-Learning Methods:

- Experiment Techniques
- Data collection
- Data analysis

Week 13-14. Testing

In-class Activity

Duration: 2x(3 x45) minutes

- Testing the prototype.

Teaching-Learning Methods:

- Experiment Techniques
- Data collection
- Data analysis

Week 14. Assessment

Out-Class Activity

- Workshop: Students will present their project results or products to experts from industry (including silent partners) and academia and receive feedback.

In-class Activity

Duration: 3x45 minutes

- Students will evaluate their own work based on their experiments and the opinions of experts.

Teaching-Learning Methods:

- Discussion

Problem 2 - Enzyme Immobilization Restrictions

Objectives:

Students will be able to;

- To learn about the inefficiencies of using enzymes in industry.
- Develop ideas for the recovery of enzymes.
- Know different immobilization methods.
- Know the advantages and disadvantages of different immobilization methods.
- Develops the ability to choose the appropriate immobilization method for the enzyme of interest.
- Measures the efficiency of the selected method.
- Apply the developed immobilized enzyme in the product.

Content:

- Enzyme technology
- Enzyme immobilization techniques

- Enzyme measurement methods
- Immobilized enzyme applications

Learning resources:

- Video on immobilization of enzymes in biotechnology. Video content and accompanying resources provide information about enzyme immobilization, characterization and applications. Applications of enzymes in related industries.
- Articles, books, lecture notes etc.

Week 1. Introduction (For All Modules)

In-Class Activity

Duration: 3x45 minutes

- The instructor informs the students about the modules.
- The tasks expected from the students during the semester are defined within the course.
- Students also receive information on how to access additional resources on the topic (university library, online resources, etc.).
- The topic of each module is introduced to the students.
- Students are divided into groups.
- Each group decides on the problem they will work on.

Teaching-Learning Methods

- Question and Answer
- Discussion

Week 2-3. Empathize

Out-Class Activity

- Prepared videos and resources are shared with the students.
- Students are asked to conduct research on the ways of recovery of enzymes, immobilization techniques, advantages and disadvantages of these techniques, characterization of the efficiency of immobilized enzymes. Students are asked to learn about the experiences of researchers or workers in the field of enzyme production.
- Students are asked to obtain information about enzyme production and applications using available resources.

In-Class Activity

Duration: 2x(3x45) minutes

- Students share articles, books, etc. with group members.
- Students discuss the problems encountered when producing enzymes in industry, taking into account the literature and the experience of experts working in this field.
- Students are expected to discuss the topic as a group in all its dimensions and explain it comprehensively.

Teaching-Learning Methods:

- Brainstorming
- Discussion

Week 4. Define

Out-Class Activity

- Students are asked to conduct research on the recovery pathways of enzymes, immobilization techniques and their advantages and disadvantages, and characterization of the efficiency of immobilized enzymes.
- Each group is tasked with creating a mind map on the topic of enzyme recovery pathways (to be presented in class in Week 4).

In-class Activity

Duration: 3 x45 minutes

- Students are asked to present a mind map and explain the problems in enzyme production and applications.
- Students have the opportunity to discuss and define the problem with their classmates.

Teaching-Learning Methods:

- Discussion
- Brainstorming

Week 5. Ideate

Out-Class Activity

- At this stage, each student is asked to generate ideas for enzyme recovery methods, enzyme immobilization techniques and enzyme characterization.
- Students are asked to come up with many ideas on the subject. Unusual ideas can also be generated.

In-Class Activity

Duration: 3 x45 minutes

- Each student is asked to present his/her idea to the group and discuss it.
- Students can be guided by the instructor when necessary.
- For example; enzyme recovery efficiency, compatibility of the method used for immobilization of the enzyme with the product in which the enzyme is used, characterization of the activity of the immobilized form of the enzyme, etc.
- For each group, one or two ideas that are most suitable for implementation are selected from the ideas put forward.

Teaching-Learning Methods:

- Discussion
- Question and Answer

Week 6-7. Ideate

Out-Class Activity

- At this stage, students are asked to prepare a project proposal that includes research objectives, methods, data analysis and budget to be used in solving the problem in line with the ideas. (Annex: Research Draft for all modules)
- Expert Opinion - communication with experts working in the field about the project proposal.
- At this stage, the opinions of experts from the silent partners of the project will also be needed (recommended for Week 6).

In-class Activity

Duration: 2 x (3x45) minutes

- **Week 6:** Each group will inform the instructor and classmates about the progress of their research proposal
- **Week 7:** Each group will present their final proposal to their classmates.

Teaching-Learning Methods:

- Discussion
- Question and Answer
- Presentation

Week 8-9-10-11. Prototype

Out-Class Activity

- At this stage, students make the necessary preparations to carry out the project: Procuring the necessary materials and consumables, planning the project activities, etc.
- Associated partners of the project will be contacted to support the laboratory work.

In-class Activity (Wet Lab)

Duration: 4 x (3x45) minutes

- Optimizing and performing experiments, obtaining and analyzing results and prototyping

Teaching-Learning Methods

- Experiment Techniques
- Data collection
- Data analysis

Week 11-12. Testing

In-class Activity (Wet Lab)

Duration: 2 x (3x45) minutes

- Testing the prototype

Teaching-Learning Methods

- Experiment Techniques
- Data collection
- Data analysis

Week 14. Assessment

Out-Class Activity

- Workshop: Students will present their project results or products to experts from industry (including silent partners) and academia and receive feedback.

In-class Activity

Duration: 3 x45 minutes

- Students will evaluate their own work based on their experiments and the opinions of experts.

Teaching-Learning Methods

- Discussion

MODULE 3
Biotechnology in Agriculture

Problem 1 - Plant Tissue Culture

Objectives:

- Students will be able to:
- Understand the behavior of different plants under *in vitro* conditions.
- Evaluate the advantages and disadvantages of plant propagation *in vitro.*
- Understand the process of plant tissue establishment, *in vitro* propagation, and acclimatization of plants.
- Interpret data from laboratory observations and measurements and their relationship to theory.

Content:

- Introduction to modern plant biotechnology.
- Tissue culture of woody and herbaceous plants.
- Micropropagation and other applications of tissue culture in agriculture (virus-free plants, plant conservation and cryopreservation, haploids, somatic hybridisation, secondary metabolites).
- Internal infections of plants that cause problems in obtaining and maintaining viable tissue cultures.

Learning resources:

- The educational video produced as part of the project. A video provides information on micropropagation techniques, the preparation of culture media, the disinfection of plant material, the processes of propagation, rooting and acclimatization of plants.
- Accompanying documents such as articles, books and teacher lectures uploaded to Moodle.
- Lecture notes.

Week 1. Introduction (For All Modules)

In-Class Activity

Duration: 2x45 minutes

- The lecturer will provide information to the students regarding the modules planned for the semester.
- The tasks expected from the students throughout the semester will be defined within the scope of the course.
- Students will also receive information on how to access additional resources on the subject (university library, online resources, etc.).

- The topic of each module will be introduced to the students.
- The students will be divided into groups of 4 or 5.
- Each group will decide on the problem they will work on.

Teaching-Learning Methods

- Question-Answer
- Discussion

Week 2. Empathize

Out-Class Activity:

- The educational video and the first part of the resources uploaded in Moodle are shared with the students.
- Students are asked to learn the basics of plant tissue culture as one of the biotechnological methods. They need to familiarize themselves with various applications of plant tissue culture such as micropropagation, obtaining virus-free plants, haploids, production of secondary metabolites, and cryopreservation. As the focus is on micropropagation, students need to understand all the steps of micropropagation (selection of plant material, establishment of sterile cultures, propagation by repeated subcultures, pre-transplant conditioning and acclimatization) and recognise the advantages and disadvantages of *in vitro* propagation of plants. The resources also go into more detail about the role of plant hormones in different culture media, disinfection of media, methods of disinfecting plant material and climatic conditions in the growth chamber.
- Using the resources provided and sources found in the library or databases, students must describe the characteristics of an ideal plantlet obtained by micropropagation.
- They should illustrate the process using a flow chart and explain the conditions or factors that may play an important role in the success of micropropagation at each step.

In-Class Activity

Duration: 2x45 minutes

- Students present and discuss their ideas of an ideal plant obtained through micropropagation.
- They share their ideas on the key conditions and factors involved in micropropagation with their team members by putting sticky notes on the board. They should then present and discuss these ideas and support them with data from the relevant literature.

Teaching-Learning Methods

- Flipped learning with pre-class self-assessment in Moodle
- Presentation
- Brainstorming

- Discussion

Week 3. Define

Out-Class Activity

- As students need to deepen their understanding of micropropagation, they are given access to additional resources on Moodle this week. The resources address common contaminants that can seriously damage plant tissue cultures, describe chemical and biological contaminants, their possible sources, detection, and control. Biological contaminants, including bacteria, and ways of sterilization are specifically covered in the resources.
- Students are also asked to complete a group assignment in which they interview micropropagation experts and observe their work. The aim is for students to gain insight into the processes of micropropagation, the experts' daily work and challenges, their creativity, motivation, opinions, frustrations, and problem-solving approaches, and to collect relevant stories.
  - Students are encouraged to formulate appropriate open-ended questions to guide the interview (the assignment on Moodle).
  - They are expected to take detailed notes and create headlines summarizing the key findings and their observations from the interview.

In-class Activity

Duration: 2 x45 minutes

- Team members present the headlines from the interview to their classmates, lead a discussion and collectively summarize the findings in descriptive sentences or direct quotes, avoiding judgements and conclusions.
- Students are also expected to discuss the topic as a group and create a comprehensive description of all the important conditions at each step of micropropagation, taking all aspects into account
- The session will be moderated by the lecturer to maintain focus and facilitate a productive discussion.

Teaching-Learning Methods:

- Flipped learning with pre-class self-assessment in Moodle
- Qualitative interviewing
- Discussion

Week 4. Ideate

Out-Class Activity

- Students are asked to conduct a literature review on contaminants commonly found in micropropagation.
- Each student in a group is given a flipchart and the task of creating a poster showing all the possible contaminants at each stage that they think affect the success of plant micropropagation.
- Students are additionally asked to rephrase the identified contaminants into a sentence beginning with “How might we … (do something to avoid the contamination)?”, for example:
  - “How might we select a plant stock material?”,
  - “How might we identify healthy plant stock material?”,
  - “How might we prepare the stock material?”,
  - “How might we purify the water used in the lab?”,
  - “How might we avoid mistakes in media preparation?”,
  - “How might we … disinfect … the equipment, stock material, media, explants?”,
  - “How might we detect … certain bacteria, molds, yeasts, viruses or mycoplasmas?”, etc.

In-Class Activity

Duration: 2 x45 minutes

- In the “Brainwalking” session, students are asked to hang their posters with all the problems they have identified – contaminants (“How might we ..." questions) on a wall.
- As the students should come up with the right problems themselves, the lecturer asks the students to take turns and silently circulate between the posters and add additional "How might we" questions on each other's flip charts using markers. In this way, each participant will contribute ideas and, where possible, build on existing ones.
- Students should make the rounds until each flipchart contains 10 or more questions.

- The lecturer then asks the owner of the flipchart to select the most promising "How might we" statements and present them to the rest of the group. He/she also encourages students to build on the existing ideas and contribute their own thoughtful and innovative "How might we..." statements.

Teaching-Learning Methods:

- Poster creation and presentation
- Brainwalking
- Discussion

Week 5 Ideate

Out-Class Activity

- Students are asked to continue their literature research on contaminants commonly found in micropropagation to improve their understanding.

- Students are also asked to use their poster created in the previous "Brainwalking" session and add one or more problem-solving ideas next to each “How might we..." question.

- Students can use markers to write text, draw symbols, add drawings, or use other creative tools to express their problem-solving ideas.

In-class Activity

Duration: 2x45 minutes

- Students hang their posters with added problem-solving ideas on the wall.
- Each poster owner presents the solutions to the rest of the group.
- After each presentation, the group conducts a brainstorming session.
- Members will contribute additional ideas and refinements to the solutions presented by writing text with markers, drawing symbols, adding drawings, or using other creative tools to express and expand their ideas.
- The lecturer will encourage a dynamic exchange of thoughts and perspectives.
- After the collaborative session, each poster owner selects what he/she considers to be the most promising solutions and presents a summary of the refined ideas to the whole group.

The lecturer will encourage a feedback and discussion session where participants can share their thoughts on the solutions presented. The lecturer will also encourage constructive feedback to further enhance the quality of the ideas.

Teaching-Learning Methods

- Poster creation and presentation
- Brainstorming
- Discussion

Week 6-7-8 Ideate

Out-Class Activity

- As part of the requirements for the laboratory experiment, students are expected to prepare a project proposal for the micropropagation of a specific plant (defined by the lecturer in relation to the ongoing work in the laboratory). The project proposal (which can refer to any type of contamination) should outline the research objectives, methodology, expenses, and plan for data analysis.
- To ensure the successful completion of the proposal and the timely start of the wet lab experiment, it is important that the proposal and its improvement be presented weekly during class meetings.
- The opinions of the micropropagation experts and associated partners will also be requested at this stage (Suggested for Week 7). The experts will provide valuable feedback and advice on how to improve the project proposal.

In-class Activity

Duration: 3 x (2x45) minutes

- In weeks 6 and 7, each group will inform the lecturer and classmates about the progress of their project proposal.
- In week 8 each group will present their final proposal to their classmates.

The lecturer encourages the students to actively participate in the discussion and ask questions so that they can further improve their proposals.

Teaching-Learning Methods

- Preparation of a project proposal
- Question–Answer
- Discussion
- Presentation

Week 9-10-11-12-13 Prototype and Testing

Out-Class Activity

- Students become familiar with potential sources of contamination in the laboratory environment, cleaning and sterilization techniques and guidelines for working in a tissue culture laboratory (faculty wet lab).
- In view of the ongoing laboratory work (plant type and species, purpose of micropropagation), students are asked to prepare themselves for work in the faculty's wet lab. They will plan the previously elaborated project activities by:

- Listing the materials and supplies needed, selecting appropriate culture media, describing the properties and quantities of the components in the media and media preparation, determining methods and conditions that will promote vigorous plantlet growth, rooting and acclimatization.
- In addition, students must familiarize themselves with the critical issues of contamination, including the problems of bacterial contamination and antibiotic testing methods.

In-class Activity (Wet Lab)

Duration: 5 x (2x45) minutes

- The students will begin their work in the faculty's wet lab. They will carry out the previously devised project activities by assisting in the procurement of the necessary materials and supplies.
- Students should document when and how they:
  - select the most appropriate disinfection method/disinfectant,
  - begin culturing and obtaining explants,
  - prepare and use appropriate culture media for the various stages of micropropagation such as subculture, growth, plant organ differentiation and rooting,
  - learn a step-by-step acclimatization protocol for adapting the plantlets to the natural environment.
- Since in vitro cultures of woody plants are long-term cultures with a higher probability of latent infection with internal bacteria (endogenous bacteria), students will be familiarized with the identification of internal contaminants and one of the methods that can be used to effectively control this contamination. To this end, they will test media containing antibiotics such as cefotaxime and gentamicin, which inhibit the growth of bacterial contaminants.
- Under the supervision of the experts, students will conduct an optimized experiment, obtain results, analyze the data, create, and test prototypes.

Teaching-Learning Methods

- Experimenting
- Question–Answer
- Discussion
- Writing project report (data collection, analysis, results presentation, drawing conclusions)

Week 14. Assessment

Out-Class Activity

- Workshop: students present their project results or products to experts and receive feedback.

- Experts from industry (including associated partners) and academia.

In-class Activity

Duration: 2 x45 minutes

- Students will assess their own work based on the experiments they carried out as well as the experts' opinions.

Teaching-Learning Methods

- Presentation
- Discussion

Problem 2 - Fermentation in Winemaking

Objectives:

Students will be able to;

- Understand the role of fermentation processes in winemaking and identify the main factors influencing fermentation.
- Perform an analysis of fermentation kinetics.
- Explain how different yeast and bacterial strains affect wine quality.
- Perform an analysis of fermentation kinetics.
- Communicate about the importance of using starters for fermentation.

Content:

- Alcoholic and malolactic fermentation
- Environmental influences on the viability of yeasts and bacteria
- Nutritional status of the grape juice
- Aromatic compounds in wine
- Analyses for monitoring grape juice fermentation
- Barrels and equipment in the wine cellar
- Wine legislation

Learning resources:

- The educational video produced as part of the project. A video provides information on alcoholic and malolactic fermentation, wine maturation and factors that influence process and affect the quality of white, rosé and red wines.
- Accompanying documents such as articles, books and teacher lectures uploaded on Moodle.
- Lecture notes.

Week 1. Introduction (For All Modules)

In-Class Activity

Duration: 2x45 minutes

- The lecturer will provide information to the students regarding the modules planned for the semester.
- The tasks expected from the students throughout the semester will be defined within the scope of the course.
- Students will also receive information on how to access additional resources on the subject (university library, online resources, etc.).
- The topic of each module will be introduced to the students.
- The students will be divided into groups of 4 or 5.
- Each group will decide on the problem they will work on.

Teaching-Learning Methods

- Question-Answer
- Discussion

Week 2. Empathize

Out-Class Activity

- The educational video and the first part of the resources uploaded in Moodle are shared with the students.
- Students get access to the first part of the resources uploaded to Moodle and are asked to learn about the process of alcoholic and malolactic fermentation of grape juice/must, the differences between commercial yeast starters and indigenous yeast strains in winemaking and recognise their influence on wine quality. Through the study of resources, students familiarize themselves with the process of wine aging (maturation) and stability and understand the influence of environmental factors during fermentation/maturation on the aroma profile of wine.
- Using the resources provided and sources students have found in the library or databases, students are asked to formulate open-ended questions that can be used to guide the interview with winemakers about the challenges and expectations associated with the winemaking process. Students are instructed to formulate questions on various aspects that provide a rich and detailed insight into winemakers' background and experiences, winemaking challenges, fermentation decision-making, balance between tradition and innovation, expectations of wine quality, market trends and consumer preferences, collaboration with restaurants, innovation and continuous improvement in winemaking, advice for aspiring students, etc.

- Students are asked to write each question on a sticky note and indicate the aspect to which the question relates (e.g. background and experiences, winemaking challenges, fermentation decision-making, etc.).

In-Class Activity

Duration: 2x45 minutes

A Peer Critique and Improvement session is organized to give students the opportunity to engage with each other's work, provide constructive feedback and work together to improve the quality of open-ended questions. Students will develop important skills in communication, critical thinking, and collaborative learning.

- Students work in groups and discuss the prepared questions in rounds – aspect by aspect.
- Each student in the group presents their own set of open-ended questions to the group members.
- After each presentation, group members give feedback on the questions presented (feedback template) and discuss the strengths and weaknesses of the questions presented and areas for improvement.
- After the peer critiques, students have time to reflect on the feedback they received, and revise their questions.
- The activity concludes with a larger group discussion where students can share general insights from the peer critique process and discuss any common themes that emerged from the collaborative work.

The lecturer should create an inclusive and supportive environment that encourages active participation, collaboration, and open communication. During the activity, the lecturer encourages presenters to briefly explain the context and purpose of each question and to promote open dialogue and sharing of diverse perspectives. The lecturer also provides a simple feedback template that participants can use to structure their feedback. The template includes categories such as clarity, relevance, and the question's potential for deeper insight from winemakers.

Teaching-Learning Methods

- Flipped learning with pre-class self-assessment in Moodle
- Presentation
- Brainstorming
- Discussion

Week 3. Empathize

Out-Class Activity

- As students need to deepen their understanding of fermentation and factors influencing wine quality, they get access to additional resources on Moodle. Resources are about life stages of yeast during fermentation, nutritional status of grape juice and its impact on yeast viability, aromatic compounds in wine, the equipment, vats, and barrels used in the winery when producing white, rosé or red wines and their influence on wine quality. Students also familiarize themselves with analytical methods and with wine legislation.

- As an individual task, students will be asked to:
  - conduct an interview with winemakers using the questions they have developed and refined. They are instructed to take detailed notes during the interviews.
  - create a poster on a flipchart on which they summarize their most important findings and observations.

In-class Activity

Duration: 2 x45 minutes

- **An interview results review is organized as a poster presentation session.** It provides an opportunity for each student to share their unique insights and findings, promoting peer-to-peer learning and a deeper understanding of different perspectives of winemakers.
  - Students hang their posters on a wall and individually present findings to the audience.
  - Pears ask questions and discuss results.
- In the follow-up activity each group prepares one new, common poster on a flipchart at which students synthesize information, analyze differences and common patterns that have emerged and generate a collective understanding of winemakers.

The lecturer should be mindful of time in each poster presentation and Q&A session, allowing adequate time for each presenter and encouraging effective discussion. He/she encourages students to emphasize unique findings (e.g. through storytelling or the use of images) and to explore contrasting information that may have emerged. The lecturer also helps students connect individual findings to broader themes that may shape the collective understanding of winemaking from the winemaker's perspective.

Teaching-Learning Methods

- Flipped learning with pre-class self-assessment in Moodle
- Qualitative interviewing
- Presentation
- Discussion
- Group work

Week 4. Define

Out-Class Activity

- Students are asked to review the literature on the factors (abiotic and biotic) and conditions that influence alcoholic, malolactic fermentation, wine maturation and therefore wine quality. They will also be encouraged to extract appropriate information from the data collected during the Empathize stage.

- Students are asked to write each factor they have identified as influencing processes on the front of a sheet of paper and the explanation for its effects on the back.

In-Class Activity

Duration: 2 x45 minutes

A factor prioritization and ranking exercise is organized to enable students to refine their understanding of the factors and conditions that influence the fermentation and maturation processes by prioritizing and ranking them. The exercise requires students not only to identify factors, but also to critically evaluate and prioritize them based on perceived importance. It encourages deeper discussions about the relative importance of different elements in relation to processes that influence wine quality. This refinement is important in the Define stage as it helps narrow down the scope and identify key elements to focus on.

- Each student in the group presents a list of factors and conditions identified in the investigation and explains why he/she believes they have a significant impact on the processes.
- After a group discussion, the students decide together on important factors and conditions.
- Each group then draws three separate grids (for alcoholic fermentation, malolactic fermentation, and wine maturation) on a whiteboard or flipchart, with the cells in the first column representing each factor or condition and the rows indicating the priority scale from 1–"low" to 5–"high".
- First, students individually adjust the position of each factor along the priority scale on the grid. The students use different colors of markers or sticky notes.
- After the subsequent discussion, the group agrees on the final position of each factor on the priority scale.

The lecturer provides the students with a marker or a set of sticky notes, encourages them to collaborate and negotiate within the group and stimulates a discussion about the factors and their ranking.

Teaching-Learning Methods

- Group work
- Discussion
- Brainstorming

Week 5 Ideate

Out-Class Activity

- Students are asked to continue their literature research on factors influencing fermentation processes and maturation in different types of wine (white, rosé and red), sweetness, etc.

- At this stage, each student is asked to form ideas about how fermentation and maturation can be manipulated to obtain wine of certain quality. Students are asked to come up with many ideas. Unconventional ideas can also be produced.

In-class Activity

Duration: 2 x (2x45) minutes

A **combination of brainstorming and provocation techniques** is used during the session. Both are aimed at developing the widest possible range of creative ideas, evaluating them, and selecting the best ones.

- After defining the brainstorming topic and setting the ground rules, the lecturer starts to create a mind map by writing the core problem "how can fermentations/maturation be manipulated" in the center of the whiteboard and then students building their ideas outwards to peripheral branches which can be interrelated.
- During the session, the lecturer may draw the students' attention to ideas related to making new types of wine, conventional and organic approaches to winemaking, manipulating processes to minimize the addition of sulphites, costs, etc.
- To stimulate creative "outside of the box" thinking", the lecturer can pose hypothetical scenarios or "what if" questions, for example:
  - "What if we could manipulate fermentation using non-traditional ingredients or unconventional microorganisms or introduce non-traditional fruits or botanicals during fermentation?"
  - "What if we could manipulate fermentation temperatures dynamically throughout the process or applied artificial intelligence to optimize fermentation conditions?"
  - "What if maturation periods were adjusted based on lunar cycles?"
  - "What if we could simulate different maturation environments to achieve specific aroma profiles?"
  - "What if we experimented with alternative sources of sugars for fermentation?"
  - "What if we could use advanced sensors to precisely monitor and adjust the fermentation and maturation process in real-time?"
  - "What if we integrated concepts from other beverage industries, such as craft beer or spirits, into winemaking processes?"
- In the final part of the session, the lecturer and students select the ideas that best fit the objectives, labs' resources, budget, timeline, risks, and impacts. The most promising ideas are then used to create project proposals and later for the Prototype & Testing stage.

Teaching-Learning Methods

- Individual and group work
- Mind mapping
- Discussion
- Brainstorming

Week 6-7-8. Ideate

Out-Class Activity

The students work in pairs.

- Based on the most appropriate ideas developed in the previous session, students are asked to prepare a project proposal. The proposal should include the research objectives, the methods, the data analysis, and the budget for carrying out the experiment (Annex: Research Outline for all modules).
- Students should contact experts in vinification and experts from associated partners and get their opinions on the project proposal (Suggested for Week 7). The experts will provide valuable feedback and advice on what to improve in the proposal.
- To ensure the successful completion of the proposal and the timely start of the wet lab experiment, it is important that the proposal and its improvement be presented weekly during class meetings.

In-class Activity

Duration: 3 x (2x45) minutes

- Once a week, each pair informs the lecturer and classmates about the progress of their project proposal.
- The lecturer organizes a visit to winemakers with different approaches to fermentation management in week 7.
- Each pair presents their final proposal to their classmates in week 8.

Teaching-Learning Methods:

- Preparation of a project proposal
- Question–Answer
- Discussion
- Presentation

Week 9-10-11-12-13 Prototype & Testing

Out-Class Activity

- The students become familiar with the existing guidelines for working in the faculty's analytical laboratory and in the micro-vinification unit.

- Regarding the dynamics of project progress, students prepare themselves for work in the wet labs. They will plan the previously elaborated project activities by:
  - listing the materials, supplies, and chemicals they need,
  - selecting appropriate yeast for fermentation,
  - determining analytical and statistical methods.

In-class Activity (Wet Lab)

Duration: 5 x (2x45) minutes

- The students will begin their work in the faculty's wet labs. They will carry out the previously devised project activities.

- Under the supervision of the experts, students conduct an optimized experiment, obtain results, analyze the data, create, and test prototypes.

Teaching-Learning Methods:

- Experimenting
- Question–Answer
- Discussion
- Writing project report (data collection, analysis, results presentation, drawing conclusions)

Week 14. Assessment

Out-Class Activity

- Workshop: students will present project results or products to the experts and receive feedback.
- Experts from industry (including associate partners) and academia.

In-class Activity

Duration: 2 x45 minutes

- Students will assess their own work based on the experiments they carried out as well as the experts' opinions.

Teaching-Learning Methods:

- Presentation
- Discussion

MODULE 4
Microbiome Applications for Functional and Sustainable Food Systems

Problem 1 - Exploring and Exploiting Microbiomes in Food Systems

Objectives:

Students will be able to:

- Explain what microbiome is and its role within the One Health concept.
- Explore food microbiomes and their impact on food systems.
- Learn about the role of the food microbiome in human health.
- Become familiar with modern technologies used in microbiome research.
- Perform analysis of microbial communities in a particular ecosystem (fermented food, gut microbiome, etc.).
- Discuss microbiome biodiversity; the potential for the identification of novel strains.
- Explain how microbiome data/novel strains are used to design functional products.
- Become familiar with the approaches used to assess the impact of novel functional products on gut microbiome in vivo.
- Be able to communicate the importance of food microbiomes.

Content:

- Microbiomes
- Food microbiomes
- Microbiome and health
- Methods in microbiome research & analysis
- Microbiome and novel products and applications in food industry

Learning resources:

- Scientific video presentations.
- Classroom notes.
- Textbook chapters.
- Review articles/Original articles.
- Newspapers, short videos from media.

Week 1. Introduction

In-Class Activity

Duration: 3x45 minutes

- The lecturer will provide information to the students regarding the modules planned for the semester.
- The tasks expected from the students throughout the semester will be defined within the scope of the course.
- Students will also receive information on how to access additional resources on the subject (university library, online resources, etc.).
- The topic of each module will be introduced to the students.
- The students will be divided into groups of 4 or 5.
- Each group will decide on the problem they will work on.

Teaching-Learning Methods

- Question-Answer
- Discussion

Week 2. Emphasize

Out-Class Activity

- Food microbiomes: Each group works presenting the microbial community they are going to work with and uploads a poster before the in-class activities (the group focuses on any aspect of the microbial community they like).

In-Class Activity

Duration: 3x45 minutes

- Oral presentation of the posters (10 min each group).
- Through the discussion on the posters the various aspects of microbiome become apparent
- Groups receive literature on microbiomes and their impact under the One Health concept.

Teaching-Learning Methods

- Directed discussion.
- Brainstorming.
- Instructor presentation.

Week 3-4. Define

Out-Class Activity

- Groups work on the literature dicuss and prepare a 5 min video on the microbiome community they work on and its role and upload it.
- Each group watches the videos of the other groups and prepares for the in-class discussion.

In-class Activity

Duration: 2x(2x45) minutes

- Discussion on the videos presented, each group answers to questions on their work.
- Do we overestimate microbiome effects? Instructor gives examples.
- Wrap up - groups take notes with main points.

Teaching-Learning Methods

- Discussion.
- Flipped classroom.
- Instructor presentation.
- Cooperative learning.

Week 5. Define

Out of Class Activity

- Groups prepare a set of questions to ask the experts.

In-Class Activity

Duration: 2 x45 minutes

- Meetings with experts on the field - short presentations from experts (either online or in person).

Teaching-Learning Methods

- Directed discussion.
- Experts' presentation.

Week 6. Ideate

Out-Class Activity

- Each groups prepares a short presentation on the methods used to analyze microbiomes

In-Class Activity

Duration: 3x45 minutes

- Each group presents its presentation.
- Class-discussion on the methods used to analyze microbiomes.
- Overview of the methods used to analyze microbiomes.

Teaching-Learning Methods

- Directed discussion.

- Instructor presentation.

Week 7-8. Ideate

Out-Class Activity

- Students watch selected videos on microbiome analysis methods.
- Each group chooses an NGS platform and studies in depth the principle on which it is based
- Each group prepares a flowchart of work for the microbiome analysis using the NGS platform they have selected.

In-class Activity

Duration: 2 x (1 x45) minutes

- Discussion in class.

Teaching-Learning Methods

- Cooperative learning.
- Flipped classroom.
- Experiential learning.

Week 9-10-11: Prototype and testing

Out-Class Activity

- Groups work on their projects. A PhD student/Postdoc researcher is assigned to help the groups.

In-class Activity (Wet & Dry lab)

Duration: 3 x (5x45) minutes

- Hands-on activity in groups - Microbiome analysis - Groups work with samples of the microbiome they have selected
- Evaluation of the results

Teaching-Learning Methods

- Cooperative learning.
- Experiential learning.

Week 12. Prototype and testing

Out-Class Activity

- Evaluation of the results of the analysis.
- Report preparation. A PhD student/Postdoc researcher is assigned to help each group.

In-class Activity

Duration: (2x45) minutes

- Groups discuss their progress with the PhD student/Postdoc researcher.
- Groups choose one aspect of the microbiome field they want to highlight in a newspaper article.

Teaching-Learning Methods

- Cooperative learning.
- Experiential learning.

Week 13. Prototype and testing

Out-Class Activity

- Groups finalize their report
- Groups prepare a short newspaper article on microbiome .

In-class Activity

Duration: 3 x (2x45) minutes

- Groups discuss with the instructors.

Teaching-Learning Methods

- Experiential learning.
- Cooperative learning.

Week 14. Assessment

Out-Class Activity

- Groups work on the evaluation of the results of their project and on the report of their project activities. Then, the groups complete their report and upload it.

In-class Activity

Duration: 3 x45 minutes

- Groups present the results of their project.
- Discussion/Evaluation of the course.
- Feedback

Teaching-Learning Methods

- Cooperative learning.
- Directed discussion.

Problem 2 - Developing Functional Foods

Objectives:

Students will:

- Understand and be able to explain what functional foods are and their role in human health.
- Analyze the impact of beneficial microbial strains on designing novel functional food ingredients.
- Explore the role of plant extracts and essential oils as growth stimulators of beneficial microbes (prebiotics) and as growth inhibitors of foodborne pathogens and spoilage microbes (biopreservatives).
- Become familiar with approaches that enhance sustainability and functionality of food systems.
- Become aware with legislation issues on functional food ingredients development.

Content:

- Functional food ingredients/final products.
- Plant extracts/essential oils as prebiotics and biopreservatives.
- Designing of sustainable industrial bioprocesses.

Learning resources:

- Scientific video presentations.
- Classroom notes.
- Textbook chapters.
- Review articles/original articles.
- Newspapers, short videos from media.

Week 1. Introduction

In-Class Activity

Duration: 3x45 minutes

- The lecturer will provide information to the students regarding the modules planned for the semester.
- The tasks expected from the students throughout the semester will be defined within the scope of the course.
- Students will also receive information on how to access additional resources on the subject (university library, online resources, etc.).
- The topic of each module will be introduced to the students.
- The students will be divided into groups of 4 or 5.
- Each group will decide on the problem they will work on.

Teaching-Learning Methods

- Question-Answer
- Discussion

Week 2. Emphasize

Out-Class Activity

- Functional food ingredients: Each group works on designing a novel functional food ingredient or final food product based on sustainable approaches and uploads a poster before the in-class activities.

In-Class Activity

Duration: 3x45 minutes

- Oral presentation of the posters (10 min each group).
- Why and how design thinking can foster sustainability-oriented innovation development?
- Groups receive literature on functional food ingredients, sustainable production approaches, etc.

Teaching-Learning Methods

- Directed discussion.
- Brainstorming.
- Instructor presentation.

Week 3. Define

Out-Class Activity

- Groups work on the literature and prepare a 5 min video presenting the challenges of their project, which is then uploaded.
- Each group watches the videos of the other groups and prepares for in-class discussion.

In-class Activity

Duration: 3 x45 minutes

- Discussion on the videos presented; each group answers to questions on their work.
- Design sustainable bioprocesses for functional food ingredients production. Instructor gives examples.
- Wrap up - groups take notes with main points.

Teaching-Learning Methods

- Directed discussion.
- Flipped classroom.
- Instructor presentation.
- Cooperative Learning

Week 4. Define

Out-Class Activity

- Each group is asked to write a newspaper article on sustainable production of functional food ingredients or foods (final products).

In-Class Activity

Duration: 3x45 minutes

- How do we design a sustainable process for industrial functional food ingredients/final product production?

Teaching-Learning Methods

- Directed discussion.

- Instructor presentation.
- Cooperative learning.

Week 5: Ideate

Out-Class Activity

- Students watch videos on the methodology used to design a sustainable process for industrial functional food ingredients/final product production.
- Each group designs an in-depth presentation of a sustainable process for industrial functional food ingredients/final product production

In-class Activity

Duration: 3x45 minutes

- Each group presents the industrial process of the functional food ingredients/final product production.
- Challenges and technical issues are discussed.
- Groups discuss ideas/challenges on the development of industrial bioprocesses that foster sustainability.
- Ideas are presented following by group discussion; each group focuses on one idea to work as a research proposal.

Teaching-Learning Methods

- Cooperative learning.
- Flipped classroom.
- Experiential learning.

Week 6-7 Ideate

Out-Class Activity

- Groups prepare a project proposal with research objectives, methods, data analysis and budget in line with the ideas/challenges discussed.

In-class Activity

Duration: 2 x (3x45) minutes

- Groups discuss their progress with the PhD student/Postdoc researcher.

Teaching-Learning Methods

- Cooperative learning.
- Experiential Learning.

Week 8-9-10-11: Prototype

Out-Class Activity

- Groups work on their projects. A PhD student/Postdoc researcher is assigned to help the groups.

In-class Activity (Wet & Dry Lab)

Duration: 4 x (3x45) minutes

- Pilot scale functional food ingredients/final products production (hands-on laboratory work).
- Kinetic parameters determination and assessment of process sustainability (dry laboratory).

Teaching-Learning Methods

- Experiential learning.
- Cooperative learning.

Week 12-13. Assessment

Out-Class Activity

- Groups work on the evaluation of the results of their project and on the report of their project activities. Then, the groups complete their report and upload it.

In-class Activity

Duration: 2 x (3 x45) minutes

- Groups present the results of their project.
- Discussion/evaluation of the course.
- Teaching-Learning Methods
- Cooperative learning.
- Directed discussion.

MODULE 5 New Breeding Techniques: Tools We cannot Renounce for a Sustainable Agriculture

Problem 1 - Challenges and potentials of new breeding techniques.

Objectives:

Students will be able to:

- acquire knowledge about modern plant breeding principles, including molecular, genomic, phenomic, and biotechnological techniques in agriculture.
- gain the skills necessary to select suitable target genes for genetic engineering and gene editing for crop improvement.
- acquire knowledge about crop transformation techniques.
- gain the skills necessary to improve the selection process of new resilient varieties using NBTs.
- evaluate the advantages and disadvantages of utilizing NBTs in agriculture.
- acquire knowledge about the legislation on the use of crops obtained through the NBTs in Europe and extra-European countries.
- acquire knowledge about the techniques used for the traceability of plants obtained through NBTs.

Content:

- Modern plant breeding principles.
- Role of NBTs for food security.
- Economic and Environmental Impacts of NBTs.
- Risk assessment and authorization for NBT plants.
- Public opinion and consumer acceptance of NBTs.
- Legislation for plants derived from NBTs.

Learning resources:

- Scientific video presentations.
- Classroom notes.
  Textbook chapters.
- Review articles/Original articles.
- Newspapers, short videos from the media.

Week 1. Introduction (For All Modules)

In-Class Activity

Duration: 3x45 minutes

- The lecturer will inform students of the activities planned for the semester.

The tasks expected from the students throughout the semester will be defined within the scope of the course.

Students will also receive information on how to access additional resources on the subject (university library, online resources, etc.).

- The topic of each module will be presented to the students.
- The students will be divided into groups of 4 or 5 people.
- Each group will decide on a problem they will work on.

Teaching-Learning Methods

- Discussion
- Questions/Answers

Week 2. Empathize

Out-Class Activity:

- Learning materials (video, articles, and other resources) will be shared with students.
- Students will be required to comprehend modern plant breeding principles, understand the various applications of NBTs, recognize the advantages and disadvantages of utilizing NBTs in agriculture and assess the environmental impact of NBTs.
- Students will be required to investigate the literature on NBT application through using the resources available.

Students will deepen their understanding on the technique for the traceability of plants derived from NBTs.

In-Class Activity

Duration: 3x45 minutes

- Students will share the collected materials among team members.
- Students will discuss the problem related to NBTs based on the literature data collected.
- Students will be asked to imagine themselves working with NBTs in agriculture, describe all steps in crop improvement and define possible gaps.
- Students will discuss the legislation regulating the plants obtained through the NBTs. Each team will be asked to discuss the defined gaps and to propose possible solutions.

Teaching-Learning Methods:

- Brainstorming
- Discussion

Week 3. Define

Out-Class Activity:

- Students will be required to comprehend modern plant breeding principles, understand the various applications of NBTs, recognize the advantages and disadvantages of utilizing NBTs in agriculture and assess the environmental impact of NBTs.
- Students will be required to investigate the literature on application of NBTs in agriculture through using the resources available.
- Students will research and present (poster or oral presentation) a specific aspect of NBT application demonstrating an understanding of existing research and developments (to be presented in the classroom by Week 3).

In-class Activity

Duration: 3 x45 minutes

- Students will present their topics to their classmates, explaining the gaps they discovered in the application of NBTs.
- Students will discuss their observations with their classmates.

Teaching-Learning Methods:

- Presentation
- Discussion
- Questions-Answers
- Cooperative learning

Week 4. Ideate

Out-Class Activity:

- In this phase, each student is asked to come up with ideas on how to make the application of NBTs more effective, how to improve public acceptability and how to modify European legislation regulating plants derived from NTBs.
- Students should come up with many ideas.
- Unconventional ideas can also be developed.

In-Class Activity

Duration: 3x45 minutes

- In light of the literature search and study, students will be asked to ideate new NBT-based approaches to face issues related to food security, by implementing crop resilience.

- Most promising ideas will be selected and further discussed and implemented (see below).
- Students will be supported by the constant presence of a postdoc and an assistant researcher who will also stimulate group brainstorming sessions..

Teaching-Learning Methods:

- Discussion
- Questions-Answers

Week 5-6-7. Ideate

Out-Class Activity:

- One promising idea per each group will be used to draw a project proposal, including research goals, methods, data analysis and budget.
- Projects will be shared with experts in the field for further implementation.

In-class Activity

Duration: 3 x (3x45) minutes

- Each group will share with the lecturer and classmates the progress of their research proposal
- The final proposals will be completed in week 7.

Teaching-Learning Methods:

- Discussion
- Questions/Answers
- Presentation

Week 8-9-10-11-12-13. Prototype & Testing

Out-Class Activity:

- Students will visit research laboratories adopting NBTs in view of conducting experiments included in the projects.
- PIs and researchers will support students in designing experiments and gathering the required materials and consumables.

In-class Activity (Wet Lab):

Duration: 6 x (3x45) minutes

- Students will perform experiments,
- Experiments will be optimized and possible problems will be solved
- Results obtained in lab activities will be analyzed.

Teaching-Learning Methods:

- Experiments involving NBT techniques.
- Data collection.
- Data analysis and interpretation.

Week 14. Assessment

Out-Class Activity:

- Workshop: research results will be presented by each group of students
- Experts from industry and academia will provide feedback.

In-class Activity

Duration: 3 x45 minutes

- Students will be asked to prepare a report based on the experiments they carried out as well as the experts' opinions.

Teaching-Learning Methods:

- Discussion

Problem 2 - NBTs for sustainable agriculture.

Objectives:

Students will be able to:

- acquire knowledge about the role of NBTs in crop yield improvement.
- acquire knowledge about the role of NBTs in lowering the usage of chemical fertilizers and pesticides.
- acquire knowledge about the role of NBTs in reduced postharvest losses, and more nutritious foods
- acquire knowledge about the role of NBTs in better crop resilience to climate stress
- acquire knowledge about the different applications of NBTs to improve resilience of staple crops, such as wheat.
- learn how to increase crop yield and quality while developing varieties that are adaptable to different environmental conditions by using NBT techniques.

Content:

- Food security and malnutrition
- Global trends in agricultural productivity and hunger
- New agricultural technologies

- Application of NBTs in crop resilience improvement
- Sustainability of NBTs in agriculture
- Application of genome editing in wheat

Learning resources:

- Scientific video presentations.
- Classroom notes.
- Textbook chapters.
- Review articles/Original articles.
- Newspapers, short videos from the media.

Week 1. Introduction (For All Modules)

In-Class Activity

Duration: 3x45 minutes

- The lecturer will inform students of the modules planned for the semester.
- The tasks expected from the students throughout the semester will be defined within the scope of the course.
- Students will also receive information on how to access additional resources on the subject (university library, online resources, etc.)
- The topic of each module will be presented to the students.
- The students will be divided into groups of 4 or 5 people.
- Each group will decide on a problem they will work on.

Teaching-Learning Methods

- Discussion
- Questions/Answers

Week 2. Empathize

Out-Class Activity:

- Learning materials (video, articles, and other resources) will be shared with students.
- Students will be allowed to comprehend the agricultural impact on the environment.
- Students will be allowed to comprehend the impact of climate changes on agriculture.

- Students will be required to investigate the literature on NBT applications through using the resources available.

Students will expand their understanding on the actual concerns and constraints of food security and global nutrition and on how NBTs could be helpful for developing crop improvements and, in general, for agriculture sustainability.

In-Class Activity

Duration: 3x45 minutes

- Students will share the collected materials among team members.
- Students will discuss the problem related to food security and malnutrition based on the literature data collected.
- Students will discuss the problem related to risks derived from the intensive use of fertilizers, pesticides, and irrigation water.
- Students will discuss the possible role of NBTs as a game changer for sustainable agriculture.

Teaching-Learning Methods:

- Brainstorming
- Discussion

Week 3. Define

Out-Class Activity:

- Students will be required to comprehend successful examples of NBTs applications in staple crops.
- Students will be required to investigate the literature on application of NBTs in agriculture through using the resources available.
- Students will research and present (poster or oral presentation) a specific aspect of NBT application demonstrating an understanding of existing research and developments (to be presented in the classroom by Week 3).

In-class Activity

Duration: 3x45 minutes

- Students will present their topics to their classmates, explaining the gaps they discovered in the application of NBTs.
- Students will discuss their observations with their classmates.

Teaching-Learning Methods:

- Presentation
- Discussion

- Questions-Answers
- Cooperative learning

Week 4. Ideate

Out-Class Activity:

- In this phase, each student is asked to identify breeding objectives to be pursued through NBTs and how to approach it. Students should come up with many ideas.
- Unconventional ideas can also be developed.
- Different ideas will be combined to create hybrid or mash-up solutions to facilitate innovative approaches to increase agriculture sustainability.

In-Class Activity

Duration: 3x45 minutes

- In this phase, each student is asked to come up with ideas on how to make the application of NBTs more effective, how to improve public acceptability and how to modify European legislation regulating plants derived from NTBs.
- Unconventional ideas can also be developed.

Teaching-Learning Methods:

- Discussion
- Questions-Answers

Week 5-6-7. Ideate

Out-Class Activity:

- At this stage, in line with the ideas, students are asked to prepare a project proposal, including research objective(s), methods, data analysis and budget.
- In this stage, opinions of the academic experts will also be required.

In-class Activity

Duration: 3 x (3x45) minutes

- Brainstorming sessions will be conducted to encourage generating innovative ideas.
- Experts working in the field will provide their opinion and discuss the project proposal.
- In week 7, each group presents their final proposal to their classmates.

Teaching-Learning Methods:

- Discussion
- Questions/Answers
- Presentation

Week 8-9-10-11-12-13. Prototype & Testing

Out-Class Activity:

- At this stage, students will prepare to perform activities included in their projects.
- All the necessary materials and consumables will be identified, verified and provided by postdocs.
- Associate partners will be contacted to support wet lab activities.

In-class Activity (Wet Lab):

Duration: 6 x (3x45) minutes

- Activities included in the projects will be conducted under the supervision of postdocs.
- Experiments will be optimized
- Results will be analyzed and interpreted.

Teaching-Learning Methods:

- Experiment involving NBTs
- Data collection
- − Data analysis

Week 14. Assessment

Out-Class Activity:

- Workshop-Students will present project results or products to the experts and receive feedback.
- Experts from industry (including associate partners) and academia give students feedback.

In-class Activity

Duration: 3 x45 minutes

- Students will be asked to prepare a report based on the experiments they carried out as well as the experts' opinions.

Teaching-Learning Methods:

- Discussion

MODULE 6
Environmental Biotechnology

Problem 1 - Biodiesel Production: Addressing Challenges, Embracing Solutions

Objectives:

Students will be able to:

- Understand the challenges of renewable energy production
- Understand the entire biodiesel production process, including feedstock selection, transesterification, and quality control
- Stress down the advantages and disadvantages of different biodiesel production and purification methods
- Understand how the process can be optimized
- Select different materials for biodiesel production
- Discuss the sustainability of biodiesel production through the use of different waste sources
- Suggest research activities to improve biodiesel production methods, explore new feedstock options, or increase the efficiency of biodiesel use in engines

Content:

- **Introduction to Biodiesel**:
    - Definition and characteristics of biodiesel
    - Historical perspective and development of biodiesel as a fuel
    - Importance of biodiesel for the reduction of greenhouse gas emissions
- **Feedstocks for Biodiesel Production**:
    - Different sources of feedstocks (vegetable oils, animal fats, algae)
    - Selection criteria for feedstocks
    - Sustainable sourcing and ethical considerations
- **Biodiesel Production Process**:
    - Transesterification: the (bio)chemical process for biodiesel production
    - Catalysts and their role in biodiesel production
    - Production methods and technologies (batch, continuous, supercritical conditions)
- **Quality Control and Testing**:
    - Quality standards and regulations for biodiesel
    - Methods for analysis of biodiesel properties (viscosity, density, cetane number)
    - Common impurities and methods for detection
- **Biodiesel Blending and Utilization:**
    - Blending of biodiesel with conventional diesel fuel

- Engine modifications for the use of biodiesel
- Biodiesel handling, storage, and transportation

– **Economic and Environmental Impacts**:
  - Economic feasibility of biodiesel production
  - Life cycle analysis: assessment of the overall environmental impact
  - Comparison with fossil fuels in terms of emissions and energy balance

– **Biodiesel Policies and Regulations**:
  - Government policies to promote biodiesel production and use
  - Tax incentives and subsidies for biodiesel producers
  - Environmental regulations and compliance requirements

– **Biodiesel Research and Innovation**:
  - Ongoing research into biodiesel production methods
  - Exploration of advanced feedstock options
  - Innovations to improve the efficiency and environmental impact of biodiesel

– **Challenges and Future Outlook**:
  - Challenges facing the biodiesel industry (e.g., competition with food production, land use conflicts)
  - Technological progress and future trends in biodiesel production
  - The role of biodiesel in the future of renewable energies

– **Case Studies and Real-World Applications**:
  - Success stories of biodiesel implementation in different countries
  - Case studies of biodiesel-powered vehicles and industries
  - Lessons learned from practical applications

Learning resources:

– Textbooks and Reference Materials

– Online Articles and Websites

– Documentaries and Videos

– Industry Visits

– Research Papers and Reports

Week 1. Introduction (For All Modules)

In-Class Activity

Duration: 3x45 minutes

– The lecturer will inform students of the modules planned for the semester

- The tasks expected from the students throughout the semester will be defined within the scope of the course
- Students will also receive information on how to access additional resources on the subject (university library, online resources, etc.)
- The topic of each module will be presented to the students
- The students will be divided into groups of 4 or 5 people
- Each group will decide on a problem they will work on

Teaching-Learning Methods

- Discussion
- Question/Answers

Weeks 2 - 3. Empathize/Define

Out-Class Activity

- Students will participate activities such as video sharing and literature research
    - Students will understand the process of biodiesel production, purification, use, and impact and demonstrate an understanding of existing research and development
    - Students will research current literature data on biodiesel production and purification

In-Class Activity

Duration: 3x45 minutes over 2 weeks

- Students will present (poster or oral presentation) a specific aspect of biodiesel production, use, or impact and demonstrate an understanding of existing research and development
- A field trip to biodiesel production facilities will be organized where students will interact with workers and ask questions to gain practical knowledge and a real-world understanding of the problem
- Students will be encouraged to imagine themselves working in a biodiesel plant, identify gaps and propose solutions (Worksheet 1)

Teaching-Learning Methods

- Brainstorming
- Discussion

Weeks 4 - 5 - 6 - 7. Ideate

Out-Class Activity

- In this phase, each student is asked to come up with ideas on how to make biodiesel production more effective. Students should come up with many ideas.
- Unconventional ideas can be also developed
- Affinity mapping will be organized where students will categorize and cluster the data, observations, and findings collected

    - Students will be guided in developing project proposals with research aims, methods and budgets (Appendix: Research Outline for all modules)
    - Students will be encouraged to consider the social, economic and environmental dimensions of the identified problem
    - Specific constraints or limitations will be discussed and set for idea generation to guide students in developing solutions within a defined framework. Constraints will include budget limitations, resource availability, or sustainability goals
    - Students will have to define success criteria for potential solutions and establish a measurable criterion that indicates the effectiveness of the proposed actions
- Communication with experts in the field to incorporate the opinions of the partners involved will be established
- At this stage, the opinions of the experts from the associated partners will be also required

In-Class Activity

Duration: 4x (3 x45 minutes)

- Brainstorming sessions and discussions will be organized for students to present and refine their ideas.
- Role plays will be organized where students take on the roles of the different actors involved in biodiesel production. This will help to develop a holistic understanding of the different perspectives within the ecosystem
- Students will participate in discussions to understand how different people might approach and resolve these dilemmas, focusing on the ethical considerations involved
- A non-judgmental environment will be encouraged to stimulate creativity

    - Mind mapping techniques will be used to visually explore connections and relationships between different concepts and ideas

    - The "Crazy 8s" exercise will be introduced, where students will sketch eight quick ideas within a limited time, which initially serves to encourage quantity rather than quality

  - The SCAMPER technique (Substitute, Combine, Adapt, Modify, Put to Another Use, Eliminate, Reverse) will be used to guide students in exploring different dimensions of their ideas

  - Techniques such as asking "what if?" questions or suggesting extreme scenarios will be used to encourage students to think outside conventional boundaries

- Student will inform the lecturer and classmates about the progress of their research proposal

- In week 7, each group presents their final proposal to their classmates

Teaching-Learning Methods

- Brainstorming
- Discussion
- Presentation
- Question/Answer

Week 8-9-10-11-12-13. Prototype & Testing

Out-Class Activity

- Activities will be organized to prepare the project and establish contact with partners involved

- Students will be guided to create prototypes of their selected ideas using materials such as cardboard, paper or digital tools. The importance of rapid and iterative prototyping will be emphasized

- A workshop on prototyping techniques will be held, introducing different methods and materials that can be used. Practical experimentation and creativity will be encouraged

- User feedback sessions will be organized where students will present their prototypes to potential users for evaluation to gain insights on usability, usefulness and possible areas of improvement

- The iterative nature of prototyping, which encourages students to refine and modify their prototypes based on user feedback, will be emphasized. Multiple iterations will be conducted to improve the design

- Peer critique sessions will be organized where students will present their prototypes to other groups for evaluation to encourage constructive feedback and different perspectives

In-class Activity (Wet Lab)

Duration: 6x (3x45 minutes)

- Students will be conducted to optimize the experiments, obtain results and test the biodiesel produced

- Students will be instructed to systematically document user feedback and categorize findings into positive aspects, areas for improvement, and unexpected results. The feedback will be used as a basis for further iterations

- Students will be guided to analyze the data collected during the test sessions

- Students are encouraged to derive actionable insights for refining their prototype

Teaching-Learning Methods

- Experiment Techniques
- Data Collection
- Data Analysis

Week 14. Assessment

Out-Class Activity

- A workshop will be organized where students will present their project results or prototypes to a group of experts, including industry professionals and academics. This will allow students to present their design thinking journey and the development of their solutions. The experts will provide feedback on the entire design process, from problem definition to the final prototype. The experts will be encouraged to provide insights and recommendations for future improvements.

In-class Activity

Duration: 3 x45 minutes

- Students will evaluate their own work based on the experiments conducted
    - Students will self-assess and reflect on their individual contributions, the challenges they faced, and their personal growth during the design process Students will be encouraged to critically evaluate their roles and responsibilities

- The effectiveness of the final prototypes will be evaluated against predefined criteria such as user satisfaction, functionality, and conformance to project goals. Quantitative and qualitative benchmarks will be applied
- The feasibility of implementing the proposed solutions in real-life scenarios will be assessed, taking into account factors such as scalability, resource requirements and potential challenges
- The collective effort and teamwork within each group will be assessed, taking into account factors such as communication, distribution of responsibilities and conflict resolution
- The level of innovation and creativity demonstrated in the design process and final solutions, as well as whether the solutions go beyond conventional approaches, will be evaluated
- Outstanding projects or individuals will be recognized through awards or certificates. Exceptional achievements and contributions will be highlighted

Teaching-Learning Methods

- Discussion

Problem 2 - Facing Composting Challenges: Innovative Approaches and Sustainable Solutions

Objectives:

Students will be able to;

- Understand the challenges involved in composting
- Understand the overall composting process
- Identify common problems in composting processes and apply appropriate solutions that ensure efficient decomposition and odor control
- Identify the advantages and disadvantages of different composting approaches
- Understand how the process can be optimized
- Suggest research activities to improve composting process

Content:

- **Introduction to Composting:**
  - Definition and principles of composting
  - Importance of composting in waste management and soil enrichment
  - Historical perspective and traditional methods of composting
- **Fundamentals of Composting**:

- Organic materials suitable for composting (e.g., kitchen scraps, yard waste)
- Carbon-to-nitrogen ratio (C/N ratio) and its importance in composting
- Aerobic composting processes

– **Composting Methods and Techniques**:
  - Traditional composting methods (pile, bin, heap)
  - Vermicomposting (composting with worms)
  - Bokashi composting (fermentation composting)
  - Industrial and large-scale composting techniques

– **Composting Ingredients:**
  - Green and brown materials in composting (grass clippings, leaves, paper)
  - Prevention of compost contamination (e.g., diseased plants, pet waste)
  - Composting accelerators and activators

– **Microorganisms in Compost**:
  - The role of bacteria, fungi, and other microorganisms in the composting process
  - Microbial diversity and its influence on compost quality
  - Temperature and moisture requirements for microbial activity

– **Troubleshooting Composting**:
  - Common composting problems (odour, pests, slow decomposition)
  - Troubleshooting techniques and solutions
  - Composting mistakes and how to avoid them

– **Compost Utilization**:
  - Using finished compost in gardening and agriculture
  - Benefits of compost for soil structure, fertility, and water retention
  - Compost tea and its use as a natural fertilizer

– **Composting and Sustainability**:
  - Environmental benefits of composting (landfill waste reduction, methane emissions)
  - Composting as a tool for carbon sequestration and climate change mitigation
  - Municipal composting initiatives and their impact on local sustainability

– **Composting in Special Contexts**:
  - Composting in urban environments and small spaces
  - Institutional and commercial composting programs
  - Composting in schools and educational institutions

– **Composting Regulations and Policies**:
  - Local and national regulations for composting
  - Quality standards for compost products
  - Compliance and certifications for commercial composting operations

– **Composting Innovations and Research**:
  - Innovations in composting technology and equipment
  - Research studies on composting techniques and microbial dynamics

- Integration of composting with other sustainable practices (e.g., permaculture, agroforestry)

Learning resources:

- Textbooks and Reference Materials
- Online Articles and Websites
- Documentaries and Videos
- Industry Visits
- Research Papers and Reports

Week 1. Introduction (For All Modules)

In-Class Activity

Duration: 3x45 minutes

- The lecturer will inform students of the modules planned for the semester
- The tasks expected from the students throughout the semester will be defined within the scope of the course
- Students will also receive information on how to access additional resources on the subject (university library, online resources, etc.)
- The topic of each module will be presented to the students
- The students will be divided into groups of 4 or 5 people
- Each group will decide on a problem they will work on

Teaching-Learning Methods

- Discussion
- Question/Answers

Week 2 - 3. Empathize/Define

Out-Class Activity

- Students will be involved in various preparatory activities
  - Videos will be shown showcasing different composting methods, facilities, and success stories
  - Literature research on composting processes, challenges and innovative solutions will be conducted
  - Group discussions will be organized to share insights and promote a collective understanding of composting

- Field trips to composting facilities will be organized so that students can interact with workers, observe the processes and gain practical insights. Students will be encouraged to ask questions to gain realistic understanding of the challenges of composting
-

In-Class Activity

Duration: 2 x(3x45 minutes)

- Students will be encouraged to imagine themselves working in a composting environment to identify gaps and suggest solutions
- A structured worksheet (Worksheet 1) will be provided for students to write down their observations and proposed solutions
- Students will share the collected materials among team members
- Students will present their topics to their classmates, explaining the gaps they discovered in compost production
- Students will discuss their observations with their classmates

Teaching-Learning Methods

- Brainstorming
- Discussion
- Question/Answer

Week 4 - 5 -6- 7. Ideate

Out-Class Activity

- In this phase, each student is asked to come up with ideas on how to make compost production more effective. Students should come up with many ideas.
- Unconventional ideas can be also developed
- Students will be guided in developing comprehensive project proposals with clear research objectives, methods and budgets. Students are encouraged to consider the social, economic and environmental dimensions of composting issues
  - Constraints will be defined, such as budget limitations, resource availability, and sustainability goals
  - Success criteria and measurable benchmarks for evaluating proposed composting efforts will be jointly defined
- In this phase students are asked to develop a project proposal that includes the research aims, methods, data analysis and budget for solving the problem (Annex: Research Outline for all modules)

- Communication between students and composting experts, fostering collaborative insights will be engaged
    - A non-judgmental environment will be created to stimulate creativity and open discussions
    - Mind mapping techniques will be used to visually explore connections and relationships between composting concepts and ideas
- At this stage, the opinions of the experts from the associated partners will be also required

In-Class Activity

Duration: 4x (3 x45 minutes)

- A brainstorming session will be organized in which students develop and share ideas to solve composting problems
    - Role plays will be organized in which the different actors in the composting process are simulated to gain a holistic understanding
    - Students will engage in ethical discussions about composting practices and decision making
    - Affinity mapping will be conducted where students categorize and group collected data, observations, and findings. This will identify patterns, themes, and key issues related to composting that will form the basis for problem definition
- Key themes and potential solution areas related to composting challenges will be expended using
    - The "Crazy 8s" exercise, encouraging students to sketch eight quick composting ideas within a limited time
    - The SCAMPER technique to guide students in exploring different dimensions of their composting ideas.
    - Provocation techniques, such as asking "What if?" questions or suggesting extreme scenarios, to encourage students to think creatively.
    - Reverse thinking exercises where students explore composting solutions by considering the opposite of their assumptions.
- Student will inform the lecturer and classmates about the progress of their research proposal
- In week 7, each group presents their final proposal to their classmates

Teaching-Learning Methods

- Discussion
- Question/Answer
- Presentation

Week 8-9-10-11-12-13. Prototype & Testing

Out-Class Activity

- Students will be guided to develop prototypes of their composting solutions using materials such as cardboard, paper, or digital tools
  - The importance of rapid and iterative prototyping to explore different design possibilities will be emphasized

- A workshop on prototyping techniques will be organized to introduce different prototyping methods and materials

In-class Activity (Wet Lab)

Duration: 6 x (3x45) minutes

- Students will demonstrate their composting prototypes to potential users for evaluation. In this way insights will be gained on usability, practicality and areas for improvement from the users' perspective
- The iterative nature of the prototyping process will be emphasized to encourage students to refine and modify their composting prototypes based on user feedback. The process is repeated several times to improve the design and solve identified problems
- Sessions will be organized in which student groups share their composting prototypes with each other. Constructive feedback and different perspectives will be encouraged to enrich the design process
- Students will be guided to document user feedback in a structured way and categorize findings into positive aspects, areas for improvement and unexpected findings. The collected feedback will be used for further iterations and adjustments of their composting prototypes
- Students will be guided to analyze the data collected during the test sessions to derive actionable insights for refining their composting prototypes and ensure they address the identified challenges

Teaching-Learning Methods

- Experiment Techniques
- Data Collection
- Data Analysis

Week 14. Assessment

Out-Class Activity

- Students will present the results of their composting projects or prototypes to an expert panel of professionals and academics. Students will present their design thinking journey and the development of their composting solutions

- External experts will provide feedback on the overall composting process. The experts will provide insights and recommendations for future improvements to broaden the students' understanding and refine their composting solutions

Duration: 3 x45 minutes

- A self-assessment in which students reflect on their individual contributions, challenges, and personal growth during the composting process is encouraged
- ·The effectiveness of the final composting prototypes will be evaluated based on predefined criteria such as user satisfaction, functionality, and alignment with project goals. Both quantitative and qualitative metrics will be used to comprehensively evaluate the composting solutions
- The feasibility of the proposed composting solutions in real-life scenarios will be assessed, taking into account factors such as scalability, resource requirements and potential challenges for practical application
- The collaborative efforts and teamwork within each group will be assessed taking into account factors such as communication, distribution of responsibilities and conflict resolution
- The level of innovation and creativity demonstrated in the composting process and final solutions will be evaluated, including whether the composting solutions go beyond conventional approaches and encourage innovative thinking
- Outstanding composting projects or individuals will be recognized through awards or certificates. Exceptional achievements and contributions that motivate students and recognize their commitment to the composting challenge will be highlighted

Teaching-Learning Methods

- Discussion

References

Šalić, A., Zagajski Kučan, K., Gojun, M., Rogošić, M., Zelić, B. (2024) Biodiesel purification: real-world examples, case studies, and current limitations. Sustainable Biodiesel Real-World Designs, Economics, and Applications. Tabatabaei, M., Nizami, A. S. (ed.). Academic Press, Elsevier. 2024. 185-238.

Sokač, T., Šalić, A., Kučić Grgić, D., Šabić Runjavec, M., Vidaković, M., Jurinjak Tušek, A., Horvat, Đ., Juras Krnjak, J., Vuković Domanovac, M, Zelić, B. (2022) An enhanced composting process with bioaugmentation: Mathematical modelling and process optimization. Waste management & research, 40, 745-753.

Gojun, M., Šalić, A., Zelić, B. (2021) Integrated microsystems for lipase-catalysed biodiesel production and glycerol removal by extraction or ultrafiltration. Renewable energy, 180, 213-221.

Sokač, T., Gojun, M., Jurinjak Tušek, A., Šalić, A., Zelić, B. (2020) Purification of biodiesel produced by lipase catalyzed transesterification by ultrafiltration: Selection of membranes and analysis of membrane blocking mechanisms. Renewable energy, 159, 642-651.

Šalić, A., Jurinjak Tušek, A., Gojun, M., Zelić, B. (2020) Biodiesel purification in microextractors: Choline chloride based deep eutectic solvents vs water, Separation and purification technology, 242, 116783.

Franjo, M., Šalić, A., Zelić, B. (2018) Microstructured devices for biodiesel production by transesterification. Biomass conversion and biorefinery, 8, 1005-1020.

Šalić, A., Jurinjak Tušek, A., Sander, A., Zelić, Bruno (2018) Lipase catalysed biodiesel synthesis with integrated glycerol separation in continuously operated microchips connected in series. New Biotechnology, 47, 80-88.

Annex

Application Form

Title of the Project

Summary of the project *(publishable abstract, max. 1 page):*

Please describe the following aspects in separate paragraphs. **i) Scientific/Technological Excellence** **ii) Methodology and iii) Project Management** **iv) Importance of International Collaboration** **v) Impact**
Keywords:

Section 1: Scientific/Technological Excellence

Aims and Objectives of the Project

(~ 1-2 page)

Please describe the aims and scientific/technical objectives of the project in detail with clear and brief statements. The objectives should be measurable, realistic and achievable within the duration of the project.

State of the Art

(~ 1-2 pages)

Please describe the current national and international state of the art in the domain addressed by the project (present a literature review including [if applicable] patent/utility model/market research relevant to the project). All necessary references should be given in Section 7.

1.1. Scientific Quality, Innovation Potential and Contribution

(~ 1-2 page)

Please describe the scientific quality and innovation potential of the project as well as its methodological/conceptual/theoretical contribution to the related scientific and technological area, highlighting the expected progress beyond the state of the art.

Section 2: Methodology

(~ 1-2 page)

Please explain the scientific and technological methodology and research techniques (including data collection techniques, tools and data analysis methods) to achieve the objectives of the project. Be specific and do not describe only general directions. Describe experience or preliminary results showing feasibility.

Section 3: Project Management

3.1 Work plan

(~ 2-3 page)

Provide an overview of the work plan and timing of the different work packages using the following Gantt chart. Provide also a graphical presentation (Pert chart or similar) to show how different work packages inter-relate. Literature review, preparation of progress and final reports, dissemination activities, writing articles and purchasing of any material to be used during the project should not be a separate WP.Describe the organizational structure, the management structure and the decision-making.

3.2 Milestones, Success Criteria and Risk Analysis

(~ 1-2 pages)

Please provide a list of milestones, success criteria and potential risks (templates provided).

List of milestones

Milestone	Delivery month	WP involved	Title

Use as many lines as needed, but try to limit the number of milestones

Success Criteria

The success criterion describes the criterion for each WP to be considered successful. The success criteria should be measurable and monitorable.

WP	Objective of WP	Success Criteria (%, number, statement etc.)	Importance of the WP for the Success of the Project (%)

Use as many lines and columns as needed

The sum of percentages in the "Importance of the WP for Success of the Project" column should be 100.

Risk analysis

The risks that can affect the success of the project negatively, their potential impacts and corresponding mitigation plans should be described. The mitigation plan should not lead to deviation from the main objectives of project.

Risk description	Likelihood [1]	Impact	Mitigation plan
Role in project:			

Use as many templates as needed

Role in project:	

4.Impact

4.1 Expected impacts

(~ 1-2 page)

[1] *Rate as low, medium or high.*

Describe the expected impact(s) of the project in relation to the project objectives using the template below. Wherever possible, use quantified indicators and targets.

Type of impact	Expected Output, Results and Impacts
Scientific/Academic (Article, Proceeding, Part of a book, Book)	
Economic/Commercial/Social/Environmental (Product, Prototype, Patent, Utility model, Production license, Process Improvement, Variety registry, Spin-off/Start-up company, Audiovisual archive, Inventory / Database / Documentation Production, Work that can be copyrighted, Presented in media, Fair, Project market, Scientific activity (workshop, training where the results of the projects to be used), social impact, environmental impact and other common effects), For the projects aiming new product development, please also answer the following questions; ● Describe the added value that the project will provide and the contribution of the project output(s) to partner(s)' efficiency and competitiveness. ● Explain the commercialization potential and domestic/international market share of project output(s) including a brief comparison with other potentially competing products or services and its possibility to replace an imported product. ● Provide your estimations and assumptions for economic benefit based on the following criteria: - Time to market (where relevant) - Increase in sales rate - Increase in market share - Breakeven point	
Researcher Training and Creating New Project(s) (Graduate thesis, National/International new Project)	

5. Ethical issues

(~ ½ page)

Describe any foreseeable ethical issue that may arise during the course of the research project. Describe all mitigation strategies employed to reduce ethical risk and justify the research methodology with respect to ethical issues.

6: References

Each reference must include the names of all authors, article/journal/book title, volume number, page numbers and year of publication. If the document is available electronically, the website address should be also shared.

BRIDGING THE GAP BETWEEN BIOTECHNOLOGY AND INDUSTRY: INTEGRATING DESIGN THINKING AND FLIPPED LEARNING

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