AGRIMA

Agri-food Waste Management for Sustainable bio-economy
through Higher Education curricula and upskilling

Work package n°2 - Innovation in teaching and learning: waste valorisation

The AGRIMA teaching and learning methodology

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Deliverable Factsheet

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Abstract:	The AGRIMA Methodology includes the development of an inclusive and innovative pedagogical framework on waste valorisation and bioeconomy. It is based on innovative approaches, such as active and experiential learning, problem-, simulation based-, blended-, and service learning, which will serve in the development of joint lectures and open educational resources as part of existing courses in the HE curricula.
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Consortium

The consortium governing the project is adequately representing a wide range of expertise, as 4 Higher Education Institutions with expertise on agri-food waste valorisation research and teaching (Porto Polytechnic, University of the Aegean, Aix-Marseille University, University of Novi Sad) join hands with a R&D partner with expertise in education and citizen science (Web2Learn) and a viticulture association (AVIPE). This mix of knowledge, skills, experiences and networks guarantees a layered approach toward a diverse range of stakeholders.

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1	**INSTITUTO POLITECNICO DO PORTO**	IPP	Portugal
2	**PANEPISTIMIO AIGAIOU (UNIVERSITY OF THE AEGEAN)**	UA	Greece
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List of abbreviations

The following table presents the acronyms used in the deliverable in alphabetical order.

Abbreviations	**Description**
CA	Constructive Alignment
CE	Circular economy
EU	European Union
HE	Higher Education
HEI(s)	Higher Education Institution(s)
PaMs	Policies and Measures
PBL	Problem-based learning
SCL	Student-centred learning
SDGs	Sustainable Development Goals
WP	Work Package

Executive summary

The aim of the Erasmus+ project AGRIMA is to foster Higher Education Institutes' (HEIs) capacity building for the green transition period through innovative practices and the update of Higher Education (HE) curricula in agri-food waste management, employing principles of the circular bioeconomy. The AGRIMA methodology, as part of Work Package (WP) 2, is aligned with the specific objective (1) of the project, that is to advance the pedagogical methods for industrial agri-food waste valorisation based on business-academia synergies. Specifically, WP2 aims to:

a) increase the interaction between research laboratories and agri-food industries and,

b) increase the participation of the aforementioned in Higher Education (HE) teaching and learning practices regarding waste management and valorisation via emerging technologies.

The present document consists of an inclusive and innovative pedagogical framework on agri-food waste valorisation and bioeconomy, seeking to enhance current teaching and learning processes in HE, such as active and experiential learning, problem-based-, blended- and service learning, and simulations. Hence, the pedagogical framework will facilitate the following activities of WP2, such as the design of the joint lectures and the development of open educational resources.

1. Introduction

The transition towards a circular economy is more intensified than ever before. The reason is that the linear economy model creates endless waste and unsustainable consumption of resources. Hence, the circular economy is an economic concept based on turning waste into value for society, often linked to sustainable development, the provision of the Sustainable Development Goals (SDGs), and an extension of a green economy (European Parliament, 2023). Thus, it has emerged as a crucial approach to reduce greenhouse gas emissions through more efficient material flows.

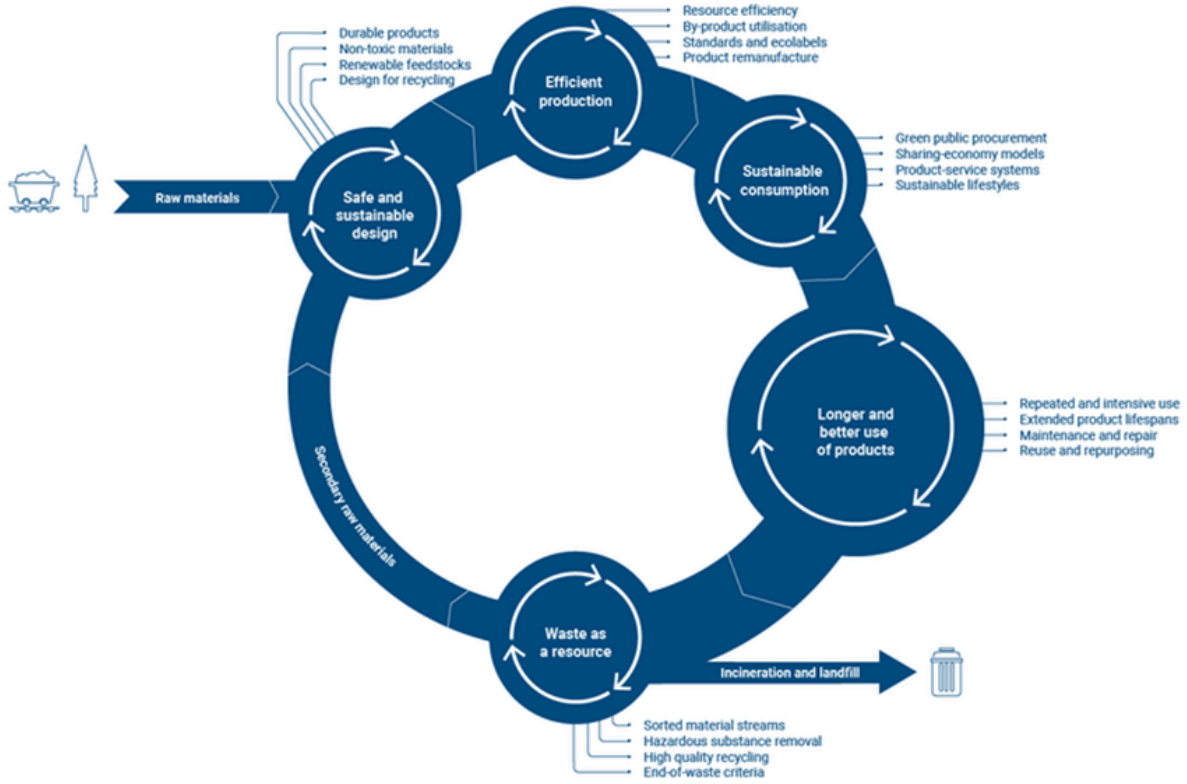

Figure 1: The circular economy concept

Source: European Environment Agency, (2024)

The European Union (EU) has set ambitious goals about the environment, climate change and sustainable growth in several agendas and transformative policies, such as the European Green Deal (2020), the EU 8th Environment Action Plan until 2030 (EAP), the New Circular Economy Action Plan (CEAP, 2020), the Bioeconomy Action Plan (2018), and the Common Agricultural Policy (2023-2027). In this context, agri-food waste management and the circular economy hold considerable potential for mitigating climate change. Hence, EU countries are including circular economy and agri-food waste actions as part of their climate change mitigation policies and measures (PaMs) (ETC CM reports 2024/01).

Thus, the sustainable valorisation of agri-food waste became an urgent need due to the destructive effects caused by climate variations on agriculture along with the continued exponential growth of the human population, according to Food and Agriculture Organisation's (FAO) statistics. Agri-food waste is stirring up significant societal challenges, such as high impact on the world economy or various environmental concerns (FAO, 2021). The mitigation of food waste has already been set as a priority area of the EU policies (e.g. EU actions against food waste). Specificallt, agri-food waste,

mostly from plant origin, offers a wide spectrum of applications to produce value-added products, as renewable natural resources and more healthy alternatives in the food, health, pharmaceutical, cosmetic, and environmental fields. The valorisation of agri-food waste can be achieved by innovative techniques to make it also more economically viable. Continuous scientific research is improving extraction techniques, and consequently, proper strategies are planned for the sustainable development and utilisation of valuable compounds from agri-food waste in real life and their application in various industries (Berenguer, 2023).

In this landscape, HEIs can contribute to the green transition through education and research by aligning their curricula and policies with sustainable development. Precisely, education can be considered an enabler to achieve Sustainable Development Goals (SDGs) adopted by the UN since 2015. Usually, the focus is mainly on research and content development delivered in various university courses, i.e. food security, sustainable agriculture, supply chain, food loss and waste, that can be linked to SDG 2 (Zero Hunger). The pedagogical practices themselves can be part of HEIs effort towards a positive impact in society (SDG 4, Quality Education). A common misconception of higher education is that it aims only to develop academic and research expertise, professional skills and competences. Nevertheless, HE is shifting its aims to also develop critical thinking skills, social engagement, and, in general, to inspire students to be responsible for creating and enjoying a sustainable future. Hence, HEIs are investing time and human resources to improve quality in teaching and learning, in an attempt to achieve a fairer balance along with the focus on research. As a result, teaching and learning challenges arise within the sustainable development context (Buerkle et al, 2023).

AGRIMA focuses on the green transition, by raising HE students' awareness of agri-food waste management that will lead to the consensual development of behavioural changes and new attitudes towards circular bio-economy. Thanks to the project, academic communities, especially students, are expected to become agents of a new lifestyle, compatible with the current and future needs of the environment.

2. The teaching and learning shift in Higher Education

Teaching and learning in HE is significantly changing in recent years. The major shift is the student-centred learning (SCL) approach that reformulates the core focus of teaching. A pedagogical framework based on SCL introduces fundamental implications in curriculum and course design; namely the learning outcomes, learning environment (teaching and learning methods and activities), and assessment processes. Some basic concepts related to SCL are inclusion, interdisciplinarity, flexibility and reflection; constituting important aspects of the pedagogical framework of AGRIMA.

2.1 Student-centred learning

Student-centred learning (SCL) (or learner-centred) is a term widely used in the teaching and learning literature; thus, it has been associated with various meanings. Although not a new concept (rooted mainly in Dewey's work), SCL describes the shift in power from the expert-teacher to the student-learner, driven by a need for a change in the traditional educational environment. Weimer (2002) summarises 5 key changes to instructional practice: (a) the balance of power, (b) the function of content, (c) the role of the teacher, (d) the responsibility for learning and, (e) the evaluation purpose and processes. The increasing criticism of teacher-focused formats, which mainly depend on transmission of information, has paved the way for alternative approaches in teaching and learning. The paradigm shift away from teaching to an emphasis on learning, encourages lecturers to obtain

the role of a “facilitator of learning” rather than a “presenter of information”. The focus on learning brings the needs of learners forward, and emphasise a) what/how/why to study, b) what learners ‘do’ to achieve knowledge. The concept of SCL, despite the various definitions, relates strongly to the constructivist view of learning, placing importance on **activity, discovery and independent learning**. The dualism of teacher-centred or student-centred learning is often presented in a theoretical level, but in reality of practice, it is more useful to present learning as a continuum in which teachers and students move, within the contextual barriers of the teaching/learning practice (see Figure 2) (O’Neill & McMahon, 2005).

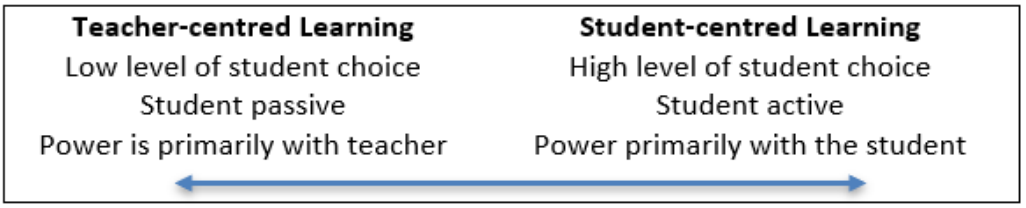

Figure 2: Teacher-centred and student-centred continuum.
Source: O’Neill & McMahon, 2005

Thus, SCL has gained political recognition at the EU level since the Bologna Process agreements (2009). SCL is not limited to a certain methodology but infuses with its principles the implementation of actions taken towards excellence and quality in HE.

2.2 Curriculum and course design

Curriculum development is drawn on pedagogical approaches and formed by models reflecting different conceptions of knowledge, roles and positions of actors, as well as the underlying learning theories. The traditional approach, that is the *syllabus* approach to curriculum design, focuses on the content (body of knowledge to be transmitted) or subjects/modules. The *product*-related curriculum (i.e. Tyler’s model) is based on setting learning objectives (goals) and brings in the fore the effect of teaching methods and assessment. Alternatively, *process*-based curriculum design focuses on teaching and learning processes, considering students’ experiences and learning engagement. A further development of the process approach can create praxis-based curricula, with emphasis on informed, committed and emancipatory action (Grundy 1987 as cited in Annala et al, 2016). Such curriculum develops around issues for which action and reflection are needed to be solved through educational practices. Examples of such issues in HE could be: climate change, economic growth, technological innovations etc. Curriculum in HE has received increasing attention during the last decades, especially around Europe, after the implementation of the Bologna Process. The idea of **curriculum as engagement and focusing on students’ process of learning** has gained a fair share of influence in the discussion on improving HE curricula (Annala et al, 2016).

Some implications of SCL to curriculum design are:

- on-going reflection process;
- recognition of different learning needs;

- differentiation of learning; inclusion and diversity;
- interdisciplinarity;
- assessment as learning process;
- focus on skills and competencies;
- flexibility and element of choice in learning paths.

Curriculum or course design is a dynamic process. The main parts of the process (in either level of design) address the basic questions of "what" (content), "how" (teaching method/assessment) and "why" (learning objective/outcome) to teach something. These parts feed each other and through reflection process can be improved.

Figure 3: Outcome-based course design

Source: Northern Illinois University, n.d.

A growing practice -aligning with SCL in course design internationally- is the setting of learning outcomes/objectives focusing on what the student will be able to do, rather than on the content being covered by the teacher. The concept of Constructive Alignment (CA) as an outcome-based approach to teaching introduced by Biggs (2014) provides a framework for course design that takes into consideration student engagement and their chances of achieving. Building on Tyler's ideas on teaching objectives, and going beyond Bloom's learning objectives taxonomy, he insisted that teachers should focus on what outcomes students intended to achieve, what are supposed to be able to do with the content they have learned, and help them to do so (solve problems, construct hypotheses, apply to particular situations), rather than students to just report back what they had been taught. Intended learning outcomes should be aligned with teaching and assessment methods and activities, to enhance learning effectively. This may be a challenge for HEIs, but steps have been taken towards quality enhancement of teaching.

SCL fundamentally changes instructional strategies and learning activities. Teaching and learning methods in a SCL context are **more interactive**, focusing on **student's active engagement**, differentiated and **adapted to student's needs** and learning experiences, fostering **autonomy** and a deeper approach to learning. Main implications of SCL for teaching and learning are active learning approaches, interaction, awareness of what students are doing and why, and focus on transferable skills. SCL shifts assessment practices as well. Apart from summative methods, a more formative assessment process is implicated, through various methods, including self-assessment, peer assessment, portfolios. Reflective process and on-going feedback are important as assessment practices, allowing students to engage in higher thinking skills (metacognitive) too.

Inclusivity is also an important aspect in HE learning environments within the SCL context. All students are equally valued, respected, and supported, regardless of their cultural background, social identity, gender, beliefs or disabilities. HEIs should help students overcome integration challenges, by ensuring that underrepresented populations are supported. Thus, teaching should foster a sense of belonging, build multicultural interactions and value positive diversity experiences (Greer, 2014).

3. Higher Education for sustainability and bioeconomy

A sustainability-based approach for HE is needed to facilitate the transition to a circular economy. In particular, the field of bioeconomy is characterised by interdisciplinarity, and special learning outcomes are required in the context of sustainability education. Teaching and learning methods that are often utilised to achieve these learning outcomes are: active and experiential learning, problem-/simulation-based, service learning and blended learning. Below, we present cases where these learning approaches in the field of sustainability and bioeconomy have been applied.

3.1 Sustainability-based approach

HEIs are viewed as "changing agents" and "catalysts" in the development of sustainability-related issues and can play a key role in the transition to the circular economy (CE). Such a transition requires both a mindset change of the population and a practical transformation of its skillset. Identifying relevant needs and shaping education to meet these needs is crucial. Especially, the need for bridging theory with practice, cognitive with technical skills. Namely, knowledge transfer from lab to industry; critical thinking and problem-solving abilities; knowledge in business models and project management; knowledge about the principles of sustainable development and the circular economy; knowledge in bio-based markets and techno-economic expertise (Paris et al., 2023).

HE impacts the shaping of attitudes in an adult's life; therefore, the integration and implementation of SDGs can be successful in the long term. HEIs can adopt a sustainability-based approach through:

1) Teaching and research centres: project development and incorporation of sustainability principles across the disciplines;
2) educators' practice: it can influence broader opinions through outreach activities;
3) institutional culture: awareness of university staff, local and broader communities;
4) the formation of future professionals: decisive impact on students' different professional contexts and social engagements;
5) implementing sustainable campus practices (e.g., reducing greenhouse emissions, promoting biodiversity, efficient use of energy and reducing the ecological footprint).

Hence, it is crucial that sustainability principles become an integral part of HE and students to be able to accommodate them into their everyday and professional lives (Žalėnienė & Pereira, 2021).

HEIs contribute to the CE through their curricula, providing students with a set of bioeconomy skills that ensure a more sustainable future. Implications for curriculum development towards this transition are:

- Identifying new skills to respond to emerging needs. Engagement with other stakeholders is important (industry, entrepreneurs, community);
- updating course content and teaching methods to align with the new skills demands, such as problem and praxis-based teaching methods;
- adopting a modular approach, allowing a level of flexibility in learning (interdisciplinarity, not one-size-fits-all model).

(European Commission, Directorate-General for Research and Innovation et al., 2022).

3.2 Interdisciplinarity

A student-centred approach to curriculum design often encourages interdisciplinary learning and collaboration, breaking down traditional subject boundaries to address complex, real-world problems. Interdisciplinary studies are the basis of the transformation towards sustainability. The importance of interdisciplinarity has been underscored in many relevant studies, because it highlights the main challenge for HE, that is to bridge life sciences and STEM with social sciences and humanities. Bioeconomy can be seen as an interdisciplinary subject, since it transcends and interlinks between the themes (food/agriculture, forestry/natural habitats and aquatic/water system bioenergy and biomaterials), sectors (primary, secondary, tertiary) and the wider economy (Paris et al. 2023). Through their curricula, HEIs can offer subjects of different topics as part of the electives, stimulating transdisciplinarity through academic modules. Furthermore, academic modules can integrate multi-faceted approaches to intertwined social phenomena, leading to stronger analytical and problem-solving skills. Multiple perspectives and potential collaborations with other stakeholders are results of system thinking and foster a holistic and inclusive approach with respect to environmental, social and economic sustainability dimensions (European Commission, Directorate-General for Research and Innovation et al., 2022). This integrated approach prepares students to work in diverse teams and apply knowledge from different disciplines in professional and societal contexts.

3.3 Learning Outcomes

Education for sustainability and bioeconomy (or circular economy) is an integrative subject. Different educational models and teaching approaches in HE can encourage the interaction of knowledge, skills and abilities, to motivate students to act according to sustainability and CE principles (Vergani, 2024). In this context, the appropriate learning outcomes (skills and competencies) should be attained by the students, as the future professionals and society leaders. A variety of different specialist skills (hard/ technical skills) will be needed to meet the demands of specific bioeconomy sectors. Apart from specialist skills, a common set of generalist skills are important, given the commonalities in the nature of the transformation needed across the bioeconomy, such as:

- Core knowledge on sustainability, circularity, systems thinking;
- transversal skills: collaboration, communication, problem-solving, creativity, critical thinking;

- entrepreneurship skills: crucial for identifying emerging business opportunities and novel solutions to catalyse sustainable growth;

(European Commission, Directorate-General for Research and Innovation et al., 2022).

Curricula that include bioeconomy skills focus on what students will be able to do after the learning process takes place. Renfors (2024), in a study which offers an overview of the current state in HE for CE, finds that environmental and economic aims are dominant in courses related with CE, such as:

- *Resource management*: addressing resource challenges and scarcity using materials efficiently and critically considering environmental impact.
- *Systems thinking*: approaching the complexity of environmental and societal challenges as interdependent, involving all stakeholders, identifying different needs, perspectives and concerns to solve problems collaboratively.

Apart from these two categories of skills, Renfors (2024) refers also to *circular design and production, circular business models, circular economy communication* and *circular economy collaboration* as important learning outcomes, as well as *green marketing* and *market knowledge, circular impact assessment* and *user engagement,* and *circular materials and manufacturing*. In addition to the transversal skills mentioned above, *strategic skills, value thinking* and *reflective skills* are also mentioned in the study as important learning outcomes (Renfors, 2024).

3.4 Teaching and learning methods

A range of pedagogical approaches and teaching or training methodologies are identified in relevant studies, indicating that HE approaches are mainly based on cognitive approaches and traditional lecture/campus-based formats with some experiential approaches integrated (Paris et al. 2023). Cognitive approaches are knowledge-based, in contrast with practice-based approaches, focusing more on learning-by-doing methods. A constructivist approach in HE pedagogy has been more effective to integrate sustainability-related issues and learning outcomes (skills) into teaching and learning methodologies, such as: project-oriented learning, simulation games, problem-based learning, service learning, case studies or any method that enhances participation and student engagement (Žalėnienė & Pereira, 2021). Furthermore, educational practices in the field of bioeconomy can have a higher impact on learning when involving other stakeholders, such as collaboration with community or industry; field trips, workshops organised by researchers and industry professionals or living labs are forms of situated learning, providing a learning experience with high level of student engagement (Vergani, 2024).

3.4.1 Active and experiential learning

Active learning in HE includes any form of activity that engages students and motivates them to participate in the learning process by thinking, discussing, investigating or creating. In contrast with traditional teaching and learning (transmission of information and memorising), students can participate in discussions, small group or individual in-class assignments, apply knowledge in real-life

situations or situated learning environments, practice skills, solve problems, make decisions and more. Teamwork and collaboration are common, as well as reflective activities. Active learning can change traditional lectures into interactive lectures by incorporating these participatory techniques.

Experiential learning allows students to '**learn by doing**' and reflect on the experience in each step of the learning process, transforming experience into knowledge i.e. Kolb's cycle (Kolb & Kolb, 2017). Usually, experiential learning in HE are considered activities, such as laboratory experiments, internships, practicums, fieldwork or research. Active and experiential learning intend to deepen understanding and higher-order thinking skills. In Renfors (2024) study (as mentioned in 3.3), most of the courses adopt an active or experiential learning approach. In these courses, the course structure involves both theory and practical research using real-life examples. Real-life examples engage students actively in problematic situations and learning through building on prior knowledge and experience to make decisions on the actions.

Example

- *Context*: Carleton University (Ottawa, Ontario, Canada), senior-level marketing students
- *Aim*: Develop the "RESCUER" framework which combines **active** and **passive** learning elements to teach food sustainability and promote responsible consumer behaviour.
- *Bioeconomy dimension*: Food Sustainability, Sustainable consumption, Marketing Education, Food loss and waste within the food supply system.
- *Method*: The framework draws on **experiential learning** (based on Kolb's theory, see above). The assignment demonstrates how active learning techniques layered on top of passive methods can be effective for students.
  (a) Resources (begins with passive learning components, such as readings and lectures)
  (b) Engaging in activities with mindfulness (active learning: planning, shopping, preparing food), and
  (c) Social influence, can result in the generation of:
  (d) Cognizance and
  (e) Underlying problem salience, both of which can be facilitated by a set of
  (f) Expediting factors. Based on these various factors, a student is likely to experience an increased willingness to engage in
  (g) Responsible behaviors.
- *Reference*: Banu, N.T. et al (2024). RESCUER: Combining Passive and Active Learning Techniques to Teach Food Sustainability. *Journal of Marketing Education, 46*(2), 123-139. https://journals.sagepub.com/doi/pdf/10.1177/02734753241226669

3.4.2 Problem-based learning

Problem-based learning (PBL) allows students to work in groups to solve an open-ended problem. The problem is the epicenter of motivation and learning. The inquiry to solve the problem is not guided by the instructor, it is open and less structured. PBL can result in multiple solutions to the problem. The problem is presented first, rather than the theory or relevant discipline content and material. PBL assignments can be short, or they can last a whole semester. Ideally, the problems are real-life challenges or situations resembling a real-world problem that students may encounter in their future. Students may take different roles or divide up the work within the group. PBL is often confused with case-based or project-based learning. They are similar student-centred teaching methods with the characteristic of students working in small groups. Case-based learning, though,

requires more structured and guided inquiry by the instructor and the case studies are usually in the form of stories or scenarios presenting different characters or problems. In Renfors (2024) study, it is mentioned that case-based learning was seen as a tool to address the circular economy challenges from a systemic perspective and increase students' critical thinking skills, while project-based learning was considered as a tool for empowering students to act on knowledge.

Example

- *Context*: Faculty of Geosciences, Utrecht University (The Netherlands), undergraduate students of honors programme.
- *Aim*: The course was designed to introduce undergraduates to the Circular Economy concept.
- *Bioeconomy dimension*: Circular economy, Sustainable development, macro-meso-micro level of CE, interactivity, non-dogmatism, and reciprocity (core CE principles), 9R framework on CE.
- *Method*: The course adopted the pedagogical principles of **constructive alignment** (outcome-based approach) and **problem-based learning**. The course started with an introductory lecture, then three lectures with interactive elements (applied theory), excursions were carried out (practice) and a critical discussion took place at the wrap-up lecture of the course. Seven novel circular economy exercises were developed: a drill game, buzzword bingo, a teardown lab, an eco-industrial park simulation, policy instruments, circular party and circular futures.
- *Reference*: Kirchherr, J. & Piscicelli, L. (2019). Towards an Education for the Circular Economy (ECE): Five Teaching Principles and a Case Study. *Resources, Conservation and Recycling, 150.* https://doi.org/10.1016/j.resconrec.2019.104406

3.4.3 Blended learning

Blended learning, also known as hybrid learning, is an instructional approach that combines the use of online learning experience and face-to-face learning experience in a seamless and complementary flow of learning. Also, it can combine asynchronous and synchronous elements. In HE, the use of blended learning as a method of instruction is experiencing rapid growth, especially after the COVID-19 outbreak. A common blended teaching method that reinforces active learning is the *flipped classroom*. Lecturers and students use the class time to engage in hands-on activities applying knowledge rather than delivering lectures alone. Lecture content or study materials are considered pre-class readings and are accessible online (or offline). Also, it is usual for students to complete short quizzes for self-assessment. Web applications and virtual learning environments facilitate online activities.

Example

- *Context*: Tecnocampus, affiliated to Pompeu Fabra University in Barcelona (Spain).
- *Aim*: Foster sustainable development and teach sustainability principles. Engage students in understanding the importance of sustainable development and introducing them to new perspectives to make changes.
- *Bioeconomy dimension*: Sustainable Development curricula, sustainability competencies

- *Method*: The process of design and development of the **flipped classroom**:
  (1) Creation and preparation of content (online/offline resources to study). Individual and collaborative activities were developed through Moodle, Office, and Drive.
  (2) Development of the **online learning environmen**t through the Moodle platform available 24h/7. Students carry out assimilation work in groups, answer questions (prepared by the teacher), enrich contents with new materials. Forums were organised to discuss ideas and clarify doubts.
  (3) During the **face-to-face class**, students presented their group work, analysed their answers, and reflected on them. Discussion and debate were encouraged in groups, knowledge was deepened, especially through the examples the students themselves brought, and the problems they encountered. Reorganise groups for final reflections, encouraging collaborative learning. Final conclusions of the most relevant topics of the contents.
  (4) Students developed a final assignment at the online platform, combining knowledge from the study materials as well as the product of discussions and reflection.
- *Reference*: Buil-Fabregá, M., Martínez Casanovas, M., Ruiz-Munzón, N. and Leal Filho, W. (2019). Flipped Classroom as an Active Learning Methodology in Sustainable Development Curricula. *Sustainability, 11*(17), 4577; https://doi.org/10.3390/su11174577

3.4.4 Service learning

Service-learning pedagogy combines community or public service with structured opportunities for learning. What distinguishes service learning from other forms of experiential learning is the moral and civic dimension of learning. Service learning prepares students for practical community-based problem solving in authentic environments. It is linked to a civic purpose reinforcing the skills of critical thinking, public discourse, collective activity, community building. It provides the benefit for the students to connect to a community and identify their civic role in it, while it requires connecting professional expertise to public discourse for wider civic engagement. Educational strategies that involve the participation of the community or industry have a higher impact on learning. Service-learning programmes –in which students accomplish tasks that benefit the community– have the right characteristics both to influence student behaviour towards bioeconomy-related issues and to promote the relationship between them and the community (Vergani, 2024). In the context of sustainability and circular economy, citizen initiatives or community projects are developed around the reuse or recycling of materials and products that can form the content of service-learning programmes.

Example

- *Context*: School of Food Science & Environmental Health (Technological University Dublin, Ireland), EU Erasmus+ project 'NEMOS A new educational model for acquisition of sustainability competences through service-learning' (2022) https://www.nemosproject.com/
- *Aim*: Develop food sustainability competences and enable implementation through service-learning, due to its dual aim of societal commitment (service) and training of professional skills (learning).
- *Bioeconomy dimension*: Food science, food sustainability competencies, food production and consumption, resilient food systems.
- *Method*: The school co-created, with its students, a professional development programme

to build capacity for integrating sustainability in its education portfolio. Informed by industry, publications and policy frameworks, the programme assimilated inputs from stakeholders across the food system, including enterprise and the public sector, food professionals and sustainability experts.
A guide for the reflective assessment of the service-learning experience was developed: a) the learner reflects on the situation, b) the learner is encouraged to construct personal knowledge about the situation, c) the learner considers ways of improving the situation and reflects on the consequences of his/her actions.
Implemented with two non-profit organisations (Dublin Zoo and the Food Safety Authority of Ireland).

- *Reference*: Dunne, J.L., Barry-Ryan, C. and MacMahon, C.H. (2024). Embedding sustainability in food degrees: A Case-study of service-learning as a signature pedagogy for developing food sustainability competencies. *Irish Journal of Academic Practice, 11*(2). https://doi.org/10.21427/vj65-ad03

3.4.5 Simulation-based learning

Generally, simulation-based learning involves creating real-world scenarios and challenges in learning activities in order to enable students to apply their knowledge and skills in contexts that mirror their future professional practice. It offers a wide range of opportunities to practice complex skills, such as problem-solving, critical thinking, communication and collaboration. Simulations are often used in HE settings, especially in STEM education. Simulation-based teaching and learning approaches (including serious games, business games, game-playing events, tournaments, role-playing, board games, living labs, design studios and laboratory exercises) were deemed essential, and they were integrated into almost half of the bioeconomy-related courses studied by Renfors (2024). Simulations increase students' awareness of the logic of the circular economy and understanding of its basic principles. They stimulate students' strategic and critical thinking, problem-solving, decision-making and long-term planning competencies. The course descriptions (in Renfors study) also highlighted those simulations that support students in better understanding of systemic complexity including the macro level issues. For example, games are typically played in groups, which improves students' understanding of different perspectives and their ability to think holistically considering the connections between different actors and sectors. Furthermore, it was stated that simulations increase students' engagement and encourage experimentation because they provide students with a chance to learn by designing and solving various scenarios and by putting themselves in a management position in a real company.

Example

- *Context*: The course main contents (with adaptations) are taught in different on campus and online masters in University College Dublin (Ireland), Universitat Oberta de Catalunya, Universitat Autonoma de Barcelona (Spain), Universidade Aberta (Portugal).
- *Aim*: Promote CE values among students and, specifically, how to deploy sustainable yet efficient transportation systems by means of simheuristic approaches.
- *Bioeconomy dimension*: Eco-efficiency, eco-effectiveness, sustainable energy, energy

optimization, sustainable business model.

- *Method*: **Simulations** and **serious games** were used as learning tools (computational tools, i.e. non-profit Games4Sustainability platform https://games4sustainability.org). Specifically, a combination of simulations with machine learning and artificial intelligence algorithms to solve optimization problems under uncertainty scenarios.
  Students have to work in small teams to: (i) analyse a complex decision-making challenge, typically one related to the optimization of different sustainability dimensions (monetary, environmental, and social) in last-mile delivery in urban/metropolitan areas; (ii) develop their own methodology, based on previously developed building blocks, and discuss it with their instructor; (iii) once their methodology has been approved, students have to implement it in code and test it against a set of benchmarks; and (iv) a statistical analysis of the numerical results has to be completed, and insights regarding possible trade-offs between alternative strategies—in terms of the different sustainability criteria being considered—have to be drawn from this analysis.
- *Reference*: de la Torre, R., Onggo, S.B., Corlu, C.G., Nogal, M. & Juan, A.A. (2021). The Role of Simulation and Serious Games in Teaching Concepts on Circular Economy and Sustainable Energy. *Energies, 14*(4), 1138; https://doi.org/10.3390/en14041138

4. Key takeaways

A holistic approach of various pedagogical educational methods will be adopted to provide a comprehensive educational experience to students involved in the "Agri-food Waste Management for Sustainable bio-economy" project, AGRIMA. The educational material will, particularly, focus on:

- **Student-centred learning**: Adopting a student-centred pedagogical approach is encouraged to empower students taking an active role and responsibility for their learning.
- **Learning outcomes**: Setting clear and sustainability-related learning outcomes in course design. Teaching and assessment methods should be appropriate to attain the intended learning outcomes.
- **Active learning and hands-on activities**: Adopting techniques that enhance students' level of engagement, interaction and collaboration, reflection and critical thinking skills is important.
- **Teaching methods**: Including diverse elements of teaching methods in course design allow students to achieve learning outcomes based on their learning needs and styles, as well as their prior knowledge and experience.
- **Real-world context**: Application of knowledge in real-life problems that need to be solved, or real-life cases need to be studied, is very important in the field of sustainability and bioeconomy. It helps students relate their studies to society and industry, preparing them for their future professional and social empowerment.
- **Interdisciplinarity**: Integrating elements across various disciplines that connect environmental, economic and social aspects of bioeconomy is crucial to encourage holistic thinking to the complexity of real-world issues towards sustainability.

5. Conclusion

The present document includes a pedagogical framework for HE teaching and learning practices which is underpinned by sustainable development and student-centred learning, affecting curriculum and course design. **Outcome-based approach, reflection, flexibility, inclusivity, interdisciplinarity** are the main concepts for advancing teaching and learning practices in HE. The methodology showcases how sustainability-related learning outcomes are better achieved through teaching and learning methodologies that focus on student's experience, initiative and active learning. These elements are included in the teaching and learning methods presented, such as: active and experiential learning, problem-based, blended learning, service learning and simulations.

The examples, accompanying each method, include applications of these. Most of the courses presented in the examples combine elements of passive and active learning. Lecturers prioritised the intended learning outcomes and designed their courses using innovative teaching and learning methods that aim to deepen learning and have the potential to transform students' attitudes and behaviour towards sustainability. The pedagogical framework suggests various innovative elements that can be included in the design of the joint lectures of the AGRIMA project (WP2A3) to achieve student engagement. Furthermore, the approach of service learning is connected to community engagement, thus any course or activity designed requires the collaboration between faculty and community partners. It is an appropriate method to link students' learning with citizen science projects (WP4 of AGRIMA) in the local community. Therefore, community-driven actions and objectives should be reflected within the learning outcomes set in the forthcoming lectures and experimentations.

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