METHODOLOGICAL ASPECTS OF TEACHING CIRCULAR ECONOMY

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Summary: Circular economy is a new area of academic knowledge, which requires the development of both new learning content and elaboration of the methodology used in teaching the subject matter. This paper supports the view that the educational process comprises several key components that work together to facilitate effective teaching and learning. These components may vary depending on the broader context and the specific objectives and approaches used. Thus, when planning the circular economy teaching process, it is essential to formulate what we want to achieve (learning objectives) in the specific context of the subject taught. On this basis, the paper aims to present in a discussion plan the main components of the methodology for academic teaching on the problems of the circular economy.

Key words: circle economy, academic teaching, learning content.

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Introduction

Circular economy is a concept for managing business processes from the extraction of raw materials, through production, to placement and their possible secondary (circular) use and recycling so that humanity can meet the needs of the present without compromising the ability of future generations to meet their own needs (United Nations, 1987). However, it is not only engineering technologies that circular economy introduces new standards in, but also in teaching in this area of academic knowledge. This calls for the

development of both new learning content and elaboration of the methodology used in teaching the subject matter.

The educational process is seen in this study as made up of several key components that work together to facilitate effective teaching and learning. These components may vary depending on the educational context and the specific objectives and approaches used. Thus, when planning the circular economy teaching process, it is essential to formulate what we want to achieve (learning objectives) in the specific context of the subject taught. On this basis, the paper aims to present in a discussion plan the main components of the methodology for academic teaching on the problems of the circular economy.

1. Broader context, learning goals and objectives.

An overarching task when teaching circular economy is to clearly communicate to the learners its principles and practices within the broader environmental, economic, and social contexts. On the environmental side, the context is shaped by the pressing global challenges such as climate change, resource depletion and pollution. The increase of global wealth (Woetzel, et al., 2021) and world population in the last two decades has led to a growth in consumption, which has respectively put to the front the question what is to be done to use our planet's resources in the most reasonable and responsible way. In this context, circular economy is a viable and promising alternative to the currently prevailing 'take-make-use-dispose' linear model. Then, it is essential that the learners understand the economic and business aspects of circular economy and most importantly, critically assess them and actively seek opportunities to create and use circular business models, such as resource efficiency, cost savings, job creation, and innovation. Last, but in no case least, as the concept of circular economy is inherently linked with the concept of sustainable development, the learners must grasp not only the key concepts such as economic growth, social-well-being and environmental sustainability, but also the interactions and the interdependencies between them in real life. As the transition to circular economy is a systemic change (Marouli, 2016), it presupposes fundamental changes that affect the whole system – in the economic, the political and in the socio-cultural aspects. It is in the last aspect that the transition will be the most difficult to implement, as it is related to the development of new values and behaviours through efficient education.

At the same time, most professionals have either little or quite superficial knowledge on circular economy, because the matter was not part of their curricula at the time, they completed their studies. In this sense, education is of paramount importance to fill this knowledge gap. As for the

younger people, who will enter the business world in the next years, the integration of circular economy into the curricula will help raising sustainability awareness, transforming the attitude towards economy, society, and nature, and empowering them with the knowledge on what is to be done.

It is in this broader context and accounting for the specificity of the educational level, institution, program, etc., the learning goals in teaching circular economy to be set. They can be sought in two directions: (1) understanding the basis of the circular model and (2) grasping the idea of a new business model. In the first direction, it is essential to develop students' understanding of the principles and practices of circular economy as paradigm that suggests a redesign of the current linear economic system and their ability to apply them in real-world contexts. In the second direction, the students need to grasp the idea that the economic activity in circular economy is to be based on creation, capturing and delivering value in a way that increases resource efficiency by extending useful life of products and parts (e.g., through long-life design, repair and remanufacturing) and closing material loops (EK, 2015) and strive to develop innovative solutions, business models, and technologies that promote circularity and resource efficiency.

While learning goals formulate the general aims to be achieved in a course, they are to be mapped in learning objectives. The learning objectives for teaching circular economy may vary depending on the level of education and the specific course or program, but some common are:

- **Understanding the Concept.** The primary learning objective is to ensure that students grasp the fundamental concept of the circular economy. This involves explaining the principles, benefits, and the importance of the transition from a linear, wasteful economy to a regenerative, sustainable one (Makio & Virta, 2019).
- **Analysing Systems Thinking.** Circular economy education should encourage students to develop systems thinking mindset. They should learn to identify and analyse on the one hand the complex relationships between the different actors, resources and processes in the context of the circular economy as well as to analyse and evaluate the interactions and interdependencies between various components of the economy itself including production, consumption, waste management, and supply chains (Iacovidou, Hahladakis, & Purnell, 2021)
- **Applying Lifecycle Thinking.** Students should learn to apply lifecycle thinking and conduct lifecycle assessments. They should be able to evaluate the environmental and social impacts of products and processes throughout their entire lifecycle, from raw material extraction and production to consumption and end-of-life disposal, and identify opportunities for improving resource efficiency, reducing waste, and increasing recycling and

reuse (Minguez, Lizundia, Iturrondobeitia, Akizu-Gardoki, & Saez de Camara, 2021)

- **Encouraging Innovation and Entrepreneurship.** Teaching circular economy involves fostering creativity, innovation, and entrepreneurship. Students should be encouraged to develop innovative solutions, business models, and technologies that promote circularity and resource efficiency (Ruiz-Pastor, Chulvi, Royo, & Sampaio, 2023). This involves developing skills in biomimicry, eco-design, and product-service systems (Andrews, 2015). They should develop an entrepreneurial mindset and explore how circular economy principles can drive new business models and opportunities.
- **Assessing Environmental Impacts.** Students should be able to evaluate the environmental impacts of different economic activities and identify strategies for reducing resource consumption, waste generation and pollution through circular practices (Tian, et al., 2020). This includes understanding methods such as recycling, reusing, remanufacturing, repairing, and redesigning products to extend their lifespan and reduce waste.
- **Critical Thinking and Problem-Solving.** Students should enhance their critical thinking skills to identify and analyse circular economy challenges and develop innovative solutions. They should be able to assess trade-offs, evaluate the feasibility and scalability of circular initiatives, and consider the broader impacts and implications of proposed strategies (Marouli, 2016).
- **Promoting collaboration, communication, and stakeholder engagement.** Circular economy education emphasizes the importance of collaboration and stakeholder engagement. Students should develop effective collaborative and communicative skills to work together in multidisciplinary teams, understanding the importance of (Salvioni & Almici, 2020) and engaging with various stakeholders, including businesses, policymakers, and community organizations, to drive systematic change towards circular economy.
- **Understanding Policy and Governance.** Circular economy education should introduce students to relevant policies, regulations and governance mechanisms that can facilitate the transition to a circular economy. This includes exploring the role of government, international organizations, and industry in implementing circular economy strategies. Students should be able to analyse existing policies, identify barriers and opportunities and explore potential policies and incentives that can support circular practices.
- **Cultivating Ethical Considerations.** Students should consider the ethical dimensions of the circular economy, including social equity, fair distribution of resources and the well-being of marginalized communities.

They should explore how circular economy practices can contribute to a more just and inclusive society.

2. Teaching approaches, principles, and methods

When teaching circular economy, various methods and approaches can be employed to enhance learning experience. Literature on teaching CE is grounded on a variety of theories of learning and teaching. Most authors adopt outcome-based teaching and learning approaches such as *constructive alignment* or *problem-based learning* (Kirchherr, 2019). Constructive alignment (CA) is a design for teaching in which what it is intended students should learn, and how they should express their learning, is clearly stated before teaching takes place. Teaching is then designed to engage students in learning activities that optimise their chances of achieving the desired outcomes. Problem-based learning (PBL) is a student-centered approach in which students learn about a subject by working in groups to solve an open-ended problem. This problem is what drives the motivation and the learning.

The teaching in circular economy is also to follow the principles of *interactivity, non-dogmatism,* and *reciprocity* (Kirchherr, 2019). The principle of interactivity suggests that students are encouraged to show active involvement in the learning process. Interactive teaching methods involve two-way communication (teacher-to-student, student-to-student, student-to-teacher). The most effective ways to engage students through interactive teaching methods are brainstorming, buzz sessions, question, and answer sessions and other. The principle of non-dogmatism postulates that the courses should be designed with the purpose of developing critical thinking, avoiding overcommitment to optimistic win-win scenarios or scepticism. The principle of reciprocity refers to continuously incorporating students' feedback into a course. It reflects the idea that the students taking a course know best how to improve it.

In terms of the teaching methods and the learning context, an education that supports the transition to a circular economy should: provide a forum for the required knowledge and skills via a classroom that fosters critical thinking, problem-solving and entrepreneurship, be relevant to the learners' own lives, promote communication and collaboration and cultivate ethical considerations. In the context of teaching circular economy, lecturers can use the typical teaching methods as follows:

- **Lectures:** Traditional lectures can be used to provide foundational knowledge about the circular economy, its principles, and relevant concepts.

This method is particularly useful for introducing key theoretical frameworks, case studies, and historical context.

- **Case Studies:** Analysing real-world case studies allows students to understand the practical implementation of circular economy principles in different industries and contexts. The method can be used to illustrate successful circular initiatives, challenges faced, and lessons learned, fostering critical thinking and problem-solving skills.
- **Group Discussions:** Facilitating group discussions encourages students to actively engage with the subject matter. Through dialogue and exchange of ideas, students can deepen their understanding of circular economy concepts, explore different perspectives, and collectively generate innovative solutions to circular challenges.
- **Workshops and Interactive Activities:** Hands-on workshops and interactive activities can provide practical experiences related to circular economy practices. These activities may include designing circular product prototypes, conducting material flow analyses, exploring business model canvases, or participating in waste upcycling projects.
- **Field Trips and Industry Visits:** Visiting businesses, waste management facilities, recycling centres, or other relevant sites can offer students firsthand exposure to circular economy practices. They can observe circular initiatives in action, interact with professionals in the field, and gain insights into the challenges and opportunities associated with circularity.
- **Guest Lectures and Expert Panels:** Inviting guest speakers, industry experts, or practitioners to share their experiences and insights can provide diverse perspectives and practical knowledge. These sessions can inspire students, provide real-world context, and facilitate networking opportunities.
- **Simulations and Gamification:** Simulations or gamified activities can immerse students in a virtual environment where they make decisions related to resource management, circular design, or policy development. Such simulations can enhance problem-solving skills and allow students to explore the consequences of different strategies.
- **Project-Based Learning:** Assigning projects or group assignments that require students to address specific circular economy challenges fosters practical application of knowledge. Students can engage in research, problem analysis, and develop innovative solutions, encouraging creativity and teamwork.
- **Online Resources and Multimedia:** Utilizing online platforms, digital resources, videos, and interactive materials can supplement classroom learning. These resources can provide additional information, case studies,

interactive simulations, or video documentaries that enhance understanding and engagement.

- **Assessment and Feedback:** Assessments such as quizzes, exams, presentations, or research papers can evaluate students' understanding of circular economy concepts. Providing constructive feedback helps students improve their understanding and encourages critical thinking.

It is important to employ a combination of these methods to cater to different learning styles, encourage active participation, and facilitate practical application of circular economy principles.

3. Learning content

As noted above, when teaching circular economy, most authors adopt outcome-based teaching approaches, and in particular the principle of constructive alignment (Biggs, 1996), which approach we also highly recommend. It provides for clear and explicit articulation of expected learning outcomes (what students are expected to know and to be able to do upon completion of the course) and ensures that the teaching/learning activities and resources as well as assessment are systematically linked with the learning objectives.

The lecture goals when teaching circular economy can be classified as conceptual and generic. Conceptual lecture goals are more related with giving knowledge on circular economy, while generic goals are more related with developing skills.

Some lecture goals when teaching circular economy are:

- to introduce the concept of circular economy (providing a definition and explanation of the CE concept, its key principles, and key characteristics).
- to explore the environmental impacts of CE (negative consequences of the linear model, pollution, waste generation, etc.).
- to present the benefits of CE (resource conservation, waste reduction, energy efficiency, creation of new business opportunities, etc.).
- to explain various CE strategies (product design for recyclability, resource recovery and regeneration, sharing and collaborative consumption, optimization of supply chains).
- to discuss case studies and real-life examples of successful companies from various industries and regions, the approaches they used, the challenges they faced and the outcomes they have achieved.
- to analyse the economic implications and potential advantages of CE such as job creation, saving costs through resource efficiency, the shift to service-based models, etc.

- to address policy and regulatory frameworks.
- to encourage systems thinking through emphasizing the inter-connectedness of economic, social, and environmental systems in the context of CE.
- to consider the lifecycle impacts of products and processes.
- to foster innovation and entrepreneurship through inspiring students to think creatively and develop innovative solutions to promote circularity.
- to engage in discussions on challenges, trade-offs and barriers to CE and encourage students to critically evaluate the feasibility and scalability of CE solutions.
- to encourage student projects and research on specific aspects of CE
- to promote awareness and action, highlighting the role of individuals, communities, and businesses in the transition to CE.

When teaching about circular economy, it is important to provide a comprehensive learning experience that covers key concepts, principles, and practical applications. Table 1 gives an outline of potential learning content to include when teaching about circular economy:

Table 1.

Potential learning content when teaching circular economy

Topic	**Sub-topics**
1. Introduction to CE.	• Definition and basic principles of CE • Contrasting linear economy and circular economy models • Environmental, economic, and social benefits of CE
2. Circular Economy strategies and approaches.	• Design for CE: cradle-to-cradle, eco-design, biomimicry • Product life extension: repair, refurbishment, and remanufacturing • Resource recovery and recycling: waste reduction and close-loop systems • Sharing economy and collaborative consumption • Digitalisation and circular economy
3. Circular business models	• Overview of the different business models (product-as-service, leasing, sharing platforms) • Case studies and examples of successful circular businesses • Benefits, challenges, and risks associated with the different business models. • Strategies for transitions from linear to circular business models

4. Circular supply chains and logistics	• Sustainable sourcing and procurement practices • Reverse logistics and product recovery • Waste management and recycling infrastructure • Collaborative networks and partnerships in circular supply chains
5. Policy and regulatory frameworks	• Overview of national and international policies promoting circular economy • Extended producer responsibility (EPR) and product stewardship • Legal and regulatory considerations for circular business models • Incentives and subsidies for circular practices
6. Circular economy in different sectors	• Circular economy applications in industries such as manufacturing, energy, fashion, food, and construction • Industry-specific challenges and opportunities for circularity • Case studies and best practices from various sectors
7. Circular economy and innovation	• Role of innovation in driving circular economy solutions • Technological advancements supporting circularity (e.g., IoT, blockchain) • Start-ups and entrepreneurship in the circular economy • Circular economy as a source of competitive advantage and market differentiation
8. Assessing the environmental and social effect	• Life cycle assessment (LCA) and environmental impact assessment (EIA) • Social and ethical considerations in circular economy practices • Metrics and indicators for measuring circularity and sustainability
9. Circular economy and consumer behaviour	• Educating consumers about circularity and sustainable consumption • Influencing consumer behaviour towards circular choices • Role of marketing and communication in promoting circular products and services
10. Future trends and emerging topics	• Circular economy in the context of the Fourth Industrial Revolution • Circular economy and the transition to a low-carbon economy • Circular economy and the role of cities and urban planning • Circular economy and global initiatives (e.g., Sustainable Development Goals)

4. Evaluation aspects

Evaluation is a key component of teaching and learning process which helps teachers and learners to improve it (Ifeoma, 2022). When evaluating the efficiency of teaching circular economy, various aspects can be considered to assess student learning and the overall impact of the educational program. It is essential to align the evaluation aspects with the specific learning objectives and desired outcomes of the circular economy education program. This alignment ensures that the assessment provides evidence of the intended learning outcomes and guides the assessment process (Table 2).

Table 2.

Alignment between learning objectives and evaluation aspects

Learning objective	**Evaluation aspects**
Understanding the concept	• evaluation of students' comprehension of circular economy concepts, principles, and key elements. • assessment of their understanding of the interconnections between economic, environmental, and social factors within a circular economy framework.
Analysing systems thinking	• evaluation of students' ability to identify and map system components, analyse interconnections, and feedback loops, and propose interventions or solutions. • assessment of the ability to do in-depth analysis, clarity of system diagrams, and ability to identify leverage points within the system.
Applying life cycle thinking	• Evaluation of students' ability to identify relevant life-cycle stages, analyse impacts, propose sustainable alternatives, and critically reflect on the implications of their findings
Encouraging innovation and entrepreneurship	• Evaluation of students' ability to apply circular economy principles creatively, think critically, develop viable business plans, and demonstrate an entrepreneurial mindset. • Evaluation of students' ability to make strategic decisions, identify circular opportunities, and manage the complexities of running a circular economy business within a simulated environment
Assessing environmental impacts	• Evaluation of students' ability to identify and assess potential environmental impacts, propose mitigation measures, and analyse the overall environmental

	sustainability of the project. • Assessment of students' understanding of environmental impact assessment methodologies, data analysis, and their ability to communicate the findings effectively
Critical thinking and problem-solving	• assessment of the students' ability to apply critical thinking skills to analyse circular economy challenges, identify opportunities, and propose innovative solutions. • evaluation of students' capacity to consider multiple perspectives, evaluate trade-offs, and think systemically.
Promoting collaboration, communication, and stakeholder engagement	• assessment of students' capacity to effectively communicate their ideas, engage in collaborative activities, and work in multidisciplinary teams. • evaluation of students' ability to articulate and present their thoughts on circular economy topics to both expert and non-expert audiences.
Understanding policy and governance	• evaluation of students' understanding of policy concepts, their ability to critically assess policy effectiveness, and their capacity to identify strengths, weaknesses, and potential areas for improvement in policy and governance approaches. • Evaluation of students' understanding of different viewpoints, their ability to present coherent arguments, and their capacity to engage in critical discussions on policy implications and governance considerations
Cultivating ethical considerations	• evaluation of the students' understanding and awareness of ethical dimensions within the circular economy. • assessment of students' ability to consider social equity, inclusivity, and environmental justice in the context of circular practices.

The evaluation of students' knowledge and understanding of circular economy, their ability to apply the acquired theoretic knowledge in practice and their mindset and values towards sustainability and circularity, can be done using a combination of various **assessment tools** such as exams, quizzes, presentations, project evaluations, case studies, portfolios, reflective journals, etc. (Table 3). It is essential to note that the link between assessment instruments and corresponding assessment criteria is crucial for evaluating learning outcomes effciently. Assessment tools refer to the specific tools or

approaches used to gather evidence of student learning, while assessment criteria are the specific standards or expectations against which student performance is evaluated. The connection between these two elements ensures that assessment aligns with the intended learning outcomes and provides meaningful information about student achievement.

Table 3.
Assessment methods and corresponding assessment criteria for evaluation of learning outcomes

Assessment method	**Assessment criteria**
Written assignments (Essays, reports, research papers)	• students' ability to articulate key ideas, analyse case studies, and propose innovative solutions within a circular economy framework
Presentations on topics related to CE	• students' ability to communicate effectively, synthesize information, and present their findings and ideas in a clear and engaging manner. • Students' understanding of circular economy principles and their ability to apply them to real-world contexts.
Project or case studies (Individual or group assignments)	• Students' ability to apply circular economy principles, analyse potential impacts, and propose feasible and sustainable strategies. • students' critical thinking, creativity, and problem-solving skills.
Exams or quizzes	• students' knowledge and comprehension of circular economy concepts, theories, and frameworks. • Students' understanding of key principles, their ability to apply them to different scenarios, and their grasp of the economic, environmental, and social dimensions of circularity.
Practical implementation (Workshops, hands-on activities, etc.)	• students' ability to apply circular economy principles in practical settings. • students' technical skills
Peer-review and feedback	• the quality of feedback provided by students to their peers. • students' ability to effectively collaborate and communicate with their peers during the peer review process. • ability to recognize and analyse circularity in their peers' work, and their capacity to provide suggestions for improving circularity
Reflection and self-	• the depth and quality of students' reflections on

assessment	their learning journey in the course • ability to articulate insights, identify areas of strength and improvement, and demonstrate a thoughtful understanding of the course material ability to self-assess their knowledge, skills, and abilities related to circular economy concepts, strategies, and implementation
Portfolios	• depth and breadth of the portfolio, • students' ability to reflect on their learning and growth
Surveys, questionaries to assess students' attitudes and values	• students' attitudes and values towards sustainability, circularity, and responsible consumption and production

It is also important to note, that assessment methods should allow for differentiation and provide opportunities for students to demonstrate various levels of achievement. The assessment criteria should include diverse levels or benchmarks of performance that align with the learning outcomes and provide a clear progression of skills or knowledge. This link ensures that the assessment methods provide sufficient depth and breadth to capture diverse levels of student achievement. It is also important the methods and criteria to be designed and implemented in a way that ensures reliability and consistency in the evaluation of student performance. They should provide consistent and comparable results when applied to different students or in different contexts.

Conclusion

To achieve the optimal efficiency when teaching a subject, it is best to formulate the learning goals and objectives within the broader context of the matter taught. Teaching circular economy makes no exclusion, the overarching task being the clear communication of its principles and practices within the broader contexts of increasing global wealth and world population that call for taking steps to use our planet's resources in a way that will not only ensure the economic welfare of our generation but will also give a chance to the future generations to meet their own needs. Placed within this broader context, the learning goals when teaching circular economy can be sought in two directions: (1) understanding the basis of the circular model and (2) grasping the idea of a new business model. In concert with these two main learning goals, upon the completion of the educational process the students are expected to know and understand the principles, benefits and the importance of the transition to circular economy and be able to apply systems and

lifecycle thinking, critically assess and develop innovative solutions, business models and technology that promote circularity and resource efficiency in the context of policy barriers and opportunities and in the spirit of social equity, fair distribution of resources and the well-being of marginalized communities. There are various approaches to achieve these learning objectives, the two recommended by most authors being constructive alignment and problem-based learning.

When teaching circular economy instructors can use typical teaching methods such as lectures, case studies, group discussions, workshops, field trips and industries visits, simulations and other. What is specific is that these methods are to be selected and their use balanced in a way that will follow the principles of interactivity, non-dogmatism and reciprocity and cater to the different learning styles, encourage active participation, and facilitate practical application of circular economy principles. The learning content covered by a course in circular economy should provide a comprehensive learning experience that covers key concepts, principles, and practical applications. Relevant topics in this context are knowledge of the basic principles and benefits of circular economy in comparison with linear economy, strategies and approaches employed in CE and their real-life implementation in successful business models, knowledge of circular supply chains and logistics and of policy and regulatory frameworks, of the opportunities technological advancement offers and of the future trends in CE in the context of the Fourth Industrial revolution, etc. It is essential that the learning content not only gives knowledge on circular economy but is also aimed at developing the necessary skills.

The efficiency of the teaching process in circular economy can be evaluated with the help of various assessment methods, including exams, quizzes, presentations, project evaluations, case studies, portfolios, reflective journals, etc. However, we should have in mind that the evaluation aspects are to be aligned the with the specific learning objectives and desired outcomes of the education program. The assessment methods are also to be linked to the corresponding assessment criteria, ensure reliability and consistency in the evaluation of student performance, and provide consistent and comparable results when applied to different students or in different contexts.

The prior research on the methodological aspects of teaching circular economy does not exhaust the problems instructors face when they need to adapt the learning content to these priority areas of economic knowledge. It is important for us to summarize that, in addition to a classical conservative framework for teaching the subject matter, we should also define possible flexible components in the curricula, where the latest useful examples from the real economy can be integrated into the learning content. Finally, the assess-

ment process should maintain its open and flexible nature to achieve the goals of academic training in circular economy, where maintaining the balance between teaching methods, conceptual base, and specificity of technological innovations in the recycling of paper, plastics, metals, and glass requires ongoing attention and upgrading.

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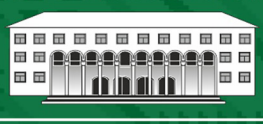

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