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Circular economy escape room

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Circular economy escape room: a teaching innovation strategy to address the ecological crisis

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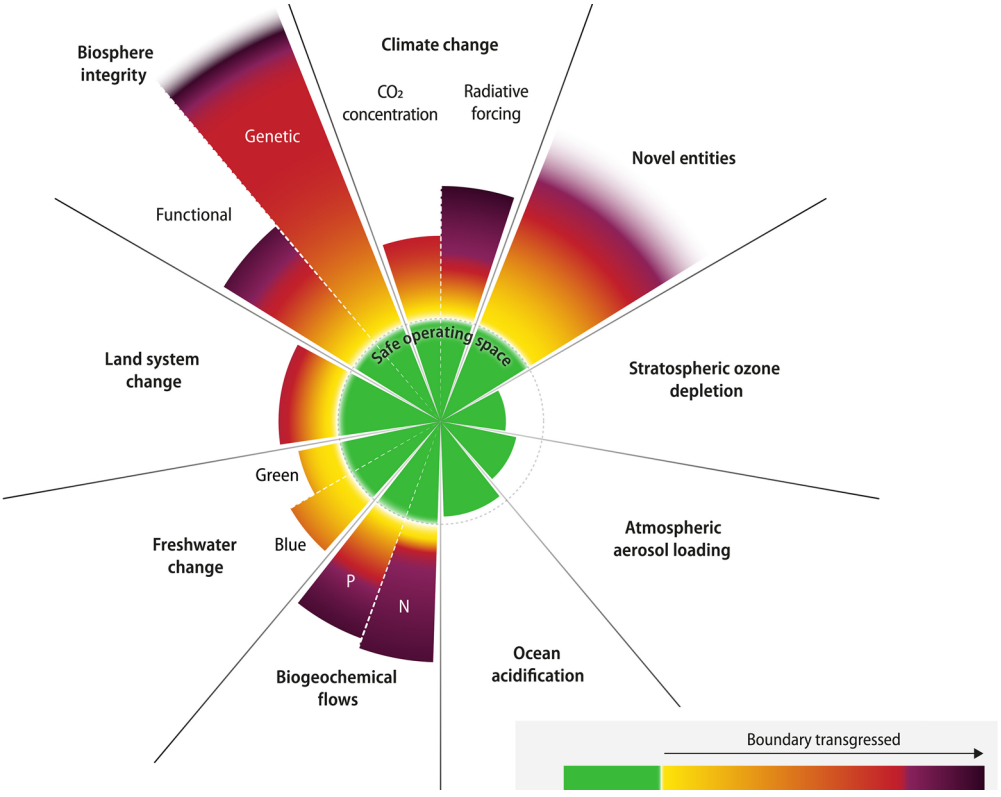
Introduction

The importance of circular economy

We live in the Anthropocene (Crutzen, 2002), a geological epoch that evidences the intensification of human drivers, such as the use of land or resource exploitation, on nature (Folke et al., 2011; Steffen et al., 2015). Human activity, which is inescapably connected with Biosphere systems (Young et al., 2006), is generating unsustainable regime shifts (Hughes et al., 2013) and irreversible environmental changes that endanger human prosperity (Griggs et al., 2013). In this scenario, scientists have identified nine Earth-system processes that govern the stability and resilience of the planet (Rockström et al., 2009). Each of these processes comprises a planetary boundary, a control variable value that determines "a safe operating space for humanity" (Rockström et al., 2009, p.472). As presented in Figure 1 below, six Earth-system processes have been already surpassed, triggering effects such as ocean acidification, biodiversity loss, and climate change, including extreme weather events.

Figure 1: Current status of control variables for all nine planetary boundaries.



Source: Richardson et al. (2023).

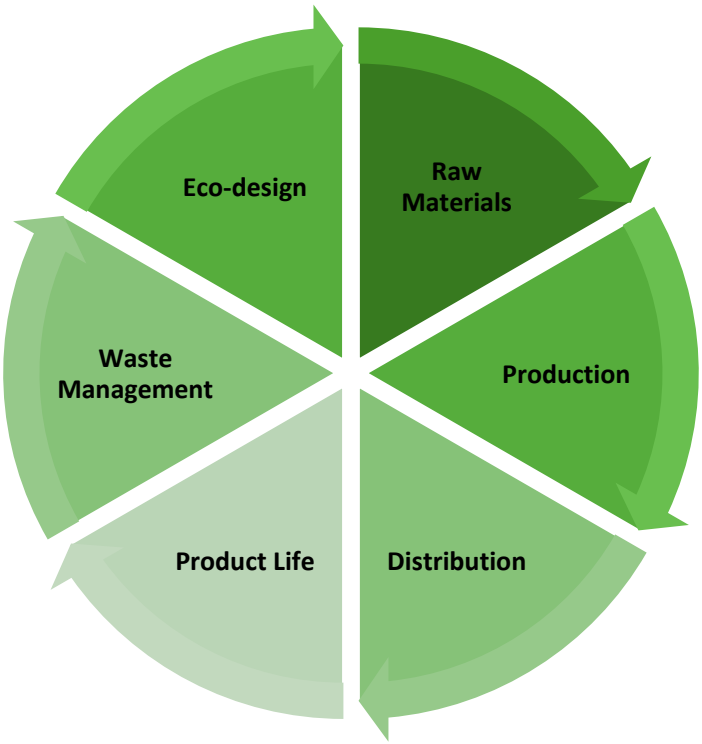
Given the ecological crisis humanity is confronting, new economic systems are imperative. The circular economy stands out as an industrial system that is restorative by design: it aims to rely on renewable energy; minimizes, tracks, and eliminates the use of toxic chemicals; and eradicates waste through careful design (MacArthur, 2013). By encouraging the reuse, recycling, and regeneration of materials, the circular economy seeks to implement a regenerative model that aligns with planetary boundaries. This approach not only promotes environmental sustainability but also enhances economic resilience and social well-being, paving the way for a more sustainable future for humanity.

The circular approach contrasts with the traditional linear business model of extract-produce-dispose and proposes a system of extract-produce-reuse that aims to minimize the use of resources and the generation of waste.

So… what can a business do to become more circular? (Accenture, 2014; Bocken, De Pauw,Bakker y van der Grinten,2016; Ellen MacArthur Foundation, 2014).

The first step is *ecodesign*. Once resources, infrastructures, and activities are committed to a certain design, only minor changes can be made. **Ecodesign** is the incorporation of preventive measures during the development and planning of a product or service in order to reduce its environmental impact throughout the phases of its life cycle (production, distribution, use, and end-of-life), and to facilitate its reuse or recycling once the cycle is completed. Indeed, ecodesign is the cornerstone of the circular economy—it enables circular economy strategies. It's essential to emphasize that the entire product ecodesign must be approached from the perspective of a **Life Cycle Assessment (LCA)**. This allows us to identify the main environmental impacts (wastewater, solid waste, air emissions, consumption of raw materials and energy) by considering all stages of its life cycle: from its origin—meaning the extraction and processing of raw materials—through production, transportation, and distribution, to use, maintenance, reuse, recycling, and disposal in landfills at the end of its useful life. To make our business circular, we must aim for its **inputs to be as regenerative as possible**, powered by renewable energy. Circularity is encouraged by the use of regenerative raw materials and secondary inputs—that is, resources that have been recovered, already used in previous economic cycles, and are now recycled or reclaimed. The **production** process must be **optimized**, meaning the consumption of all resources, including energy, should be minimized. The use of local resources, proximity distribution, and transport optimization are some of the specific strategies to reduce the environmental impact of **distribution**. Reverse logistics for recycling increase its relevance in circular business models. Regarding **product use,** to minimize resource extraction and waste, it's best to **design durable products**. This means designing goods to last and extending their useful life. Sharing and redistributing products through **servitization** (turning products into services) and collaborative platforms we can increse the intensity of products use and less products are needed as society. Once these goods lose functionality, we can recover part of their resources through **waste management**, recovering elements to reintegrate into the cycle.

Figure 2: Circular economy



Source: authors.

Figure 2 illustrates the different phases of the circular economy proposed in this escape room, associated with the different tests that players will have to solve to beat the game.

Circular economy escape room: a teaching innovation strategy

An escape room is an immersive experience to help students understand the circular economy in a hands-on engaging way. This approach leverages the principles of gamification, a promising strategy for enhancing student engagement, motivation, and learning outcomes in higher education (Roig-Vila, 2019). Specifically, the literature has shown that gamification increases student engagement and improves student outcomes (Koppitsch & Meyer, 2022), in addition to encouraging and reinforcing learning (Lin et al., 2018). Among its most effective applications are *escape room* experiences, which foster active participation, critical thinking, problem-solving, and teamwork, while enabling students to apply theoretical knowledge in practical, real-life scenarios (González-Yubero et al., 2023). These gamified activities have proven particularly valuable across a wide range of disciplines—from health sciences to STEM fields—which are often perceived as complex or intimidating by students (Sidekerskienė & Damaševičius, 2023). A growing body of research supports the educational potential of escape rooms, highlighting their ability to increase knowledge retention (Krishnan et al., 2023) and significantly boost student satisfaction (Dugnol-Menéndez et al., 2021). Motivation also plays a key role: components frequently present in escape room dynamics—such as creative thinking, activation, and a sense of autonomy—have been positively associated with intrinsic motivation (González-Yubero et al., 2023). In addition, when used as assessment tools, escape rooms can help create a relaxed and collaborative learning environment that fosters the development of 21st-century skills (Feng et

al., 2024). In summary, escape room activities represent an innovative and effective pedagogical tool in higher education. Their flexible design offers the potential to transform traditional teaching methods by integrating emerging technologies such as artificial intelligence, virtual reality, and augmented reality, thereby creating immersive, student-centered learning environments (Lampropoulos & Kinshuk, 2024; Marín-Rodríguez et al., 2023). As education continues to evolve, investing in technology-enhanced, game-based learning models appears to be a promising path for fostering student motivation, engagement, and academic success (Krishnan et al., 2023).

Objective

This escape room is part of the Erasmus + project "Learning for Sustainable Future - Higher Education for Green Transition in Southeast Asia (GreenEdAsia)" which aims to promote environmental sustainability through higher education in Vietnam and Thailand by integrating sustainability principles into various academic disciplines. The escape room on circular economy emerges as a form of "student-centred and competence-based education", responding to one of the project's key tasks. In its current form, the escape room is designed for 12 participants from two universities in Vietnam and two universities in Thailand, and they will be randomly selected into two groups to work collaboratively in an in-person setting. The participants are academics with diverse responsibilities and levels of seniority, including vice rectors, a rector, a dean, a director of PhD programs, and lecturers. Their fields of expertise include engineering, education, and business. The scape room will take place by May 2025 at Universidad de Burgos, Spain, and the duration of the activity is estimated for 1 hour and 15 minutes, including a preliminary explanation.

The objectives of this escape room are: (i) to promote understanding of the circular economy in a transversal way, and (ii) to develop problem-solving through interdisciplinary collaboration. These objectives will help students achieve the following competencies: (i) critical thinking, (ii) problem solving, (iii) teamwork, (iv) creativity, and (v) technical knowledge on circular economy.

Design

The premise for this escape room is that the circular economy emerges as a promising solution to overcome the ecological crisis. Players are selected to solve critical challenges that will help implement the circular economy principles and develop new solutions aligned with a sustainable future.

The escape room features six distinct challenges related to the phases of the circular economy. Each time players manage to solve a phase, they will receive a code that leads them to a piece of a circular puzzle that represents Figure 2. After completing these challenges, players must place all the pieces correctly in the puzzle, it represents the integration of all circular economy phases, showcasing how they can be applied to achieve a sustainable future. Each challenge has unique game dynamics tailored to its specific phase of the circular economy, as presented below.

Phase one – eco-design: Eco-design is a fundamental stage within the circular economy model. Eco-design is carried out from product's Life Cycle Assessment perspective. It is essential to consider, during the product design phase, all the environmental impacts at each stage of the product's life — from the extraction of resources or inputs involved, to manufacturing, product

use, and waste management. In this test, players are given a table that provides them with information about the number of CO2 emissions and the number of uses that the different types of bags have. Students must take this into account to later answer some true or false questions. Whith this activity the player realized that ecodesign involves taking into account the use that product is going to have.

Phase two – raw materials: Improving environmental efficiency and reducing dependence on raw materials is very important in a circular economy model. Through Circular Economy actions related to supply management, companies can reduce their environmental impact. This activity aims to link the name of the action to its description.

Phase three – production: In the journey towards a circular economy, understanding the emissions generated during the production of electricity is vital. In this challenge, participants will explore different energy sources and their impact on the environment. Their mission is to classify from the highest to the lowest sources of CO2 emissions.

Phase four – distribution: Reducing the distribution process for products can reduce a large part of the carbon footprint associated with our consumption. In this test, players are given images of fruits characteristic of certain geographical contexts, and they must correctly locate them on a world map.

Phase five – product life: It is important to make products as durable as possible, but it is also essential to consider the intensity of their use (for example, by sharing them through servitization or collaborative platforms) and to ensure that all stakeholders involved (such as manufacturers or users) have incentives aligned with environmental impact efficiency. In this activity, participants receive cards showing different types of household appliances, and only the washing machines have different usage scenarios on the back. These scenarios must be ranked from least to most environmentally efficient. The key lies in the intensity of use of the washing machine and the incentives that the manufacturer, the washing machine service provider, and the user have, which determine how environmentally efficient each situation is.

Phase six – waste management: An efficient waste management in an industrial cycle can lead to new sources of income and minimize its environmental impact. In this challenge, the players should match waste or by-products from an economic activity with products made from raw materials derived from those by-products.

At the start of the game, there's a person who directs and contextualizes the activity. Specifically, this person is a “sustainability manager” who provides information about environmental issues and the circular economy. This manager suggests that the players help him to implement a circular economy model in the company by passing tests and completing the circular economy circle. She then leaves them in the room where students will only have access to the information from the first test. After solving this one, they will be given access to the others successively, using codes and keys.

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