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Integrating Sustainability into Data Science Education: A Framework for Fostering Social and Environmental Commitment

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Abstract

This paper explores the integration of sustainability into business education, specifically within the context of the 'Fundamentals of Business Organization' course in the Data Science Degree at UPV. By analyzing the current state of sustainability education and its alignment with the institution's strategic goals, we propose the introduction of a new practical activity designed to foster Social and Environmental Commitment among students. This activity, which integrates the Pattern Categorization Framework, aims to engage students in real-world challenges, focusing on SDG 12: Responsible Production and Consumption. Through this initiative, students will not only deepen their understanding of business strategies and operations but also develop key soft skills related to ethical decision-making, sustainability, and responsibility. The paper highlights the importance of equipping future professionals with the tools and knowledge needed to design and manage business systems that contribute to long-term social, environmental, and economic sustainability.

Keywords: *Data Science; Sustainable Development Goals; Business practices.*

1. Introduction

In the face of pressing global challenges such as climate change and social inequality, universities are increasingly recognized as key agents in shaping professionals capable of driving sustainable development (Raimo et al., 2024). The Universitat Politècnica de València (UPV, Spain) has responded to this call by embedding the United Nations' Sustainable Development Goals (SDGs) into its strategic framework. This institutional commitment promotes an educational model that extends beyond technical proficiency, fostering social and environmental responsibility among students (Boni et al., 2019).

Within this context, the course Fundamentals of Business Organization (FOE), part of the Bachelor's Degree in Data Science Engineering, has emerged as a strategic platform for integrating sustainability into engineering education. Introduced in the 2021/2022 academic year, the degree program equips graduates to lead data analysis projects across diverse fields, including industry, by training them to design, manage, and communicate data-driven solutions for process optimization and decision-making.

FOE is taught in the first semester of the first year and is coordinated by the Business Management Department (DOE) at UPV. Positioned early in the curriculum, the course provides students with foundational knowledge of business management to guide their professional development. It introduces key concepts in organizational theory, strategic management, human capital, market dynamics, and core functional areas such as finance, operations, and marketing.

Beyond technical and managerial knowledge, FOE aims to develop critical soft skills, as outlined in the current Teaching Guide (Diego et al., 2025). These include innovation and creativity, teamwork and leadership, and effective communication, which are essential competencies for addressing complex societal and professional challenges.

Given the pivotal role of data infrastructures in enabling knowledge sharing, innovation, and informed decision-making, there is an urgent need to embed sustainability principles into data-related education. A well-designed, equitable data system can create long-term value aligned with environmental, social, and economic goals. Integrating sustainability alongside current soft skills and technical education ensures that future data scientists are equipped not only to manage information, but to do so ethically and responsibly.

The FOE course, situated at the intersection of education and industry, offers an ideal context for developing sustainability capabilities. In this paper, we propose integrating the recently developed Pattern Categorization Framework (Rosa et al., 2024) into FOE's practical sessions to engage students in real-world, problem-based learning focused on Sustainable Development Goal (SDG) 12: Responsible Production and Consumption (Johnston, 2016).

This study aims to explore how the integration of this sustainability-oriented framework impacts students' learning experiences and contributes to the development of social and environmental commitment as a core soft skill. Specifically, it addresses the following research question: How do students perceive and engage with sustainability-focused, problem-based activities within the FOE course?

2. A broader perspective

While engineers can act sustainably on an individual level by reducing personal consumption, recycling, choosing less polluting transportation options, or collaborating with NGOs; the

greatest impact engineers have on society and the environment stems from their professional work (Sánchez-Carracedo et al., 2020). Given the rapid pace of technological change, Data Science engineers play a crucial role in driving sustainable innovation. By leveraging data analytics, machine learning, and artificial intelligence, they can optimize resource use, enhance energy efficiency, and develop predictive models to mitigate environmental and societal risks. Their expertise enables informed decision-making, fostering sustainable practices across industries and contributing to the broader transition toward a circular and responsible economy.

Incorporating the Social and Environmental Commitment soft skill means acting with ethics and professional responsibility when facing social, environmental, and economic challenges, all while being guided by democratic principles, values, and the Sustainable Development Goals (SDGs). To foster this, we propose a learning process centered around student involvement, in collaboration with their professors and peers, where they are encouraged to act as societal game-changers.

To integrate the concept of sustainability into students' work, a new classroom activity is introduced. The primary objective is to raise awareness of key sustainability competencies: systems thinking, futures thinking, values thinking, strategic thinking, and interpersonal competencies (Redman et al., 2021). In particular, this new activity will focus on Sustainable Development Goal (SDG) 12: Responsible Production and Consumption, highlighting the role of companies in promoting sustainable practices. Additionally, young people represent a significant consumer group, and the evolution of their consumption patterns will greatly influence the sustainability trajectory of the companies they will lead in the future. This activity aims to empower students to become change agents equipped with the knowledge, resources, motivation, and courage to take transformative action for sustainable development.

2.1. The pattern categorization framework

To support students in understanding the complex decisions required for sustainable development and to inspire them to drive transformative changes in both them and society, it is essential to first clarify key concepts.

At the forefront, sustainability competency is closely linked to the broader concept of sustainable development (Sánchez-Carracedo et al., 2020). Sustainable development is fundamentally rooted in the definition proposed by the Brundtland Commission (Brundtland, 1987): “the ability to meet present needs without compromising the ability of future generations to meet their own needs,” emphasizing intergenerational justice.

Both the Brundtland Commission and the United Nations Sustainable Development Goals (SDGs) (Johnston, 2016) identify three foundational pillars of sustainable development: social equity, environmental protection, and economic growth. To uphold the principle of

intergenerational sustainability justice outlined by the Brundtland Commission, these pillars must be systematically integrated into higher education curricula.

On the other hand, the value chain studied in this course as a sequence of activities that facilitate the movement of a product or service from production to consumption (Porter, M., 1985), traditionally operates within a linear economic model characterized by the take, make, dispose paradigm. In contrast, the circular economy model promotes a continuous cycle of resource preservation and regeneration, aiming to optimize resource utilization and minimize waste (Ellen MacArthur Foundation, 2015).

While the circular economy is often illustrated through visual representations such as the Ellen MacArthur Foundation's butterfly diagram (Ellen MacArthur Foundation, 2015), we propose an alternative conceptual framework, the funnel metaphor, to address certain limitations (see Fig. 1). This metaphor acknowledges two key aspects: first, that not all waste generated along a value chain can be indefinitely reintroduced; and second, that resource flows can be exchanged between different value chains, a process that can be just as valuable for circular economy objectives as recirculating resources within a single value chain. Thus, the funnel metaphor offers a more nuanced representation of the current economy (Rosa et al., 2024).

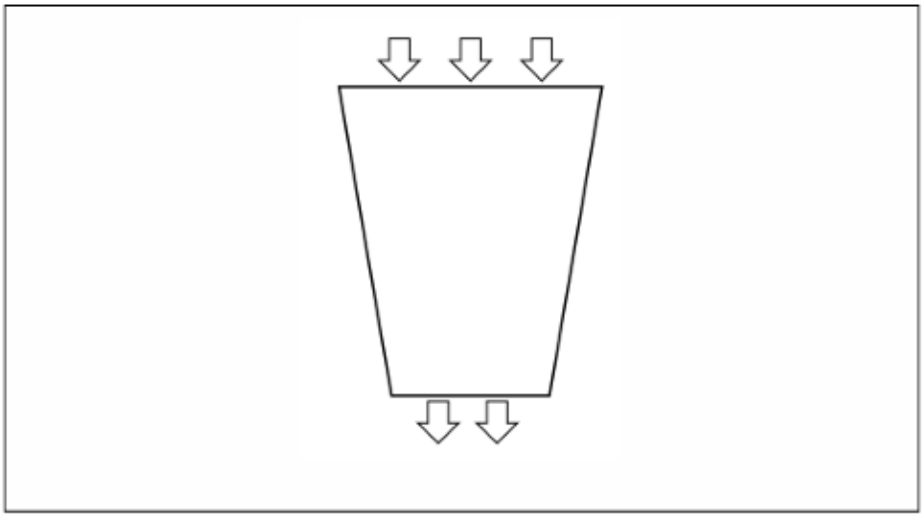

Figure 1. The funnel metaphor. Source: Author's elaboration.

Following this, a pattern categorization is introduced as a continuous journey toward circularity rather than a fixed, attainable state devoid of material and energy. This perspective aligns with a dynamic and evolving approach to sustainability. To illustrate this concept, a three-step configuration of the funnel metaphor is adopted (see Fig. 2), highlighting the progressive nature of circularity and the interconnected strategies required for its implementation. First, the

optimization of resources entails reducing the reliance on raw materials and non-renewable energy, enhancing efficiency, and minimizing waste. Second, the preservation of product value involves slowing the flow of resources by extending product lifespan through strategies such as reuse, repair, remanufacturing, and refurbishment. And finally, the interconnection of multiple funnels which emphasis the importance of collaborative networks where resources are recycled and repurposed across value chains to enhance circularity

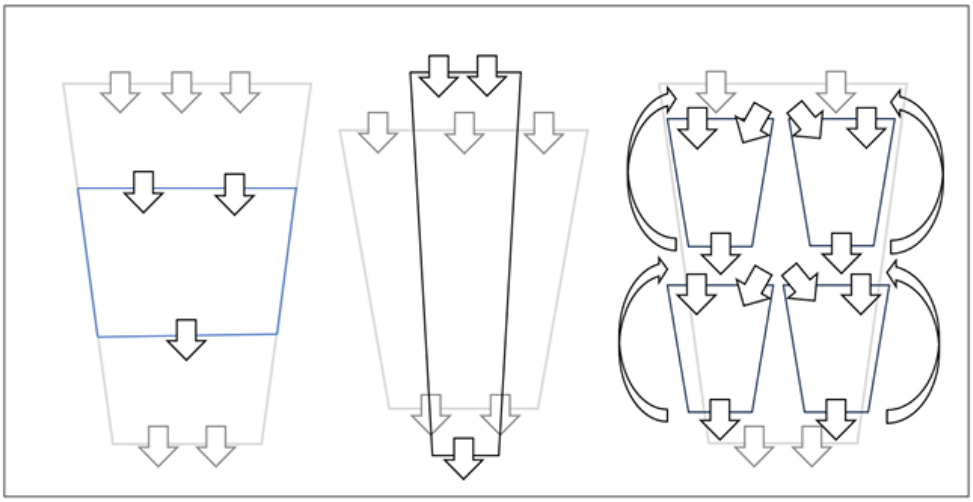

Figure 2. The pattern categorization: (1)optimization, (2) preservation and (3)cycling resources. Source: Author's elaboration.

2.2. Adapting the pattern categorization framework in the classroom

Each academic year, the FOE course is delivered in two main groups: one taught in Spanish with approximately 65 students, and the other in English with around 65 students. The Spanish-based class primarily consists of students who have recently completed secondary education in Spain. In contrast, the English-based group often includes Erasmus students, many of whom are in the final years of their degree programs and choose FOE as one of the English-taught courses available. Given this composition, we believe it is advantageous to initially implement the framework with the English-based group. These students typically bring more academic experience and diverse perspectives from various higher education institutions across Europe, which may enrich classroom discussions and facilitate the adoption of sustainability-focused, problem-based learning approaches.

Before engaging in this new activity, students in the English-based group will have already been organized into small teams of five members during the practical sessions. Each group will have selected a company to analyze and will have completed several assignments to examine the company's mission, vision, and values. Specifically, students will have applied strategic tools

such as PESTEL and Porter's Five Forces to identify key variables affecting the company, as well as the factors influencing industry rivalry and the company's bargaining power over suppliers and customers. Furthermore, they will have conducted an internal analysis using Porter's Value Chain framework to describe the company's value creation process, highlighting its strengths and weaknesses. This analysis will be complemented by a SWOT analysis, which will explore the opportunities and threats posed by the external environment.

These analyses will have equipped students to assess the company's strategy using additional strategic tools, such as the BCG Matrix and Porter's Business Strategies. To conclude this part of the project, students will have also analyzed the company's organizational structure, information systems, and financial situation, alongside its marketing and commercial strategy (Font, L., 2012).

In the new sustainability-focused activity, students will begin by illustrating the funnel metaphor for their selected companies. They will map out the flow of resources; materials, energy, and labor, used throughout the value chain. These diagrams will show how products pass through different stages of the life cycle, from production and distribution to use and disposal.

Next, students will engage with the pattern categorization framework and develop sustainability initiatives based on one or more of the three identified patterns. For each initiative, they will describe its key attributes using the pattern concept card proposed by the authors (Rosa et al., 2024). These attributes such as value creation, target, focus, and technology, represent crucial dimensions that bridge academic research and industrial practice. The pattern card serves as a structured tool for designing and analyzing sustainability and circularity strategies, recognizing the multifaceted nature of business innovation for sustainability.

The FOE course includes ten practical sessions, two of which are currently dedicated to team presentations. We propose a revised allocation: seven sessions for the existing activities (six for teamwork and one for presentations), and three sessions for the new activity. These final three sessions will be structured as follows; (1) first session focused on learning key sustainability concepts, (2) second session for hands-on experimentation using the framework and (3) third and final session for students to present their sustainability initiatives to their peers.

3. Conclusion

Data Science engineers have the potential to drive sustainable innovation by applying data-driven insights to environmental, social, and economic challenges. In alignment with the UPV's strategic focus on sustainability, this paper proposes the integration of a sustainability-focused, problem-based activity into the FOE course, leveraging the Pattern Categorization Framework.

This activity is designed to actively engage students in analyzing real-world business practices through the lens of SDG 12: Responsible Production and Consumption. By incorporating tools

that structure their analysis and stimulate critical thinking, the activity aims to enhance students' understanding of sustainability in a business context and foster their Social and Environmental skills.

The forthcoming implementation of this activity will explore how students perceive and engage with these sustainability-centered challenges. Specifically, it will examine their motivation, participation, and reflections as they navigate ethical, environmental, and strategic dimensions of business decisions. The anticipated outcome is a deeper connection between course content and real-world sustainability issues, equipping students with the skills and mindset needed to become proactive contributors to a more sustainable economy.

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