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Chapter

Fostering Education for Circular Economy through Life Cycle Thinking

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Abstract

Since 2002, the University of the Basque Country has supported several teaching experiences related to the so-called Life Cycle Thinking and Ecodesign in collaboration with local and regional public institutions and private companies. The implementation of a Master's Degree entitled 'Circular Economy: Business Application' constitutes a milestone in the framework of these teaching experiences. From the very moment the European Green Deal was approved and, subsequently, before the state and regional strategies were launched, thanks to our prior experience, we have been able to offer the postgraduate course required by our administration and companies. The courses have been specifically designed to provide education for Circular Economy for new graduates as well as professionals with backgrounds as varied as product manufacturing engineering, environmental engineering, business administration or economics. It aims to become a European reference in its goal of promoting Circular Economy, life cycle thinking, ecodesign, industrial symbiosis and sustainable development and, at the same time, support the transition to circular economy in our region. As a result, in just two years the master's degree has led to the creation within our university of a knowledge hub in Circular Economy, which hosts more than 20 research groups.

Keywords: Life cycle thinking, Circular Economy, life cycle assessment, lifelong learning, education for Circular Economy

1. Introduction

Circular Economy is a viable and promising alternative to the currently prevailing linear economic system. The fact of having a world with finite resources involves the need to adopt a sustainable economic system where sustainable processes must be prioritized [1]. Therefore, in this context of finite resources, Circular Economy seeks economic growth only if achieved in a sustainable way by keeping resources within closed cycles as long as possible. The significant importance of the decisions taken during the design phase of products and services results in the fact that over 80% of all product-related environmental impacts are originated in their design phase [2].

Meanwhile, the United Nations (UN) warns that if the world's population were to reach 9.5 billion in 2050, the natural resources of nearly three planets would be needed to sustain current and predicted lifestyle [3]. On the other hand, the Global

Footprint Network advises us that by 2020 the resources we had for the whole year were already spent by August 22th [4].

If that were not enough, we have been witnessing climate change for too many years. According to the Intergovernmental Panel on Climate Change [5], since the beginning of the industrial age, the average temperature of the planet has increased by 1°C. If the trend continues, it is expected to rise by between 3°C and 5°C by 2100. Furthermore, the extraction and processing of natural resources has accelerated significantly over the last two decades and, it is responsible for half of the impacts related to biodiversity loss, water stress and climate change [6]. Besides, our planet lives in a systemic crisis, with alarming social and economic inequalities, increasing rates of loss of natural biodiversity and cultural heritage, and a senseless growing pressure on natural resources and systems.

It is in this context that the concept of sustainability has gained in importance, with the steadily rising awareness of the necessity for a deep change that started in the end of the 80s. Parallel to this, the word "sustainability" seems to have become a multipurpose and valid term for any context, objective, argumentation or ideological-political stream [7].

Continuing the work started in 2000 with the Millennium Development Goals in 2015, the 2030 Agenda for Sustainable Development [8] was adopted by 193 countries at the United Nations (UN) General Assembly. The 2030 Agenda, our roadmap for the next 15 years, is acknowledged as transformative, universal and integrated, and it provides a shared blueprint for peace and prosperity for people and the planet, now and into the future [9].

The 17 goals of the 2030 Agenda for Sustainable Development cannot be achieved without systemic transformations on several fronts. Indeed, the 12th goal for sustainable development points at a responsible production and consumption system. Remaining within the paradigm of the linear system and establishing purely *ad hoc* changes will not be enough. In addition, the 4th goal for sustainable development, which reads "Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all", has always been kept in mind. This quality education and lifelong learning requires a continuous review-adaptation of our formative programmes.

Currently, the UN's Global Action Programme on Education for Sustainable Development [10] aims to contribute substantially to the 2030 development agenda, through two objectives:

- Reorienting education and learning so that all people have the opportunity to acquire the knowledge, skills, values and attitudes that empower them to contribute to a sustainable future.

- Strengthening education and learning in all agendas, programmes and activities that promote sustainable development.

In parallel with this UN Programme, the European Commission has launched the European Green Deal [11], a new growth strategy aiming to transform the European Union (EU) into a fair and prosperous society, with a modern, resource-efficient and competitive economy. Its main goals are, on the one hand, zero net emissions of greenhouse gases by 2050 and, on the other hand, keeping economic growth decoupled from resource use.

Besides, the new Circular Economy Action Plan [12] announces initiatives along the entire life cycle of products, such as targeting their design, promoting Circular Economy processes, fostering sustainable consumption and ensuring that all resources used are kept in the EU economy as long as possible.

The Spanish Strategy for Circular Economy 2030 [13], approved in June 2020, is fully aligned with the European strategy. In this way, all materials are used to the greatest possible extent, so waste generation is minimized. Thus, this Strategy contributes to Spain's efforts to achieve a sustainable, decarbonized, resource-efficient and competitive economy.

In terms of circular economy, the Basque Country is one of the leading regions in Spain. It underwent a traumatic industrial reconversion in the 1980s and since then has been committed to a development in harmony with the environment. It is worth highlighting the great compromise on the part of public institutions and companies in this task.

By means of the Agenda Euskadi - Basque Country 2030 [14], and the Strategy for Education for Sustainability of the Basque Country 2030 [15], the government of the autonomous region of the Basque Country is also aligned with the aforementioned 2030 Agenda.

In this context, in January 2020, the Basque Government issued the key points of its Circular Economy Strategy 2030 [16], and among these strategic objectives and challenges, it promoted research and degree studies at university level. More recently, the Basque Green Deal [17], issued in May 2021, proposes its own roadmap for a more sustainable future while addressing the post-pandemic crisis and leaving no one behind.

The mission of the Basque Country's Circular Economy Strategy, with a time horizon of 2030, is to promote the transition of the Basque Country towards a Circular Economy model and to position itself as a reference region in Europe. It aims to achieve positive results for our territory in three main areas:1) increasing the turnover of Basque companies regarding circular products up to 10,000 million Euros, 2) creating 3,000 jobs in the field of Circular Economy and, 3) reducing by 26% the carbon emissions associated with consumption.

The implementation of these strategies requires qualified people, either people who are working or people who are studying for a degree/master's degree. Qualified people and specialists in circular economy are required but also - and this is very important - that people working in other fields or studying other disciplines are aware of this new paradigm of Circular Economy. Circular Economy requires a systemic change and that change will only be achieved if the majority of people are aware of this need and have enough knowledge on the kind of actions to be taken.

Since Education for Sustainable Development constitutes a mature field of study, scholars aiming to teach sustainable development can draw on many degrees in Education for Sustainable Development. On the contrary, despite the overall Circular Economy literature, research on Education for Circular Economy is still somewhat limited. Currently, with at least 850 articles published in academic journals regarding Circular Economy, academia is making efforts to include that subject in diverse teaching programs [18].

Therefore, the development of a master's degree in Circular Economy focused on Product Lifecycle Thinking is the answer to the environmental, social and economic needs of our industry and society. A secondary objective of the master's degree is to form a group of professors from different disciplines to integrate the principles of Circular Economy education in all bachelor and master degrees at the university.

The innovative aspect of the experience is that it is a long-standing, successful and scalable experience. It is also transferable to other universities or higher education institutions.

This article presents first a definition of the concepts of Circular Economy and the Product Lifecycle Thinking, together with a perspective on the relationship between Product Lifecycle management (PLM) and Circular Economy. Second, presents a contextualization of the various studies and innovation projects related

to Ecodesign and Circular Economy carried out at the Faculty of Engineering of Bilbao. Third, presentations of other relevant European studies that offer programs with partial or general similarity are listed. Finally, the last part gives a brief overview of the Master in "Circular Economy: Business Application" of the University of the Basque Country, including the intended learning outcomes together with a summary of the course related to... with a detailed description of each course.

2. What gives circularity to the product life cycle thinking?

The idea of Circular Economy is an integral vision that helps us to rethink our economy and our society. Therefore, it is not a question of "circularizing" the economy but of "circularizing" society [19].

Therefore, Circular Economy constitutes a driving incentive to this transformation and contributes to achieve the Sustainable Development Goals (SDGs) of UN 2030 Agenda. It offers a holistic framework to redesign the system, a new model that would take us into the "humanity's sweet spot" within Kate Raworth's "doughnut" [20] of social impacts and needs (**Figure 1**).

In principle, Circular Economy redefines the relationship between economy, society and nature. Its model distinguishes economic growth from natural resource depletion and ecological overload. Circular Economy aims to eliminate accumulated imbalances in the linear system and it combines economic prosperity with environmental caution. The concept of Circular Economy is based on the fundamental and obvious assumption that resources are limited and they must be preserved for future generations. It mimics nature by cycling resources. This requires sustainable consumption and production based on the so-called eco-design or environmentally responsible design [1, 21].

According to the Ellen MacArthur Foundation, "Economics by design must be restorative and aim to maintain products, components and materials at maximum utility and value, differentiating technical from biological cycles" (**Figure 2**).

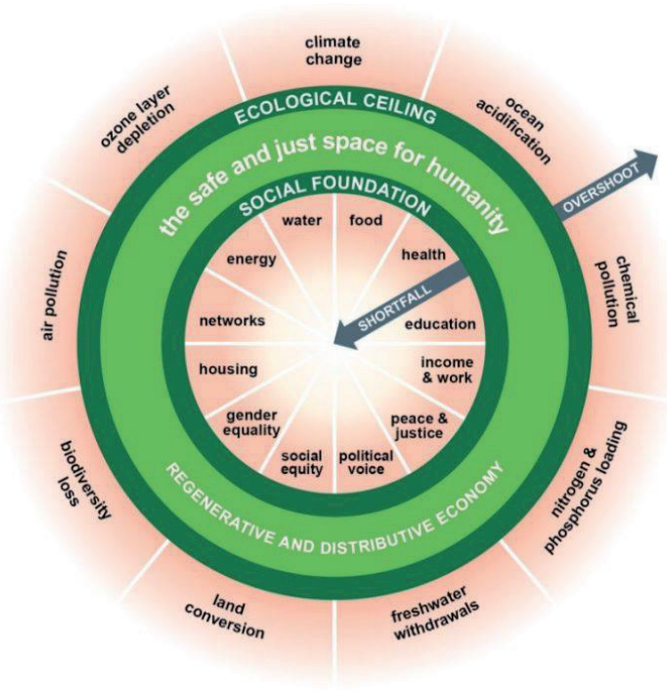

Figure 1.
The doughnut of social impacts and needs. Source: Kate Raworth, doughnut economics [20].

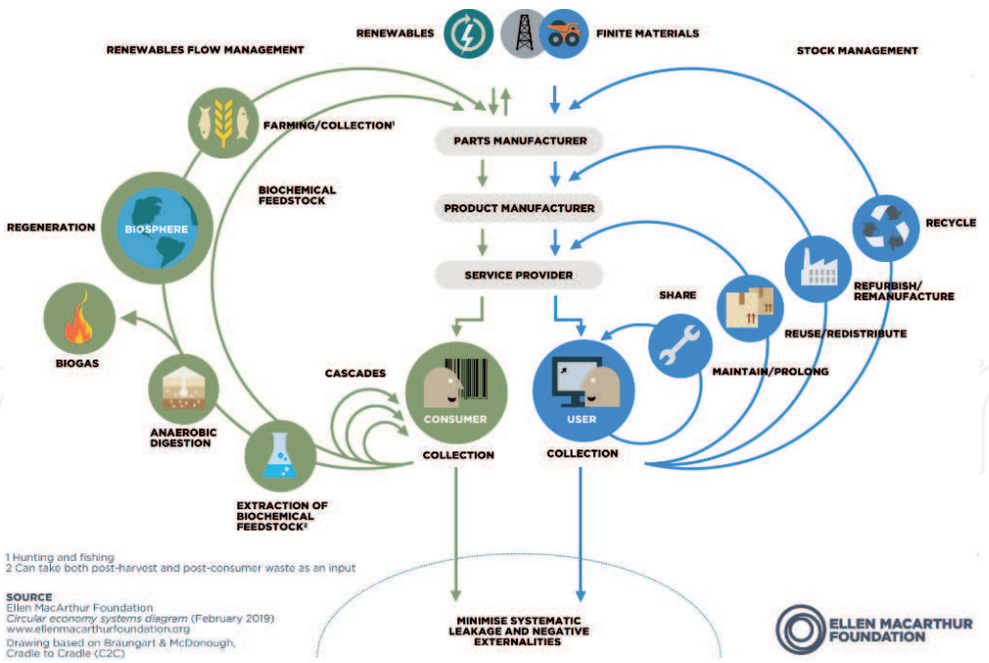

Figure 2.
Diagram of circular economy systems. Source: Towards the circular economy. Economic and business rationale for an accelerated transition [1].

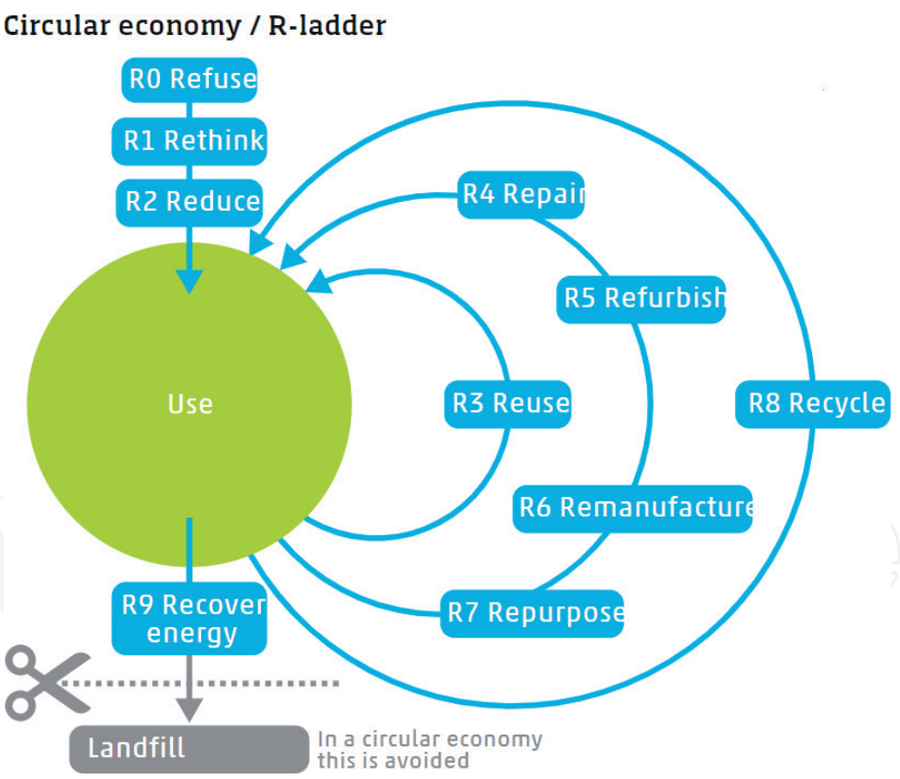

Figure 3.
R-ladder of circularity strategies. Source: Netherlands environmental assessment agency [22].

In the last decade, many companies in different sectors in Europe have opted for circular models through five fundamental axes [22]: circular entries, extension of product use, recovery of resources, platforms for sharing and product as a service.

In other words, companies are moving from the linear model of extracting, making and throwing away, to the circular model highlighted by the 9R Framework of Circular Approaches or the so-called 10R ladder of circularity strategies [6, 23].

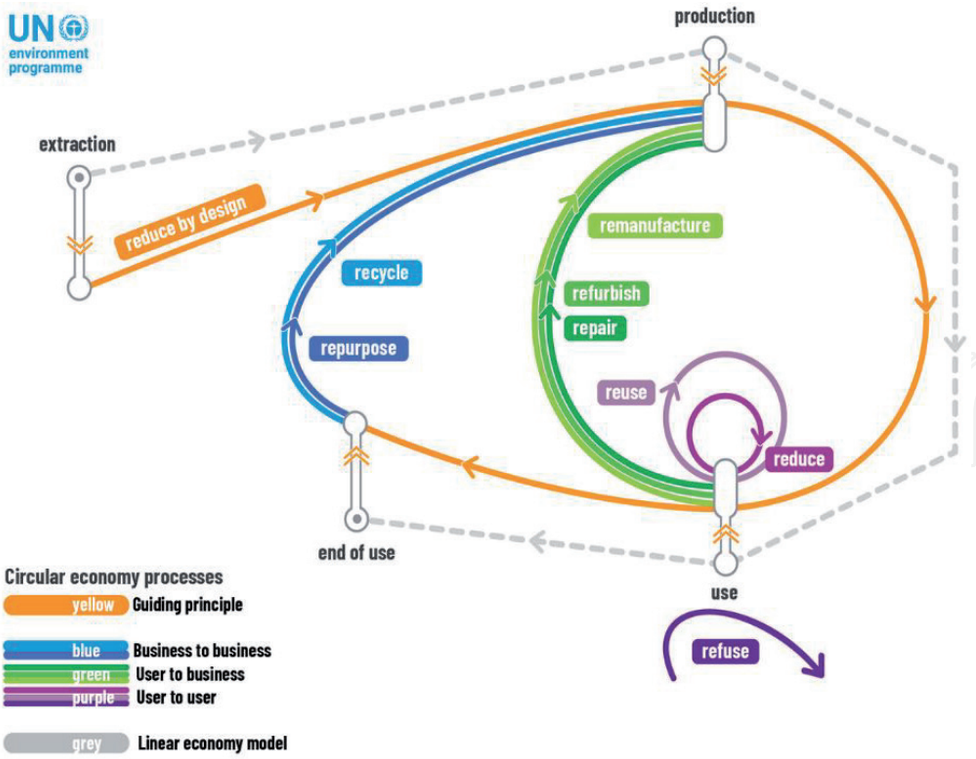

Figure 4.
Circularity diagrams. Source: United Nations environmental Programme's circularity platform [6].

From greater to lesser impact, these strategies are: R0 refuse, R1 rethink, R2 reduce, R3 reuse, R4 repair, R5 refurbish, R6 remanufacture, R7 repurpose, R8 recycle, R9 energy recovery (**Figures 3** and **4**).

In the circular model, apart from recycling, with the emphasis lying on reduction and reuse, it is necessary to make greater efforts. The concept of circular economy covers the entire lifecycle of the product, so it requires a much broader and systemic approach, with a special emphasis on education, than the traditional approach to production. For instance, regarding the fashion industry, a key question would be: Should our model of sustainability clothing be based only on the recycling container?

3. Product life cycle and circular economy

For manufacturers, product design has traditionally meant "design for manufacture". In other words, producers want to place on the market quality products as quickly as possible and at the lowest possible cost, without worrying about what will happen at the end of the product's life. Instead, "design for circularity" considers the entire life of the product, from design to production, through its use and its reuse, to the end of life. Circularity is a feasible way to serve both, people and the planet, while still making a profit, and has become a "hot topic" in engineering studios as well as boardrooms and legislative chambers [24, 25].

A challenge that needs to be addressed in Product Life Cycle Management (PLM), in a decentralized knowledge intensive environment, is the collaboration between the stakeholders involved in all product lifecycle activities and in an extended enterprise context, this collaboration involves, among others, the network of researchers, designers, producers, retailers and consumers. Technologies such as the Internet of Things (IoT) or Big Data could enable this challenge. At the same time, new challenges related to growing concerns with sustainability issues

and the increasing significance of Circular Economy approaches, which require improved products that can be used longer and with multiple lifecycles are emerging [26]. This scenario poses challenges to future PLM systems, especially those intended for small and medium-sized enterprises (SMEs), which have limited internal resources and strongly rely on collaboration with external partners, suppliers and customers.

Therefore, PLM has become an important Circular Economy driver [27]. It has a paramount importance because PLM involves the whole lifecycle of a product, consumer good or service, from cradle to cradle and it is the only management system capable of addressing all the sustainability information necessary to pass from a linear design and manufacturing concept to a circular one.

PLM systems are information management systems that can integrate data, processes and business systems in extended enterprises. PLM systems have become interesting supporting tools in the transition to the Circular Economy, as they help integrating information across multiple life cycles as well as various stakeholders in the value chain [28].

In summary, when in the late 1970s Walter R. Stahel coined the term "cradle to cradle" C2C [29] and in 2002 Michael Braungart and William McDonough published a book entitled "Cradle to Cradle: Remaking the Way We Make Things" [30], a manifesto for cradle-to-cradle design that exposed specific details of how to achieve the model, few would have imagined the importance of the PLM through the entire Lifecycle and even less the introduction of sustainability concepts involved in the Circular Economy definition, such as reducing, reusing, repairing, remanufacturing, repurposing, recycling, etcetera [31].

4. From education for sustainable development to education for circular economy

Both, younger professionals, who have just started working, and senior professionals need to integrate circular economy in their daily activity. However, they have little or no knowledge on this field because the concept of circular economy did not exist at the time they completed their studies. Therefore, special efforts must be made in order to create a knowledge and competence base to foster circular innovation at all levels of education as well as to promote lifelong learning in this field. The integration of Circular Economy and Systems Thinking into the curricula of higher education institutions should be encouraged to help to raise sustainability awareness and transform our mentality [18, 32].

According to the Ellen MacArthur Foundation, the way people think shapes the world around them and, people's ways of thinking are built throughout their process of learning. The transition from linear to circular economy requires people to transform the way they create products, services, and systems.

In order to support people's learning about Circular Economy, the Ellen MacArthur Foundation places an emphasis on interdisciplinary, project-based, and participatory approaches [33]. This Foundation's aim is to help people understand how they can influence the complex systems around them.

According to other experts such as Sitra, the Finnish Innovation Fund for a sustainable future, to create a Circular Economy society, circular industries need a new kind of expertise, with co-operation between silos, a development of the operating environment and a general change in attitudes and operating methods. Professionals, experts and decision-makers, both now and in the future, will play a decisive role in building a new future, and education plays an important role in preparing those experts on Circular Economy for our near future [34].

5. Master's degrees related to circular economy in Europe

Several Master's degrees in prestigious international universities in Europe have served as inspiration and reference for preparing and offering the Master's degree in Circular Economy at the University of the Basque Country. Postgraduate degrees on Circular Economy exist all over the world, mainly in North America, Oceania and Asia, but as nearby courses are our immediate competitors, only the European Master's degrees have been listed.

Before presenting these degrees, it should be highlighted again that Education for Circular Economy is still in its infancy. It is foreseeable that in the short-medium term the offer of postgraduate degrees will increase. Regarding the number of credits assigned to them or regarding their theoretical and practical content or interdisciplinarity, there will be substantial differences among these degrees. In addition, these degrees will offer a variety of approaches to the subject, this is, with general contents or specifically focused on economics, engineering or marketing.

The European studies that have inspired and served as main reference for our master's degree proposal constitute the CIRCLE program, which is an Erasmus Mundus International Master's Program on Circular Economy. The objective of the Master's Programme on Circular Economy is to offer international and interdisciplinary studies at the highest level, which will allow participants to make an essential contribution to understanding and proposing solutions to problems in order to support the transition towards a sustainable society.

The following is a summary of the main study programs offered in Europe related to Circular Economy:

ERASMUS MUNDUS CIRCLE PROGRAMME

- Website: https://www.jointdegree.eu/en/circle-erasmus-mundus-international-masters-programme-on-circular-economy/
- Degree awarded: Master of Science in Technology
- Credits: 120 ECTS
- Duration: 2 years
- Partner universities:
    - University of Graz (coordinator) (Austria)
    - Chalmers University of Technology (Sweden)
    - Delft University of Technology (The Netherlands)
    - Leiden University (The Netherlands)
    - Norwegian University of Science and Technology (Norway)
    - Curtin University (Australia)
    - Tsinghua University (China)
    - Waseda University (Japan)

FINLAND
Master's Programme in Circular Economy

- Website: https://www.lut.fi/web/en/admissions/masters-studies/msc-in-technology/environmental-technology/circular-economy
- Degree awarded: Master of Science in Technology
- Credits: 120 ECTS
- Duration: 2 years
- Campus: LUT University (Lappeenranta-Lahti University of Technology)

UNITED KINGDOM
Technology Innovation and Management for a Circular Economy MSc

- Website: https://www.cranfield.ac.uk/courses/taught/technology-innovation-and-management-for-a-circular-economy
- Degree awarded: Master of Science in Technology, Postgraduate Diploma and Postgraduate Certificate
- Duration: 2 years
- Campus: Cranfield University

UNITED KINGDOM
Innovation, Enterprise and Circular Economy MBA

- Website: https://www.brad.ac.uk/courses/pg/innovation-enterprise-and-circular-economy/
- Degree awarded: Master of Business Administration
- Duration: 2 years
- Campus: University of Bradford - Faculty of Management, Law and Social Science

THE NETHERLANDS
Circular Economy: An Introduction + Engineering Design for a Circular Economy

- Website: https://www.edx.org/course/engineering-design-for-a-circular-economy
- Duration: 7 + 6 weeks (free course)
- Campus: Delft University of Technology TUDelft

SPAIN
Master's Degree in Circular Economy

- Website: https://www.ubu.es/
  master-universitario-en-economia-circular-semipresencial
- Degree awarded: Master of Science in Economics
- Credits: 60 ECTS
- Duration: 1 years
- Campus: University of Burgos (Faculty of Economics and Management)

ITALY
Master Circular Design

- Website: http://www.mastercirculardesign.it/
- Degree awarded: Master of Science in Technology
- Credits: 60 ECTS
- Duration: 1 years
- Campus: Iuav University of Venice

THE ELLEN MACARTHUR FOUNDATION - Network Universities

The Ellen MacArthur Foundation is committed to working with universities and higher education institutions worldwide to enable the transition from a linear to a Circular Economy. Together, through collaborative work, they develop, share, and scale Circular Economy learning.

Website: https://www.ellenmacarthurfoundation.org/our-work/activities/universities.

EIT RAW MATERIALS

EIT RawMaterials Academy goes from innovative education projects launched via calls and run by the Innovation Community's partners to a number of centrally operated projects across some European universities. Circular Economy plays a predominant role in the degree programs offered.

Website: https://eitrawmaterials.eu/eit-rm-academy/labelled-masters/

6. The master's degree in circular economy at the University of the Basque Country

6.1 Starting point of the master's degree in circular economy

The University of the Basque Country is a public research university, deeply rooted in Basque society, open to the world, with an intellectual leadership and an ethical and social commitment. Its mission is to nurture a cultivated population by providing quality education and training based on knowledge, innovation and equity.

As it happens with other organizations, the University of the Basque Country considers UN 2030 Agenda and its SDGs as a model or framework that can accommodate the high quantity of the programmes implemented in recent years. In this area, certain degrees and research projects showed that SDGs were not unrelated

to who we were or what we did when the UN initiated this agenda in 2015. These degrees and projects promoted a human rights culture, gender equality policies, the development of university cooperation, as well as environmental management or joint projects alongside organizations operating in the third sector [6].

Aligned with the policies mentioned in previous sections, the University of the Basque Country has supported different teaching experiences related to the so-called Life Cycle Thinking or Ecodesign in collaboration with some local Institutions in the last two decades.

The kick-off for these experiences was established in 2002 with the foundation of the Ecodesign Learning Center at the Faculty of Engineering in Bilbao [35].

The Basque Ecodesign Center (www.basqueecodesigncenter.net) is a partnership framework between firms in the private sector and the Basque Government. It aims to foster the design and execution of innovative ecodesign projects. Besides, Ihobe (www.ihobe.eus/home) a publicly owned company under the auspices of the Basque Government's Ministry for the Economic Development, Sustainability and Environment supports the Basque Government in the implementation of its environmental policy and in the spreading of the environmental sustainability culture in this region.

Boosted by Ihobe, the Basque Ecodesign Center and the Sustainability Directorate of the University of the Basque Country, in October 2019 the university launched the first edition of a postgraduate course about circular economy (consisting of 36 ECTS. At that moment, a new master's degree with 60 ECTS for the next academic year was on its way. This new master, entitled "Circular Economy: Business Application", places a special emphasis on the aspects related to ecodesign and product life cycle thinking [36].

It should be noted that these studies were a necessity for the Basque Country, as there was no master's degree or training of these characteristics neither in our region nor in neighboring regions, and our industrial fabric needed this type of officially regulated courses.

6.2 Facts of the master's degree in circular economy; business application

The master's degree in Circular Economy [36] takes place from September to June (**Table 1**) plus the Master's thesis to complete the 60 ECTS required to obtain the degree.

The maximum number of students has been fixed to 25 and more than 35 associate professors, full professors and professionals from the governments and industrial sector take part in it. Candidate students are sought among engineers and economists working in local-regional industry, service companies or public administration. Courses are imparted at the Faculty of Engineering and the Faculty of Economics and Business in Bilbao.

The courses are programmed with participatory and active learning methods such as flipped classroom, jigsaw techniques or Problem Based Learning (PBL). Other aspects such as interactivity, non-dogmatism and reciprocity are taken for granted.

Regarding the organization of teaching, each subject has a digital learning platform or course management system (Moodle) where teachers can upload the content of their classes as well as additional material for students to consult previously (flipped classroom method) or later. In addition, classes can be followed online through the university's own videoconferencing platform integrated in the course management system. In this way, students who are confined or unable to attend classes for justified work reasons can follow the explanations of the teachers from home.

	Course	ECTS credits
1	Circular Economy: General Context. Eco-innovation as a Business Opportunity.	6
2	Environmental Impacts Derived from the Production-consumption of Products and Services	3
3	Environmental Management Tools in the Company	3
4	Ecodesign and Circular Economy	3
5	Life Cycle Thinking 1: Tools for Calculation and Communication	3
6	Life Cycle Thinking 2: Quantification of the Product Environmental Footprint	3
7	Circular Economy and Industry 4.0	3
8	Circular Economy in the Company: From Ecodesign to Product Commercialization	6
9	Circular Economy in the Company: Sustainable Entrepreneurship, Business Models in Circular Economy	3
10	Circular Economy Initiatives. Business Cases	9
11	Practical Workshops on Circular Economy	6
12	Master's Thesis	12

Table 1.
Courses of the master's degree in circular economy for the 2020-2021 academic year.

As a whole, the course is evaluated by means of a survey prior to the commencement of the course, together with a special face-to-face session at the end of the course in which the students present their learning experience and from which the strengths and weaknesses of these master's degree are extracted. In addition, at the end of each course a small survey is carried out to find out the students' opinion of the teaching methodology.

Besides, the academic board of the master's degree offers voluntary internships in companies. Only a small number of students are interested in these internships because the majority of them are professionals with more than 10 years of experience.

The academic board of the master's degree is considering the possibility of the course becoming an Erasmus Mundus master's degree in the future. This would require teaching agreements with several European universities. It is not considered urgent because the initial intention of the sponsors is to respond to a local educational need and not so much the exchange and mobility of students and professors.

In summary, the main strength of the course is the multidisciplinarity of its topics and courses, together with the wide representation of professionals representing the most important industrial sectors of the region.

6.3 Life cycle thinking: ecodesign and life cycle assessment

The transformation towards a more circular business model requires information about the inputs and outputs of different systems and processes, all of this together with the measurement of their impacts, data management and data exchange across the value chain.

What is the right way to assess and communicate impacts? Through the concept, acknowledgement and implementation of Life Cycle Thinking incorporates this evaluation of the environmental, economic and social aspects of the products (material goods or services).

Life Cycle Thinking allows industries to go beyond traditional linear thinking and focuses on production and disposal by including environmental, social, and economic impacts of a product over its entire life cycle, that is, from cradle to grave and, consequently allowing a more holistic assessment, highlighting, comprehension and possible prevention/reduction of impacts [37].

The courses closely related to Life Cycle Thinking make up 9 ECTS, which are divided into 3 modules consisting of 3 ECTS:

Ecodesign and Circular Economy

1. Introduction to the concept of ecodesign: basic principles and implications for the design of material products and services.

2. Standards in ecodesign.

3. Ecodesign methodology.

4. Ecodesign and companies: Integration of the Ecodesign in the enterprise management systems. Product-service systems.

Life Cycle Thinking 1: Tools for Calculation and Communication

1. Product life cycle: background and concepts. Life cycle and extended producer responsibility. Implications for the product designer.

2. Methodological principles of Life Cycle Analysis based on international standards. Life Cycle Assessment Software: Open LCA and SimaPro.

3. Communication and marketing with a Life Cycle approach.

Life Cycle Thinking 2: Quantification of the Product Environmental Foot-print

1. Social and environmental impacts.

2. Calculation of the environmental footprint of products and organizations. Combination of Life Cycle Assessment tools and Input–Output sector tables. Global Multi Regional Input–Output methodology (GMRIO).

3. Sustainable Product Design Tools. Product design cycle for a Circular Economy.

4. The R framework in Circular Economy. Reuse, Repair or Recycle + Restructure, Revalue, Relocate and Reconceptualize.

Overall, emphasis is made on how ecodesign serves to reduce the environmental impacts associated with a product along its whole life cycle. It also points out the relevance of servitization - or Product System Service (PSS) - as a more sustainable new business model. Within an ecodesign framework, it also describes the methodology for LCA thoroughly using different software tools. It also provides a deeper understanding of these matters by the calculation of different footprints. All of this will enable students to get a wide and deep overview on the concept of Environmentally Conscious Design.

6.4 Intended learning outcomes or specific competencies

When drawing up the Master's program, the aim was to ensure that students become experts in the challenges that the new Circular Economy poses for local-regional companies. Consequently, the most relevant specific competencies (knowledge, skills, and attitudes) that students must have acquired at the end of their Master's studies are the following:

- To define the concepts of Circular Economy, Sustainable Economy, Low Carbon Economy, Industrial Symbiosis and Eco-Innovation.
- To understand and explain the changes involved in the transition from a linear to a circular type of economy, as well as to recognize the opportunity they represent.
- To identify the current applicable environmental regulations (air, water, waste and soil) in order to carry out proper environmental management in the company.
- To define the concept of ecodesign and to become aware of the environmental, economic and social implications of product design.
- To apply the ecodesign methodology and manage the tools available for ecodesign in the industrial field
- To define the concept of life cycle and identify the phases of the life cycle of a product, as well as list the regulations of the Life Cycle Analysis.
- To know and apply the evaluation methodologies and software tools for product life cycle analysis.
- To formulate guidelines for communication and marketing with a life cycle approach.
- To define and understand corporate and competitive strategies to integrate the environmental variable in the company and select the most appropriate strategy for each particular case.
- To identify business opportunities in the field of the Circular Economy for different sectors, stakeholders and design proposals.

These intended learning outcomes are fully aligned with the targets proposed by some European universities that are considered to be at the leading edge in this area of knowledge and education [38–40]. The master's degree covers the proposed seven Circular Economy competencies for design to a greater or lesser extent. These competences are the following: Circular Impact Assessment, Design for Recovery, Design for Multiple Use Cycles, Circular Business Models, Circular User Engagement, Circular Economy Collaboration, and Circular Economy Communication.

7. Other achievements derived from the master's degree in circular economy

We are pleased to see that the master's degree in Circular Economy has promoted other important projects related to Education for the Circular Economy and SDGs.

The postgraduate course has been the catalyst for various initiatives that are complementing the university's educational initiatives in other areas of interest such as research and knowledge transfer.

These achievements can be summarized as follows:

- The postgraduate course is the nexus of the so-called Circular Economy Knowledge Hub at the University of the Basque Country.
- As a complementary activity to the master's degree, the summer course "Circular Economy and its opportunities for the public sector in the post-pandemic scenario" will be organized in June at the University of the Basque Country.
- A new university-company research laboratory has started its research work based on Circular Economy and Green Energy, the involved researchers and students came mainly from the master's degree course.
- The postgraduate course also connects the academia with private small, medium and large enterprises, thanks to the internships carried out by the Master's students in them.
- The master's degree is working as a catalyst for the work of several research groups on topics related to Life Cycle Thinking (https://www.ehu.eus/en/web/lifecyclethinking/), Secondary and Raw Materials, Sustainable Economy, etc.
- In addition, the professors of the master's degree course give educational support to the Basque Circular Hub (http://www.basquecircularhub.eus).

In addition, the social and economic impact of the course is clear. Every year, 25 students are trained to become experts in circular economy and will become the drivers of the circular change in their respective companies.

8. Conclusions

From previous sections it can be concluded that postgraduate studies in Circular Economy were a necessity and continue to be an ongoing reality at the University of the Basque Country.

These studies are ambitious and they are highly developed in the fields of Ecodesign and Life Cycle Thinking. This, it is expected that graduated students will help in advancing towards a sustainable society as they are incorporated into public services, higher education institutions, research centers or industry. This will enable not only a more efficient integration of the Circular Economy and Life Cycle Thinking concepts into our community, but it will also allow enterprises to get ahead of the many legislative changes that are expected to occur in the near future.

The master's degree has fostered numerous initiatives promoting knowledge transfer in Circular Economy.

This is a pioneering experience in Southwestern Europe, and in the near future, alliances will be sought with other European universities to offer a joint degree or at least to be able to offer mobility to students so that they can experience other academic realities.

The currently ongoing global pandemic of COVID-19 further encourages us to rethink our current economic system and provide a resilient approach to battle

the deep economic recession that our society is facing. The NextGenerationEU recovery plan can help but it will take the whole of society working together. In this context, the postgraduate studies in Circular Economy offered by the University of the Basque Country may serve as a common ground to boost a coalition between academia, industry and public institutions and exploit the full potential of a circular model.

Because of the work carried out, in just two years the master's degree has led to the creation within our university of a knowledge hub in Circular Economy, which hosts more than 20 research groups.

In the near future, and continuing with the product life cycle approach, we hope to promote more initiatives that provide us with opportunities for the challenging sustainable transformation of our society.

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