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**Faculdade de Design,
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Transition to Circular and Sustainable Economy through Design

Orientadores: Ana Margarida Ferreira e José Vicente

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Tese apresentada ao IADE – Faculdade de Design, Tecnologia e Comunicação da Universidade Europeia, para cumprimento dos requisitos necessários à obtenção do grau de Doutor em Design realizada sob a orientação científica da Doutora Ana Margarida Ferreira, Professora Associada com Agregação do IADE – Universidade Europeia e do Doutor José Manuel Andrade Nunes Vicente, Professor Auxiliar da Escola de Artes – Universidade de Évora.

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Dedico este trabalho à minha filha Salomé e que este trabalho possa contribuir para que o seu futuro seja mais sustentável

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resumo

Este trabalho de investigação foca-se na promoção da prática do Design orientada para o desenvolvimento de produtos e serviços inovadores, alinhados com as políticas, metas e objetivos nacionais e internacionais, que visem a transição para uma sociedade mais sustentável e circular.

A evolução da sociedade e o aumento da produção e do consumo de produtos para satisfazer as necessidades crescentes das pessoas, com o aumento do consumo de recursos naturais, está a levar a sociedade a um ponto de rutura, que a ser ultrapassado, dificilmente terá retorno, pondo em causa o futuro da sociedade e das gerações futuras.

Desde meados dos anos 70 que se percebeu que os padrões de produção & consumo são insustentáveis e que é necessária uma nova abordagem rumo a uma sociedade mais sustentável e com mais valor para todos os *stakeholders* da cadeia de valor.

Neste âmbito, a importância do Design nesta transição é inegável. No entanto, face à constante evolução das necessidades dos vários intervenientes da cadeia de valor torna-se fundamental capacitar e dotar os profissionais de Design com metodologias, ferramentas e orientações que potenciem a sua atividade dando origem a produtos mais eficientes, sustentáveis que resultem num aumento do valor para os utilizadores, para o negócio e para os profissionais desta área.

A aposta no desenvolvimento de produtos e serviços com melhorias no perfil de sustentabilidade com, menos impactes

nos sistemas naturais, não é nova. Nas últimas décadas, designers e outros profissionais têm desenvolvido a sua atividade com o objetivo de alcançar a sustentabilidade no processo de desenvolvimento, visando aumentar a eficiência e inovação e explorando diversas abordagens, desde produção mais limpa, o ecodesign, o Design para sustentabilidade ou desenvolvimento de sistemas de serviços de produtos, entre outros. No entanto, apesar de existirem inúmeros bons exemplos, principalmente ligados a nichos de mercado, essas práticas estão longe de estar globalizados e amplamente assumidas pela sociedade. Atualmente e de modo global, em resposta à pressão crescente, fruto das crises económicas e sociais, da escassez de recursos e do aumento da poluição, entre outros aspetos, a orientação para a Economia Circular, fortemente promovida por governos, centros de investigação, instituições de educação e formação, associações e muitos *stakeholders*, afirma-se como um novo caminho para alcançar a sustentabilidade e o bem-estar da sociedade. Tem o potencial de aumentar a prosperidade, riqueza e bem-estar, reduzindo a dependência e pressão sobre as matérias-primas e a energia.

A Economia Circular é vista como uma abordagem para a sustentabilidade, com um potencial de sucesso, alvo de inúmeros projetos e iniciativas de investigação e desenvolvimento, de aplicação prática nas empresas, na educação, apoiado por financiamento público.

No entanto, apesar de todos os esforços neste sentido, existe ainda uma lacuna significativa entre a investigação e a prática dentro deste paradigma profissional.

No contexto específico do Design, existe a necessidade de apoiar a prática do profissional e a educação neste domínio de métodos e ferramentas que permitam a transposição de estratégias de circularidade no desenvolvimento de soluções

inovadoras e eficazes que deem origem a produtos e serviços sustentáveis ajustados às necessidades de todos os atores envolvidas na cadeia de valor.

Neste sentido, de modo a atender às necessidades e objetivos da Economia Circular, a prática de Design deve integrar novas estratégias e critérios que promovam o fecho dos ciclos de vida dos produtos, mantendo os materiais, componentes e produtos em uso durante longos períodos de tempo, a redução do consumo de matérias-primas virgens e a eliminação da geração de resíduos. Estas ações aumentam a eficiência e a eficácia de todo o sistema de produção e consumo e informam uma prática de projeto mais atual.

Assim, a presente investigação, com o objetivo de promover e demonstrar o papel do Design para a Economia Circular aos diversos atores da cadeia de valor dos produtos e serviços, especialmente aos profissionais de Design e empresas, orientou-se pela seguinte hipótese:

"O Design, através dos seus métodos e ferramentas específicas, é fundamental para a transição efetiva para a Economia Circular Sustentável".

O trabalho desenvolvido com base na análise das necessidades e oportunidades emergentes resultou no desenvolvimento do conceito "*Roundig the Vertices*" o qual se pode traduzir de forma literal por arredondar os cantos.

O conceito tem como base a melhoria na eficiência do sistema projetual através da otimização e melhoria da eficiência em quatro eixos /vértices prioritários, nomeadamente 1) a economia, 2) o ambiente, 3) a sociedade e 4) a funcionalidade dos produtos e serviços.

Visando estes objetivos, foi desenvolvido um modelo de

atuação, definido por três níveis distintos que se interligam formando uma abordagem holística. Este modelo compreende um nível relacionado com o desenvolvimento do negócio, integrando a geração de riqueza e valor na sua estratégia. Um nível relacionado com a gestão do projeto, atuando na transposição das necessidades do negócio e dos clientes/utilizadores, e por último, um nível operacional, ligado à atividade projetual.

O modelo é operacionalizado através de um *toolkit*, desenvolvido e validado por um grupo de especialistas internacional no âmbito desta investigação. O *toolkit* de Design para a Economia Circular contempla um conjunto de ferramentas práticas, alinhadas com o processo criativo que visa promover. Constitui-se também como uma ferramenta didática para apoiar os designers no projeto e na identificação e desenvolvimento de soluções inovadoras e circulares.

Como referido, o *Rounding the Vertices – Toolkit for circular design* desenvolvido visa orientar o projeto ajudando na sua definição e planeamento, na identificação de opções de melhoria e na identificação de ideias para desenvolver novas soluções. Permite ainda validar e demonstrar o desempenho de circularidade do processo de Design realizado e dos seus resultados. Este recurso é composto por quatro ferramentas que se complementam, a saber:

A **ficha de definição do projeto** que se traduz numa ferramenta que apoia o início do projeto e a definição do que é necessário desenvolver. Facilita o processo de recolha e análise inicial de informações com base na abordagem estratégica de negócio. Garante que a equipa de desenvolvimento obtenha as informações e orientações necessárias para o desenvolvimento do projeto deste âmbito.

A **ficha de planeamento do projeto** é uma ferramenta que

facilita a definição do trabalho a ser feito e a criação de um roteiro a seguir dentro do projeto para atender aos objetivos definidos. A ferramenta organiza o projeto pela identificação das atividades a realizar, dos recursos necessários para o efeito e da sua duração.

A **Circular Design Mbox** combina o conceito da caixa morfológica e é uma ferramenta a utilizar pelos designers para a criação de soluções a partir de dez princípios de Design para Circularidade e Sustentabilidade. Os dez princípios que compõem a abordagem *Rounding the Vertices* foram selecionados a partir de um processo de pesquisa e da análise de diversas metodologias, ferramentas e diferentes abordagens. Com o apoio desta ferramenta, as equipas de Design podem implementar os princípios de design de forma sistematizada, criando e desenvolvendo novos produtos e serviços na linha pretendida.

Por último, a **Ferramenta de Avaliação da Circularidade** tem como objetivo avaliar o desempenho do projeto de Design e seus resultados, aferindo o modo em como este contribui para a transição que se pretende. Com base no conceito *Rounding the vértices e* através da utilização da ferramenta, o designer pode avaliar a integração da abordagem circular no projeto e validar os resultados do projeto em termos de circularidade.

Tal como já afirmado, o trabalho desenvolvido no âmbito desta investigação foi validado por um grupo de especialistas internacionais que através de workshops e da exploração dos materiais criados, tiveram a oportunidade de experiênciar e testar os recursos desenvolvidos e avaliar de que modo respondiam aos objetivos propostos nesta investigação.

Em conclusão, os materiais resultantes deste projeto, assim como o Modelo de Design para a Circularidade constituem-se

como recursos de apoio à prática projetual que orientam o processo de Design e a integração de estratégias e princípios de sustentabilidade e circularidade no desenvolvimento de novas soluções. Constituem-se também como recursos importantes para a capacitação dos designers e outros profissionais para novos registos profissionais, através de, entre outros, conteúdos didáticos que complementam as ferramentas desenvolvidas e os ajudam a um exercício projetual mais circular e já num novo paradigma.

keywords

Industrial Design; Design tools; Conscious Production and Consumption; Circular Economy; Behavior Change; Sustainability.

abstract

The evolution of society and the increase in consumption of products to meet more and more consumer needs is taking society to a breaking point that, if surpassed, will hardly have a return, jeopardizing the future generations.

Since the mid-1970s, it has been realized that the current model is unsustainable and that a new approach to production and consumption is needed towards a more sustainable society with added value for all stakeholders in the value chain.

In this context, designers have a fundamental role in the development of innovative and sustainable solutions that meet the needs of both consumers, producers, and society in general.

Currently, the Circular Economy is seen as an approach to Sustainability with great potential for success and which is being the target of numerous research and development projects and initiatives, of practical application in companies, public funding, and education. However, despite all efforts in this direction, there is still a large gap between theory and practice. There is a need to support the practice of Design with methods and tools that allow the transposition of circularity strategies in the development of effective solutions that result in sustainable and circular products and services adjusted to the needs of all actors

involved in the value chain.

In order to meet these needs, the research carried out in this PhD Thesis resulted in the development of the Rounding the vertices, Design for the Circular Economy toolkit, which includes a set of practical implementation tools, aligned with the Design process and which is also a didactic tool to support designers in their projects and in the identification and development of innovative and circular solutions for projects.

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Abbreviations and acronyms

B2B – Business to Business

BAT – Best Available Technics

BCSD – Business Council for Sustainable Development

C2C – Cradle to Cradle

CE – Circular Economy

CSR – Corporate Social Responsibility

DfS – Design for Sustainability

EEA – European Environmental Agency

EMF – Ellen MacArthur Foundation

EoL – End of life

EPD – Environmental Product Declaration

EPR – Extended Producer Responsibility

ERDF – European Regional Development Fund

ESG – Environmental, Social, and Governance

GHG – Greenhouse gas emissions

GRI – Global Reporting Initiative

GPP – Green Public Procurement

IADE – Faculdade de Design Tecnologia e Comunicação da Universidade Europeia

ISO – International Organization for Standardization

LCA – Life Cycle Assessment

LCC – Life Cycle Costing

LCT – Life Cycle Thinking

LNEG – National Laboratory of Energy and Geology

MIPS – Material Intensity per Service

PAEC – Portuguese Circular Economy Action Plan

SDG's – Sustainable Development Goals

SDI – Sustainable Development Index

UNEP – United Nations Environment Programme

Glossary

Circular Economy

The Circular Economy is a system that is restorative and regenerative by intention and Design, which maximizes ecosystem functioning and human well-being with the aim of accomplishing sustainable development. It replaces the end-of-life concept with closing, slowing and narrowing the resource flows in production, distribution and consumption processes, extracting economic value and usefulness of materials, equipment and goods for the longest possible time, in cycles energized by renewable sources. It is enabled by Design, innovation, new business and organizational models and responsible production and consumption (Rocha et al. 2020).

Closed Loops

System in which products, components or materials are reused or recycled into the same, similar or different products, components or materials with minimal loss of quantity, quality or function (British Standards [BSI], 2017).

Closing resource loops

Is to close the loop between post-use and production through e.g recycling or reuse. Closing the loop in terms of resources is fundamental to attaining a circular model. A circular flow of resources can be achieved through recycling, by closing the loop between post-use and production (Bocken et al, 2016).

Cradle to cradle design principles

Cradle to Cradle design principles were defined and promoted in the book “Cradle to Cradle: Remaking the Way We Make Things” (McDonough & Braungart, 2002), and provide guidance to product development in five key categories:

Material Health – Chemicals and materials used in the product are selected to prioritize the protection of human health and the environment, generating a positive impact on the quality of materials available for future use and cycling.

Product Circularity – Products are intentionally designed for their next use and are actively cycled in their intended cycling pathway(s).

Clean Air & Climate Protection – Product manufacturing results in a positive impact on air quality, the renewable energy supply, and the balance of climate changing greenhouse gases.

Water & Soil Stewardship – Water and soil are treated as precious and shared resources. Watersheds and soil ecosystems are protected, and clean water and healthy soils are available to people and all other organisms.

Social Fairness – Companies are committed to upholding human rights and applying fair and equitable business practices

Design for a Circular Economy

Design for Circular Economy is the Design and development of products, services and product-service systems that replace the conventional end-of-life concept by closing, slowing and narrowing the resource flows in production, distribution and consumption processes. It is enabled by innovation and novel business and organizational models and aims to accomplish sustainable development through maximising ecosystem functioning and human well-being, and through responsible production and consumption (Rocha et al. 2020).

Design for all

The Design of mainstream products and/or services that are accessible to, and usable by, as many people as reasonably possible (...) without the need for special adaptation or specialised Design (British Standards [BSI], 2005).

Dematerialization

Delivery of a function with no or reduced requirement for materials, often by a move from a physical to a digital alternative (BSI, 2017).

Design for Sustainability

Design for Sustainability is the Design of products that are sustainable throughout their lifecycle. It is a holistic Design approach that enables the integration and assessment of the Sustainability dimensions in different stages of the product or product-service development process aiming to not diminish or damage the available natural resources throughout the product's life cycle (Rocha, C. S., Antunes, P., & Antunes, P. 2019; Ameta, G. 2009).

Downcycling

The process of converting secondary raw materials/by-products into new materials, components or products, typically of lesser quality, reduced functionality and/or lower value compared to their original intended purpose, it's a process of recycling something in such a way that the resulting product or material is of a lower value than the original item (BSI, 2017; Merriam Webster, n.d.).

Ecodesign

The integration of environmental aspects into the product development process, by balancing ecological and economic requirements. Ecodesign considers environmental aspects at all stages of the product development process, striving for products that make the lowest possible environmental impact throughout the product life cycle (BSI, 2017; European Environmental Agency [EEA],2017).

Environmental product declaration (EPD)

EPDs signal a manufacturer's commitment to measuring and reducing the environmental impact of its products and services and report these impacts in a hyper-transparent way. With an EPD, manufacturers report comparable, objective and third-party verified data that show the good, the bad and the evil about the environmental performance of their products and services (*International EPD System | EPD International*, n.d.).

Greenwashing

An attempt to make people believe that your company is doing more to protect the environment than it really is, an attempt to make a business seem interested in protecting the natural environment when it is not *(Cambridge Dictionary, n.d.)*

Inclusive Design

The Design of mainstream products and/or services that are accessible to, and usable by, as many people as reasonably possible (...) without the need for special adaptation or specialised Design (BSI, 2015)

Life cycle

Consecutive and interlinked stages of a product or service system, from Design, acquisition of raw materials, production, distribution, use and end of life management. It's the series of changes that a product, process, activity, etc. goes through during its existence *(*BSI, 2017*; Cambridge Dictionary, n.d.)*.

Life cycle thinking

Life Cycle Thinking (LCT) is about going beyond the traditional focus on the production site and manufacturing processes to include environmental, social and economic impacts of a product over its entire life cycle. The main goals of LCT are to

reduce a product's resource use and emissions to the environment as well as improve its socio-economic performance through its life cycle (*Life Cicle Initiative*, n.d.).

Narrowing resource loops

Narrowing the resource loops is linked to the efficiency and optimization achieve through using fewer resources per product unit (Bocken et al 2016).

Planned obsolescence

All techniques by which an organization seeks to deliberately limit product lifetime in order to increase the replacement rate (BSI, 2017).

Product system

Collection of unit processes with elementary and product flows, performing one or more defined functions, and which models the life cycle of a product (International Organization for Standardization [ISO], 2006).

Product–service systems

A business model combining both products and services and using results as a basis for innovation

A Product-Service System starts from the premise that companies must offer the function of the product, not the product itself. This concept is maturing concerning the real needs of the consumer, who does not necessarily want to own things, but to benefit from using them (BSI, 2017; *Product Discovery: Product-Service Systems and the Future of Products*, 2021).

Slowing resource loops

Slowing resource loops is achieved through the extension of the life cycle of a product. This can be done through the Design of long-life goods, product-life extension, or intensification of the utilization period of products (Bocken et al. 2016).

Project

A temporary endeavour undertaken to create a unique product, service or result (*Project Management Institute | PMI*, n.d.).

Social innovation

Social innovation can be seen as a process of change emerging from the creative re-combination of existing assets (social capital, historical heritage traditional craftsmanship, accessible advanced technology) and aiming at achieving socially recognized goals in new ways (*DESIS Network*, 2019)

Sustainable Consumption and Production

Sustainable consumption and production is about doing more and better with less. It is also about decoupling economic growth from environmental degradation, increasing resource efficiency and promoting sustainable lifestyles. It refers to "the use of services and related products, which respond to basic needs and bring a better quality of life while minimizing the use of natural resources and toxic materials as well as the emissions of waste and pollutants over the life cycle of the service or product so as not to jeopardize the needs of future generations". (*Goal 12: Ensure Sustainable Consumption and Production Patterns*, n.d.; *Sustainable Consumption and Production Policies*, n.d.)

Sustainable Development Goals, SDGs

17 goals established by the United Nations in 2015 and adopted by all United Nations Members to support the global sustainable development towards 2030 that provides a shared blueprint for peace and prosperity for people and the planet. These are an urgent call for action by all countries – developed and developing – in a global partnership (*THE 17 GOALS | Sustainable Development*, n.d.)

Upcycling

Process of recycle materials or products in such a way that the resulting new materials, components or products, are of better quality, improved functionality and/or a higher value (BSI, 2017; Merriam Webster, n.d.).

Introduction

Context of the research

Sustainability is a leading concept defined in the Brundtland Report in 1987 as a development model that "*responds to the needs of the present without compromising the ability of future generations to meet their own needs*" and has evolved and been a widely promoted, disseminated and exploited (Brundtland, 1987, p.16) as a strategy to improve our society.

The Design practice plays a key role in the definition of the environmental profile of products and services. The materialization of ideas in Design solutions and placement of products and services in the market, available for society can have huge impacts and it is at the Design stage, through the definition of the characteristics and features that about 80% of the environmental and social impacts of a product are defined (*Sustainable Product Policy*, n.d.)., the solutions developed and adopted by the designer have a high influence in the definition of the profile of the product and hat happen in all stages of the life cycle (Tischner, 2016)

The environmental and social concerns and the impacts in the society and the environment in relation with the Design activities had already received attention, as defended by Victor Papanek in his famous publication "Design for the Real World" (Papanek, 1971) and have been explored widely.

Since the 1990s, the integration of environmental considerations in product development with the objective of optimizing products by reducing their impacts throughout their life cycle has been the subject of research, development of methodologies, training, demonstration and implementation in companies. It's also widely known that all products and activities have impacts on the environment, which may occur at all stages of their lifecycle, from raw material extraction and processing, to manufacturing, distribution, use, and end-of-life.

Today, new challenges are faced by designers and product developers. The role of designers and their practice is recognized as a catalyst and driving force in the transition from the traditional model of take-make-dispose to achieve a more restorative, regenerative and Circular Economy. To meet the need for a Circular Economy, products need to be designed and redesigned aiming to closed loops, maintaining materials, components and products in use and adapted to generate revenues (Moreno et al., 2016). The Design practice oriented towards Circular Economy and Sustainability, as Design in a broader sense, has the aim and responsibility of meeting the users, businesses and society needs, responding to product,

service and system problems, by promoting the integration of various criteria and expertise in problem-solving in a systematic, innovative, efficient and sustainable way.

Aiming to Sustainability, the designer has the function of translating the strategies and concepts of circularity into the Design process to promote the transition from the traditional linear model based on an intensive consumption of resources to a circular model focused on closing resource cycles, on the efficiency and Sustainability of the system. However, to support an effective transition, there is a need to capacitate Design practitioners, business stakeholders and product developers with knowledge, recommendations, and practices of how to rationalize, operate and apply specific Design strategies for different circular business models and results (Moreno et al., 2016).

The value chains are directly influenced by the Design of products and services. Within a Circular Economy approach, the establishment and creation of new value chains, more sustainable and more effective, inevitably imply important changes in the practice of Design and despite the importance and recognition of the role of designers as fundamental actors in the promotion of Sustainability, there are still numerous barriers to its implementation in practice within companies and businesses (De los Rios & Charnley, 2017; Prendeville et al., 2013).

Several research and development projects and activities have been carried out all over the world, however, their impact on society is still low, and most of the literature available is academic or from industrial examples mostly from business-to-business (B2B) level (De los Rios & Charnley, 2017).

In recent years, the fast evolution of the concept lead to the development of numerous initiatives, research projects, methodologies and tools to support companies in their path towards more sustainable growth. These initiatives have been tested and validated in companies, however, the integration of the Sustainability and a circularity perspective is still seen as an ad-hoc activity, most of the cases with superficial, not substantiated, and with a low level of engagement. In many examples, companies enrol in these projects and development processes with the main objective of using it as a marketing resource for the promotion of the product and the company, and in several cases, unfortunately, it is linked to greenwashing results (Alves et al 2011). The constant evolution and increase in the importance of the topic, mainly in the academic and research fields resulted, in the development of numerous examples of research activities, literature, web-based platforms

and repositories to support companies in process of integration and transition for circularity, however as mentioned by Dekoninck et al., (2016), there is a lack of results, and few examples reporting on success cases resulting from the practical application in companies are available.

In this sense, the transition to a more sustainable way of Design, production and consumption is a crucial goal for the development of society (Bhamra & Lofthouse, 2007; Braungart & McDonough, 2009; Manzini & Vezzoli, 2010; Margolin, 2014; Pereira, 2021). In 2015 the European Commission adopted and published an ambitious Circular Economy Package (European Commission, 2015) to support European businesses and consumers to enrol in the transition to Circular Economy, a new approach to consumption and production where resources are used in a more sustainable and innovative way.

The plan set a group of actions that were developed aiming to “closing the loop” of the resources and product flows, considering their life cycles and promoting the extension of the lifespan of products, increasing the reuse of materials and products, promoting effective recycling, with benefits for both the environment and the economy. The plans aim to extract the maximum value and use of all raw materials, products, and waste, promoting energy savings and reducing greenhouse gas emissions. The plan has a strong lifecycle perspective covering the full lifecycle: from production and consumption to waste management considering and promoting new business models, such as the market for secondary raw materials, product -services systems, and other innovative solutions.

In Portugal, the Portuguese version of the plan, the National Action Plan for the Circular Economy was published by the Portuguese Council of Ministers (PAEC, 2017) was published in December 2017. The plan was part of the strategy to be followed up to 2020 and aimed to redefine the concept of end-of-life of the traditional linear economy, based on the production and elimination of waste, focusing on the concepts of reuse, repair, and renovation of products, materials and energy.

The Portuguese version of the document aligned with Portugal's international commitments, such as the Paris Agreement, the Sustainable Development Goals, and the European Union sets a strategic model for growth and investment based on efficiency and value of resources and minimization of environmental impacts.

The commitment of Europe in the transition to circularity is a continuous process, and in March 2020, the European Commission launched a new action plan, (European Commission,

2020), built on the actions and initiatives implemented since 2015 and provides a future-oriented agenda for achieving a cleaner and more competitive Europe in co-creation with economic actors, consumers, citizens and civil society organisations, aiming to accelerate the transformational change required by the European Green Deal (European Commission, 2019a).

Within the Circular Economy packages and the objectives defined at the European level and adopted by the European countries, Design plays a crucial role and is one of the instruments and expertise that supports the implementation of a Circular Economy. Within the plan, Design is mentioned and promoted through concrete actions. The Design professionals involved in the development of new products and services should seize the momentum to promote their activity and their role in the transition and add value to its activity and its results.

Motivations

The world as we know it is changing drastically and fundamental and structural changes are taking place worldwide in the way society is producing and consuming products and services, and industries are facing increasing pressures from economic crises, resource scarcity, and pollution (De los Rios & Charnley, 2017). The Circular Economy concept is gaining attention in Europe and around the world and is seen as a potential way for society to increase prosperity while reducing dependence on primary materials and energy (Ellen MacArthur Foundation [EMF], 2015).

The current Circular Economy concept, which is built on several schools of thought, such as the functional service economy or performance economy from Walter Stahel; the Cradle to Cradle from William McDonough and Michael Braungart; biomimicry from Janine Benyus; the industrial ecology of Reid Lifset and Thomas Graedel; natural capitalism by Amory and Hunter Lovins and Paul Hawken; and the blue economy systems approach described by Gunter Pauli (EMF, 2015) is a relatively new concept with a tremendous development in Europe which is receiving increasing attention worldwide as a way to overcome the current production and consumption models based in so-called “linear economy” or “take, make and dispose model” that is proved to be inefficient and is based on the over consumption of materials, resulting in the depletion natural resources and destruction of ecosystems.

In the past, several approaches to attain Sustainability were widely explored, and despite the perception of practitioners and the society of the importance and need to adopt it in the production and consumption of products and services, in practice, Sustainability was seen as a complex subject or as an accessory approach, focused on niche markets with low added value (Ferreira, 2003) and in several cases used mainly as a marketing tool. With the Sustainability approach, the ecodesign methodology was seen as a Design practice with potential, with many tools and methods available to support product designers in their practice, but the actual application of ecodesign has not reached companies worldwide, mainly due to difficulties in implementation and management (Pigosso, et al., 2013).

As explained before, the transition to the Circular Economy and the need to empower the designer's community, supporting their practice with knowledge, guidance and resources for the development of successful projects aiming at sustainable and circular solutions that promote the well-being of the society today and in the future are the main motivations to develop this research.

This research, developed within the scope of the doctoral Thesis carried out at IADE, Universidade Europeia, is the result of more than 20 years of experience in which the author has developed his activity in the field of research in Design and Sustainability.

Having started his career focused on the development of ecodesign methodologies and tools for a systemic implementation in practice, the work presented in this Thesis, oriented towards Design in the context of the Circular Economy, is aligned with its path and evolution in the face of the evolution of society.

The problem addressed

In the current context of transition to the Circular Economy, it is intended that Design and the professionals engaged in the development of products and services act as catalysts for this paradigm shift. The Circular Economy, despite the importance and relevance it is having at the global level, must be materialized in practical solutions available to society. The change from theory to practice, which represents a key factor in this transition, needs the support of methodologies, resources and knowledge of the entire value chain, concrete knowledge of the link between products and services and their underlying business models, as well as its

societal infrastructure and governance determining their lifecycle, is fundamental. This holistic approach requires changes in the production and consumption system, going well beyond resource efficiency and waste recycling.

Designing products and services in a smarter, more efficient and more innovative way, extending their useful life and changing their influence and relation within the system is crucial to the achievement of that transition (European Environment Agency [EEA], 2017). Therefore, the problem we are addressing in the current research is how to develop a new strategy and practice, supported by improved methods and effective tools for designers.

Structure of the Thesis

The Thesis was designed from the beginning as an evolutive product that was created, developed and adapted along with the conducting of the research that supports the results developed to improve the Design practice and methods towards circularity.

The documents consist of nine main parts:

In the first part of the document, which is the introduction, the context of the research, the main motivations and objectives for undertaking the current research and the definition of the problem that was addressed and explored are explained.

Chapter 01 – in this chapter, the research Design and methodology defined to structure the research are explored. Here the introduction, the objectives and the research structure are addressed.

Chapter 02 – This chapter is composed of a review and definition of Circular Economy and Design, where the concepts are explored and defined within the research context and the state of the art of Circular Economy in Portugal is addressed.

Chapter 03 – The identification of the perspectives and perception of Circular Economy and Design from experts, users and the general society points of view are addressed in this chapter.

Chapter 04 – Explores the identification of tools that are available to support the Design practice for Circular Economy and are developed and applied in several contexts.

Chapter 05 – Aiming to define a set of Design principles for Circular Economy, the chapter includes an extensive review of the principles, strategies and criteria used to support a Circular Economy, Sustainability and Design developed by relevant authors, and the definition of 10 Design principles that are applied later in the toolkit to support the circular Design practice.

Chapter 06 – This chapter explores the development and definition of the Design model and development of a toolkit created to help designers and product developers in the integration of circularity aspects in project development.

Chapter 07 – Presents the process and activities held to validate the model and toolkit by experts that are implementing Sustainability and Circular Economy in the daily activities of research, academia, and businesses.

The final part of the document includes the Conclusions of the research and Future Work defined to explore the results achieved.

References and annexes are also included at the end of the document.

1. Research Design and Methodology

1.1 Introduction

In the context of Design for the Circular Economy, this chapter presents the structure developed, the methodology, and planning outlined as guiding elements of the research process.

This initial chapter therefore serves to present the scope as well as the objectives, the research questions issues and the hypothesis to which all the research work intends to respond in order to provide designers with instruments that promote their activity in the context of the transition to the circular economy and sustainability.

1.2 Objectives

The current research project was designed and developed having as the main objective to support the transition to a more sustainable and Circular Economy through Design, contributing to a more sustainable and resilient society today and for the future.

Design, through its impact and influence at all levels in society, has a crucial role in shaping and defining the characteristics of the products and services that meet the needs of the society and their impacts in the life cycle.

The Circular Economy approach is seen in the current context as the potential successful path to achieve a sustainable future. The transition from the linear model to a new economic model operating in closed and more efficient loops (Figure 1), catalysed by innovation along the entire value chain, is advocated as an alternative solution to minimize global impacts, material consumption and energy losses (Ministério do Ambiente e Ação Climática, n.d.). And within this new approach, designers must have the knowledge and the tools to leverage the process (Vicente, 2012), and be engaged in this process.

Therefore, this research project aims to identify, explore and develop an effective strategy supported by improved methods and tools which will be easy to apply in practice, in order to promote the transition to a Circular Economy through Design.

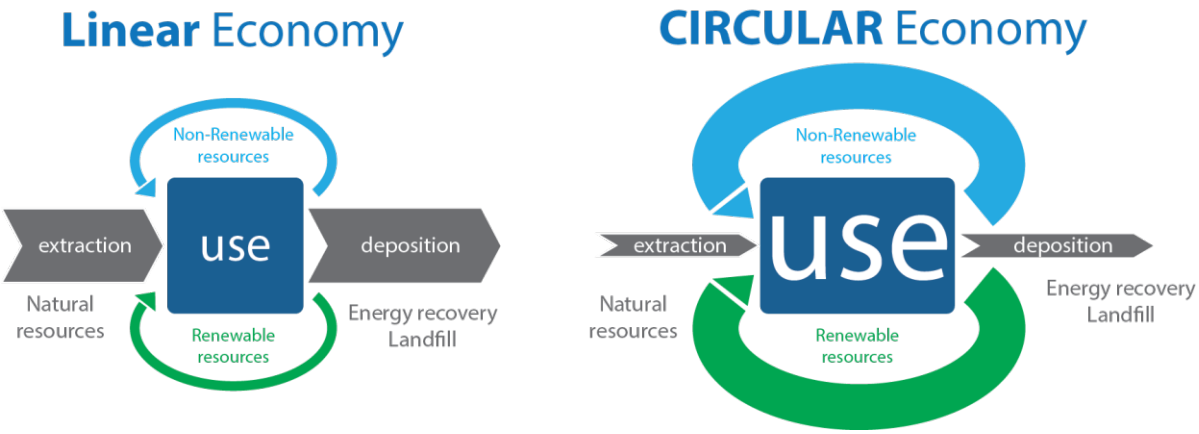

Figure 1 – Transition from the linear model to Circular Economy (PAEC, 2017) – Adapted

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1.3 Research questions and hypothesis

Aiming to promote and increase knowledge in the fields of Design for Sustainability and Circular Economy through Design, 4 research questions were established to guide and support the research, these are:

- How will Design support the transition from the linear economy to the new model of Circular Economy?
- Which tools can designers apply to support an effective Design practice for a successful transition to a Circular Economy in the real world?
- How can designers overcome the barriers in the implementation of a Design practice that effectively result in more sustainable products and services aligned with the European policies for Circular Economy?
- How can the Design practice and the role of the Design professionals be promoted in a Circular Economy context?

To answer these questions, the research is developed having as central point the role and importance of Design. The Design has the responsibility of responding to the needs and problems related to products or services, by integrating criteria and innovative solutions in problem-solving, meeting the needs of users and the society as a whole. This is a key argument of Sustainability that results from the perception that designers must give a more universal and inclusive response and not only depend on the economic interests of companies or focused on niche markets (Ferreira, 2008).

In the Circular Economy approach, the designer, through its practice, methods, and tools, has the function and capability of translating and applying the strategies and concepts of circularity in the creation and development of new products, services, and systems that promote the transition from a linear model to a circular model.

In this sense, and aiming to promote Design and the role of Design, and demonstrating it to the actors in the products and services value chain, especially the key practitioners and companies, the hypothesis, defined as the base stone and verified by the activities and results attained in the Thesis is:

Design, through its specific methods and tools, is an important factor for an effective transition to a Sustainable Circular Economy.

1.4 Contributions of the study

The authors, based on their experience and previous knowledge, were convinced since the beginning of the research that the study will add value to the Design practice in the areas of Design, Sustainability and Circular Economy at business and educational levels.

From the beginning of the process, the research carried on aimed to analyse the needs related to promoting and supporting the transition to a Circular Economy by developing a strategy to promote an effective application of the Design practice, supported by methods, guidelines and tools, increasing the knowledge and contribute to a more sustainable and Circular Economy, aligned with the needs of designers and other practitioners, and the needs of the society, today and for the future.

1.5 Research structure

The Thesis and its methodology presented was designed with the objective of supporting the development of a research aiming the creation of added value for the Design professionals and the society. Focusing on the transition to Circular Economy, the results will strengthen the role of Design by providing professionals with a set of resources for innovative and more effective Design practice.

The research structure is composed of three main methodological moments that are linked to the three main steps in the development process (Annex 01).

In the first methodological moment (Figure 2), which results in a systematic analysis and identification of the current state-of-the-art performed through mapping Design and Sustainability practices and the identification of the main drivers and barriers faced by companies, designers, and practitioners. This moment comprises 3 main activities:

- Literature Review. A systematic and methodological review and analysis of the most relevant references published on the subject;
- Benchmarking of methods and tools. A qualitative analysis of the methods and tools available in the literature, internet, result of international research projects, and other sources, that are available for application in the development of sustainable products and services;
- Field research as the primary source of information. Methods and tools applied in practice. Identification of sustainable products that are produced in Portugal and placed in the national or international markets.

The analysis of the tools and methods applied in product development through contact with the designers and producers of a selection of the identified products by questionnaires, phone and face-to-face interviews, aimed to understanding of how sustainable products are developed in Portugal and which tools and methods are applied in practice. This task aimed to the identification of the main motivations, drivers, challenges, barriers and needs faced by practitioners in their daily activities and how the Circular Economy is perceived by the practitioners, however, due to the lack of national products developed and available in Portugal, this task didn't have the expected results in providing useful data.

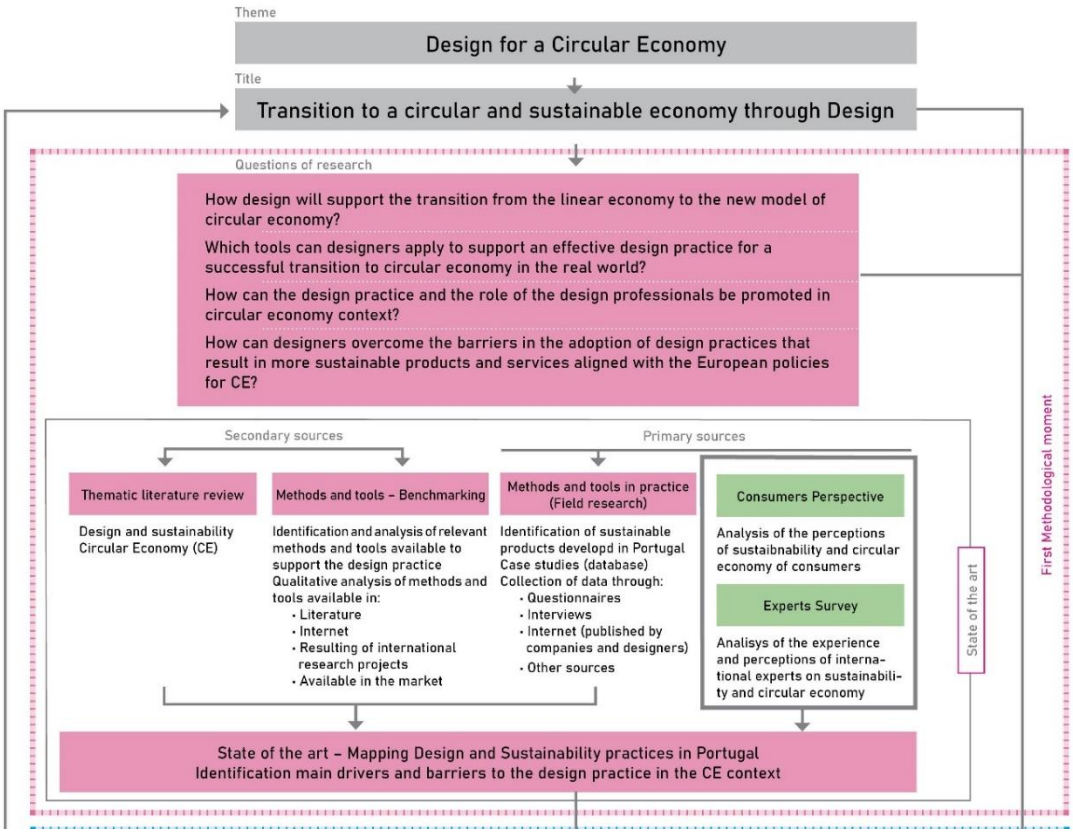


Figure 2 – Research plan – Structure – First methodological moment (design by the author)

The second methodological moment (Figure) focuses on answering to the research questions and verifying if the hypothesis is valid. In this step, it was defined a new strategy and guidelines to improve the role of Design in the transition for a circular and sustainable economy. The strategy for the Design practice within Circular Economy is materialized in a new toolkit that can be applied by practitioners in their activity to develop innovative and sustainable circular solutions.

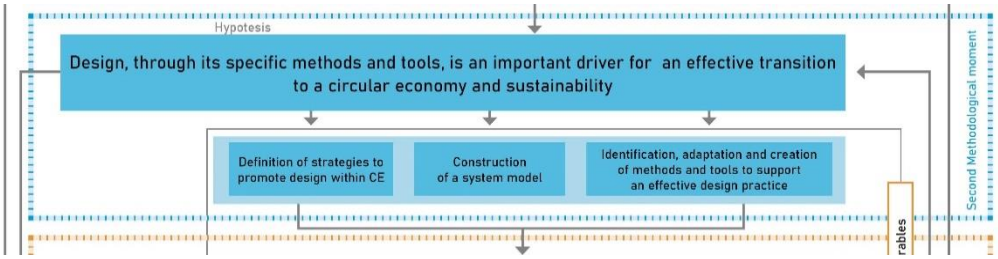


Figure 3 – Research plan – Structure – Second methodological moment (design by the author)

The third methodological moment (Figure 4) is related to the test and validation of the previous research work, namely the model of more sustainable Design activity and the toolkit to support it. The assessment of the proposed Research results was made in workshops with experts from the fields of Design, Sustainability, and Circular Economy through contact with European experts, to discuss, review and validate the results achieved.

The test phase delivered valuable feedback on meeting the needs and showing the practicability, benefits and innovation potential of the results.

This evaluation activity was held by focus groups in workshops with experts in several fields related to the topic to discuss, test and validate the results of the research.

The interaction with experts gave an insight on the status and potential for implementing Circular Economy strategies and input on how to meet current and future designers needs to support them on the transition towards Circular Economy.

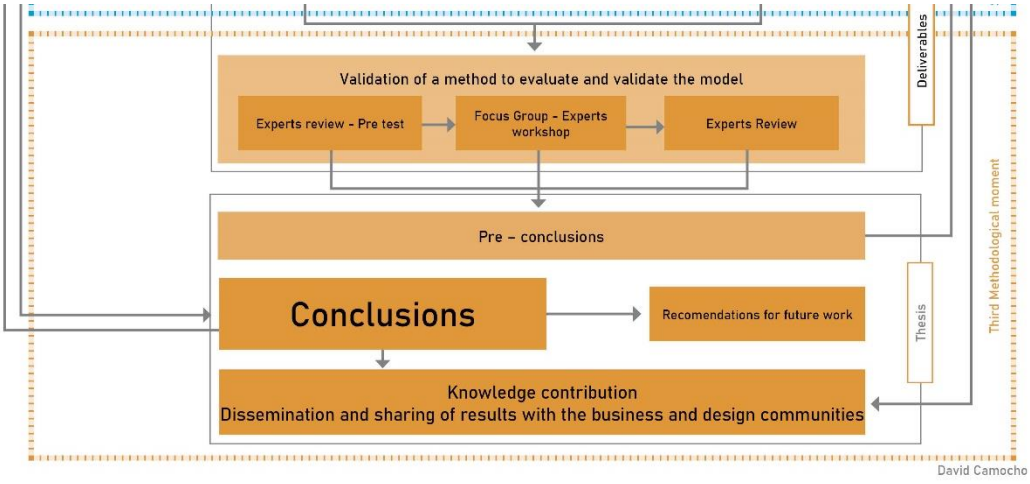


Figure 4 – Research plan – Structure – Third methodological moment (design by the author)

Based on the previous moments, the research team developed the conclusions of the research, which by answering the research questions and validating the hypothesis, increases knowledge and contribute to a more sustainable and Circular Economy, aligned with the needs of designers and companies.

2. Circular Economy and Design

2.1 Overview of Circular Economy and Design

2.1.1 Circular Economy

The wide dissemination and development of the Circular Economy led to an over exploitation of the terminology. In literature, we can find many definitions of the Circular Economy to define this concept that has been widely developed. In this context, several authors and project tend to develop a definition that best suits their interests and the diversity of definitions do not help in the communication and practical implementation of the Circular Economy (Camocho et al. 2018).

The Ellen MacArthur Foundation, an institution that had a major role in the dissemination and development of the Circular Economy has one definition that is widely known, however many others were published and are available. Back in 2017, an article analysed 114 definitions of Circular Economy and concluded that there is not one coherent understanding or definition of Circular Economy (Kirchherr et al., 2017), and from 2017 till now, many other definitions emerged.

On what concerns this current research the author considers that the definition developed and published by the international consortium of the project KATCH_e (KATCH_e, 2019a), in which the author collaborated, meet the needs of the research. The project is based on the reinforcement of the Design skills and competencies in the field of product-service development for the Circular Economy and Sustainability. Within the project, the consortium developed a definition inspired on several definitions and concepts from the main key players on Circular Economy.

"Circular Economy is a system that is restorative and regenerative by intention and Design, which maximizes ecosystem functioning and human well-being with the aim of accomplishing sustainable development.

It replaces the end-of-life concept with closing, slowing and narrowing the resource flows in production, distribution and consumption processes, extracting economical value and usefulness of materials, equipment and

goods for the longest possible time, in cycles energized by renewable sources. It is enabled by Design, innovation, new business and organizational models and responsible production and consumption" (Rocha et al. 2019, p.3).

2.1.2 Design for Circular Economy

The transition from the traditional linear and non-sustainable approach to the Circular Economy has to be in an integrated and holistic approach on which all value chain has to contribute. The production and consumption system needs to change in innovative and sustainable ways, in which the Design makes an important contribution. Design, according to its nature, plays a key role in the definition of the features and the profile of products and services (Bhamra & Lofthouse, 2007; Braungart & McDonough, 2009; Manzini & Vezzoli, 2010; Margolin, 2014) available in the society that, according to recent studies, is less than 9% circular (De Wit et al., 2019). In response to the needs of society, designers must integrate Sustainability and circularity criteria and their know-how in problem-solving innovatively, adjusted to the needs of users, businesses, and society's dynamics (Ferreira, 2008). Is in the interface between production and consumption that design takes place. The designer, who works usually for a company, meeting the needs of the business, has to translate the needs of the users or clients for whom the products and services are developed (Tischner, 2016).

The Integration of the circularity aspects and needs in the Design process and the underlying practice can be seen as more challenging and complex, requiring changes in the way of thinking and guiding projects focusing often on new systems based on a shift from product-based solutions to more sustainable and innovative system-based or function-based approaches. In this regard, designers need to align their development process with the Circular Economy approach requirements and to replace the conventional end-of-life concept in which the products lose their value and are disposed of after fulfilling the initial function, by new solutions for closing, slowing and narrowing the resource flows in the product and service systems (Bocken et al., 2016). In their practice, designers need to have the knowledge to apply several strategies in the development process focusing on the efficiency and Sustainability of the entire product system (Rocha et al, 2019).

The development of innovative and smart products and services with an extended lifetime and an adjustment of their functions within the system will be crucial to achieving the transition to circularity (Camocho et al. 2018; EEA, 2017).

Society has evolved based on the over-consumption of always new and better goods and services, leading to massive consumption of natural resources and the production of large amount of waste and emissions, (Medkova & Fifield, 2016) and this had been promoted globally by industries and business.

The Portuguese National Action Plan to the Circular Economy, which is a reference document to support the transition to circularity in Portugal, is based on concrete actions to be implemented. In these actions, the Design is referenced all over the document due to its importance in the practical implementation of circularity (PAEC, 2017).

Aiming and promoting an efficient Design practice, there is a need to provide designers and product developers with guidelines, resources and practices to integrate Design strategies for different circular business models (Moreno et al, 2016; Bocken, 2016), and influencing and managing the value chains. The Design practice will be updated given the creation of circular and sustainable value chains that are highly influenced by product and service Design (Camocho et al, 2018; Prendeville et al 2013; De los Rios & Charnley, 2017).

Currently, in the post-COVID19 scenario, society has experienced numerous and radical changes at all levels. The effects of the pandemic have further reinforced the need to create a more ecological and resilient society. Companies, businesses and society must adapt to a new reality, and new revitalization mechanisms must be adopted. The Europe recovery plan (European Commission, 2020) was launched by the European Commission and is focused on measures to revitalize and support organisations. In this context, as mentioned previously Design plays a fundamental role in adapting and creating solutions to new needs that enhance innovation, Sustainability, employment and the creation of value for all stakeholders.

Several strategies for circularity are available to support designers and product developers in creating products and services in a more sustainable way. In chapter 5. Design principles for a Circular Economy, explored the topic in detail. Many approaches from different authors were identified and analysed. Having as an example the principles and strategies published by the Ellen Macarthur Foundation.

The main principles are proposed: (EMF, 2015)

- Preserve and enhance natural capital by controlling finite stocks and balancing renewable resource flows
- Optimize resource yields by circulating products, components, and materials in use at the highest utility at all times in both technical and biological cycles
- Foster system effectiveness by revealing and designing out negative externalities

These three principles are translated into the ReSOLVE framework which considers six actions or strategies that should be adopted by Design (Table 01).

Table 1- RESOLVE framework (EMF, 2015)

Regenerate	Shift to renewable energy and materials; Reclaim, retain, and restore the health of ecosystems; Return recovered biological resources to the biosphere
Share	Share assets (e.g. cars, rooms, appliances); Reuse/second hand; Prolong life through maintenance, Design for durability, upgradability, etc.
Optimize	Increase performance/efficiency of the product; Remove waste in production and supply chain; Leverage big data, automation, remote sensing and steering
Loop	Remanufacture products or components; Recycle materials; Digest anaerobically; Extract biochemicals from organic waste
Virtualise	Books, music, travel, online shopping, autonomous vehicles, etc.
Exchange	Replace old with advanced non-renewable materials; Apply new technologies; Choose new product/service (e.g. multimodal transport)

2.1.3 The Circular Economy context

2.1.3.1 EU action plan for the Circular Economy

A new circular action plan aiming to promote a cleaner and more competitive Europe, was adopted by the European Commission in March 2020.

This new EU action plan (European Commission, 2020) (Figure 5), built on the actions and initiatives implemented since 2015 aligned with the initial Action plan for a Circular Economy. It provides a future-oriented agenda for achieving a cleaner and more competitive Europe in co-creation with economic actors, consumers, citizens and civil society organisations, aiming to accelerate the transformational change required by the European Green Deal (European Commission, 2019a).

Figure 5 – Circular Economy Action Plan

Aiming to a zero-waste policy, the current plan is composed of a set of interrelated initiatives to establish a strong and coherent product policy framework aiming to promote sustainable products, services and business models as the norm to transform consumption patterns.

The expected transition of the European actors to a Circular Economy will reduce pressure on natural resources and will create sustainable growth and jobs.

The new action plan announces initiatives along the entire life cycle of products. It strengthens the role and impact of Design, promotes circular and more efficient processes, encourages sustainable consumption, and aims to ensure that waste is prevented, and the resources used are kept in the loop, and within the European boundaries for as long as possible.

The plan introduces legislative and non-legislative measures bringing real added value for Europe, as such:

- Make sustainable products the norm in the EU,
- Empower consumers and public buyers,
- Focus on the more resource-intensive sectors and where the potential for circularity is high such as electronics and ICT, batteries and vehicles, packaging, plastics, textiles, construction and buildings, food, water and nutrients,
- Promote a zero-waste approach,
- Make circularity a global approach, focusing on people, regions and cities,
- Lead global efforts on Circular Economy.

2.1.3.2 Ellen MacArthur Foundation

Currently, the most known reference for Circular Economy, the Ellen MacArthur Foundation was founded on 23 June 2009 and publicly launched on 2 September 2010 by Dame Ellen MacArthur (EMF, 2015).

The Foundation develops its extensive work in Education and Training, Business and Government, Insight and Analysis, Systemic Initiatives and Communications, with the mission of accelerating the transition to a Circular Economy by developing and promoting the concept.

The Foundation works with, and inspire, business, academia, policymakers, and institutions to mobilise systems solutions at scale, globally with the vision of a new economic system that delivers better and more sustainable outcomes.

The approach is based on business models, products, and materials that are designed to increase the use and reuse, following the natural principles, replicating natural processes where nothing becomes waste and everything has value, and supporting the transition to the use of renewable energy and materials, in a distributed, diverse, and inclusive way.

The Foundation's work focuses on six interlinking areas:

- Learning, by developing the vision, skills and mindsets needed to support and promote the transition to a Circular Economy,
- Business, by promoting circular innovation and creating the conditions for it to reach scale,
- Insight and analysis, by providing robust evidence about the benefits and implications of the transition,
- Systemic Initiatives, by transforming key material flows to scale the Circular Economy at a global level,
- Communications, by engaging a global audience around the Circular Economy.

The EMF is also the author of the most used and known infographic that illustrates the continuous flow of technical and biological materials through the 'value circle', the Circular Economy System Diagram (Figure 6).

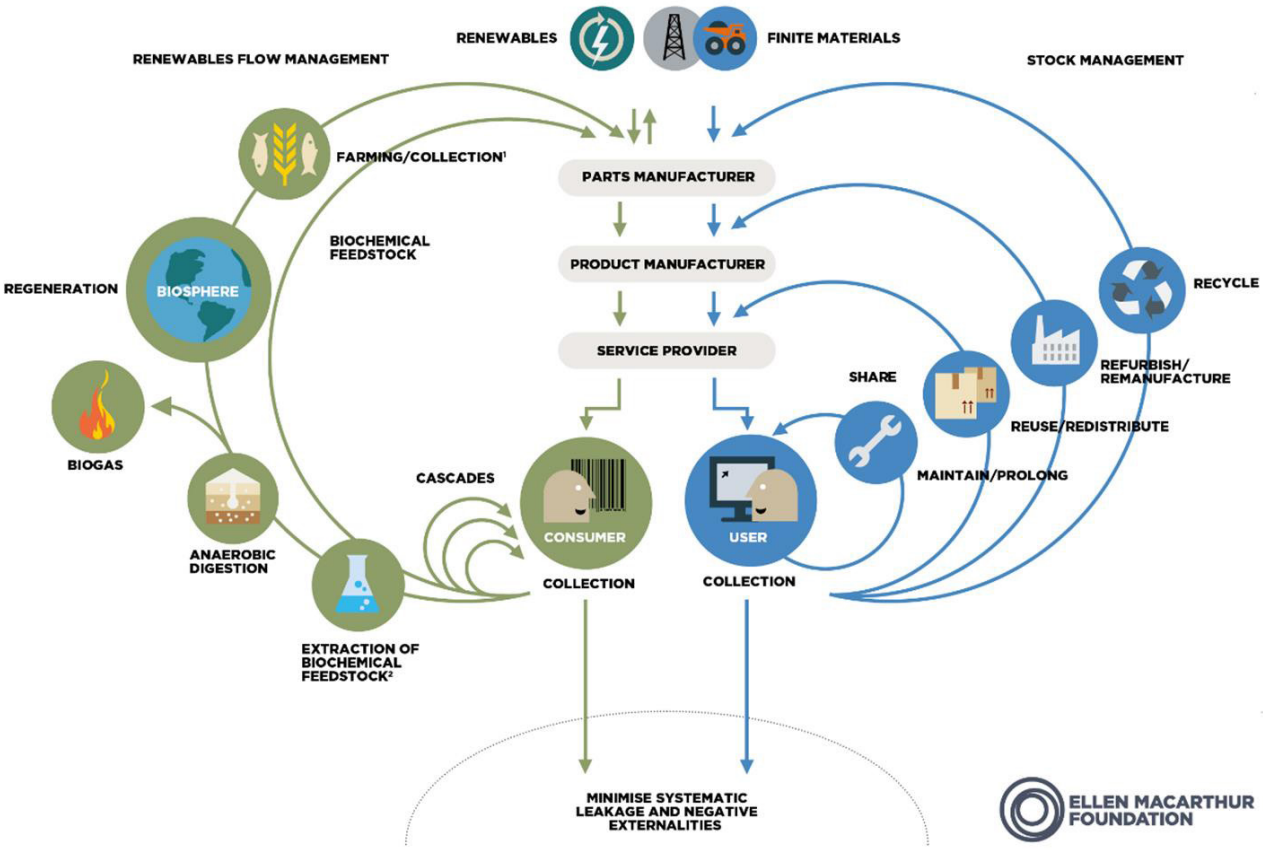


Figure 6 – EMF Circular Economy System Diagram (EMF, 2015)

2.1.3.3 Circular Design project

The ‘Circular Design’ project aiming to promote sustainable production and consumption of products and services in Europe involved thirteen partners including European universities, Design centres and companies from four different regions: Catalonia, Ireland, Netherlands and Sweden (*Circular Design Project*, n.d.).

Aligned with European policies on the Circular Economy, the project aimed to find common solutions that help minimise the environmental impact of consumption and reduce the use of resources, which requires a new approach in the way societies work.

Figure 7 – Circular Design Project – Logo

Focusing on Design (Figure 7), which has a key role in developing innovative solutions to current challenges – approaches that must consider the needs of end-users and integrate Sustainability criteria in processes and strategies for creating products and services. The main objectives of the project are:

- Increase and improve the learning strategies of Design for Sustainability, by identifying opportunities for sustainable products and services as well as new business opportunities,
- Development of open educational resources and training courses for industry staff and academics in Innovative Design for Sustainability to academics, students and companies,
- Train up innovative and entrepreneurial designers who are capable of dealing with a transition towards Design for Sustainability,
- Promote cooperation and mobility with the EU’s partner countries,
- Establishment of a basis for a permanent and active European Network of Design for Sustainability.

In the resources developed and made available by the project consortium, users can find a useful set of relevant information, such as:

- *Open Educational Resources database*, with a systematized repository of available tools and methods for Design for Sustainability and Circular Economy developed by numerous authors,
- *The Best Practice Publication* with case studies on some of Europe's most interesting projects in Design for the Circular Economy,
- *Digital Fabrication Labs Handbook*, an introductory guide to bring together digital fabrication labs (e.g. FabLabs, hackerspaces, maker spaces, etc.) and the related practices enabled through digital knowledge sharing into Design education for Sustainability and Circular Economy,
- *Professional Development Courses* for Design and Circular Economy,
- *Handbook in Innovative Design for Sustainability*, a "starters guide" for circular Design to help those who want to apply, teach or take the Circular Design Professional Development Course.

2.1.3.4 Cradle-to-Cradle

Cradle to cradle considered as part of the foundation principles of Circular Economy, (EMF, 2015) is a model based on a system of "lifecycle development" developed by Michael Braungart and William McDonough at the Environmental Protection Encouragement Agency in the 1990s.

In their famous book, book Cradle to Cradle: Remaking the Way We Make Things, published in 2002, the authors presented an integration of Design and science that provides enduring benefits for society from safe materials, water and energy in circular economies and eliminates the concept of waste (McDonough & Braungart, 2002). This book has become one of the most influential works of ecological thought worldwide (Ideia circular. n.d.).

The framework developed and promoted in the Cradle-to-Cradle publication, based on nature, identifies three main principles:

- Elimination of the concept of waste. In nature, everything is a resource for something else. The "waste" of one system becomes food for another and this can be promoted by a conscious Design that promotes the development of products with materials that

are safe, efficient and that can be disassembled and reused or reintroduced in nature without contamination.

- Use clean and renewable energy. Design for the use of these abundant resources while supporting human and environmental health.
- Celebrate diversity and respect human and natural systems. Adapt the Design solutions to the challenges and opportunities related to each place, respecting local issues and natural and cultural life.

The book emphasizes also the role of Design as an agent to improve society, acting as a positive and regenerative force in the change of paradigm and increasing the value and innovation of systems.

Cradle-to-cradle (Figure 8), is also a certification standard globally recognized to measure safer and more sustainable products for the Circular Economy (Cradle to Cradle Products Innovation Institute. (n.d.). The Standard requirements are developed through a stakeholder engagement process with input from technical experts, market leaders and the public.

To receive certification, products are assessed for environmental and social performance across five critical Sustainability categories:

- Material health,
- Material reuse,
- Renewable energy and carbon management,
- Water stewardship,
- Social fairness.

The certification has a three levels structure, and a product is assigned an achievement level (Bronze, Silver, Gold, Platinum) for each category.

The standard promotes continuous improvement over time by awarding certification based on ascending levels of achievement and requiring certification renewal every two years.

Figure 8 – Cradle to Cradle logo

2.1.3.5 BS 8001:2017- Framework for implementing the principles of the Circular Economy in organizations

The British Standard (British Standard Institution [BSI], 2017), published in May 2017, provides guidance and recommendations to support organizations and individuals to consider and implement more circular and sustainable practices within their businesses. It proposes improved ways of working, providing more circular products and services or redesigning their entire business model and value proposition.

This standard aims to provide a framework and guidance to a broad range of organizations of differing sizes and with varying levels of knowledge and understanding of the Circular Economy.

The standard is divided into two aspects:

- What is the Circular Economy and why move to a more circular and sustainable mode of operation?
- How to implement the principles of the Circular Economy within an organizational context?

The standard contains:

- A comprehensive list of Circular Economy terms and definitions,
- A set of general Circular Economy principles,
- A flexible management framework for implementing Circular Economy strategies in organizations,
- And a detailed description of economic, environmental, Design, marketing, and legal issues related to the Circular Economy.

2.1.3.6 IEC 62430 – Environmentally Conscious Design – Principles, requirements, and guidance

The IEC 62430:2019 standard (International Electrotechnical Commission [IEC], 2019), developed by the International Electrotechnical Commission, who is an organization that develops and publishes International Standards for all electrical, electronic and related technologies, describes principles, specifies requirements and provides guidance for

organizations intending to integrate environmental aspects into the Design and development in order to reduce the environmental impacts of their products.

The standard applies to processes on how environmentally conscious Design is integrated into the Design and development in any organization, regardless of its size, type or sector.

Having in mind that every product has environmental impacts, and these can occur during all stages of its life cycle, ranging from slight to significant; at short-term or long-term; and may occur at the local, national, regional or global level, the standard aims to minimize these impacts. For this, it is essential to implement an environmentally conscious Design, which is a systematic approach to achieve a reduction of these adverse impacts of a product throughout its entire life cycle.

2.1.3.7 Circularity Gap Reports

Based on the need to measure the Circular Economy performance in the society and the lack of reliable tools and initiatives to understand how can the society move towards the transition to circularity, the Circle Economy initiative (Circle economy, 2018; de Wit et. L, 2019) launched in January 2018 the first Circularity Gap Report in which it is stated that our world is only 9.1% circular, which leads to a huge circularity gap. The publication provided also a framework and data to measure and monitor progress in bridging the global circularity gap.

A second edition was launched in January 2019 which constitute again an important reference with reliable and fundamental information and data regarding the performance of the society.

Currently, the Circularity Gap Reporting Initiative delivers an annual global circularity metric that measures the performance of the world economy and identifies key levers to transition to global circularity, providing also insights into the circularity gap of individual countries and sectors. Till now, 5 editions of the Circularity Gap Report were launched, providing interesting data on the status and evaluation of the Circular Economy in practice (Figures 9 &10).

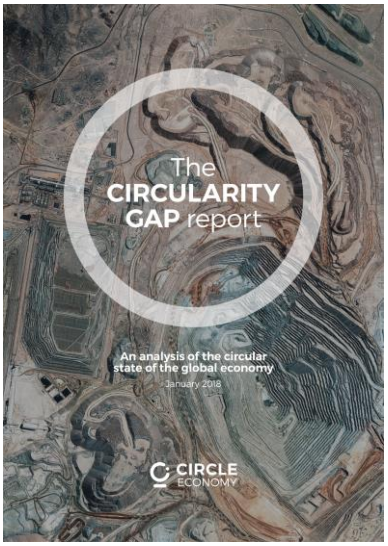


Figure 9 – Circularity Gap Report 2018

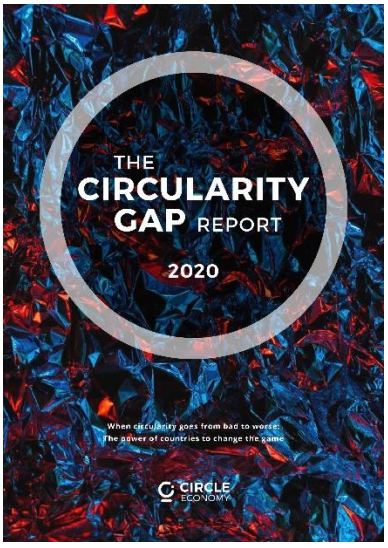


Figure 10 – Circularity Gap Report 2020

2.1.3.8 CIRCO-NL Programme

The CIRCO – Creating Business through Circular Design program (https://www.circonl.nl/) was created in the Netherlands in 2015 and is based on the application of Design and Design Thinking to the development of circular solutions (products, services and business models). The program was developed by the Dutch company CLICKNL and has the support of the Ministry of Infrastructure and Water Management of the Dutch government, and the model is being exploited and shared internationally with the support of the authors through local hubs.

CIRCO accelerates the development of a Circular Economy through a circular Design program that activates and facilitates the implementation of circular business by industrial companies and designers.

The method was crafted from academic frameworks and offers participants circular Design strategies, circular business models and helps to create a roadmap to implement new circular propositions. It is developed around the framework developed by C. Bakker and M. den Hollander, available in the Publication "Products that last" and it's structured in five circular business models and six circular Design strategies. The method includes a defined set of Design tools, inspiring cases and examples and it offers training support and interaction.

The training, structured in 3 main blocks (Figure 11) allows companies to acquire the knowledge and experience to implement circularity in practice.

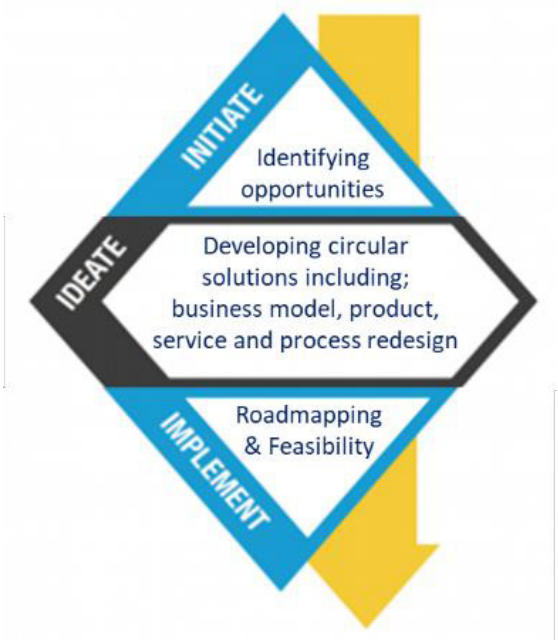


Figure 11 – CIRCO method – structure

It is structured in:

- Initiate – this step is based on Design principles for the Circular Economy, mapping of the value in a linear economy and identification of circular business opportunities for each company.
- Ideate – the circular proposition from the first part is analysed and the most promising is elaborated using the circular Design strategies and business models. This step will

result in the definition of a circular customer proposition with a business model, product re-design and additional services.

- Implement – In this stage, the companies develop a roadmap to plan and implement their business idea. All material processed during the training is documented in a Circular Business Canvas, and the activity ends with a pitch to present the ideas and future work.

The success of the initiative is measured by the high implementation of the results. Around 66% of participants implemented their new circular proposals in practice (Click.NL, 2015).

2.1.3.9 Circular Design guide

The Circular Design Guide (Ellen MacArthur Foundation & IDEO, n.d.) is a collaboration between the Ellen MacArthur Foundation and IDEO that has been co-created in a participatory process including the contribution of ideas to the testing of resources, in an iterative and inclusive Design thinking process, from more than 400 people.

Available at www.circulardesignguide.com, the platform includes a large number of resources available to promote the transition for the Circular Economy.

Besides the practical and user-friendly knowledge base, it includes data on the concept of Circular Economy and a set of methods (Figure 12) to be applied in practice according to the needs of each project.

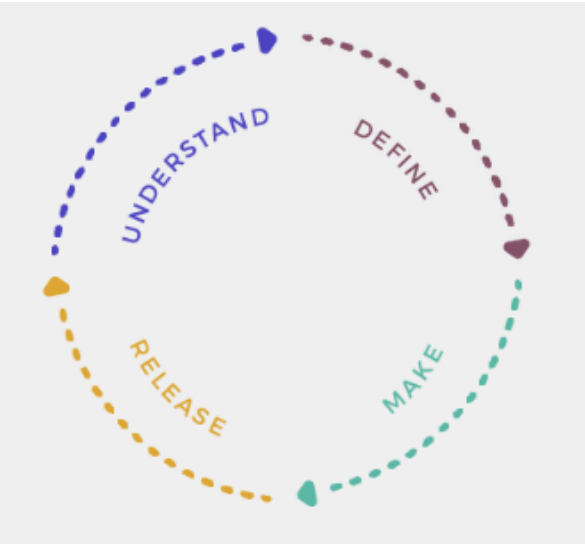


Figure 12 – Circular design guide – Methods structure

The Methods section, display many activities to help users to understand, define, make, and release circular innovations.

For each stage, a set of activities are presented and is explained through theoretical content and short videos in a step-by-step approach. A downloadable document is available to promote better use of the developed resources. Examples and cases studies are also available to illustrate the potential of the adoption of the methods.

The platform includes also a section on mindset, promoting the reflection and the rethinking of system, process and products, a section with illustrative stories and a large resource centre with resources for workshops, worksheets, videos, useful links, case studies and a glossary.

2.2 Circular Economy in Portugal

2.2.1 National Action Plan for Circular Economy

The Action Plan for the Circular Economy in Portugal (PAEC, 2017), approved by Resolution of the Council of Ministers No. 190-A / 2017, of 23 November, aims to define a national strategy for the Circular Economy based on production and elimination of waste and the concepts of reuse, renovation and renewal of materials and energy.

This Plan called "Leading the Transition" embodies a national strategy with the objective of promoting the change of the economic paradigm from "linear" to "circular", encompassing a set of seven concrete actions to be fulfilled and which aim to accelerate this change, but simultaneously promoting job creation, economic growth, investment and social justice:

- **Design, Repair, Reuse: an extended producer responsibility**.

  With the goals of increasing the reuse of products, reducing the production of waste and moving towards a Design of products with multiple useful lives (less obsolescence).

- **Promote a circular market**

  With the objective of analysing the economic and environmental potential of the progressive introduction of instruments that support sustainable production and

consumption, encourage the financial sector to capture investment opportunities for the Circular Economy and promote the adoption by the productive sector of the principles of circularity.

- **Educating for a Circular Economy**

  With the objectives of establishing a collaborative, strategic and cohesion commitment in the construction of environmental literacy in Portugal materialized through the National Strategy for Environmental Education (Estratégia Nacional de Educação Ambiental [ENEA], 2017), considering the pillar of the Circular Economy, Educating citizens for environmentally conscious choices of goods and services and, sensitize society about the consequences in the conditions of the ocean of choosing goods and services that do not consider environmental impacts.

- **Food without leftovers: sustainable production for sustainable consumption**

  With the objectives of knowing and monitoring the national reality in terms of food waste in the value chain, reducing the production of waste and increasing the productivity of the value chain; with a higher focus in the sectors related to the food industry, contributing to the conservation of natural resources and contributing to the education of the producer/consumer.

- **New life to waste!**

  With the objectives of increasing the introduction of secondary raw materials in the economy, reduction of waste production, reducing costs for companies, and promoting the minimization of the extraction of natural resources

- **Regenerate resources: water and nutrients**

  With the goals of improving water efficiency, increasing water reuse, improving the recirculation of nutrients and organic matter through their natural cycles.

- **Research and innovate for a Circular Economy**

  With the objectives of defining key research and innovation areas for the acceleration of the Circular Economy in Portugal, defining, developing and enhancing competencies for the identified areas and identifying and enhancing knowledge networks in the Circular Economy.

The Portuguese National Action Plan, in which Design is presented as one of the main drivers for the transition to circularity, presents 3 levels of actions, namely:

- Cross-cutting and national actions (macro actions),
- Sectoral agendas, especially for sectors that are more resource-intensive and export-oriented,
- Regional agendas, to be adapted to the socio-economic specificities of each region (micro-actions).

2.2.2 Portal Eco.nomia

The ECO.NOMIA portal (https://eco.nomia.pt/) is a knowledge-sharing platform developed under the Ministry of Environment's action plan. The portal is a key element in the national panorama and actively contributes to the transition to the Circular Economy, constituting an important repository of knowledge for public institutions, companies and the community, and as an interaction platform for the development of new projects and also an important source of inspiration.

The portal (Figure 13) is a dynamic platform in constant evolution and updating and counts on the collaboration of several entities, mainly linked to Design, science and technology, business sectors, logistics, final consumer and waste management actors, in the construction and sharing of knowledge.

With a simple and user-friendly structure, it contains relevant information about the Circular Economy, about the concept, strategies and policies, includes a vast repository of examples and case studies related to the Circular Economy, funding opportunities, relevant resources and events. All these resources are available to everyone, and the platform is updated regularly.

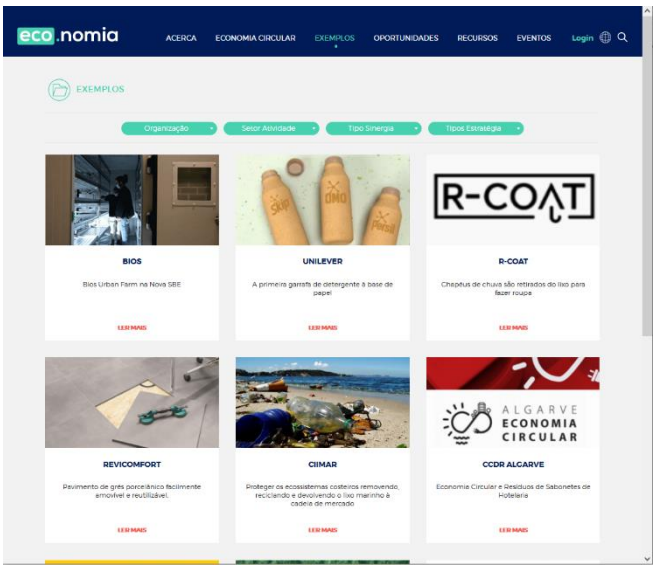


Figure 13 – Portal Eco.nomia (https://eco.nomia.pt/)

2.2.3 Circular Economy at National Laboratory of Energy and Geology

The Portuguese National Laboratory of Energy and Geology – LNEG (www.lneg.pt) is a State Laboratory attached to the Ministry of Environment and Climate Action that undertakes advanced R&D in the fields of energy and geology. LNEG´s mission is to promote innovation in science and technology with the objective of increasing the competitiveness of economic agents in the context of the sustainable progress of the Portuguese economy.

Within the research units at LNEG, the UER – Resource Economics Research Unit develops R&D activities and decision-support for both public policymakers and the private sector on energy and geology resource economics, towards carbon neutrality and sustainable resource exploitation and use.

With more than two decades of experience and development of numerous research projects and activity's, this unit, among other activities, is developing relevant research in the Circular Economy, including the Design of products, services, systems, business models and public procurement.

LNEG (Figure 14) has extensive experience in the development, application and training and tools oriented towards Design and circular and sustainable business models.

Figure 14 – LNEG – National Laboratory of Energy and Geology

2.2.4 CIRCO Hub Portugal

The CIRCO Hub Portugal, (CIRCO Hub Portugal, 2021) established in 2021, aims to encourage the Circular Economy through Design. In this project, companies and designers work together to develop products, services and circular business models, according to the

training methodology developed in the Dutch CIRCO program. In this context, the challenge is to train 100 companies and train 60 designers by December 2022.

This project (Figure 15) is developed under a Protocol of Technical and Financial Collaboration between the Portuguese Environmental Fund, the National Laboratory of Energy and Geology (LNEG), the Agency for Competitiveness and Innovation (IAPMEI) and the Portuguese Environment Agency (APA).

Figure 15 – CIRCO Hub Portugal

2.2.5 Circular Economy Portugal

Circular Economy Portugal – CEP (https://circulareconomy.pt/) is a non-governmental organization, formed by an interdisciplinary team of professionals with a passion for Circular Economy and experience in project management, whose main objective is to translate the principles of the Circular Economy into concrete projects, using zero waste strategies, social innovation and collaborative action.

With an approach focused on practical and replicable solutions with positive and structural impact, creating value for society and the environment, the organization offers support and facilitates the transition to the Circular Economy through technical skills and social innovation strategies, facilitating processes of institutional and behavioural change. The organization has a vast number of projects and consulting initiatives to support the transition to the Circular Economy (Figure 16).

Figure 16 – Circular Economy Portugal

3. Perspectives of Circular Economy

3.1 Perspectives of Circular Economy: Expert's review

3.1.1 Framework and methodology

As mentioned before, the Circular Economy approach is getting attention from a large number of actors in the society. The research community is very active, many research projects and initiatives are being developed at a global level and this number is increasing every year. In line with this evolution, the number of co-financed projects and approved investments are increasing. According to the information from the Portuguese Innovation Agency, within the QREN – Quadro de Referência Estratégico Nacional (http://www.qren.pt) program period, 14% of the financed R&D projects included Circular Economy as a thematic area. In the PT2020 period, the percentage of approved projects with Circular Economy aspects increased to 17%. As for the investment for Circular Economy projects the increase was from 12% within the QREN to 22% for the PT2020, as we can see in Figure 17Figure (Agência Nacional de Inovação [ANI], 2018).

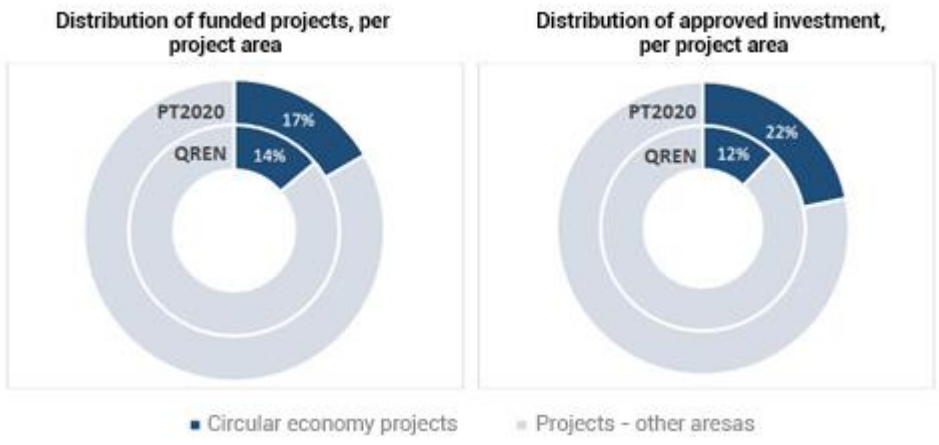


Figure 17 – Funding and investment in projects – (ANI, 2018)

Despite the evolution of the Circular Economy approach and a wide promotion at all levels of society, which lead to the development of new business opportunities, new business models and developing new markets (European Commission, 2019b), is Circular Economy the solution to attain a sustainable society?

To try to answer this question, the current research conducted an international survey, in which a group of international experts were contacted and invited to collaborate by sharing

their experiences, and perspectives about the current and future status of Circular Economy in practice (Annex 3a and Annex 3b).

In order to develop an efficient survey, the purpose, goals and audience were clearly defined to ensure focus, concise and provide useful data (SurveyMonkey, 2018). The collected information allowed the identification of an international overview of the practice, motivations and barriers in the transition to a Circular Economy through Design, and support the research and development of methods, tools and guidelines to promote an improved Design practice.

To capture the right audience, before the development of the survey, a database of international experts was developed. Through several sources, mainly the participation in European and international projects related to the topic, authors of relevant publications, and personal contacts of the authors, a list of around 150 experts were identified.

The questionnaire developed in an online platform was based on a compromise between the length and time needed to fill in and the needs of data to support the analysis. The structure was divided into three sections:

- The first section explains the objectives of the survey, how to fill in and information regarding the property of data and consent to use the information within the research under development,
- The second section collects general information about the expert, such as name, institution, nationality and expert profile,
- In the third section, a set of eight open questions aim to collect the perceptions and experiences of the international experts related to the Circular Economy, Sustainability and Design.

In the third section of the questionnaire, through the questions, the research aims to understand the views and perspectives of the experts on the field on what concerns the practical implementation of a Circular Economy.

In the questionnaire, the first question asks if the experts consider that a Circular Economy is a way to achieve a sustainable society in the future. The Circular Economy is mentioned by several authors in the literature as a way to attain Sustainability, but are these the perceptions of the professionals that are working and implementing circularity in practice?

The Circular Economy is seen by many as a new concept and a solution to solve the problem of society. However, we can understand the term as an evolution of the work that has been developed in the past decades. What is considered the novelty that the concept and approach can bring to society is asked to experts in this section.

The next questions in the survey aim to identify, based on the experience and knowledge of the experts, a) which are the main drivers and motivations to adopt Circular Economy in practice; b) which are the main barriers and c) how we should overcome the current obstacles and promote the Design practice towards innovative and sustainable solutions. To close the topic, the respondents are asked to express, based on their perspective, d) what are the practitioners doing wrong in translating the Circular Economy approach into practice.

Sustainability approaches are being developed for many years, however, the efficiency in the implementation didn't have the coverage and success to overcome the needs of our society. The business-as-usual and the inefficiencies in the implementation must be solved to succeed in the transition to a circular and sustainable economy. This question promotes the reflection on the practice and through several approaches and views pinpoints the known lessons from the past to promote a more successful implementation of Circular Economy.

To end the survey, e) an open question was included to collect other ideas, comments, and suggestions on how to promote an effective Design practice towards the Circular Economy, Sustainability and innovation.

Before starting to send the questionnaires to the experts identified, a pre-test of the questionnaire was performed with 4 European experts, two from Portugal, one from Spain and one from Austria to validate the questions and adjust the structure format and content.

The final version of the online questionnaire was sent by email to around 120 experts and during the Mid-December 2019 till Mid-February 2020, 40 questionnaires were received, with a response rate of around 30%, which demonstrates that experts in the field are willing to collaborate in research projects and the promotion of Circular Economy by sharing their knowledge and experiences (Figure 18).

The data collected was analysed using MAXQDA 12 software and the results are presented in the next sections

Geographic distribution of the answers received (Figure 18).

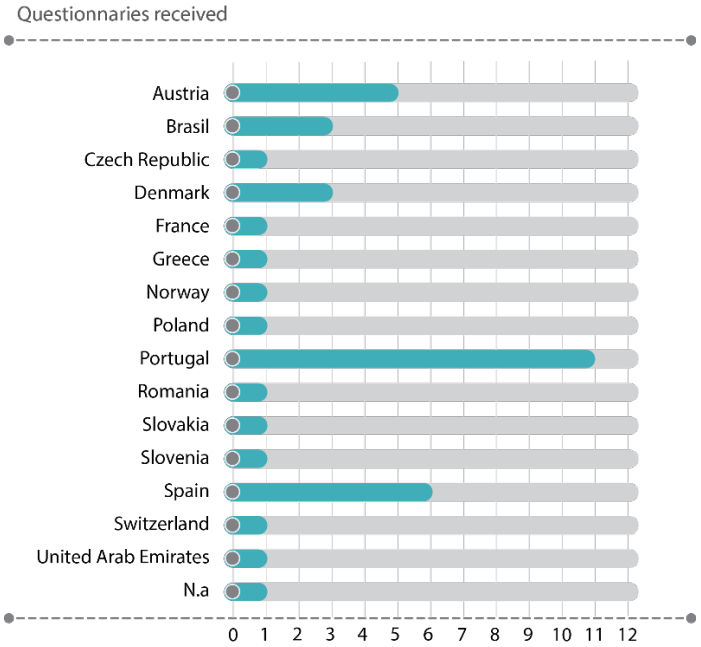


Figure 18 – Distribution of the questionnaires received per country.

3.1.2 Profile of experts participating in the survey

The experts were selected to cover a wide range of expertise (Figure 19). The majority of answers received were well distributed between Research (32%), Academia (26%) and Business (26%). The remaining 16% is related to Consulting (7%), NGO (5%), Government (2%) and Public authorities (2%).

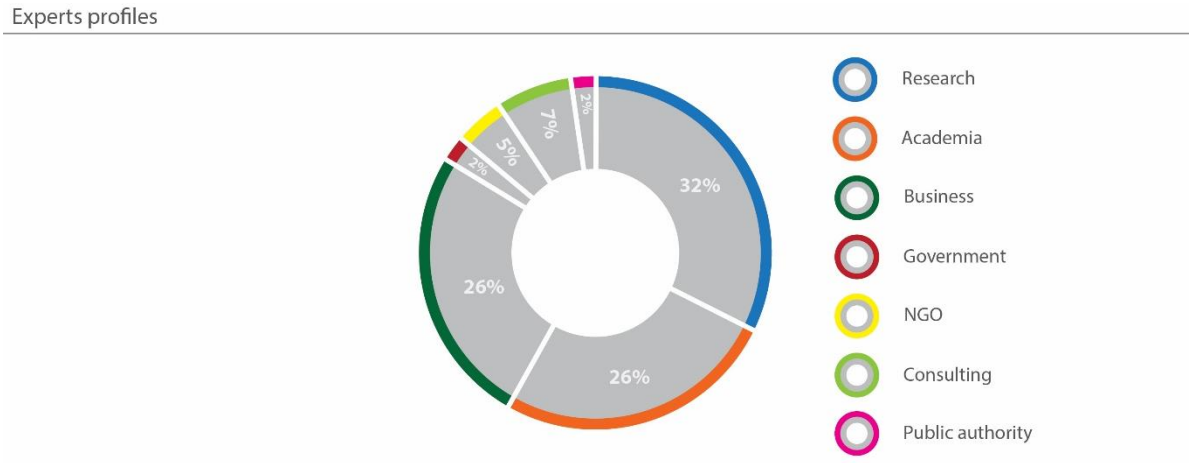


Figure 19 – Profiles of the experts

3.1.3 Main questions addressed

The first question of the survey had the objective of understanding the perspectives of the experts to understand if they consider the Circular Economy as the way to achieve Sustainability.

3.1.3.1 Question 1

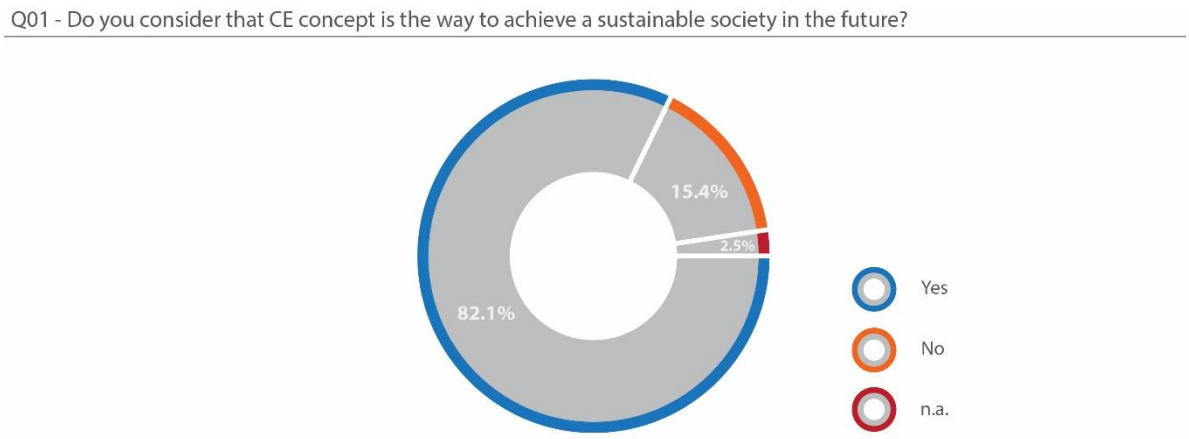


Figure 20 – Answers to the first question of the survey

The Circular Economy concept is seen by 82,1% of the respondents as a way to achieve a sustainable society in the future. The remaining respondents, 15.4% don't believe that a Circular Economy is the way to Sustainability and 2,5% didn't answer the question (Figure 20).

3.1.3.2 Question 2 – Please justify your answer to the previous question

The second question asked the participants to justify the selection made in the previous question.

From the 6 experts that do not consider Circular Economy as the way to attain a sustainable future the reasons expressed are pretty much in line with each other. For them, the Circular Economy is important and a good approach to Sustainability but is not the only approach. The Circular Economy is considered as one important strategy, but many other approaches

must be integrated and considered in the development of our society and future patterns for production and consumption.

In order to attain Sustainability, we need to consider other aspects such as Zero emissions principles, creative and solidary economy, product-service systems, cleaner production, degrowth, transdisciplinary, ethics, happiness.

The Circular Economy has a positive and important impact on resource efficiency, but we need to change in terms of the consumption of new products and materials. And Circular Economy does not solve problems such as biodiversity loss, desertification, soil degradation, and most important, Circular Economy does not tackle social Sustainability issues related to inequality, health, safety, etc.

The Circular Economy is also mentioned as a good start in the education and preparation of stakeholders to become more sustainable but is not the solution to alleviate social and economic inequalities, and do not avoid certain environmental impacts.

However, even for the experts that indicated that Circular Economy is the way, Circular Economy is not the only way, Circular Economy is seen as an umbrella approach that combines several approaches and ways to attain a sustainable future. We need to combine several strategies and it involves several fields as part of the answers in the creation of new business models, new products and new ways of production and consumption.

The new Circular Economy approach is seen by experts as the way to achieve a more sustainable prosperous future for our society.

It's a concept that will allow in the first phase better management of resources, whose consumption continues to increase, and in parallel, a potential solution for develop of new mentalities and solutions that allow the adoption of new patterns of production and consumption considering both new value chains and life cycle considerations always considering the life cycle of the attend solutions, taking into account the micro, meso and macro levels.

We must change the existing linear economy patterns and the Circular Economy concept will support the efficient use of our resources and additionally being less environmentally harmful, substantially contributing to the environmental pillar of Sustainability.

Circular Economy, a concept inspired in the natural cycles and the natural process to deal with the consumption of resources, and in natural principles, is a way to continue to use the means we have today, but with a new orientation to prevention but also to recovery, reuse and recycling, keeping all resources in the circular loops, allowing more efficient and sustained management of resources offering the chance to reuse limited raw materials by intelligent processes.

The transition to Circular Economy results in new business models that create competitive advantage through superior customer value and contributes to the sustainable development of the companies and the society in the future, contributing with a very important focus on resource optimization and the need for services rather than products.

By preventing and/or eliminating waste, reducing CO2 emissions and water consumption by preserving embodied resources, creating local meaningful jobs, saving money for owner-users, combating the environmentally and socially unsustainable production system strengthen the way to more democracy and participation in societies and the creation of jobs and wealth in our society

In conclusion, for the experts interviewed, the Circular Economy approach is considered as an important approach with the potential to improve the Sustainability profile of our society, the creation of value, innovation and better jobs. Nevertheless, it is a very broad approach that combines several strategies and methods for its introduction in the production and consumption of products and services and must be complemented with methods, tools and strategies according to the specificities and particular needs of each situation that can and should be linked to Design opportunities.

One expert has also indicated that currently Circular Economy it's only jargon, research, and debate at the expense of action and the main interest is proposals and action and not more debate. This clearly reflects the need to implement Circular Economy in practice.

3.1.3.3 Question 3. Which is the novelty that Circular Economy brings?

The Circular Economy is not a new concept, however, is seen by many as a new approach that can lead our society on a more sustainable path.

Sustainable development and Design for Sustainability have been a topic developed by many in the past, with good results and cases studies, however without a broader integration as it was expected by the researchers and professionals involved in the process. The Circular Economy can bring a new impetuous to achieve Sustainability, and as seen in the previous section, for many experts in the field, Circular Economy is the way to proceed.

The next question in the survey, intended to analyse which is the novelty that Circular Economy brings into our society.

- The main topics considered as a novelty within the new approach to circularity are:
- The efficiency of resources – This aspect was mentioned by 41% of the expert as one novelty,
- New patterns of consumption and production – Considered by 24% of the experts as the novelty related to Circular Economy,
- New business models – Mentioned by 19%,
- Innovation – Mentioned by 11% of the experts.

The analysis showed that at the moment the innovative aspect that CE brings to society is essentially related to the need to combine convergent, parallel and complementary actions in three fundamental axes: policies/support legislation, business models and business practices and appropriate forms of information/communication to the consumer to gradually encourage adherence to new forms of more responsible consumption.

The Circular Economy can lead to different and innovative ways of fulfilling societal needs, with great efficiency improvement in the use of resources, in decoupling the resource use from economic growth.

The economic revenues could be created through attractive business models, new ideas, new approaches and projects where innovation and the responsible use of resources can reduce environmental impacts, use intensification, lifetime extension, reuse of products or parts, remanufacturing, recycling, etc.

One novelty is the strong emphasis on economic side / economic and financial benefits – which is more tangible for people, and so more understandable.

This new approach is also leading to new consumption patterns such as the circular use models such as products as a service, sharing platforms, sell and buy back/leasing, thus reducing demand for new products and products made from virgin raw materials. It can provide incentives for returning to efficient economic practices such as repair, maintenance, and reuse.

From the point of view of product Design, it can help to achieve products to be more sustainable without taking away their functionality or even, by improving their features. Focusing on the function and the fulfilling of the need with different solutions, with new business models and new ways of production, distribution, etc, Circular Economy can lead to a more dematerialized and sustainable path.

The Circular Economy can also solve the extraction and waste problem (take-make-dispose), which holds the promise for a much more efficient economy when including the cost of the current externalities. Circular Economy can be a unique opportunity to explicitly close mass and energy balances in every value chain.

This new approach is also changing society in terms of job creation, increasing the need for professionals with a Sustainability orientation in all stages of the value chain with a life cycle thinking approach.

This ‘umbrella’ concept has the ability to bring us back to a somewhat forgotten reality. It brings back some behaviours from the past, such as sharing goods, optimising resources, producing locally, etc that can lead to the implementation of innovative and sustainable models/solutions to ensure a day-to-day activity aligned with the capabilities of the planet.

Circular Economy can bring a change in the current consumption system, by “killing” the idea that what is "new" is trendy and changing it to make trendy the Circular Economy, with the gradual awareness of society.

In conclusion, Circular Economy can be seen as a change of mindset for consumers and industries, leading to the development of different ways of production and consumption, focusing on the real needs of the users, business and the society by adopting new development paths and new business models which can lead to a more dematerialized and efficient ways to fulfil the needs of all stakeholders in the value chain.

3.1.3.4 Question 4 – Which are the main drivers and motivations to adopt a Circular Economy in practice?

The drivers and motivations to adopt a Circular Economy in practice expressed were grouped in 13 different categories and the frequency in the answers is shown in Figure 21, below.

In total, around 75 drivers and motivations were collected, with a higher dominance in drivers related to Economic factors, with 13 references, Legislation with 10 references and impact reduction and new businesses, both with 9 references. Consumer demand driver was mentioned by 8 experts and resource efficiency and social benefits were mentioned 6 times. Other drivers such as stakeholder's involvement, awareness, differentiation from competitors, marketing, and innovation were mentioned by 4 or fewer experts.

One interesting remark is innovation was mentioned only by 3 experts. Other drivers mentioned are related to innovation, for example, new businesses, which was mentioned 9 times is related to innovation. This can mean that, for the experts, innovation is the result of other aspects that are promoting the transition to Circular Economy.

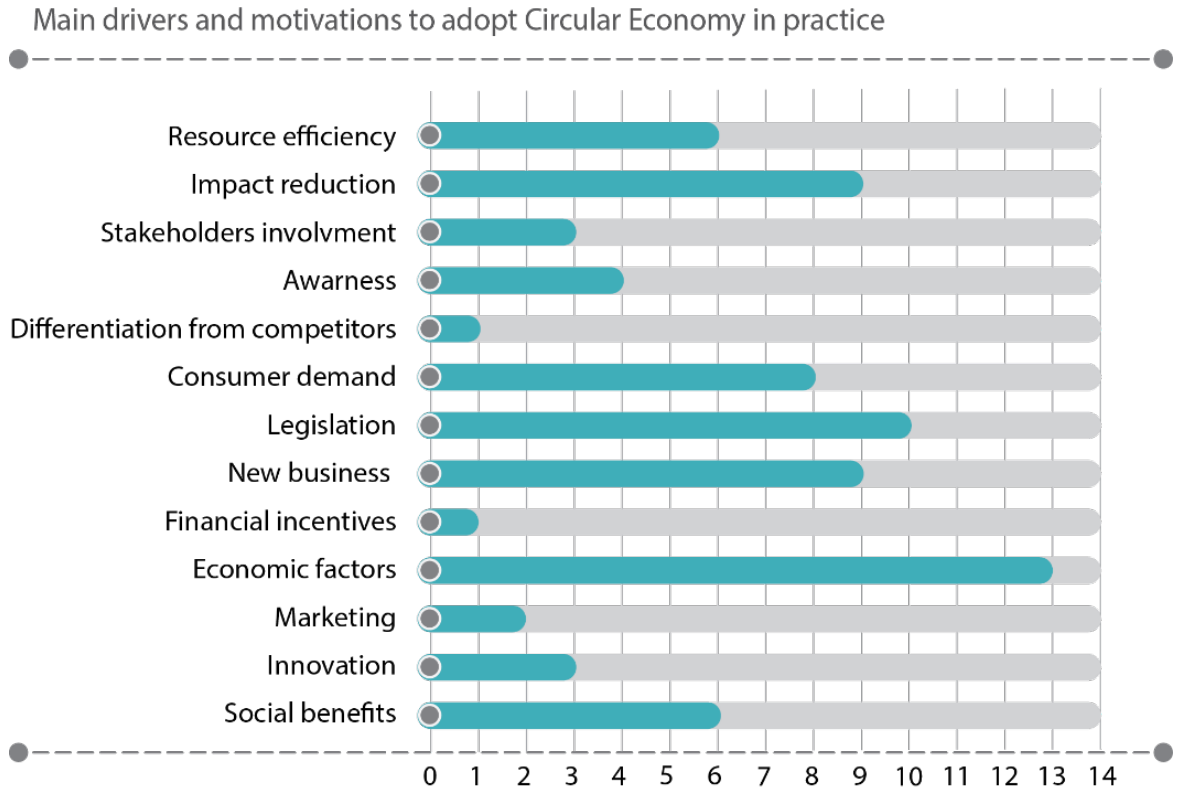


Figure 21- Drivers and motivations to adopt Circular Economy.

Main drivers and motivations per category

Economic factors:

Economic profit is the main driver and motivation to adopt a Circular Economy. Most drivers in this category are related to financial benefits, increase in value and profit, cost reduction and savings, the development of solutions with low prices and high value and the opportunity to explore the use cheaper and sustainable materials.

In this category was also mentioned that the main reasons are the economic advantages for the community which lead us to the need to make the Circular Economy economically attractive from the production and consumption sides.

Legislation:

In the category the main ideas expressed are related legal requirements, legislation, regulations, public policies and taxes, such as high taxes on landfilling of waste, CO2 taxes and taxes on fossil resources.

New business:

The transition to a new model can be promoted or be the result of a new approach to businesses. New businesses and new business models are a driver for circularity.

Aspects like new business opportunities, new ways of generating income, new patterns of consumption and production, the need to adopt efficient concepts like “design out waste”, closed loops, etc, and the change in the consumers, which are changing their relationship with products, where people are not so interested in owning "stuff" anymore but are rather subscribing to have access to the functions of the product, leading to Product-service solutions, are extremely important in the promotion of Circular Economy.

Impact reduction:

The reduction of the impacts on the environment, the overexploitation of natural resources, pollution problems, climate change, the consciousness that we need to act now to maintain the future, are the main aspects identified as drivers to the new approach.

Consumer demand:

Consumer behaviour is an important factor identified as a driver to Circular Economy. We are facing a clear push and pressure from a more “green” and committed society.

Consumers are more informed and motivated for the Circular Economy. A general feeling of over-consumption and a rejection of the designed short life of products are becoming clear in some parts of our society, and these consumers are demanding form more efficient solutions to fulfil their needs.

Social benefits:

Society itself is demanding for circular behaviour. The degradation of productive systems and the quality of life compromise the future, linked to, to some extent, a social panic related to the future of our society with a decrease of social pressure to material consumption as a demonstration of social status, etc, are drivers and motivations to the Circular Economy, which might be a way out to try to re-establish the balance in society and natural resources.

Resource efficiency:

Resource protection, with the valorisation of what exists instead of pushing constantly to newness, a growing resource consciousness, an opportunity to convert waste into a precious commodity, the increasing scarcity of resources and new business models focused on the efficiency of resources, are also drivers and motivation to adopt circularity.

Awareness:

The gradual awareness of society of the current situation, the awareness that it is necessary to radically change the existing linear model of production-consumption, and the global consciousness about Sustainability that is beginning to become a reality, are divers and motivation in the current context.

Innovation:

The term Innovation was not mentioned often in the survey, however, many of the drivers indicated to have a close relation to innovation and are innovative approaches that lead to a circular approach to Design and to new business models and innovative ways to fulfil the need of users.

Within the survey, only three experts mentioned innovation. One indicates that a driver to circularity is by “Adding (sustainable) value and innovation to systems across the economic sectors” and the other two indicated “news way of producing and consuming”, and “Innovative companies and entrepreneurs”. The latter reflects the maturity of the companies and entrepreneurs and their relation to the Circular Economy.

Stakeholders' involvement:

The involvement of stakeholders in the value chain of circular systems, products and business is crucial for an effective transition to the Circular Economy. By explaining the benefits and providing a reward to all stakeholders of the loop will foster the adoption of the methodology and result in a more efficient solution. This can be and should be, promoted by the development of circular production chains, motivating all actors in the value chain to adopt Circular Economy models through consumers choices.

Marketing:

Even though a high percentage of companies only embrace Sustainability and Circular Economy for marketing purposes, marketing was only considered as a driver by two experts. These had referred that "Public relations and marketing purposes" are drivers and the other mentioned "Branding and Marketing aspects from the producer side".

The driver categories with lower inputs from the experts was "Financial incentives", mentioned only by one expert, indicating that a driver for adopting circularity is "Incentives and development of public policies", and the other category with also one reference was "Differentiation from competitors", which included "Legitimation and the ambition of being front runners in the Circular Economy".

3.1.3.5 Q05 – Which are the main barriers to implementing the Circular Economy in practice?

From a total of 93 barriers mentioned, 45 different barrier types were identified by the experts.

Within the analysis, the different answers were gathered, analysed and grouped according to their type.

The type of barrier mentioned more often was Knowledge. There is a common understanding that despite all the efforts that are being done, we still face a problem related to the lack of knowledge in general, a lack of academic education, lack of skills needed for the implementation of Circular Economy in practices, lack of information and lack knowledge and awareness of the society. Of the 40 experts interviewed, 15 mentioned that the lack of knowledge is a barrier to the implementation of Circular Economy.

The second type of barriers mentioned was related to costs. 12 experts mentioned costs as a barrier for Circular Economy. In this typology, cost of materials, costs related to environmental and social costs, additional costs that are needed for the implementations, lack of awareness that embracing circularity at a company level can be very cost-efficient and will protect on future price increase of raw materials, the prices for resources don't reflect their true costs and an important aspect mentioned was that the currently linear models are very much cheaper.

Legislation barriers were mentioned by 8 experts. In this regard, the current legislation, some weak EU policies, contradictory legislation, high taxes regulations do not support Circular Economy principles and solutions.

Another barrier often mentioned was related to behaviour, with 8 references. For the experts, the barrier is the mindset that is established, and which is really difficult to change. There is a natural resistance of humans to behavioural changes and novelty.

The lack of incentives, little government support and lack of market incentives for businesses and consumers were also mentioned by five experts.

Many other barriers were mentioned, however with lower frequency or mentioned once were the following:

- Difficulties in implementing the Circular Economy model,
- Lack of studies available that could support the implementation,
- Lobbies,
- Difficulties in the involvement of the different actors in the value chain, including users,
- Lack of inspiration,
- The existence of specific stakeholders with economic interests that benefit from continuing with the linear economy,
- Openness and transparency of business and business processes to know the real composition and quantities of materials introduced into the products,
- Non-sufficient DAPs for all products available on the market,
- Poor financial instruments,
- Lack of cooperation and trust among companies,
- People do not trust new innovative solutions, or they feel uncomfortable with them,

- Lack of infrastructure,
- Circular business models complexity for consumers,
- The current structure of industries and financial organizations which are demanding an ever-increasing GDP rise,
- Inertia and lack of willingness to change and to move towards new ways of production and consumption,
- Logistics,
- The old economy in fear of loose business, convenience and politicians depending on the old economy,
- Lack of vision by top management,
- Lack of belief in science in politics,
- Current production interests,
- Lack of belief in science in politics,
- Politicians afraid of decisions,
- Existing practices,
- Resistance to thinking out of existing business models and new business models that involve all the value chain,
- Lack of networking between demand and offer,
- Lack of unification in concepts and legislation,
- New business models that seem to be only acceptable or profitable for large companies, leaving behind SMEs and small entrepreneurs,
- Consumer confusion and perceptions,
- Inability to manage volumes and types of waste,
- Trust, transparency on the loop,
- Stakeholders in charge of the linear economy are not willing to change unless that affect them directly,
- The whole model is built on growth and profits, we need to see value in the new model, and it can't be just economical.

3.1.3.6 Q06 – How should we overcome the current obstacles and promote the Design practice towards innovative and sustainable solutions?

To overcome the current obstacles and barriers and to promote the Design practice, the experts in the survey mention a large set of ideas. These were also analysed and grouped according to the types and concepts behind each idea.

The main ideas mentioned were the following:

- The creation of a structure supported by tools with a simple final interface that allows a solid aid to information, education, legislation, innovation and the addition of sustainable value. But that the different pieces of this puzzle all fit into a common Design and not mere stray pieces of reality and context,
- Through networking with the different stakeholders of the value chain, developing new socio-technical solutions (not only from the point of view of technology but integrating also new ways of delivering the product/service),
- Integration of ecological tax reform (taxing what we do not want [such as carbon emissions] while relieving taxes for what we want [labour]),
- Through the incorporation of criteria in public purchase and with legal imperatives, for example, through strict requirements in the Circular Economy marking and with commercial tariffs to extra communitarian products that did not contemplate measures of the Circular Economy,
- Improve education, communication and provide useful tools for all stakeholders. Circular Economy should be included as a mandatory subject in all curricula (from schools to universities),
- Introduction of a carbon tax,
- Demonstration and dissemination of best practice examples and business models
- Creation of networks of technological dissemination,
- Society-governments-industry dialogue to create opportunities, policies and incentives,
- Strengthen the role of academia in the formation of cooperatives, networks and promote a value chain collaboration, preferably also by involving the users.
- Stronger policies and their enforcement; the ecodesign requirements should embed much more product types, stronger and larger EPR schemes,

- Use economic instruments, demonstrate the financial benefits of circularity put realistic price tags on externalities including GHG emissions,
- A mix of instruments – from regulatory bans and economic stimuli (e.g. bans on certain products, obligatory ecodesign criteria, pricing and tax policy), to financial support (e.g. through ERDF funds), to voluntary instruments (e.g. GPP), to available technical assistance and awareness-raising activities (towards both industry and general public/consumers),
- Lobbying regulators and politicians. And promoting the champions,
- Integrated work between engineers, product developers and designers that can bring a consumer and consumption perspective into the development process. Challenging ideas of newness and ownership via communications. Simplify the use phase for circular business offerings,
- Introducing and promoting cost-benefit analysis taking not only into account economical aspects and cost but also the costs of environmental-related costs and benefits,
- By making product designers aware of designing considering Circular Economy principles to launch to the market more circular products and to use Design to help the consumers to behave "circular",
- People's pressure, talk to people and make it better,
- Work hard in the different layers of the decision-making process, and involve effectively the corresponding key stakeholders,
- "One of the main actions should be addressed to the educational field, Circular Economy should be included as a mandatory subject in all curricula (from schools to University),
- Make Circular Economy a fashionable strategy to be adopted by young generations,
- Developing concise strategies for the industry with clear messages and legal requirements,
- Strongly bet: spreading the concept at all levels of society (preventing the concept from becoming a fad or a buzz word), training (at all levels of education), developing regulations that stimulate innovation (change current business models) supported by financial incentives, the development of partnerships (organizations, education, NGOs and citizens) that stimulate the development of new solutions and approaches,
- Legislative changes and enforcements,

- Give more information about the Circular Economy to the enterprises,
- A shift from selling goods to selling the function of goods – operational leasing, renting, borrowing, sharing,
- Improving education in Sustainability, give to consumers easy access to credible information about the products, promoting more I&D to develop products well designed for Circular Economy models and incentives that promote Circular Economy products with low price and high value that can compete with similar linear products prices. So, with society better educated, products well designed for Circular Economy models and products with competitive prices in the market, I think it is possible to overcome the current obstacles and promote the Design practice towards innovative and sustainable solutions,
- Public awareness,
- Innovation on NEW businesses that may give win-win to all involved,
- More successful examples. establishment of public-private partnerships, creation of a legal framework to promote it,
- Behavioural economics instead of command-and-control approach. Nudging = influencing stakeholders with "soft power" = showing them small benefits/advantages step after step,
- With incentives (e.g. taxes) to well-designed products.
- The EU has a good opportunity to make the Green Deal and the Action Plan for the Circular Economy a reality, and not just one more document locked the closet. For this, I believe it is necessary to invest money, create new directives and carry out concrete actions (setting examples, not just waiting for things to happen magically). To promote innovative Design, with a life-cycle perspective, the innovation could start by separating Design from the stereotypes that relate it only to aesthetics and luxury, and start relating Design with science, to present it presented as the first piece for the creation of products that are not going to be turned into the garbage in a few weeks,
- Constant awareness, technological innovation directed to Circular Economy; government incentives to accelerate implementation,
- Analyse loops and make sure there is an efficient set-up for each section,

- The first step is the education of consumers to help them to understand which packaging is recyclable and which is not. Then support the penalisation of producers who will not redesign their products to enable the end-of-life reprocessing,
- Building awareness that circularity is the future – creating and offering nicely designed circular lifestyle products – create a circular ecosystem that can support on every level in Design and supply chain,
- Policymaking and education, in general. Design Schools, Business Schools, etc. And especially for the long term...basic education, for it to be sustainable.

From the ideas mentioned, the most relevant and more often mentioned are related to education and awareness. The creation of knowledge in all fields, especially in the designer communities, in companies and businesses, and in consumers should be promoted and supported by user-friendly and reliable tools.

The demonstration through best practices and examples and the demonstration of the benefits of the adoption of circularity in practice is also seen as a way to promote circularity.

New ways of production and consumption, new business models, the creation of synergies, networking and the involvement of stakeholders in the process is in line with the adoption of circularity on a larger scale.

3.1.3.7 Q07 – In your perspective, what are we doing wrong in translating the Circular Economy approach into practice?

Despite all the efforts, all the research, projects and many initiatives that are being developed and promoted at several levels of our society, there is still a lot to do, and several barriers to overcome.

As mentioned before, the Circular Economy is not a totally new concept. Cleaner production, Ecodesign, Design for Sustainability, etc, have been approaches that have been studied, researched, developed and implemented, however, without the expected success. Currently, the Circular Economy is having wider dissemination and an exclusive role in our society, and to achieve the expected success, to attain the desired level of Sustainability, the approach has

to be more efficient, practical and with clear benefits to all stakeholders and the society in general. For this, it is important to learn from the past and exploit the acquired knowledge that was gathered and the experiences and lessons from the past.

In this regard, the survey attempts to analyse the perspectives of the experts in understanding what we are doing wrong in the process. From the ideas expressed by the expert in the survey, the following are the more relevant:

- Information and communication of what is intended and what can attain it, what we should do and how to achieve it,
- There is a lack of vision and alignment of policies at European, national and local levels,
- Incentives for companies to change behaviour in the direction of more resource efficiency are too small,
- The current understanding of Circular Economy is very limited: on the one hand, people, in general, do not know what Circular Economy is and on the other hand, many of those who have heard of it, have a very limited understanding and approach. On the other hand, from the academic point of view, these kinds of solutions (incl. ecodesign, for example) are still presented as options and not as obligations,
- We are taking too long, we need laws and systems to be changed faster,
- We are slowly migrating from generation to generation, from those who believed that the world should be intensely exploited for those who have seen its limitations and are developing the means to live within these limits. Perhaps even the concept that we should always be overcoming our limits has to be revised from the basic education of our children. The human being has been educated to make a difference. We praise our idols who can overcome themselves. We reward them in Olympians, award them the spotlight and then blame them because their super needs demand too much from our planet. We must question the very form of organization of our society,
- We need much stronger regulation – the Circular Economy will not happen by itself. It should be both carrot and stick. We need to make it hurt very much on the industries that are the worst, and we need to promote the initiatives and products that are the best,
- We do almost nothing. Except some best practices here and there not using economic instruments,

- Maybe it is still promoted as a "green" theme, which is not catchy enough.
- Communication strategy. it should be more consumer-oriented,
- Circular solutions are being created in a vacuum, with little knowledge about the user, their context of use, the limitations, both technical and behavioural, to using the solutions,
- The discussion should be more complex meaning taking into account not only environmental aspects but also economical aspects (even when they are negative meaning e.g. increasing the costs) and in general negative aspects of the concept of Circular Economy (e.g. greenwashing, waste exports etc.),
- There is a lack of practical ideas and "things to do in real life" when teaching the Circular Economy concept,
- Not enough pressure from the policymakers' side,
- We are too academic, and not walking the talk,
- There must be projects that demonstrate their viability and that there are no financial losses when we think long term and from a life cycle perspective,
- Often too academic approach and little cooperation with innovative and willing companies,
- There is currently a non-effective holistic approach as it is too much identified with the (challenges of) waste management approach. That is the result of fragmentation within the different policy frameworks – where the dynamics go to the environmental-related policy files have currently more momentum, e.g. plastics, than the energy-related ones. We believe that the urgency in climate action will soon put the CO2 on the agenda to a point of addressing the negative emissions in a more correct way),
- The high complexity of the message transmitted. Citizens need to be on board, businesses are made of people that need to adopt the strategy in day-to-day life,
- Perhaps we are not doing anything wrong, it is just simple as not all society is highly concern because we do not have interiorise clearly the need of moving to a circular approach and it is something more cultural that fail in the approaches developed. Perhaps more educational campaigns are needed but for all society. It is clear that the academia and research world besides some specific institutions and part of the policy world have clear this need but they represent a part of the society and probably they are not the majority, so a great effort should be done to cover the whole society,

- Ambition and some willingness to do different are lacking, although the issue is already on the agenda of governments and organizations. The developed projects have minimum impact and are poorly publicized. Citizens are far from the concept. The existing formation has little expression. Inability to tell the advantages of implementing the concept on organizations,
- We see only in the near future and our life expectancy and not the big picture
- we focus on materials instead of liabilities,
- I think we don't have enough information about the products or services at the time that we decided to buy them. We don't know if the product is made with Circular Economy models or linear, we don't have credible information for it and we don't know how big is the impact of our choices. I think that this is the big gap when we translate the Circular Economy approach into practice,
- It looks like a threat, not like a chance,
- We/the politicians don't really follow up on the Circular Economy policies and plans. They should set more requirements but also reward Circular Economy solutions economically, e.g. through taxation systems, reward schemes, etc. That is, we're doing far too little on creating and supporting the systemic changes,
- The success of it is because the company leaders understand this kind of language, but it takes time, and people and companies will do as usual until governments allow them to,
- Not combining it with economic issues and its advantages,
- We do not listen to other experts, we are trying to invent a new approach instead of promoting already existing solutions. We shall ask ourselves a question about how to help to already existing initiatives,
- To make it economically profitable. No one will buy something more expensive. In the beginning, companies will not do something that is more expensive,
- We are trusting too much that the private sector and companies will do most of the work. Education and technical institutions should gain more visibility and be more supported,
- I wouldn't say it's going bad, but it could be accelerated. It is a long and slow process, which implies profound changes in consumption and production systems. The perspective of linear production has been deeply rooted in society since the first productive initiatives,

- Too much industry focused,
- The whole idea has no viable basis in theory or practice, it’s a talking point for academic debate, governments and producers who want to avoid doing anything practical about the problem,
- Not have a holistic approach – lack of building a strong ecosystem to drive a systemic shift – badly designed products – not reflecting on the end of life; dismantling, and repurposing in the Design prices,
- The cost of it is high, so it's unattractive to businesses. Also, we are not training our designers to think in that direction as Design schools are still market focuses. There is a need for government intervention and a whole mindset and behaviour change. That is a massive shift that probably will not happen organically since it's not the easiest way. The third law of Newton applies here: Unless there is another force to change our direction, we will continue to move that way.

From the several ideas mentioned above by the experts, it's clear that we need to innovate, we need to demonstrate the feasibility and benefits of the transition to the Circular Economy and we need to change the consumption and production patterns, supported by clear and transparent information, and improving the knowledge of the actors in the value chain, especially the designers who have the role of translation the needs of the system in the development of new products and services.

It is important to learn from the past and have a holistic approach to attain an effective transition to the Circular Economy leading the society towards a more sustainable path.

3.1.3.8 Q08 – Do you have other ideas, comments, or suggestions on how to promote an effective Design practice towards a Circular Economy, Sustainability, and innovation?

The questionnaire designed to understand the views and perspectives of experts in the research field covered the topics considered the most important by the research team, however, the final question was an open question to collect other ideas, comments or suggestions.

The survey was answered by 40 experts as mentioned above. The professionals selected for the survey were very active and participative. In this final question, several important inputs were collected, which support the research undertaken.

The ideas were analysed and grouped, and the main concepts were the following:

- The practice of Design in the context of the Circular Economy to succeed must work together with other disciplines of knowledge, namely: sociology, psychology, various engineering, management and marketing. Not forgetting in this way that all solutions will have to be consistent in environmental, social, economic and technological terms, from a value chain and life cycle perspective,
- Since the economic return is the main motivation, to speed up the transition, the increase in rates for landfill use and the prohibition of certain products could have a positive impact leading to the development of new solutions of product Design, the simplification of legal procedures for the use of secondary materials and the increase of funding for research and support of innovative practices to facilitate the creation of new business models,
- Ensure that all designers are made aware of, during the different phases in their professional life, the huge benefits to be reaped if they practice circular Design.
- The current need for more research, more community action and new ideas all the time,
- It should be illegal to sell a product if there is no plan for how to maintain it, how to repair it, how to upgrade it (e.g. by modules if it's tech), how to reuse/recycle all parts of the product after end-use,
- Apart from that, there should be strict rules about how to use materials. What materials can you mix, what materials are you not allowed to mix. e.g. can you mix plastic materials or should they be one component only? We also need some kind of transparency about the amount of energy that has gone into a product and will go into the after-use life (reuse, up-cycle, re-cycle),
- Legal requirement to have a certified environmental management system including ecodesign,
- Basic Design requirements should be provided by regulations (Ecodesign Directive). Then economic frameworks should motivate producers to manufacture products that

last longer, are easy to be repaired, dismantled and recycled. Also, the existence of relevant technical standards could help,

- Designers need to communicate the need for a deeper market understanding before developing any solutions. It is dangerous to assume that the end-user will adopt a solution just because it is more sustainable or circular. People are not rational,
- Involvement and engagement of stakeholders in the development process and the creation of good practices that can be used for demonstration,
- The media can and are doing a lot. And it should be exploited,
- Think in function, always think first of all how it can be reduced. Do I really need this material? Can I get recycled or second-hand material? And apply the concepts in daily life,
- Integrate the concept of value, relating the indirect and direct value proposed to the value added by innovation in product services and product-service systems,
- Adoption of continuous awareness. People have a short memory and need to be reminded frequently of the right strategy and behaviour,
- Education of Circular Economy. It should be integrated as a mandatory discipline in the educational plans,
- Innovation incentives to sponsor more friendly products, new tax legislation to promote Sustainability, and national contests aiming to award projects related to Circular Economy,
- This topic has already been widely discussed in the academic environment, but this discussion needs to be taken to the society,
- Circular Economy Label. As the first step to promote Circular Economy models and products. We need to know that it is actually a Circular Economy service or product, and to know "how much" circular they are (some products are more circular than others and we need to know it). Promote that the companies compete for more effective Design practices towards a Circular Economy through credible information on the labels, as happed with the energy efficiency label,
- Demonstrate the business opportunities and best practices related to the adoption of Circular Economy,
- Innovation in the way consumers supply their needs, e.g. with the use of mobile phone applications, ideally "gamification" approach,

- Changes in social paradigms, for example, the rejection of the culture of waste and speculation must be general, and not perceived as something that makes a few who "want to change the world"; the fight against climate change, pollution or the implementation of the EC is still seen as something that only economic elites can carry out, and not the normal citizens,
- Create value for the waste that is disconnected from the residual value of the material collected,

From the ideas and comments included in the survey, it reinforces the need to innovate, the need to improve the education models with the integration of Circular Economy in the agendas, the change in behaviours and the need to demonstrate the feasibility and benefits for the transition from the linear model to the new Circular Economy approach.

3.2 Perspectives of Circular Economy: User's review

Around 80% of impacts of the products life cycle are defined in the Design and development phase. This relation is important in addressing the consequences and responsibility of Design and for successful integration of Circular Economy, a holistic approach is fundamental, considering all aspects from production to consumption.

In the Design and development, in order to meet the needs for circularity, it is important:

- To understand how sustainable products and services are developed and placed on the market,
- How the sustainable profile is communicated to users and other stakeholders,
- How consumers understand the information conveyed,
- Which are the user's perceptions about the profile and characteristics of products.

This chapter is about the communication on products and the consumer perceptions of Sustainability aspects.

In the development of innovative, efficient and sustainable products, the designers should be able to translate the needs from several actors in the value chain:

- The needs of the users who will buy and consume the products and services,
- The needs from the companies and businesses, who will develop, produce and place them on the market,
- The needs from society, who will indirectly benefit or suffer from the Sustainability impacts of the products.

In the past, the ecodesign and Design for Sustainability approaches already have these concerns integrated into the development process with relative success in some niche markets, but not on a large scale as expected.

The new approach to development, based on Circular Economy, has new challenges and must be implemented through innovative products and services that supply the needs of consumers and businesses from one side, and new consumption behaviour from the other.

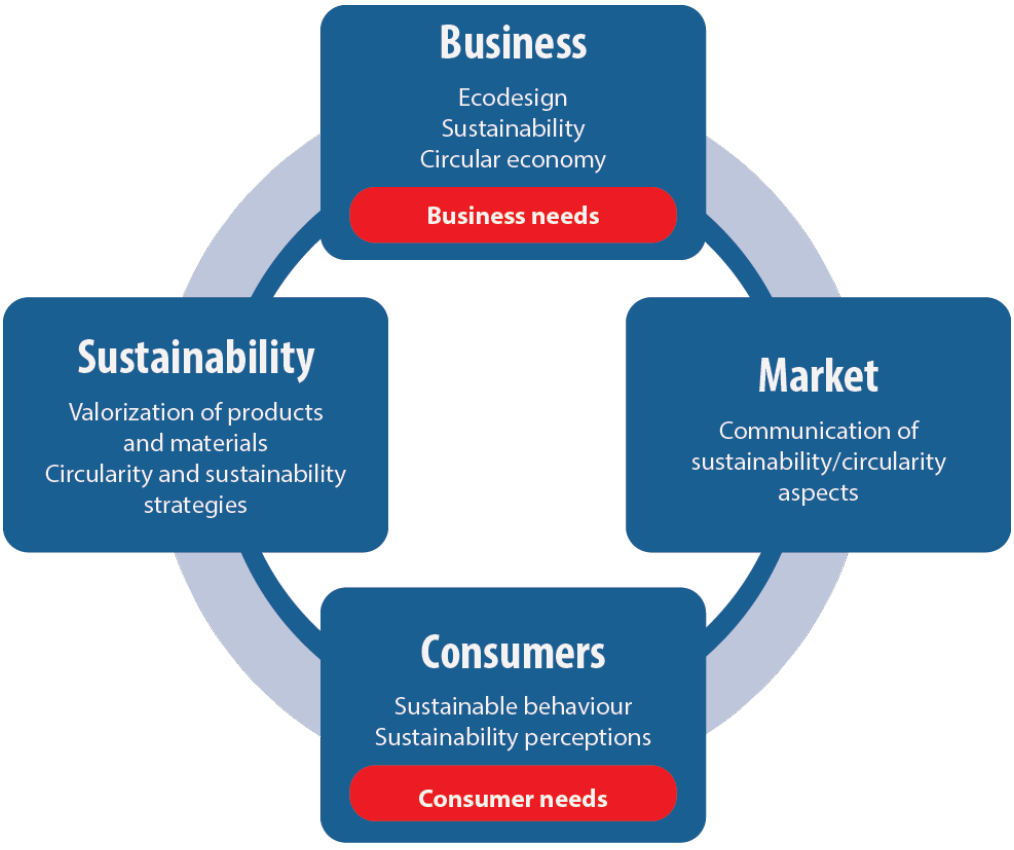


Figure 22 – Four pillars to circular production and consumption (Camocho et al. 2019c)

The transition to a Circular Economy through the Design of products and services needs a global and structures vision based on an approach that integrates four fundamental pillars (Camocho et al. 2019c) (Figure 22):

- **The Business perspective**

  Products placed on the market must respond to the needs of the companies that develop them, they must promote economic and business development, contributing to the development and well-being of society. In this context, it is essential to have a broad knowledge of the business aspects, the needs of companies and how they can contribute to the company's strategy.

  We have witnessed the development of numerous products oriented towards Sustainability, which despite their properties being presented as innovative concepts, for not responding to the needs of the business in which they operate, were not successful in the market, thus questioning the possibility of satisfying the consumers' needs more efficiently.

- **The market Perspective**

  For products to have success and a sustained implementation in the market, they have to be able to communicate their characteristics to the consumer efficiently. The consumer must have the perception of the message through the image, specific content, labels, certification, declarations, etc.

- **The consumer perspective**

  Knowing the consumer and their needs and expectations is fundamental to the success of any Design and development project. Consumer perceptions are a decision mechanism that impacts their preferences and choice behaviours (Campbell et al., 2015). In this regard, which are the behaviours of consumers and their needs?

  In the Design project, the designer must be able to translate these needs in an efficient way and must be aligned and promote sustainable attitudes and behaviours. However, although there is a growing awareness, the way consumers perceive Sustainability issues is not always adequate, or they are influenced by diverse factors that overlap

Sustainability. Another relevant remark is the difference between what consumers say and what they really do. As referred by Bhamra, 2015 and Vringer et al., 2015, this trend is explored in diverse studies.

Consumers, in general, have the notion and perception that a change in consumption patterns is needed, however, in practice this is not accompanied by the adoption of more sustainable consumption styles (Rousseau, 2016).

- **Sustainability perspective**

  Focusing on the Circular Economy by closing the cycles of products and materials, it is necessary to adopt an approach that integrates strategies to close resource cycles through the valorisation of products, components and materials. Integrating a holistic approach, based on Design, adopting methodologies and tools at a strategic level, could allow the transition to a more efficient, healthier and more Circular Economy.

3.2.1 Sustainable products

The terminology adopted to communicate the Sustainability profile of products has many forms: such as eco products, green products, sustainable products, circular products, and many other terms. Within this research, the objective is to explore products that have a better Sustainability profile and performance, which are developed and produced with a life cycle approach and products that are placed on the market claiming those features (Annex 4).

Therefore, the term “Sustainable products” which is a more comprehensive term that includes all the other concepts, was selected as the terminology to use within the research project

3.2.2 Types of products

Society since prehistoric times has developed based on the production and evolution of products. These assume the most diverse forms and functions and respond to diverse needs. Within the scope of Sustainability and considering the products by their characteristics, they can also present several typologies according to their function, characteristics, the materials that compose them and the relationship they have with the surrounding environment.

Within the scope of research and with the aim of typifying the products in order to guide circularity strategies for their development, four types of products were defined (Camocho et al. 2019c):

- **Type A: Silent products**

  Silent products are sustainable products, which integrate Sustainability concerns and a life cycle thinking approach in their development, but despite these characteristics, for various reasons, this information is not conveyed to users. These are placed on the market like any other traditional product.

  The Sustainability aspects are relevant for their development, however, this lack of communication can be part of the strategies of the company that produces them.

- **Type B: Naturally sustainable**

  These are naturally sustainable. Its producers do not integrate methodologies, tools or Sustainability concerns, however, due to their intrinsic characteristics, related to the raw materials used, the production processes used, the way they are used by the consumer, etc., these have reduced impacts, being therefore considered sustainable.

- **Type C: Sustainable products**

  These are the products traditionally perceived as sustainable. In its development, the designers and producers aimed to create solutions that minimize the impacts on their life cycle. In its Design, methodologies and tools are used that allow the integration of Sustainability strategies, resulting in more efficient products.

- **Type D: Sustainability influencers**

  These are products that have a positive influence on the system in which they are integrated. The product itself may be not sustainable, but when included in a system they have a positive influence on the overall performance of the system. In the category, products that influence users to have a more sustainable behaviour are also considered.

3.2.3 Sustainability communication in products

The transition to a Circular Economy has several challenges in its practical implementation. In this context, the way aspects of Sustainability and circularity are communicated in products and how the message is perceived by consumers is extremely relevant and must be explored effectively. Many of the products that are currently on the market have communication elements, labels and certification, promoted also through campaigns, green marketing initiatives, and claims, that are not recognized and valued by the consumer.

This communication of the Sustainability profile of products to the consumer has taken different forms and methods. However, the most adopted and successful ones seem to be eco-labelling schemes that rely on credible and standardized information.

Environmental labelling or eco-labels are important tools available to companies to communicate and guarantee that their products and services comply with standardized environmental requirements beyond what is established by law.

The European Commission in its Action Plan for the Circular Economy (European Commission, 2015) emphasizes the adoption of reliable communication elements that promote knowledge and information about the environmental aspects of products and services to the consumer in order to avoid misleading information that does not promote the adoption of greener consumer choices.

Many environmental labelling possibilities are available to companies, some of them regulated by International Standards, based on the ISO 14020 family standard (ISO,2000), and many others not covered by standards. According to ISO, the International Organization for Standardization, there are three types of environmental labels:

- **Type I labels (ISO 14024):** "third party" voluntary labels based up-on life cycle considerations that indicate the performance to pre-determined, multi-attribute criteria that identify environmentally preferable products within a particular product category (ISO, 2018).
- **Type II labels (ISO 14021):** self-declaration statements made by producers, importers, distributors, retailers, etc., focusing on the environmental characteristic and improvement of some specific aspect of their products, such as energy consumption, compostable, degradable indoor air quality, recycled content, etc (ISO, 2016).

- **Type III labels (ISO 14020 and 14025):** These labels, often referred to as Environmental Product Declarations (EPDs), present in a transparent and comprehensive way, the product information based on quantitative validated Life Cycle Assessment (ISO, 2000; ISO, 2006a).

As mentioned before, there are many possibilities to inform consumers about Sustainability criteria or content and companies should be proactive and assure that their messages do not lead to incorrect perceptions (Campbell et al., 2015).

3.2.4 The relation between consumption and production

To achieve economic growth and more sustainable development, our society needs to reduce its ecological footprint by changing the way we produce and consume goods and resources. (United Nations, n.d.) In a recently released report from Circular Economy (Circle Economy, 2018) our society is only 9% circular and the trend is negative. In the last 12 months despite all the efforts made at the global level, the upward trend in resource extraction and greenhouse gas emissions has continued.

Our society is evolving and for the next two decades, more people at the global level will join the middle class, meaning that a huge part of the population will increase their consumption and therefore, increase the demand for natural resources (United Nations, 2016).

This pressure in the natural capital demands new approaches to ensure sustainable growth by promoting an effective and innovative relationship between sustainable production processes and the consumption behaviour of our society.

3.2.5 Consumer perceptions

The market is dynamic, and its constant transformation is the result of interactions between supply and demand, and consumers, through their choices and practices, play a fundamental role, whether directly or indirectly, consciously or even unconscious of its evolution. These choices impact the performance of businesses, companies, governments, and all those involved in the value chain.

Companies on the other hand have also a key role in the market. By placing more and more products and services on the market, they are shaping it, creating needs and expectations.

In this way, and through this symbiosis between the user and the producer, the way our society consume will determine supply and the way production is organized and how it will evolve in the future.

This topic has been widely explored and several studies demonstrate that sustainable behaviour is changing, and the awareness is increasing in most consumers segments. A growing trend in communication properly to consumers about the environmental aspects to consider when buying products is observed (Young, 2008).

When choosing more sustainable products, consumers usually do not have enough information to make an informed decision. The information provided, in most cases, is not sufficient and does not allow a reliable and realistic comparison of the various product options available. Usually, the consumer only has access to information regarding functionalities, technical characteristics, marketing claims, etc. Information on the Sustainability profile demonstrated and verified, is usually only available on products with Sustainability labels or certification (Goleman, 2009). This lack of information is also verified in products and services that claim to be sustainable.

There is a common-sense assessment of Sustainability belief supported mainly by self-declarations and allegations available in products covering only in few aspects of the life cycle, and in some cases, misleading consumers in their perception regarding the products and in some cases a through greenwashing approaches (Camocho et al. 2019c). For this reason, understanding the consumer's perception of the Sustainability profile and what are the real properties of the products is crucial for placing products and services in the market.

Aiming for a sustainable and circular society, consumers must make informed and conscious decisions (United Nations, 2016), however, the information gap between producers and consumers is still a problem that we need to surpass. The lack of reliable information jeopardizes the market system itself, while sound and reliable information allow for conscious and informed decision-making (Goleman, 2009).

Another challenge faced in this transition is the lack of consumer awareness regarding their impacts on society. Many consumers don't perceive the impacts related to their consuming behaviour (Bhamra, 2015).

We must consider the differences in the consumers. In this regard, based on the study "Identifying the green consumer" by Finisterra et al. (2009), we can define three main types of users as presented in next page (table 2).

The knowledge about the characteristics and perceptions of these types of consumers, is important for the Design practice, guiding the designers in the management and development of their projects successfully.

Table 2 – Different types of consumers (Adapted form Finisterra et al, 2009)

Type	Composition
Type 1 – The uncommitted	Young people with high educational levels and living in urban environments. This type of consumer claims to have knowledge about Sustainability issues; however, they have very negative behaviours in relation to environmental aspects.
Type 2 – The green activists	Individuals with the highest education levels. They have a favourable position concerning environmental aspects, particularly towards perceived efficiency, buying behaviour, recycling, sensitivity to economic factors and resource-saving. The segment tends to be critical about the promotional and advertising claims made by firms.
Type 3 – The undefined	Individuals that consider that their individual action does not contribute to the improvement of the environment. This segment includes individuals with lower educational levels than the other segments and has very negative positions towards environmental issues. For these, the environment is not a major concern and they claim to have little knowledge about environmental issues. With a positive attitude towards recycling and are highly sceptical about the promotional and advertising claims made by companies.

3.2.5.1 Method to assess consumers' perception of Sustainability in products.

The perceptions of consumers regarding the Sustainability aspects in products and their knowledge on communication elements, such as labels, certifications, self-declarations, as discussed before, used to promote products is an important area to consider in the Design process towards circularity and Sustainability. In order to understand this, within the research project, a survey to collect data from Portuguese consumers, was performed in January 2019 using two different approaches:

- An online questionnaire that was distributed through social media and email databases to participate by filling in the form online (Annex 5a)
- A paper version of the questionnaire, aiming to broader dissemination and a collection of feedback and distributed and collected personally by the author (Annex 5b).

The questionnaire is based on a trade-off between the complexity/length and the amount of data needed, was composed by an initial part with the introduction, aims and objective of the survey, followed by 5 sections:

- Section 01- Basic questions regarding the demographic characteristics of the interviewee,
- Section 02 – Developed to access the knowledge regarding ecodesign, Design, Sustainability, and Circular Economy,
- Section 03 – Based on questions to evaluate consumer habits and the influence of environmental labelling on products,
- Section 04 – Aiming to understand if the Sustainability perception of the consumer corresponds to the reality and how consumers rate sustainable products based only on perception,
- Section 05 – An open area to collect remarks, suggestions and relevant ideas from the respondents.

3.2.6 Findings/ analysis

The questionnaires filled in by consumers in a paper version and sent by social media, had the collaboration of 105 individuals aged over 18.

Since it had wide dissemination and the respondents were asked to share the questionnaire with other consumers, it is difficult to have concrete numbers of the scope of the survey, however, it is estimated that around 500 individuals received the questionnaires, representing a response rate of around 20%.

The sample, includes 55% women and 45% men (Figure) with different educational levels, (Figure 24) 36% graduation, 31% 12º year, 24% master, 5% less than 12º year, 3% PhD and 1% with a professional degree, with a diversified professional activity.

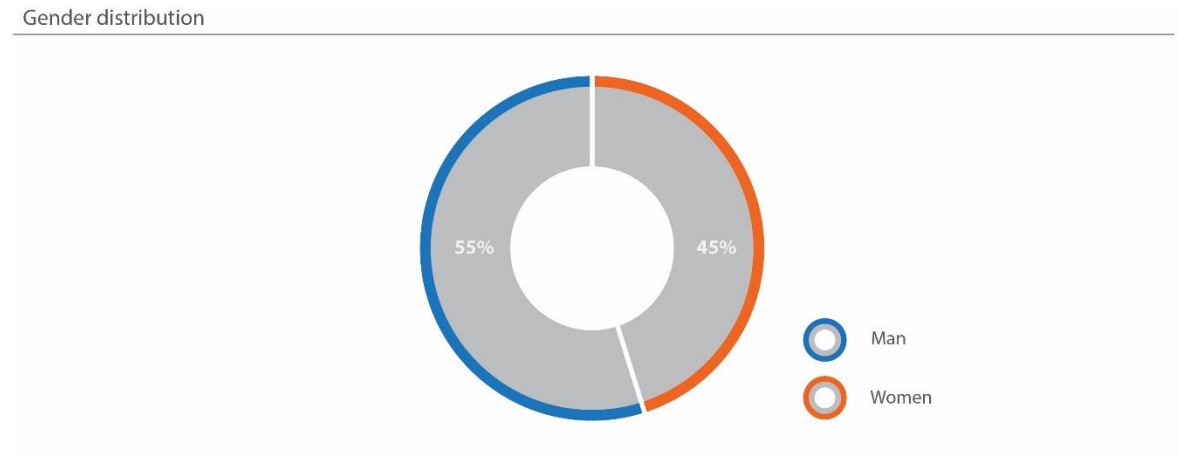


Figure 23 – Gender distribution of the sample

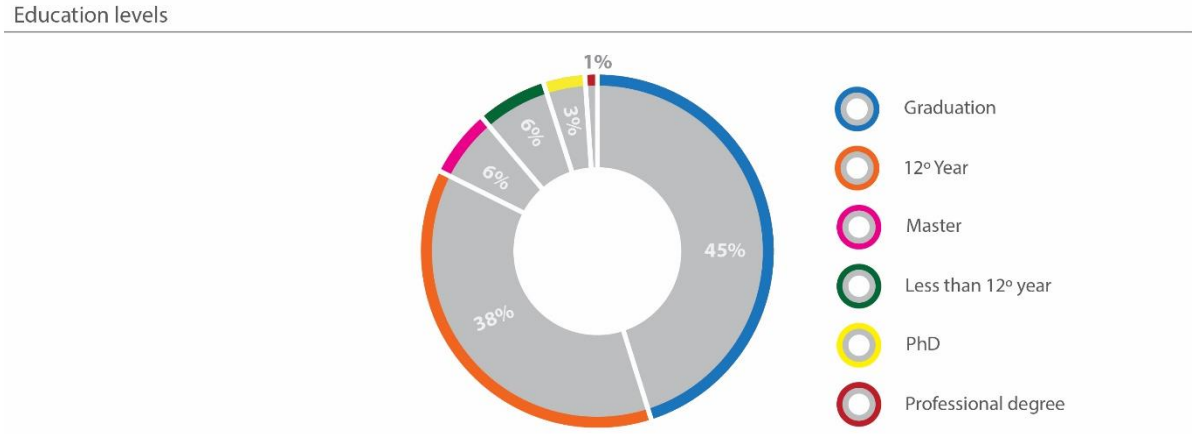


Figure 24 – Education level of the sample

From the total number of answers received, 75% consider having sustainable behaviour in daily activities, which also is a clear indication of the gap between what consumers say and what they really do.

When analysing this data by gender, between male and female respondents do not identify a significant difference, 70% male and 78% female consider having sustainable behaviour. The difference in behaviour according to education is also not relevant, 73% in respondents with higher education and 79% in lower education respondents.

These high levels of respondents indicating higher levels of Sustainability concerns are in line with several consumer surveys like for instance, the sustainable consumption paradox referred by Vringer Kees (2015) when studying the Dutch consumers.

3.2.6.2 General knowledge in the field

For an evaluation of the general knowledge in the topic, the perceptions regarding Design, Ecodesign, Sustainability and Circular Economy were addressed.

In general, most respondents indicate having basic notions about the 4 concepts, around 78% consider having basic notions or above. The most known concept is Sustainability (49% have basic notions, 30% high level of knowledge and 6% are experts in the field) and Design, in which (51% have basic notions, 22% high level of knowledge and 12% are experts in the field). The less known concept is the Circular Economy, in which 18% do not know the concept and 24% have heard about it. This lack of knowledge about Circular Economy is understandable since it's a new concept for most respondents and the term "Circular Economy" can have wrong interpretations for those who are not aware of the approach.

In figure 25, the results regarding the knowledge are presented.

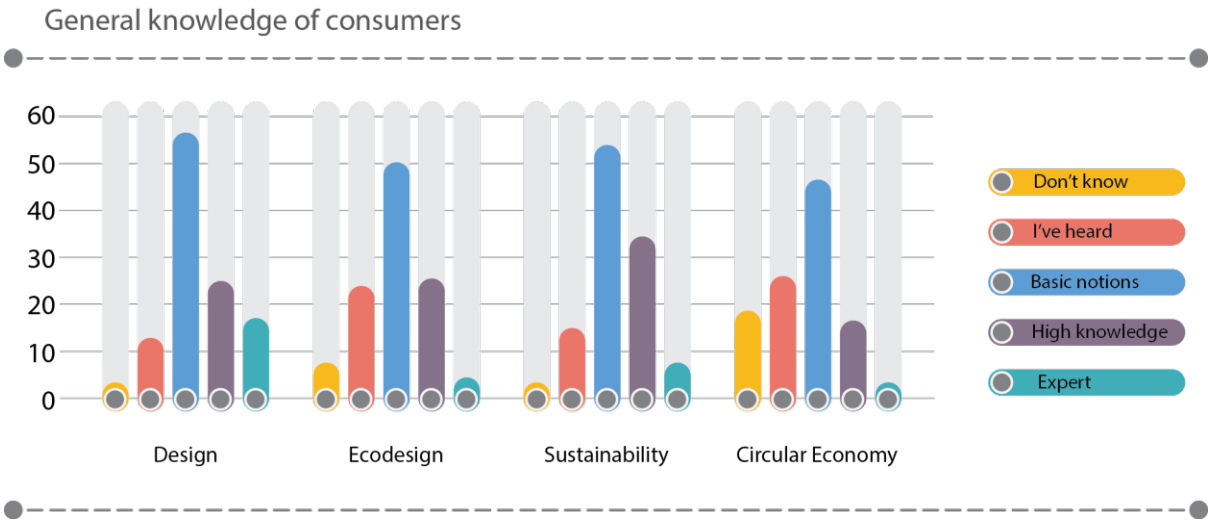


Figure 25 – General knowledge of consumer

3.2.6.3 Sustainability attitudes and practices

When questioned about their attitudes and practices, the classification is good. Only 7% do not make a waste separation for recycling, 2% do not apply water-saving measures, 9% do not buy organic products and 9% do not buy sustainable products. Although the classifications are good, there is always a problem regarding this type of question, since, these topics, there is a tendency not to demonstrate the reality.

In Figure 26 we can see that consumer involvement in these issues is relatively high, there is a high level of consumers separating products for recycling and in the implementation of water and energy-saving measures, these last two aspects are mainly due to economic aspects related to the high prices of these resources. The consumption of organic food and the acquisition of sustainable products present a lower level of implementation, which is assumed to be related to the acquisition value and the availability of these products in the market.

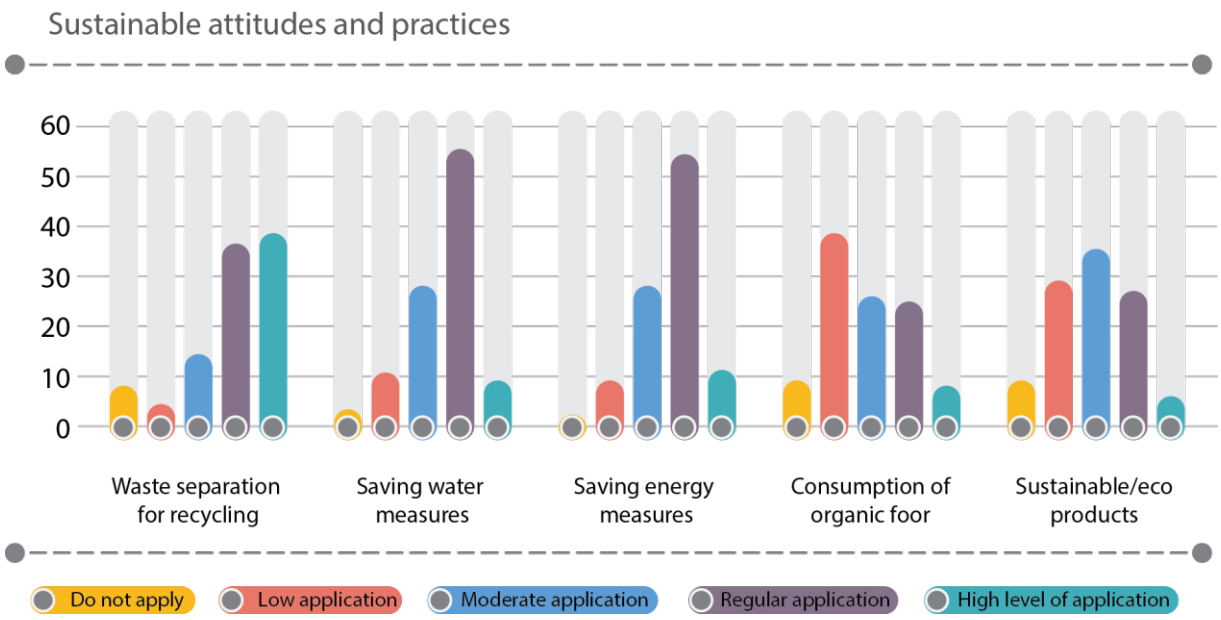


Figure 26 – Sustainability attitudes and practices

3.2.5.4 Influence of ecological and Sustainability factors in the acquisition of products

The influence of ecological and Sustainability factors is considered moderate to high in most of the cases analysed. Considering all types of products included in the survey, only less than 30 % of the respondent consider that their choice is not influenced by Sustainability criteria.

3.2.5.5 Influence of labels and environmental certification in purchasing decision and related trust in the allegations

The influence of labels and certifications available in products is a factor that influences 76% of the consumers. There is a certain level of confidence in the allegations. However, a high confidence level is only observed in 18% of the answers. 62% have a medium level of confidence, 19% a low level and only 1 % do not trust in the allegations from producers.

3.2.5.6 Knowledge about labels

Labels are widely used in the product. However, the knowledge about the meaning and criteria in these are not well known by users. In order to understand the knowledge about products' labels, a selection of 10 examples was presented in the survey and consumers were asked to express if:

- They know the label and its meaning,
- They recognize it but do not know what it is,
- They do not recognize the label at all.

From the analysis, the main conclusion is that in most of the examples, the consumer does not know the labels or do not know their meaning.

In the case of the European eco-label, which is an important label developed by the European Commission established in 1992 and used across Europe and worldwide (European Commission, n.d.). Only 26% know the label and the meaning, 32% recognize it and 42% do not know it. Regarding Cradle to Cradle, is the global standard for products that are safe, circular and responsibly made, 65% do not know the label and only 13% know it.

The more known labels, known by more than 90% of the consumers are the Green Dot Society symbol (Sociedade Ponto Verde) EoL packaging management system in Portugal (SPV), the Energy efficiency label and the recycling symbol.

The labels that are less known are the Cradle to Cradle, the European eco-label, the Fair-trade label, and the Euro leaf (Figure 27).

Figure 27 – Less known labels

3.2.5.7 Perception of the Sustainability profile of products.

The perception of consumers was analysed in the questionnaire through the presentation of 3 well-known products with the function of serving coffee, a ceramic cup, a paper cup, and a polystyrene cup. Based on the images and indication of the material, consumers were asked to indicate which option is considered the most sustainable and less sustainable.

These examples were selected from the "Disposable Cups vs. Reusable Cups" study developed by Carbon Clear (2012) in which an LCA – Life cycle assessment was performed and published.

The ceramic cup was the product considered by 75% as more sustainable (Figure 28) with (75%), followed by the paper solution (23%). Polystyrene was indicated as the more sustainable by 2% of the respondents.

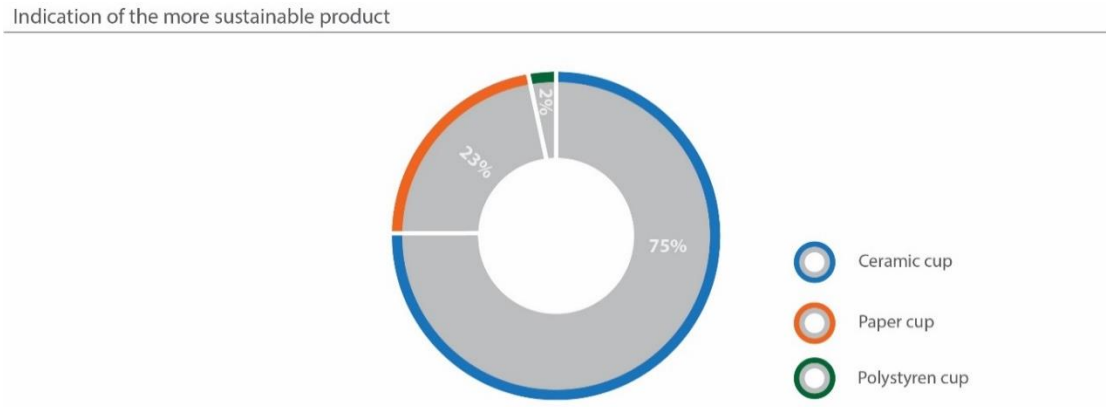


Figure 28 – Sustainable product – Survey results

In the analysis of the most sustainable product, the majority selected the ceramic product, however, the solution of products produced in paper also had a considerable percentage. This analysis, in the formulation and presentation of the objects of study, deliberately did not refer to the functional unit. Thus, it was not indicated whether to compare only one unit of product or to consider the function in a universe of various uses over time. Some consider ceramics because it is a durable product that can be reused for many uses, those who only looked at the product unit, indicated that the paper solution, as it consumes fewer resources and has a natural and recyclable base, would be the more sustainable option.

When asked which would be the product with the greatest impact and with a lower Sustainability profile, almost all respondents indicated the polymer-based product. 90% of the consumers selected the polystyrene product and 2% the ceramic product.

As mentioned before, this example was based on an LCA study performed by Carbon Clear, which revealed that, based on the energy and emissions needed per 2,000 servings for the selected cups, produced in paper, polystyrene and ceramic, the ceramic is the more efficient solution, and the paper is the less efficient one.

The results of the survey indicate that the perceptions of most consumers regarding the more efficient solution were correct. However, their perceptions regarding the less sustainable solution were wrong in 90% of the cases.

In the last question, an image with 6 different pencils was shown (Figure 29), one made with solid wood without painting, one green, one black, one fluorescent orange, one white, and the last with printed numbers in two colours.

Figure 29 – Image of the survey – perception of sustainability

Without more information regarding materials, process, quality, etc it is impossible to determine which product is more sustainable. However, the respondents were asked to rank the products according to their perception of Sustainability.

Only 4% of the respondents indicated that do not have information to give a correct answer, which is the most correct answer we expected. 92 % have ranked the pencils being the one without painting the first option in almost all answers. 4% of the respondents did not answer the question.

3.2.6 Key takeaways

The evolution of society is directly linked to the way we produce and consume, and currently, we are facing major challenges related to the scarcity of material and energy resources, social and economic crises, among others. In this context, we must act quickly and promote sustainable and circular growth that promotes well-being, culture and resilience of society for the future.

Much has been done over the years in this direction. However, the reality is that according to recent studies, namely the Circularity Gap reports (Circle Economy, 2018-2022), our society continues to have very low rates of circularity. Less than 9% of our world is circular, and despite the various measures implemented, its effect is still relatively marginal.

In this evolution of society, the orientation towards the development of more efficient products has been incremental. However, we can observe that Sustainability, in most cases is still a marketing flag or a greenwashing tool.

In order to succeed in this intended new orientation through the Circular Economy. It is essential to analyse the mistakes and learn from the lessons from the past. We should therefore define an efficient approach that responds to the needs of the entire value chain of products and services promoting the relation between production and consumption and the translation of the needs from the consumers, the business and society.

In terms of consumers, who are key players in this system, we are witnessing evolution and change in their way of thinking and acting. They are increasingly aware of environmental and social challenges and are looking for innovative and efficient solutions at all levels. However, the perception they have, due to the way products and services are placed on the market and

the way they are promoted is not always the most favourable in this context. For example, the communication made available in products and the allegations from inefficient labels are not perceived by most users who do not understand these topics. These should be designed more efficiently.

The results attained with the survey to consumers indicates that these believe in a common-sense assessment of Sustainability based on their perceptions. These perceptions are not always correct and are partially supported in part by self-declarations and allegations that are displayed in the product and aired by designers, product developers, producers, and retailers. The communication allegations, in most cases, are only focusing on a few aspects of the life cycle, and in some cases are misleading consumers leading to greenwashing messages.

For an effective transition to a more circular and sustainable economy, through the Design practice, the market and consumers perspective must be integrated from the beginning of the development process in a holistic way, covering all value chains.

4. Circular Economy Tools

4.1 Introduction

The integration of Sustainability and circularity aspects within the Design activities can be supported by tools that systematise the development process and can lead the Design teams to achieve sustainable solutions in a more efficient way. The evolution of the tools available to designers has been an important aspect that supported the evolution of the Design profession and the solutions proposed by designers to solve the problems and needs of society (Vasantha et. al, 2012).

The Design practice relies on methods and tools (Vicente, 2011). and these, which have a significant impact on the development process, are in constant development and evolution, especially in the digital environments (Witkowski, 2017).

For the support of a Circular Economy approach, tools are starting to appear, and due to their limited availability, it seems that in most cases, designers are integrating Circular Economy strategies in an ad-hoc way, without the support, guidance, and validation of tools at different stages of the process.

Within the research, based on the literature review, tools were collected and analysed to identify which were available to designers and their adequacy to the Design practice for a Circular Economy having in mind the needs of the Design process and their relevance in the Circular Economy. The results of the search resulted in a collection of relevant academic and non-academic resources that are available and can be applied by designers and product developers.

4.2 Methodology

Although numerous tools are available in diverse platforms (online, software's, board games, etc) and have been developed to support the development of more sustainable products and services (as example LCA software like SimaPro, Gabi, and many others), within the current study, only the tools that indicate their relevance to the Circular Economy were selected. The study considers mainly those that were developed and disseminated claiming to have an orientation to the Circular Economy.

In the analysis of the tools, along with the general information such as the identification, editor/publisher, author, source, availability and short description, a set of variables were defined to access the potential for application by designers.

The variables were the following:

- The aim of the tool,
- Scope – Circular Economy; Ecodesign, Design for Sustainability, LCA, etc,
- Assessment indicators/strategies – how the tool is applied? Which indicators or strategies are applied?
- Life cycle perspective – indication if the tool has an LC perspective or if only focus on a specific stage,
- The influence on the Design process – How can the tool influence the Design?
- The influence in the business model – Can the tool and the results influence the business model?
- Type of inputs – Qualitative or Quantitative,
- Inputs – Which inputs are needed to use/apply the tools,
- Level of complexity – Level complexity in using the tool by Design professionals
- Sectoral focus – sectoral, to which sector the tool is applicable or if it has a generic approach,
- Expected results – which type of results are attained with the tool,
- Pros and cons – Analysis of the main Pros and cons of the tool related to the Design practice in the development of circular products and services.

In the next chapter, seven tools that were analysed within the research project under development according to the variables explained above are presented. These resources were developed aiming to introduce circularity aspects in the development of new products and services and can be applied by Design professionals.

Remark. This analysis was done in the initial stage of the research. In the course of the research, other tools were developed and identified, however, they did not integrate the analysis carried out that served as the basis for the development of resources. At the end of the chapter, other relevant tools are identified.

4.3 Tools

4.3.1 Circularity Check

The Circularity Check is an online tool to support companies to achieve a more sustainable and circular or resource-efficient performance. Developed by Ecopreneur, Wesustain, and MVO the tool, acts as a useful instrument for self-evaluation, through a questionnaire with around 60 questions that scores a circularity value for a specific product and/or service (Circularity Check, n.d.).

The tool is structured in a checklist (Figure 30) with a questionnaire that can be filled out online considering five main indicators:

- Design, procurement, and manufacturing,
- Delivery,
- Use,
- Recovery,
- Sustainability.

The outcome is a total score for circularity (0-100%) and partial scores related to the five indicators (0-100%). This approach shows to companies the overall strengths and weaknesses of the product or service.

Based on the results of the tool, presented through the circularity score calculated, the charts provided, and by analysing and answers to the questions, and the individual scores on each indicator, the Design team can identify potential improvement ideas redesign the product or service.

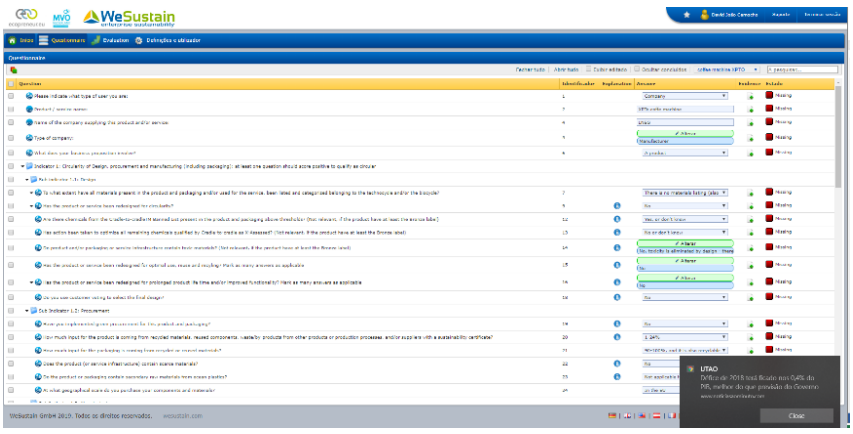


Figure 30 – Circularity Check

4.3.2 Circular Economy Toolkit

The Circular Economy Toolkit (Evans J. (n.d.) is a free online resource that aims to support businesses in developing more environmentally sound decisions which will create new opportunities, save money and attract new customers.

Circular Economy Toolkit (Figure 31) provides an insight into how companies would function within a Circular Economy in the creation of more sustainable products and services. For this purpose, the tool is based on a set of 33 questions that result in the indication of the potential improvement according to the strategies:

- Design, manufacture and distribute;
- Repair/Maintenance of the product;
- Reuse/Redistribution of the product;
- Remanufacturing/ Refurbishment of product or part;
- Products as a Service; and product recycling at end of life.

Besides the assessment features, the tools, in each strategy, provide useful information to supports the knowledge creation in the companies.

The tool has a simple and user-friendly structure and its results cover the life cycle stages and highlight the potential in each one. Through the analysis of the questions and results, the user can identify improvement options for the product under analysis.

Figure 31 – Circular Economy toolkit – Logo

4.3.3 Material Circularity Indicator

The Material Circularity Indicator (MCI, n.d.), which is part of a broader 'Circular Indicators Project' developed by Ellen MacArthur Foundation and Granta Design, is a tool aiming to measure how restorative the material flows of a product or company are allowing companies to identify additional, circular value from their products and materials, and mitigate risks from material price volatility and material supply.

Through the comparison to similar industry-average products, the MCI for a product measures the extent to which the linear flow has been minimized and the restorative flow maximized for its component materials, and how long and intensively the product is used. The assessment provides the combination of three product characteristics: the raw material used in production, the unrecoverable waste that is attributed to the product, and a utility factor that accounts for the intensity and duration of the product's use.

This user-friendly tool (Figure 32) with an intuitive interface is useful to demonstrate the circularity level of a specific product and the results may be used by designers to analyse a reference product or service and the analysis of potential options in new solutions. The results can be used also for internal reporting, procurement decisions, and the evaluation or rating of companies.

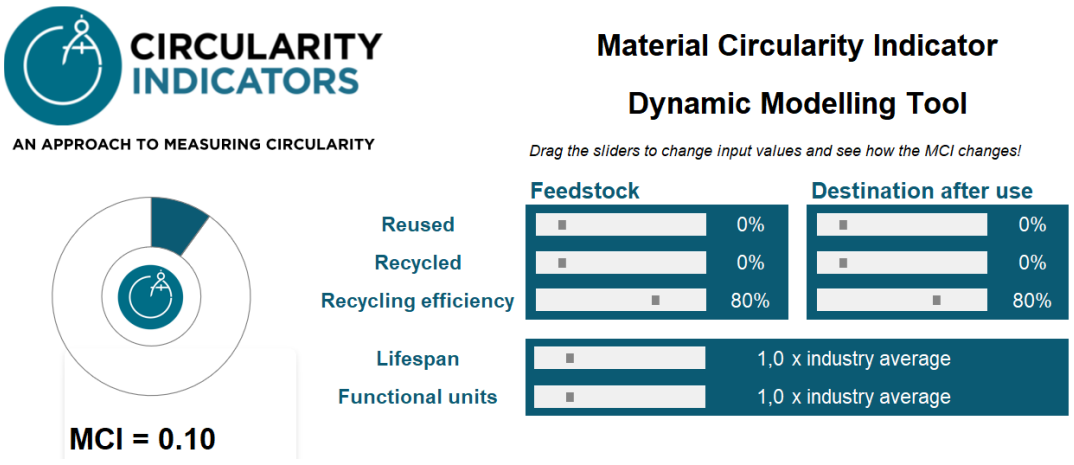


Figure 32 – Material Circularity Indicator – Overview

4.3.4 KATCH_e Tools

The EU research project KATCH_e – Knowledge Alliance on Product-Service Development towards Circular Economy and Sustainability in Higher Education, (KATCH_e, 2019a) developed by an international consortium coordinated by the National Laboratory of Energy and Geology in Portugal, aimed to develop resources to support the transition to Circular Economy resulted in the development of numerous resources relevant to designers. From the several tools developed, four tools have a higher potential to be applied in the Design practice and in the context of this research project.

KATCH-Up Board game

This creativity board game tool (Figure 33) aims to create and develop ideas and opportunities for new products or services according to the needs of the users and to define the most appropriate circularity Design strategies and business models to launch the product/service into the market. The objective of this game is to apply circular Design and circular business strategies and stimulate the users to generate valuable ideas based on a business challenge.

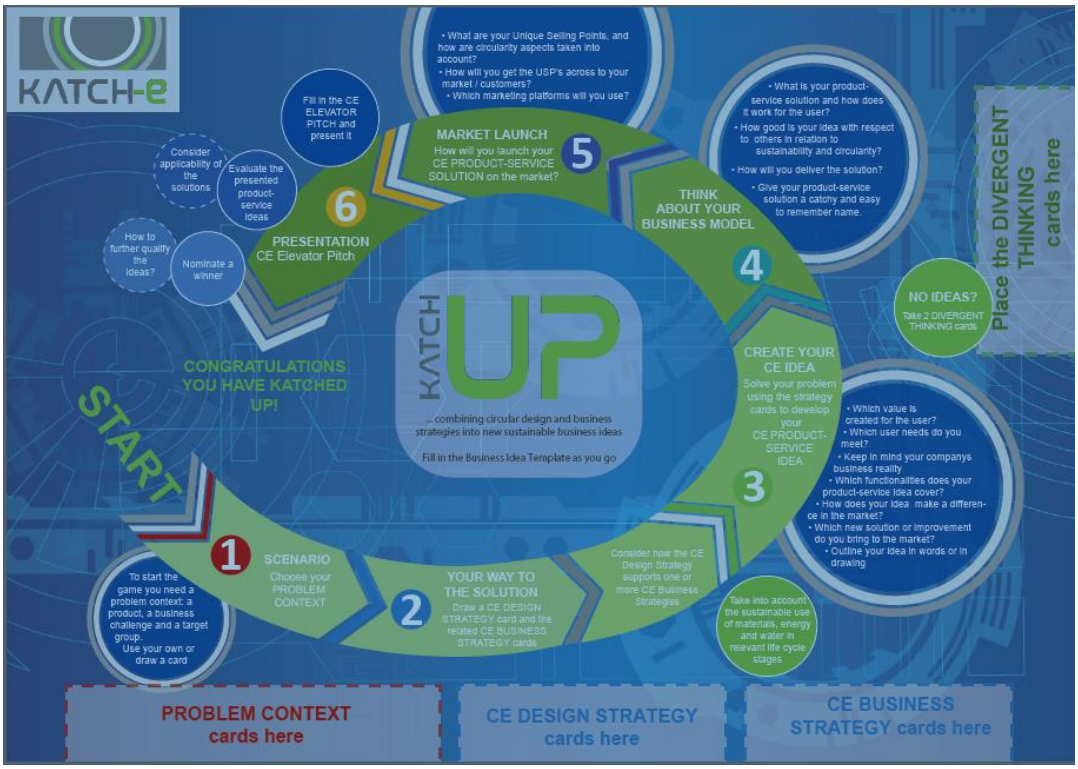


Figure 33 – KATCH UP Game – Playing board

The Game available to download to be printed by the user is based on six basic steps:

- Problem context: Presentation of the product-service category, business challenge and target group,
- Way to the solution: Presentation of Circular Economy strategies that can be used to deal with the problem context,
- Idea creation: Development of the innovative idea that will solve the initial problem,
- Business model: Definition of the most appropriate business model,
- Market launch: Definition of how your product-service will be launched to the market,
- Presentation and scoring: Circular Economy ideas got as a result of the game should be pitched by the groups and scored.

The game acts as a guide to create an innovative product-service or to solve a real business problem and improvement opportunities.

4.3.5 KATCH_e CE Strategist

The tool aims to support designers and development teams in the identification of business opportunities of the Circular Economy and how to integrate these opportunities in the Business Model (Figure 34). The tool evaluates value capture opportunities along the product life cycle, lets users select the best fitting Circular Economy business strategies, and shows how these strategies influence business model elements.

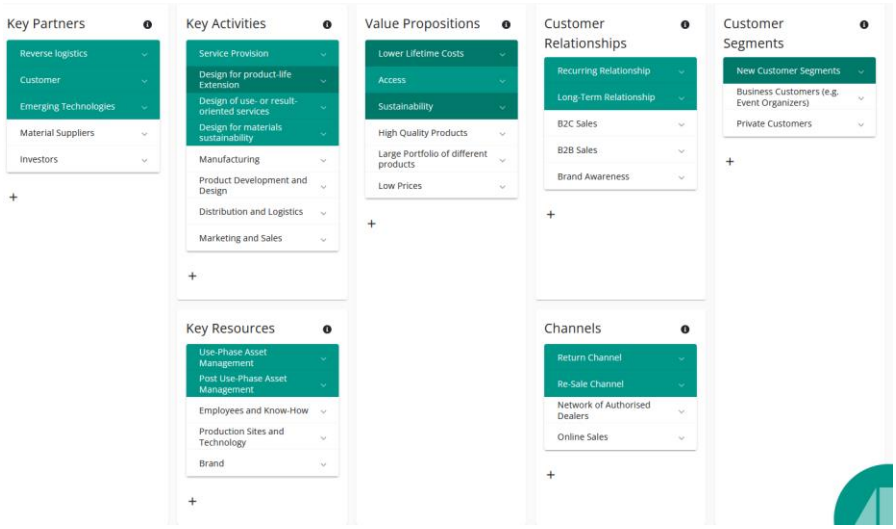


Figure 34 – CE Strategist – Overview

The tool is structured in 3 main steps:

- Evaluating circular opportunities – Assessment of a product or business to identify circular strategies that fit best to the predefined circular business strategies.
- Finding circular strategies, examples and Design strategies – After assessing the opportunities the tool proposes several strategies to choose from. The tool shows a definition of each strategy and provides existing business examples and shows how the strategies are connected to the Design Strategies
- Defining a Circular Business Model – definition of a business model using an adapted version of the Business Model Canvas framework which highlights the implications and effects of circular models in the form of questions.

The tool also allows comparing the "original" version of the business model with the new "circular" version of the business model.

4.3.6 KATCH_e CE Designer

The CE Designer is a semi-quantitative tool for the integration of circularity strategies in the development process focusing on prioritization, assessment and idea finding of circular solutions for product and/or service Design (Figure 35).

It consists of a checklist structure supported by 8 key strategies that address the most relevant issues to consider in the development process of new products or services to support the transition to a more circular society.

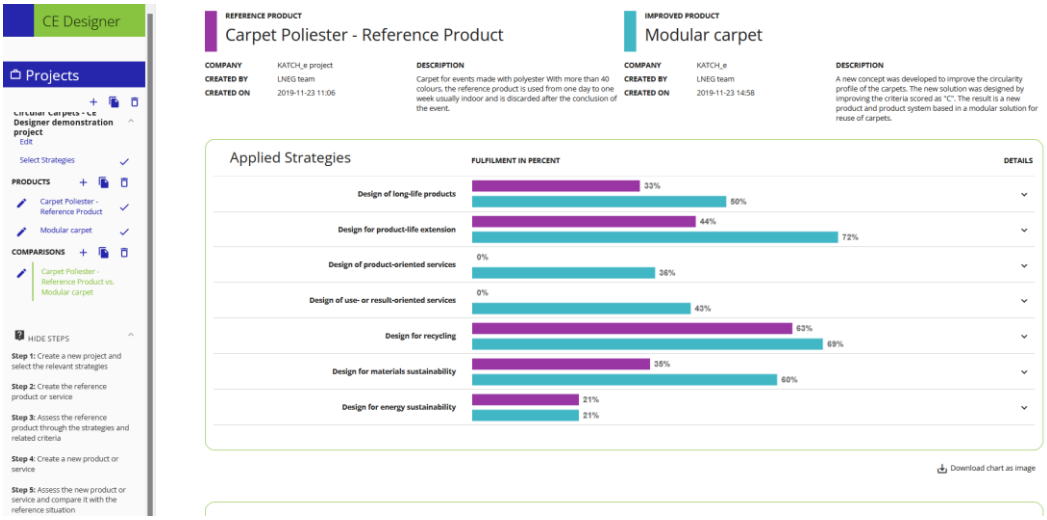


Figure 35 – CE designer – Overview

The tool starts by asking the user to reflect on each strategy, its adequacy, and relevance for the project under development. In the next phase, the user evaluates the profile of the reference product through the analysis of each strategy according to a set of predefined criteria. This analysis of the reference products allows the identification of the hotspots or problems in the product which can be improved, and, by answering the questions in each criterion, through the analysis of the variables and options in each question, the user can identify improvement opportunities that can be applied in the project.

The hotspots and opportunities identified in the process are useful resources to the basis for brainstorming and development activities.

After the implementation of the ideas resulting from the previous activities, the tool is used to compare the reference situation with the new concepts or new products /services resulting from the project. This Design-oriented tool is simple to be used and the process and its results allow the development of new and innovative circular solutions.

4.3.7 KATCH_e CE Journey

Through an exploratory and visual assessment, the tool aims to help the users to assess the overall product / service / system journey, in the three stages – uphill, top hill and downhill – by identifying the touchpoints between several identified factors: materials, producers, stakeholders, and users, providing a model for analysis and identification of opportunities to optimize the journey and to enhance the closing of the loops to present a more circular solution (Figure 36).

Figure 36 – CE Journey Map – Overview

Being a physical tool composed of a printed canvas, cards, pins and colour threads, the tool promotes the identification of new opportunities and ideas, innovation, discussion and brainstorming in creative sessions.

4.4 Key takeaways

Aligned with the fast and intense development of the Circular Economy, tools to support the development of new products and services are being developed and promoted. The Design professionals have at their disposal different tools, both qualitative and quantitative tools with different levels of complexity, costs, focus, typologies of results. However, their application in practice is not as wide as expected and most designers and development teams have not used them in a systematic way.

From the past experiences, is clear the influence and the relevance of the support of concrete and specific tools to ensure that the products and services developed are indeed circular. In Design projects, it is necessary to apply several methods and tools that support the development, validation, and communication of their circularity aspects. But these tools, in order to become widely used, must combine the perspectives of circularity with the needs of the Design practice.

The tools presented in this chapter address the challenge of integrating circularity in Design. However, most of them are still not used widely. There is still the need to continue the development of more efficient and innovative tools or toolkits to support the Design of innovative circular products and services. The new or redesigned tools must be focused on the Design practice and the needs of designers and the characteristics of Design projects. These tools must be cost and time effective and their results must be perceived as an added value to Design projects showing clearly the benefits of their application.

Other tools and guides identified to support of Design and Circular Economy not included in the previous analysis

Circularity deck

Author: Jan Konietzko

Description: A card deck with circular economy strategies and principles developed for designers, entrepreneurs and managers.

It's a learning and organizing tool containing circular economy principles and product and business model examples that illustrate the application. It's a simple tool that can serve as a checklist to identify gaps in the current approach and knowledge and supports the identification actions and ideas towards Circular economy

Source: www.circularitydeck.com

Circular Business Model Design Guide

Authors: PA Consulting in collaboration with Ellen Macarthuur Foundation and University of Exeter

Description: A practical guide to help business leaders in the identification of circular opportunities and design business models that create, deliver and capture value. The guide helps businesses explore and design circular business models by providing practical steps and templates to identify opportunities and define the business model, to support the analysis of the linear business and how to improve it to awards circular solutions.

Source: http://www2.paconsulting.com/rs/526-HZE-833/images/Circular%20Business%20Design%20Guide_10.pdf

Circulytics – Measure Business circularity

Authors: Ellen MacArthur Foundation

Description: Circulytics is a comprehensive tool for measuring the Circular Economy performance of companies, informing their decision making and guiding their circular economy strategies. It helps companies understand the true extent of their Circular Economy

performance. The tool, through the measurement of the performance of a company's entire operations, using a comprehensive set of indicators empowers the business strategy development, allowing the identification of opportunities to generate revenue, design out waste, keep materials and products in use, generate environmental benefits, monitoring progress, and improve band value and recognition from stakeholders

Source: https://ellenmacarthurfoundation.org/resources/circulytics/overview

EMBRACE Toolkit v2.0

Authors: EMBRACE project

Description: The Embrace Toolkit, developed within the EMBRACE project co-financed by the European Regional Development Fund is a compilation of free tools and materials to help create more sustainable products, services and business models. The project addresses SMEs, Intermediary Organizations, Clusters, Policy Makers, in agro-food and wine sectors engaged in the transition to circular economy. With 18 main tools, the Toolkit addresses sustainable design and business innovation, including environmental criteria/assessment and strategy tools for the development of circular business models.

Source: https://embrace.interreg-med.eu

Circular Transition Indicators v2.0 – Metrics for business, by business

Authors: WORLSD Business Cuncil for Sustainable Developmento – WBCSD

Description: The CTI Tool supports businesses to measure and improve their circular performance by supporting and guiding companies through the Circular Transition Indicators process. It structures data and calculates outcomes, supporting businesses in taking concrete actions towards their circularity goals.

CTI Tool enables companies to accelerate their transition towards a circular economy and fully understand their circularity baseline.

Source: https://ctitool.com/

EcoEconomy 4.0 – Ferramenta de avaliação do desempenho circular

Authors: AEP – Associação Empresarial de Portugal

The tool is mainly intended for Micro, Small and Medium Enterprises in the industry, commerce and services sectors that wish to assess their maturity level in adopting Circular Economy practices and develop opportunities for improvement.

In addition to allowing an assessment of the circular performance of companies, this tool also results in recommendations for good practices, which will contribute to improving the performance of companies.

The tool has two versions, a simplified and a detailed one, and is composed of a set of questions (10 in the simplified version, and 28 in the detailed version) divided into five categories:

- Management & Strategy
- Relationship with external stakeholders
- Innovation & circular design in products/services
- Resources & Emissions
- Awareness & Communication

As a results, the tool indicates the global maturity level, the indication of maturity level by category and the identification of circularity practices that will allow the company to improve its degree of maturity.

Source: https://ecoeconomy.aeportugal.pt/

5. Design Principles for Circular Economy

5.1 State-of-the-art

The integration of Sustainability and circularity in the development of products and services has been a widely explored theme and several authors have defined different approaches based on systematization of the process using sets of strategies, principles and criteria. These adopted together or individually, according to needs, project goals and objectives, provide guidelines for transposing the concepts of Sustainability and circularity into practice and are a fundamental tool to inspire Design teams and validate their Design options.

In this sense, and in order to define a set of principles optimized to guide designers in their activity with an orientation towards circularity, an identification and analysis of 18 relevant international references, was carried out.

Based on the identified strategies, principles and criteria, these were classified, grouped and typified in order to identify the trend in terms of the types of principles adopted. This study allowed the identification of 10 large groups, which led to the construction and definition of the principles that will be adopted in the definition of a new toolkit that results from this research and which has the main objective of supporting designers in the transition to the Circular Economy through of its Design performance.

The 18 references identified and analyzed (Annex 6) were the following:

- Key Elements of The Circular Economy from the Circularity Gap Report 2021
- KATCH_e Project (KATCH_e 2019a)
- SinnDesign Project (SinnDesign 2016)
- CIRCit Norden – Design guidelines for circular strategies (https://circitnord.com)
- NIKE – 10 Principles of circular design (*Nike Circular Design Guide*, n.d.).
- Action plan for Circular Economy in Portugal: 2017-2020 (PAEC, 2017)
- Circle Economy – Key elements (www.circle-economy.com)
- Product Design and business model strategies for a Circular Economy (Bocken et al., 2016)
- Taxonomy of Design strategies for a circular Design tool (Moreno et al., 2017),
- RESOLVE Framework (EMF, 2015)
- Circular Design guide (Ellen MacArthur Foundation & IDEO, 2017)

- BS 8001:2017 (BSI, 2017)
- Building Design and construction strategies for a Circular Economy (Eberhardt, et al., 2020)
- Circular Economy Practitioner guide (World Business Council for Sustainable Development [WBCSD], 2018)
- 10 Golden rules of ecodesign (Luttropp & Lagerstedt, 2006)
- 10 principles for good Design (Rams, 1976)
- The 9 R's (Potting et al. 2017)
- Products That Last (Bakker et al. 2014)

5.1.1 Key Elements of The Circular Economy from the Circularity Gap Report 2021

The circularity gap report initiative (Circle Economy, 2018), developed by the Circular Economy platform recognises the urgent need to accurately measure the Circular Economy. Since 2018, several Circularity Gap reports have been launched providing a framework and fact-base to measure and monitor progress in bridging the global circularity gap.

The Initiative delivers an annual global circularity metric that measures the state of the world economy and identifies key levers to transition to global circularity.

Within the Circular gap report released in 2021 (Haight et al., 2021), the Key elements of the Circular Economy are important as inspiration for the identification of a set of principles for the Design practice towards circularity.

5.1.2 KATCH_e Project

The Katch_e – Knowledge Alliance on Product-Service Development towards Circular Economy and Sustainability in Higher Education (KATCH_e 2019a) is an EU funded project that was part of the ERASMUS+ programme of Knowledge Alliances. KATCH_e was developed by 11 partners from four EU countries to address the challenge of reinforcing the skills and competencies in the field of product-service development for the Circular Economy and Sustainability in the construction and furniture sectors. Within the project, a complete set

of training materials for enabling Circular Economy in the construction and furniture sector was developed. The contents address students and professionals in the industry and specifically focus on the development of sustainable product-services and within the materials developed, a set of strategies and criteria were developed and integrated into training materials and in the CE Design Tools developed to support the integration of Circular Economy in the development of new products and services, as presented.

5.1.3 SinnDesign Project

The SInnDesign – Sustainable Innovation Through Design Project, (Sinndesign. 2016) aimed at the development of training materials and Design tools for Sustainability to three specific sectors related to the habitat cluster (furniture, habitat textiles and building materials), resulted in innovative and competitive solutions. Within the several resources developed, the Design for Sustainability checklists tool includes a set of relevant strategies to support the development of sustainable products and services.

5.1.4 CIRCit Norden – Design guidelines for circular strategies

The CIRCit research project, (https://circitnord.com) with operations in Denmark, Sweden, Norway, Iceland and Finland, supports the Nordic industry to discover and implement the opportunities of Circular Economy, through the development, testing and implementation of science-based tools.

Within the results of the project that are available, the Guidelines for circular product Design and development provide relevant information about Circular Economy and includes a circular strategy scanner where different strategies and dependencies are mapped to enhance the understating of a Circular Economy and the various strategies (Shahbazi, 2020).

5.1.5 NIKE – 10 PRINCIPLES OF CIRCULAR DESIGN

Inspired by Global Fashion Agenda, Nike has created the “Circularity: Guiding the Future of Design” (*Nike Circular Design Guide*, n.d.). This guide and its related workbook share principles that support a universal call to action for the sports industry. “Move to zero” is

Nike’s journey toward zero carbon and zero waste to help protect the future of the sport. Within the circularity workbook: guiding the future of Design, a set of 10 Design principles are defined to support the circular and sustainable development of Nike's sports products.

5.1.6 Action plan for Circular Economy in Portugal: 2017-2020

The Portuguese Action Plan for the Circular Economy (PAEC, 2017) defines a strategy for the Circular Economy until 2020 has three levels of actions to be introduced and worked on during three years: national initiatives, which consolidate some of the actions of various government areas for this transition; sectoral agendas, especially for sectors that are more resource-intensive and export-oriented; and regional agendas, which must be adapted to the socio-economic specificities of each region.

This plan adopts a strategy that seeks to replace the “end-of-life” concept of the linear economy, based on the production and elimination of waste, through the reduction, reuse, recovery and recycling of materials and energy. Through this action plan, Portugal intends to dynamize a transition to an economy less dependent on the intensive consumption of raw materials, minimizing the extraction of material resources, ensuring the regeneration of the natural systems, maximizing reuse, increasing efficiency and in the development of new business models.

Within the scope of the action plan, the 10 R’s are adopted distributed by 3 groups: Smarter product use and manufacture, Extended life span of products and their parts, and Useful application of materials.

5.1.7 Circle Economy – Key elements

The Circular Economy platform (www.circle-economy.com) within its mission is to accelerate the practical and scalable implementation of the Circular Economy is also responsible for the definition of a set of key elements for the Circular Economy. This key elements framework integrates the elements of the Circular Economy and acts as a basis to derive contextual strategies and interventions. The Framework consists of 3 core elements with activities directly handling product or material flows and 5 enabling elements which are those that remove obstacles for core actors.

5.1.8 Product Design and business model strategies for a Circular Economy

This paper, published in the Journal of Industrial and Production Engineering (Bocken et al., 2016) presents the development of a framework of strategies to guide designers and business strategists in the transition from a linear to a Circular Economy. Based on the research developed by Walter Stahel (1994), the terminology of slowing, closing, and narrowing resource loops is here introduced. The article includes also a list of product Design strategies, business model strategies, and examples for key decision-makers in businesses, to promote the transition to a Circular Economy.

Being a widely known reference, the research developed by these authors, and especially the framework here presented, is a fundamental inspiration and source for the development of principles and strategies for the designers practice towards circularity

5.1.9 Taxonomy of Design strategies for a circular Design tool

In this article, published at PLATE, Product Lifetimes and the Environment conference at the Delft University of Technology (Moreno et al., 2017), the authors present a taxonomy of Design strategies useful to guide product designers on how to conceptualise durable and single-use products for a Circular Economy by identifying and exploring potential solutions for closed-loop systems. The Design strategies are included in a tool that was tested in a practical context in supporting the Design practice.

The taxonomy presents the relation of circular Design aspects with the DfX approach and the related strategies relevant to promoting the Design and development process.

5.1.10 RESOLVE Framework

The ReSOLVE framework (EMF, 2015) offers companies a tool for generating circular strategies and growth initiatives. The framework takes the three principles of the Circular Economy, Preserve and enhance natural capital, Optimise resource yields and Foster system effectiveness, and translate it into six business actions: regenerate, share, optimise, loop, virtualise, and exchange.

5.1.11 Circular Design guide

In the Circular Design Guide platform (Ellen MacArthur Foundation & IDEO, 2017) which is a collaboration between the Ellen MacArthur Foundation and IDEO (2017), a method that includes a set of activities to understand, define, make and release circular innovations was developed and is available to all. The different activities are explained in a step-by-step approach, and supported by auxiliary tools to promote the integration of circularity aspects in the Design practice

5.1.12 BS 8001:2017

The British Standards Institution launched the standard (BSI, 2017) – "Framework for implementing the principles of the Circular Economy in organizations" as a practical framework and guidance for organizations to implement the principles of the Circular Economy and has been developed to be applied to any organization, regardless of location, size, sector and type.

The standard contains a comprehensive list of Circular Economy terms and definitions, a set of general Circular Economy principles, a flexible management framework for implementing Circular Economy strategies in organizations, and a detailed description of economic, environmental, Design, marketing, and legal issues related to the Circular Economy.

In the standard, Potential Design strategies are presented, distributed by 4 Design focus areas and the identification of a set of Non-exhaustive options for Design improvement

5.1.13 Building Design and construction strategies for a Circular Economy

This article, which was built on the needs identified in the construction sector (Eberhardt, et al., 2020), the sense that Circular Economy initiatives are being developed and explored in industry. However still lacking in wide-scale adoption, and the fragmented development and implementation of Circular Economy building Design and construction strategies.

The study presented offers state-of-the-art in building Design and construction strategies for a Circular Economy. The overview of Design strategies was supported by a literature review

that resulted in the identification and analysis of 34 publications select from a wide group of publications identified.

The study resulted in a taxonomy summarising 16 building Design strategies which were analysed according to the level of application, level of readiness and further described. The taxonomy provides a hierarchy of the strategies according to their occurrences in the accessed references which is an important factor for the selection of Design strategies to support the Design practice.

5.1.14 Circular Economy Practitioner guide

The Circular Economy practitioners guide, developed by the World Business Council for Sustainable Development [WBCSD], 2018 includes in their online platform a set of strategies and practices according to 6 thematic areas or functions in the company: Design, buy, make, sell, dispose and finance.

In the Design area, which is relevant for the current study, the guide indicates 14 practices to support companies towards the Circular Economy. In each practice or strategy, a detailed explanation is provided to promote the application in practice. In some cases, examples and case studies are used to illustrate the strategy.

5.1.15 10 Golden rules of ecodesign

The EcoDesign and The Ten Golden Rules (Luttropp & Lagerstedt, 2006): generic advice for merging environmental aspects into product development article, published in the journal of cleaner production stresses the important role of Design and its impact and relevance in the initial phases of the process.

Based on the hypothesis that there is a strong need for a tool to facilitate the integration of reasonable environmental demands into the product development process, it presents the tool “The ten golden rules” which provides a common foundation that can be used as a base and guidelines for the development of specific product-design challenges.

The rules have a generic approach and should be customized as needed.

5.1.16 10 principles for good Design

Dieter Rams, the head of the Design team at Braun for over 30 years, is one of the most influential industrial designers in the world.

In 1976, in New York, Dieter Rams presented his 10 principles for good Design (Rams, 1976) which were a method of organizing and systematizing his view and thinking about what makes good Design. The ten principles, with a simple and clear approach, have influenced generations of designers and are part of the curriculum of the majority of Design schools.

5.1.17 The 9 R's

Several references explore the R's concerning Sustainability (Potting et al. 2017), ecodesign and Circular Economy. Within the Policy report "Circular Economy: Measuring Innovation in The Product Chain" which is a study developed for the Dutch Ministry of Infrastructure and the Environment to support the knowledge on the progress made in the transition from linear to circular product chains, the Circular Economy transition process as well as its effects on the consumption of natural resources and materials, the environment and the economy.

Within the report, a set of circularity strategies within the production chain are explored and presented in order of priority and represents the transition from the linear economy to the Circular Economy.

5.1.18 Products That Last

Products That Last (Bakker et al. 2014) it's a Dutch project led by the Industrial Design Engineering faculty of the Delft University of Technology, which resulted in a methodology to support new business opportunities, models, and Design strategies for the Circular Economy. The Methodology, developed for designers and companies is based on a set of five business model strategies to help businesses and designers in a thinking shift towards a Circular Economy and six strategies for Circular Product Design. Through the application of the strategies, the Design team can identify where the decrease of the value occurs in the Sistema and allows the identification and development of Design solutions to create value for the product and the company.

The identification of the different strategies, principles and criteria defined by reference authors, allowed a collection of a wide group of approaches to Design, circularity and Sustainability.

These were translated in a matrix, which allowed a global overview in order to identify trends, and common concepts on how to implement and support the development of products and services. In Figure 37 we can see the global view analysed references.

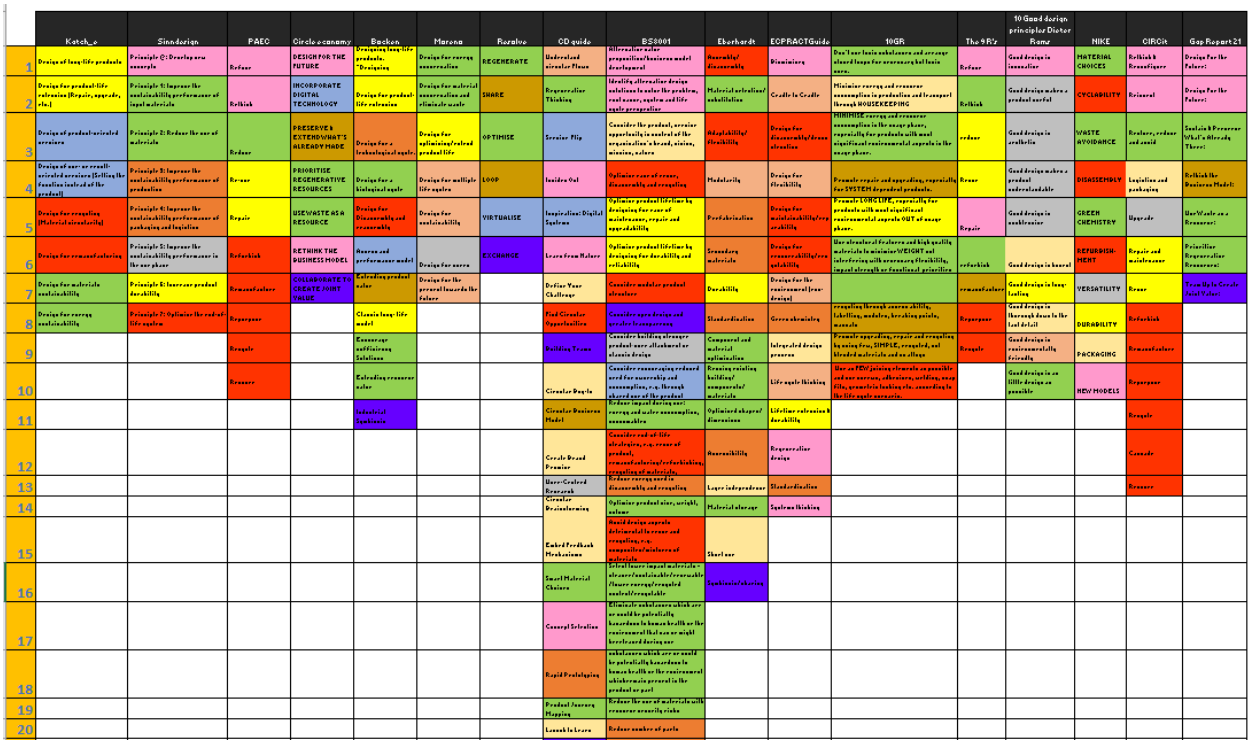


Figure 37- Matrix of strategies

This analysis allowed the identification of 11 groups, according to their concepts, aims, and specificities. These concepts can be seen as an orientation for the definition of an improved set of principles to support the Design practice towards circularity in line with the research developed in this Thesis.

The 11 groups or types of strategies identified were the following:

- New concept development,
- Optimization of resources,
- Optimization of the production process,
- Improvements in the use of products or services,

- Durability,
- Services and virtualization,
- New business models,
- Collaboration, synergies and co-creation,
- Life cycle perspective,
- Closing the loop,
- And a 11º group with lower expression defined as “other”.

5.2 Definition of Design principles for Circular Economy

In the Design practice towards Circular Economy and Sustainability, the Design team can apply a set of principles that support and systematize their innovative processes.

Inspired by the review and the analysis of a wide set of different strategies and principles that are being applied by several authors, the analysis of tools and different approaches to Design for the Circular Economy, 10 principles to support the Design process towards more sustainable and circular products and services were defined (Figure 38).

Figure 38 – Ten principles for circular design projects

5.2.1. Design with a Life Cycle Perspective

It is estimated that over 80% of all product-related environmental impacts are determined in the Design phase. Therefore, it is crucial to Design with a life cycle perspective in order to minimize or eliminate impacts considering the entire life cycle of products and services.

The Design and development teams should ensure that Circular Economy aspects are integrated into product Design and development early in the development process with the aim of improving circularity and reducing impacts throughout the entire life cycle of the product or services (BSI, 2017), while still taking into account other Design aspects such as safety, quality, ergonomics, aesthetics, and also, considering the trade-offs and compromises between different environmental aspects and the attained solutions (IEC, 2019).

Designing for the Circular Economy and aiming for a more effective and optimized management of resources across the life cycle with a holistic perspective should lead to a positive impact on the natural environment and society (BSI, 2017). Therefore, top management and decision-makers should ensure that strategies are planned, implemented and maintained, considering all stages in the life cycle of a product (ISO, 2020), through Design.

What to consider in the Design phase?

5.2.1.1 Consider all life cycle phases

The Design team, when designing with a circularity and Sustainability focus, must adopt a holistic approach and consider the entire life cycle of the product or service in the process, considering all “Consecutive and interlinked stages of a product (or service) system, from the raw material acquisition or generation from natural resources to final disposal. (…) including the acquisition of raw materials, Design, production, transportation/delivery, use, end-of-life treatment and final disposal” (ISO, 2015).

5.2.1.2 Analise the impacts in each phase/ Conduct LCA studies

In order to guide the Design process towards the minimization or elimination of impacts in the life cycle of products or services, the Design team must have knowledge about the environmental profile of the products. In this regard, a life cycle assessment is fundamental to have a clear overview and perception of the impacts in each stage.

For the identification and evaluation of environmental aspects, the team should establish, implement and maintain a process to identify and evaluate product-related environmental aspects and impacts throughout the life cycle. This assessment, according to the objectives and resources of the project can have a qualitative or quantitative evaluation and prioritization of the environmental aspects, however, where feasible, the quantitative approach is encouraged (IEC, 2019).

By conducting LCA studies, the team can also identify opportunities to improve the environmental performance of products acting in several stages in their life cycle, support the information to decision-makers for strategic planning, priority setting, product or process Design or redesign, marketing purposes, or other (ISO 2006b).

5.2.1.3 Avoid the transference of impacts for other phases of the life cycle

The life cycle approach, through an overview of the impacts in all stages, can avoid the transference of impacts from one stage to another, which is a common result of projects developed without a life cycle approach.

The transference of impacts can occur from one stage to another, from one region to another or even from one impact category to another. For example, one solution can reduce the quantity of a material used in the product, however, for this reduction, the material was substituted by a different material, produced in a far location, resulting in a material with a higher embodied energy.

5.2.2 Design the Function /Rethink the System

The Circular Economy can be characterized by a Rethink approach. To make something more circular requires a rethinking process (Morseletto, 2020).

Rethinking the system and the function of the product is a way to look at your product and envision sustainable alternatives by thinking outside the box and have new approaches and perspectives for the product and the system which are translated into new or reshaped objectives for the Design project.

Rethinking allows an identification of alternative Design solutions to solve the problem (BSI, 2017). In a circular Design approach, the focus should be on the outcome to fulfil a specific need. The key is to Design the most sustainable way of producing that outcome. Outcome-driven thinking places the focus on the function the user needs and not on the solutions of how to produce or deliver the offering (Niinimäki & Hassi 2011).

Rethinking is about developing new ideas and solutions to provide certain product functions in line with the needs of the users, including the re-elaboration/reconceptualisation of ideas, dynamics, processes, concepts, uses, and post uses of a product (Morseletto, 2020).

What to consider in the Design phase?

5.2.2.1 Question the function

In a Circular Economy approach, aiming to close the material and component loops in a sustainable way, the Design team should put into question the function of the product. Perhaps, the users do not need a product at all, or their needs can be fulfilled with a totally different solution. The Circular Economy needs an out-of-the-box approach in attaining innovative solutions.

By approaching the process through the function, the potential to innovate is higher. In this regard, a function analysis, which is a fundamental phase in the value analysis methodology that consists of a systematic process to describe the product through its function, can be implemented. The product is not considered as a specific solution with a group of

components, but through a set of functions that will satisfy the needs of the user (Catarino et al., 2007), it supports a creative problem-solving approach by moving the focus away from the expected solution and placing the focus on the required performance or need (Value Analysis Canada, n.d.)

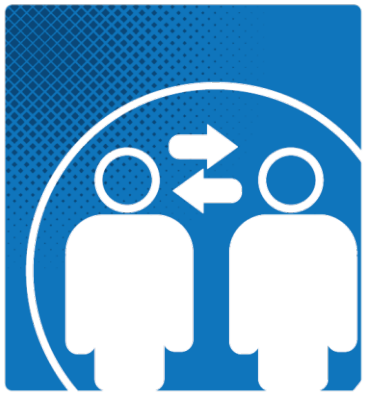
5.2.2.2 Develop new concepts

Design projects are developed frequently with a lower innovation level, focusing mainly on product improvements or product redesign. With this approach, the new attained solutions can improve the systems by developing different products with lower environmental impacts. However, disruptive solutions with a higher potential for Circular Economy and Sustainability are difficult to occur.

To have an effective approach and reach a higher level of innovation and Sustainability, the Design teams should innovate with alternative ways to fulfil the functions and the needs of the users.

It is recommended to start by thinking "out of the box" and develop new concepts (Rocha et al, 2015) and new solutions that rethink the entire system. Not only the product itself but the entire context in which the product operates.

5.2.3. Design with Synergies and Co-creation



The Design practice has been evolving. This evolution, from a user-centred approach to co-designing, is changing the roles of the designer, the researcher and the users (Elizabeth, 2008).

In Design for a Circular Economy, as a new step in the Design evolution, changes are needed in the field of Design and Design education towards disruptive innovations for transformation, intelligent systems, open Design and others, and new views and approaches on Design processes. The participation of the stakeholders in the process is being promoted, especially through collaborative forms like open Design, co-creation and participatory Design (Hummels, 2012), and the establishment of synergies in the value chain.

Some authors even consider that without collaboration initiatives, it is unlikely that an organization can achieve successful and substantial progress in the transition to a more circular and sustainable economy (BSI, 2017).

What to consider in the Design phase?

5.2.3.1 Collaborate and co-Design

The Design practice for Circular Economy and Sustainability should promote the collaboration of designers and other professionals in order to attain the needs of the projects along the life cycle. Building teams to strengthen knowledge and expertise, building relationships with stakeholders (Ellen MacArthur Foundation & IDEO, n.d.), providing space for customers and users, to be actively involved in the Design and development of products and services (Marlien, 2019) will influence the innovation and the identification of new ideas with a higher potential of success.

Adopting co-creation initiatives into the Design practice will cause several changes to occur in the process. It will change the Design practice, what is designed, and who designs (Elizabeth et al., 2008). Co-designing will promote a close collaboration between stakeholders in the Design development process together with other professionals with other skills (Elizabeth et al., 2008) allowing to explore the potential of each actor, creating value in the process, reducing risks, costs and increasing the potential for success.

5.2.3.2 Synergies

In a Circular Economy, it is advocated to optimize resources, optimise the material flows and create alternative and efficient ways of production and consumption focusing on maintaining materials and components in use without the generation of waste. These goals, to be effective and implemented in practice through Design, must consider and explore the potential synergies that can be created in the value chain.

The creation of synergies that promote collaboration throughout the supply chain will increase transparency and create a joint value (Circle Economy, 2018).

5.2.3.3 Industrial Symbiosis

The Design of new products, services, or systems must consider the potential for the establishment of industrial symbiosis solutions, in which the waste or by-products of an industry or industrial process becomes the raw materials for another. The application of this concept allows more sustainable use of resources and contributes to the creation of a circular and sustainable economy (European Commission 2018; European Commission, 2019a)

This process-orientated, approach focused on using residual outputs from one process as feedstock for another process must consider the geographical proximity of businesses (Bocken et al., 2016) in order to be efficient and add value for all actors involved in the process or system.

The benefits for the business network can have significant impacts, such as the reduction in overall operating cost and risks, the establishment of reliable alliances, increase the trust in partnerships, joint innovation processes, sharing of assets, services, etc.

5.2.4. Design Durable Products

Designing durable products with a long-life is concerned with ensuring a long utilization period of products, maintaining its function and service over a longer period of time without loss of performance (Rocha et al., 2019), aims for a maximum potential lifetime of a product, component or material to perform a required function under intended conditions of use and maintenance before it becomes obsolete because it can´t fulfil its function (BSI, 2017).

New products should be Designed to be durable for a long lifetime through the integration of solutions and features that facilitate easy repair, particularly by third parties, (BSI, 2017), maintenance, upgrade, etc. The Design team must also select effective materials and components that guarantee the durability of the product.

Designing for durability is mainly focused on the physical durability, by the development of products that can take the wear and tear without breaking down, attained by Design solutions and effective material selection, by designing reliable products that will operate throughout a

specified period without (Bocken et al., 2016), and by developing product life extension features concerned with an increase in the use period of products, through maintenance, repair and upgrading characteristics defined at the Design stage (Rocha et al., 2019).

The objective of this principle is to extend the technical, aesthetic and emotional lifetime of the product so that it will be used for as long as possible. While this strategy may seem unattractive for companies because they would "sell less", it can be interesting and competitive for certain types of products and market segments where high quality and durability are a strong sales argument (Rocha et al., 2015).

Developing durable products, that are used and maintained for longer is the counter-strategy to the implanted programmed obsolescence, which is linked to techniques and solutions by which an "organization seeks to deliberately limit product lifetime in order to increase replacement rate" (BSI, 2017).

What to consider in the Design phase?

5.2.4.1 Quality of materials

The selection of the more suitable materials to fulfil the needs of the product and their function is crucial in Design for the Circular Economy. The adequate material will promote the durability of the product without creating additional needs in the life cycle of the product.

The quality of the materials in the product should be selected according to the function, considering the implications and trade-offs in the life cycle of the product. For example, the selection of a high grade and high-quality material for a product that has a short life and will be recycled after a short period of time is not a good option.

5.2.4.2 Reparability

Durable products that can be used for long periods of time should rely on the possibility of being repaired easily and at an affordable cost for the user.

In the Design phase, the Design team should include features to promote and facilitate the reparability of the product. Features like a Design for easy disassembly, the use of standard components, diagnosis systems, repair information, repair services, etc, should be developed.

5.2.4.3 Maintenance

Easy and affordable maintenance of the product can have a high impact on the durability of a product. Maintenance involves functional checks, servicing, replacing consumables, cleaning, and other activities. For example, a product that due to its shape or material is difficult or expensive to clean tends to be discarded and replaced easily by the user.

5.2.4.4 Upgradability

The needs of the users tend to evolve over time, and these new needs can be attained by the replacement of the product by new versions of updated products, or by the upgrade of the current products. In the Circular Economy, to develop sustainable solutions, the product must be in use for the longest possible period of time. This can be attained by solutions to upgrade the existing products by developing solutions that promote the technical or aesthetical upgrade potential, with an added value for the user.

5.2.4.5 Wear-resistant Design solutions

Durable products must be resistant to wear and loss of properties over time. The Design team must consider these aspects and include solutions to minimize them. This can be achieved by the selection of adequate materials, as well as by the Design of the product. For example, products that are not user friendly, with complex features tend to have a higher pressure on the structure of the product, leading in most cases to a reduced use due to wear.

5.2.4.6 Product-user relation

The challenge for designers is to create products with a stronger emphatic relation with the user. Products that, due to their characteristics, will be attractive for users to purchase, use and maintain (Rocha et al 2015). Designing for attachment and trust or for emotional durability refers to the creation of products that will be used, liked or trusted longer (Bocken, 2016).

By attaching this emotional aspect to products, the Design team is able to develop solutions that by exploring the potential, will avoid the replacement by other products, reducing the

needs of producing and placing more products in the market and therefore, the reduction of impacts in the system.

5.2.4.7 Simplicity principle

The simplicity principle has the potential to increase the durability of the products and it can be implemented in several ways. Simple solutions will promote better use of the product, with a lower margin of error. The simple architecture of the product will promote the reparability and maintenance of the product. Simple and timeless Design solutions will avoid disposal due to fashion issues.

5.2.5. Design with Sustainable Materials and Energy

Material selection is a key step in Design for Circular Economy and Sustainability. The objective is to select sustainable materials without increasing costs or degrading the product functionality (IEC, 2019), seeking the best match between Design requirements for the product and material properties (Rocha et al., 2019).

The selection of the energy that is used for and by the product is a crucial factor to be considered as well. In the Design phase, the Design teams can select materials and energy with lower impacts. The decisions taken in the Design phase are fundamental to influencing the efficiency and optimization of material and energy consumption in the life cycle of the product or service (Rocha et al., 2020).

The properties and functionality of materials are continuously evolving as a result of material innovation and new and more effective material applications. The selection of materials must have in consideration their Sustainability and the designers should take into account the social, economic and environmental aspects throughout the material's life cycle (BSI, 2017).

What to consider in the Design phase?

5.2.5.1 Recyclable materials

In a Circular Economy approach, to attain the goal of closing material loops, the selection of materials has an important role. The materials selected for a new product must allow that after its use they can be recycled.

5.2.5.2 Recycled materials

In order to maintain the materials in the circular loop, the Design solutions must replace virgin materials and consider the selection of recycled materials as much as possible.

5.2.5.3 Low embodied energy materials

In the transition to circular and sustainable solutions, the embodied energy should be considered by designers in the development of a product. Embodied energy comprises the energy consumed during the extraction and processing of raw materials, transportation of the raw materials, manufacturing of materials and components and the energy used for various processes during the end of life (Rocha et al 2020). The higher the energy consumption, the higher the environmental impact of the product.

5.2.5.4 Renewable materials

The selection of materials to meet the needs of the product must consider the use of renewable materials. These are potentially more sustainable since they are “resources that are able to be renewed or replenished by ecological cycles or agricultural processes at a rate equal to or greater than consumption so that the products and services provided by these resources are not endangered and remain available for future use” (BSI, 2017).

5.2.5.5 Renewable energy

The Design team should evaluate the consumption of energy along the product’s life cycle and prioritize the selection of renewable energy sources.

5.2.5.6 Non-toxic materials

The selection of materials must consider their toxicity. Hazardous substances in the product must be avoided.

5.2.5.7 Efficient materials

Sometimes materials may seem not interesting from a Sustainability point of view if considered alone, however they can have a positive influence on the product system and the life cycle. For example, a material can have a high consumption of energy in its production, but its application on a product will highly increase its durability.

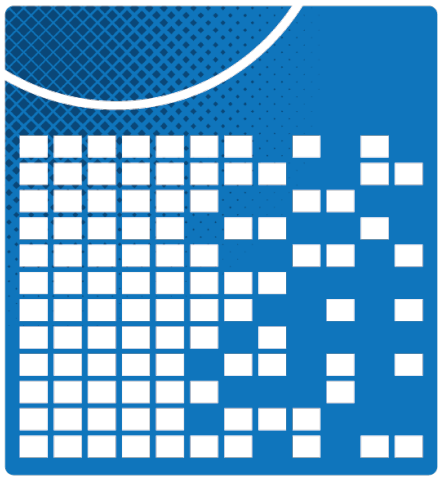
5.2.5.8 Fair materials

Fair materials are materials that are fair from a social point of view. The materials used in a product have a direct impact on the environment and on the people that are linked to those materials in all stages of the life cycle. From the conditions in which they are extracted or produced, transported, the consequences of their use in production, use and in valorisation after the use. Problems like pollution, dangerous working conditions, child labour, etc, are linked to the materials "DNA" and these aspects must be considered in the selection of materials.

5.2.5.9 Local materials

In the selection of materials, their origin must be a criterion to consider due to the environmental impacts of transport, associated with the consumption of fossil fuels and the emissions. In most cases, the preference should be given to materials that are extracted and processed near the production facilities (Rocha et al., 2015). This aspect also has social impacts that must be considered. Local materials tend to have benefits on local communities.

5.2.6. Design for Dematerializing the System



"We need to embrace dematerialisation, rethink concepts of ownership and move from resource efficiency to resource sufficiency" Janez Potočnik (Haigh et al., 2021, p.7).

We need to change the way to fulfil the needs of the users in a more sustainable and dematerialized way. If we achieve a reduction in the inputs of the material to fulfil the functions, we can achieve a higher circularity level and create more value.

With a dematerialization focus, the designer must deliver a function with no or reduced input of materials, often through moving from physical products to digital alternatives (BSI, 2017), to services or a combination of both. These new approaches to product and service development can be attained by strategies like the reuse of products and components, sharing, leasing, repair, refurbishment and recycling of products (EEA, 2017) among other solutions.

The need for the dematerialisation of production and consumption is not likely to happen through efficiency improvements. There is a need for a shift from the current technological paradigm (Idil Gaziulusoy, 2015) through the Design and development of new solutions.

Product/service-systems, as a means to dematerialize the system started to gain momentum due to the high potential for enhanced environmental performance and improved competitiveness (Mcaloone & Pigosso, 2017) and the combination of tangible products with intangible value-added services that lead to dematerialization by reducing the production of waste in the life cycle, by reducing the consumption of resources, and by decoupling the economic growth from environmental impacts, and by creating new revenue streams and extending the residual value of products (Romero & Rossi, 2017).

What to consider in the Design phase?

5.2.6.1 Sharing

Sharing of products in order to meet the needs of the users enables an increased utilization rate of products and services by making possible a shared use or ownership among consumers. It enables customers to access a product, rather than owning it, and use it only as needed (BSI, 2017). With this solution, the same product can satisfy the needs of more users which leads to solutions that use fewer raw materials and can still meet the demands of consumers, or even more.

5.2.6.2 Leasing

In leasing solutions, the needs of the users, through a contract with a regular fee, can be satisfied by products or services that are leased from a service provider. The provider retains ownership and is often responsible for maintenance, repair, and control (Rocha et al, 2020, BSI, 2017).

5.2.6.3 Virtualization

Deliver utility virtually. Replacing physical infrastructure and assets with digital/virtual services offers dematerialization advantages over tangible products, but without reducing the perceived value to the customer (BSI, 2017).

Through digitalisation, everything becomes connected, such as intelligent infrastructure, energy networks, the “Internet of things”, and social networks (Dutch Ministry of Infrastructure and the Environment & Ministry of Economic Affairs, 2016).

5.2.6.4 Increase service component

For the adoption of dematerialized solutions, the Design team must develop the system in order to maintain the added value for the users. These solutions, in general, must optimize and increase the services that are provided to the user

5.2.7. Design for Efficient and Sustainable Production

The Circularity approach is essential in the transformation of industry towards climate-neutrality and long-term competitiveness (European Commission, 2020) and continually challenges current business practices and methods (BSI, 2017).

The Design practice can support and streamline the production processes to implement circularity, reduction of waste and optimization of resource consumptions, promotion of useful applications for materials, etc (Simeone et al, 2019; PAEC, 2017).

Design for an efficient production focuses on adopting Design measures and innovative modes of operations that improve the production stage by reducing the consumption of resources per unit of output preventing/minimizing the generation of waste and emissions and improving the efficiency of the outputs, (products and subproducts) (Rocha et al., 2015, BSI, 2017).

The new product and service solutions should seek to maximise the resource efficiency, thereby minimising the waste production and the recirculation and reuse of waste and secondary products into the production (Environmental Services Association, 2013) and considering the working conditions under which the products are made, including worker's rights and working conditions (Young et al 2008).

What to consider in the Design phase?

5.2.7.1 Reduce consumption of materials and energy

In a circular Design approach, considering the entire life cycle of the product in the Design phase, the Design team must consider the production process and its stakeholders and implement measures to reduce the consumption of materials and energy. Simple solutions like changing the shape of a product can have a high impact on the production process by reducing the material needs or by eliminating steps in the productions, or even by avoiding failures.

5.2.7.2 Modularity

The adoption of modular solutions can optimize several aspects of the product life cycle. In production, this solution can have benefits at several levels. In production, it can optimize the process, reduce stocks, optimize costs, etc

5.2.7.3 Best available technics

Companies that apply the best available technics (BAT), potentially have benefits in terms of production. Usually, the new technics are more efficient in the production and consumption of resources. BAT allow also the integration of new features and developments with a higher potential to innovate.

5.2.7.4 Standardization

The use of standard solutions, materials and components in the production process tends to optimize the process, reducing production time, the needs of specific tools and equipment and the consequent reduction of costs. This approach has also benefits other stages, it facilitates the assembly and disassembly process for repairing, upgrading, repurposing, recycling, etc.

5.2.8. Design for Optimal Use

When considering the entire life cycle, the use phase is likely to have the greatest environmental impact. It involves the consumption of resources such as energy, consumables, and outputs such as waste and emissions during the use of the product (IEC, 2019).

In the Design phase decisions that are made on products are crucial to influencing the use phase positively (Rocha et al., 2019). The development team must consider and adopt strategies to prolong the life of the products, components and materials through durability, repair, upgrade etc, (BSI, 2017).

Another crucial aspect is the interface and the relation between the product and the user. Products and services must be user friendly, effective and efficient in supporting the needs of the users without creating additional needs. Designing for optimal use, will reduce the impacts and added values to the product or service system.

What to consider in the Design phase?

5.2.8.1 Reduce consumables

The Design of a product or service must consider the consumables that will be needed for the product to fulfil its function. Their optimization in terms of consumption, costs and impacts must be considered. In this stage, it is also fundamental to avoid the creation of additional needs for the user.

5.2.8.2 Simplicity principle

The simplicity principle is a good approach to attain circular and sustainable solutions. By adopting simple solutions, the product is more user friendly, the product is used better, for longer, risk and damages are minimized, and costs are reduced, etc

Through simplicity, by the opposition and in consequence of complexity, designers can potentially grant access to a better quality of life and improved access to technological artefacts and products by allowing its interaction and use in a simpler way (Duarte, 2013; Morseletto, 2020).

5.2.8.3 Inclusive Design/Design for all

Inclusive Design, as defined by the British Standards Institute is ‘The Design of mainstream products and/or services that are accessible to, and usable by, as many people as reasonably possible ... without the need for special adaptation or specialised Design. (BSI, 2005).

When designing for the Circular Economy, the Design team should, besides the circularity goals, assure that the solutions attained are sustainable considering the three pillars of Sustainability, (environment, economy and society). Therefore, social aspects, which are often forgotten by most teams, are important to sustain the solutions and the welfare of society.

Since the Design options have the potential to include or exclude users, it is relevant to consider an inclusive Design approach, which emphasizes the contribution that understanding user diversity makes to informing designers decisions, and thus to including as many people as possible as potential users (Cambridge University, n.d.).

5.2.9. Design for Recirculation and Zero Waste

The Circular Economy is seen as a new way to Design, produce and use products and services in a more efficient and sustainable way. Based on the principles of elimination of the generation of waste in the system, the recirculation of products and materials and the regeneration of natural systems, (EMF, 2015) the adoption of the concept maintains or even increases the value of products, materials and resources in the economy for as long as possible, contributing for an efficient and competitive economy (European Commission 2015).

The waste, seen as the result of system inefficiency and symbolising bad Design options, should be considered as input material, as resources with value and potential to be used in the production process. The shift from “waste” to “resources” can boost the market for secondary materials, products and components. By reusing resources in the system and decreasing the dependence on virgin raw materials, it encourages the redesign of the resource life cycles (Eduzwace, 2020) and the improvement of the entire production and consumption system.

What to consider in the Design phase?

5.2.9.1 Design for Reuse

Reuse is an action where products, components or materials can be used again for the same purpose for which they were conceived without the need for any modifications, reprocessing or treatment (BSI, 2017).

The reuse of products, components or materials means an extension of the utilization period, resulting in a slowdown of the flow of materials from production to recycling (Bocken et al,

2016). In order to promote an effective reuse, the products and services should be designed with features that optimize this potential (BSI, 2017).

5.2.9.2 Repair

By repairing the products, their lifetime is increased and the need for the consumption of materials and energy to produce new products is reduced.

Repairing has the potential to retain finished goods and their parts in the economy for longer while maintaining or improving their value. Repair is also making a broken product operational again through fixing/replacing failed parts so it can be used with its original function (Morseletto, 2020).

Through Design, features and services to promote the repairing process can be implemented. This consists of developing the product with solutions that allow the repairing process (easy disassembly, using of standard connecting elements, modular solutions, etc), and complemented by the availability of repairing services, availability of spare parts, supporting information on repairing, etc.

5.2.9.3 Refurbish

Refurbish refers to an aesthetic improvement of a product, component or material, which might involve making it look like new (BSI, 2017). After the end of their useful life, products can be refurbished in order to extend their lifetime. These solutions aim at restoring an old product and bringing it up to date. In the refurbishing process the function of a product that can be upgraded or modernized. In most cases, it does not involve a full disassembly but the replacement of parts. These products are upgraded and brought back to specified quality standards or satisfactory working and aesthetical conditions (Morseletto, 2020).

5.2.9.4 Design for Remanufacturing

Remanufacturing is a production process in which the products, after their use, return to the factory, usually through a take-back system, and the whole product or components that are still in good condition can be used again as inputs for the production of new products. This

concept avoids the need to produce new components and reduces the consumption of materials and energy, therefore, reducing the overall impacts of the product in their life cycle.

A remanufactured product should have the quality of a brand new one even when retrieving/reclaiming components from other products used as spare parts (Morseletto, 2020).

In order o allow this solution, the Design team should develop the product and its components with this criterion in mind, the quality of the materials and components must allow the remanufacturing process and most important, an efficient take-back system must be implemented.

5.2.9.5 Design for Recycling

Design for recycling is a method that incorporates recycling and recyclability criteria into the Design phase of a product intending to obtain recycled or recyclable products.

Design for recycling is an important element in a Circular Economy with the potential to be exploited in order to increase recycling rates and close loops. Recycling is an important step in reducing demand for primary raw materials, minimising the negative environmental impacts related to the production of primary material as well as reducing the volume of waste by closing the loop of material flows.

In the Design phase, aiming to optimize the recyclability of products, the Design team should consider the integration of features and properties to optimize the recycling process and optimize the quality of the materials resulting from the recycling process.

Criteria such as the selection of materials, the compatibility of materials, the easy disassembly and separation of different materials, etc, should be integrated into the Design of the new product (Schuman, 2019).

5.2.9.6 Eliminate waste

The Circular Economy approach advocates for the elimination of waste in the entire life cycle of the product and service. A zero-waste approach should be implemented by the Design teams. In this regard, the team must, according to the specificities of the product or service, identify innovative solutions without the generation of unwanted outputs.

The Zero Waste concept focused on waste prevention that encourages the redesign of the resource life cycles so that all products and components are reused and integrated into the loops, and the aim is for no trash to be sent to landfills, incinerators, the ocean (EduZWaCE, 2020) or other.

5.2.10. Design Circular Business Models

In Design for a Circular Economy, as seen in the previous pages, several solutions can be implemented to improve the circular and sustainable profile of products and services.

Many of these ideas can improve the product and the service, however, in most cases, to attain a higher potential for circularity, the business model needs to be adjusted, or new business models need to be created and developed.

This new approach to circularity is leading to new businesses, new professions and new ways to fulfil the needs of the users with new opportunities to create greater value for all stakeholders.

Sustainable business models create a competitive advantage through superior customer value and contribute to the sustainable development of the company and society (Lüdeke-Freund, 2010), focused on efficiently offering a system of circular products and value-added services, and supporting circular systems (Romero & Rossi, 2017).

The creation of new sustainable business models promotes the integration of suitable approaches such as reuse, sharing, leasing, repair, refurbishment, recycling etc. By integrating the most suitable of these approaches to one's business- and product development will play a significant role in maintaining the utility of products, components and in realizing circular business models (Mcaloone & Pigosso, 2017).

What to consider in the Design phase?

5.2.10.1 Innovate the business model

Business model innovation reflects the adjustments and changes in how a company delivers value to its customers, whether that's through the development of new structures, new

revenue streams or new distribution channels. This innovation is focused on a conscious change of the existing business model or the creation of a new business model that satisfies the needs of the customer better than the currently existing business models (Godinho, 2019).

5.2.10.2 Rethink and create new business models

Rethink the Business Model: Consider opportunities to create greater value and align incentives through business models that build on the interaction between products and services (Haigh et al., 2021). This can lead to the development and creation of new business models with a higher potential of circularity and Sustainability

6.1 Background

6.1.1 Design thinking and Circular Economy

"Design thinking is a human-centred approach to innovation that draws from the designer's toolkit to integrate the needs of people, the possibilities of technology, and the requirements for business success."

Tim Brown, IDEO

Design thinking is an approach that promotes the designer's process of thinking to transform the way organizations and individuals develop products, services, processes, and strategies. It also allows people from other fields of expertise, who aren't trained as designers to use creative tools and methods to address challenges and reach new solutions. It is a way to achieve innovative solutions by intersecting 3 main criteria in the process (IDEO, n.d.)

- What is desirable – a human-centred approach,
- What is viable – from an economical point of view,
- What is feasible – through technology.

It is seen as a way of explaining design's applications and utility so that others can practice it, too. Design thinking, like the Design practice, is a way to solve problems through creativity. It uses creative activities to foster collaboration and solve problems in human-centred ways, based on 3 core activities (IDEO, n.d.):

- Inspiration
- Ideation,
- Implementation

The novelty in this approach is that designers' work processes can help to systematically extract, teach, learn and apply human-centred techniques to solve problems creatively and innovatively – and this can be applied for different purposes, in the Design of new solutions, in businesses, in countries, and even in personal lives. (Interaction design foundation, n.d.)

Design thinking phases

The Design thinking process is divided into several phases. Nowadays we can find many variants of the Design Thinking process in use, and they are structured from three to seven phases, stages, or modes. However, all variants of Design Thinking are very similar (Interaction design foundation, n.d.).

The five most common phases of Design Thinking, (Figure 39) are as follows:

- Empathise – with your users
- Define – your users' needs, their problems, and your insights
- Ideate – by challenging assumptions and creating ideas for innovative solutions
- Prototype – to start creating solutions
- Test – solutions

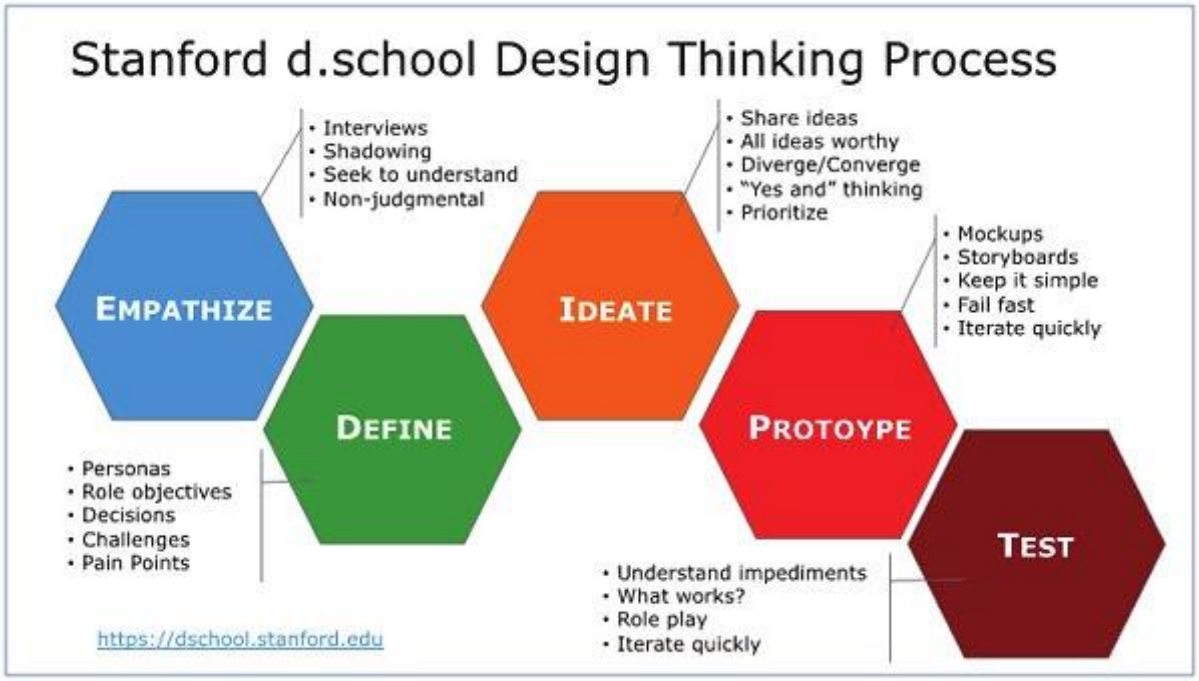


Figure 39 – Design thinking process – Stanford d.school (D.Scholl. n.d.)

It is important to note that the five phases are not always sequential, and they do not have to follow any specific order, or they even can often occur in parallel and repeat iteratively. Given that, it should not understand as a hierarchical or step-by-step process and it should be seen as an overview of the modes or phases that contribute to an innovative project, rather than sequential steps

Design and development models

Aiming to define a Design model to structure the approach to circularity, several methods were analysed in terms of structure and content (Annex 7).

The following images reflect the models analysed and were identified in referenced scientific articles, publications and internet search:

Design Thinking Process by the Interaction Design Foundation

The five stages of Design Thinking support the application of the Design Thinking methods in order to solve complex problems that occur in companies, in countries, and even on a macro scale. The Design Thinking process is iterative, flexible and is focused on collaboration between designers and users, aiming to achieve innovative ideas to life, based on how real needs of users.

The model explored by the Interaction Design Foundation is based on the five-stage Design Thinking model proposed by the Hasso-Plattner Institute of Design at Stanford (D.Scholl. n.d.), which is structured in the following 5 phases: Empathise, Define (the problem), Ideate, Prototype, and Test (Figure 40).

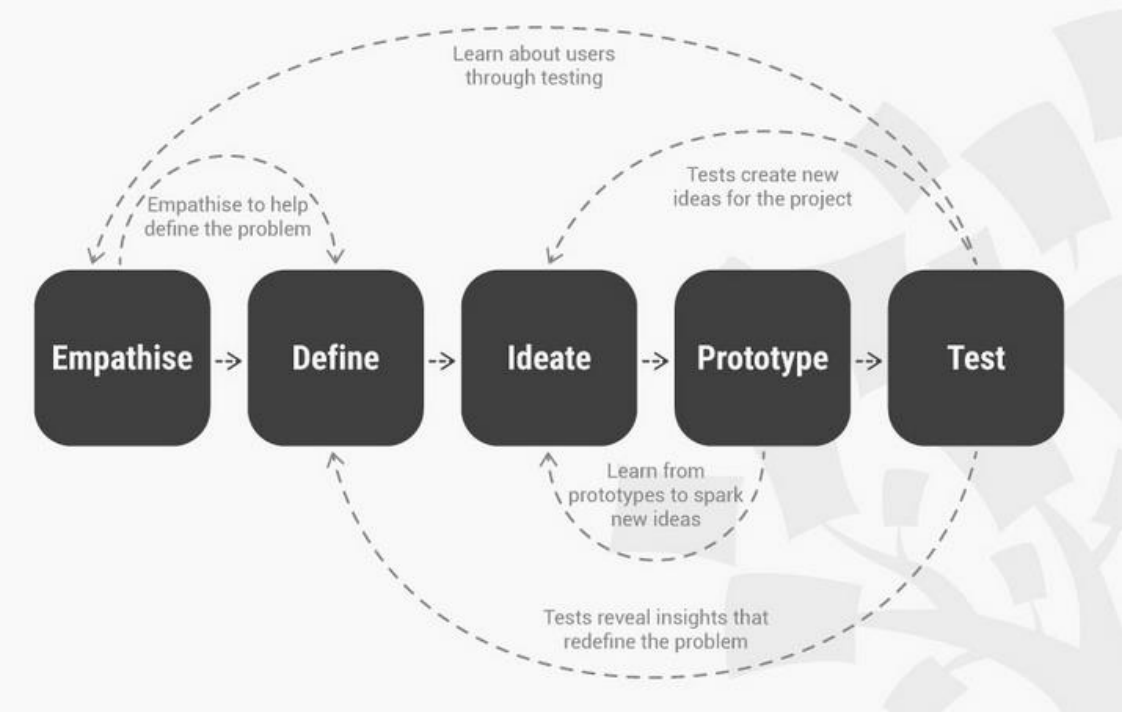


Figure 40 – Design thinking process – Interaction Design Foundation

Design Council's Double Diamond

Design Council's framework for innovation (Design Council, 2004) supports designers and non-designers to tackle complex social, economic and environmental problems. The Double Diamond is a clear, comprehensive and visual description of the Design process that was launched in 2004 and has become a world-renowned framework.

Design Council's Double Diamond represent a process of exploring an issue more widely or deeply divergent thinking and then taking focused action, convergent thinking (Figure 41).

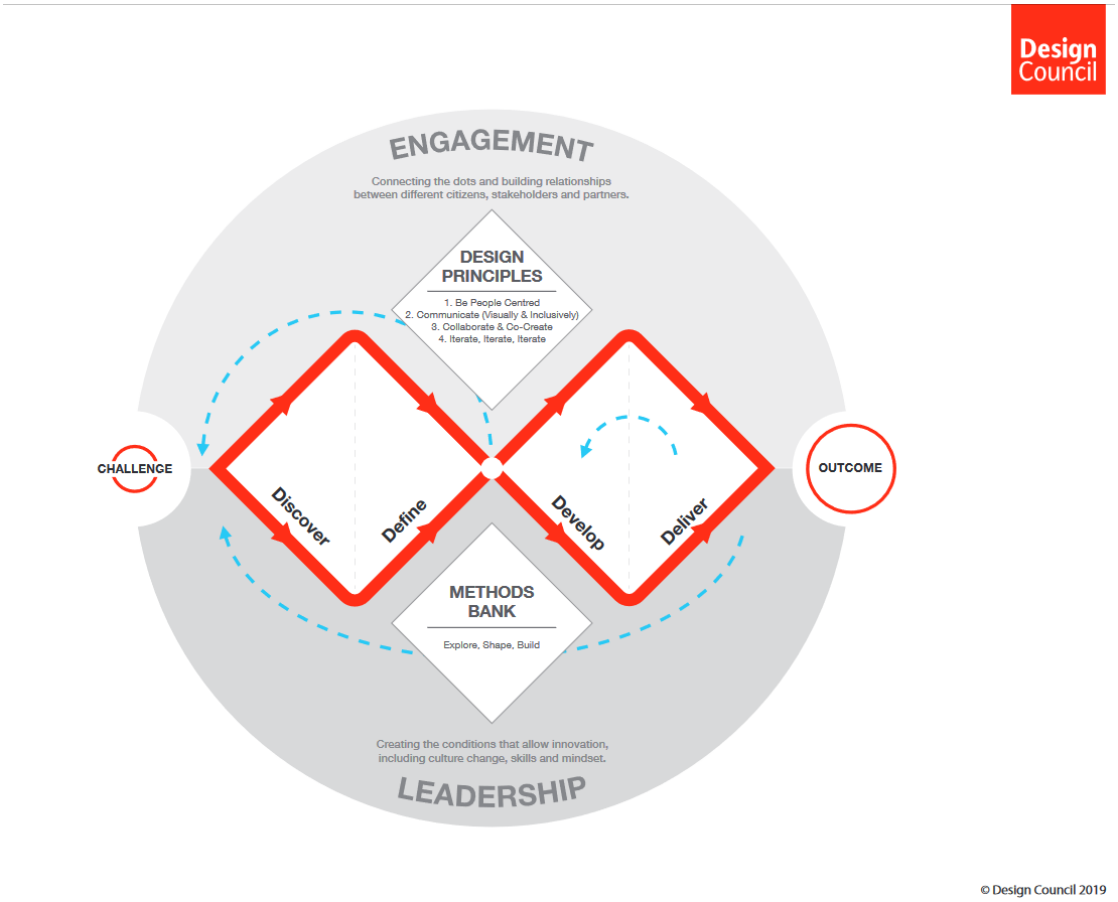


Figure 41 – Double Diamond Design process

Design thinking process by IDEO

The Design Thinking process (Riverdale & IDEO, 2012) is what puts Design into action in a structured approach to generating and evolving ideas. It consists of five phases that help the development from identifying a Design challenge to finding and developing a solution.

It's a deeply human approach that relies on the ability to be intuitive, to interpret what is observed and to develop ideas that are meaningful to the target group (Figure 42).

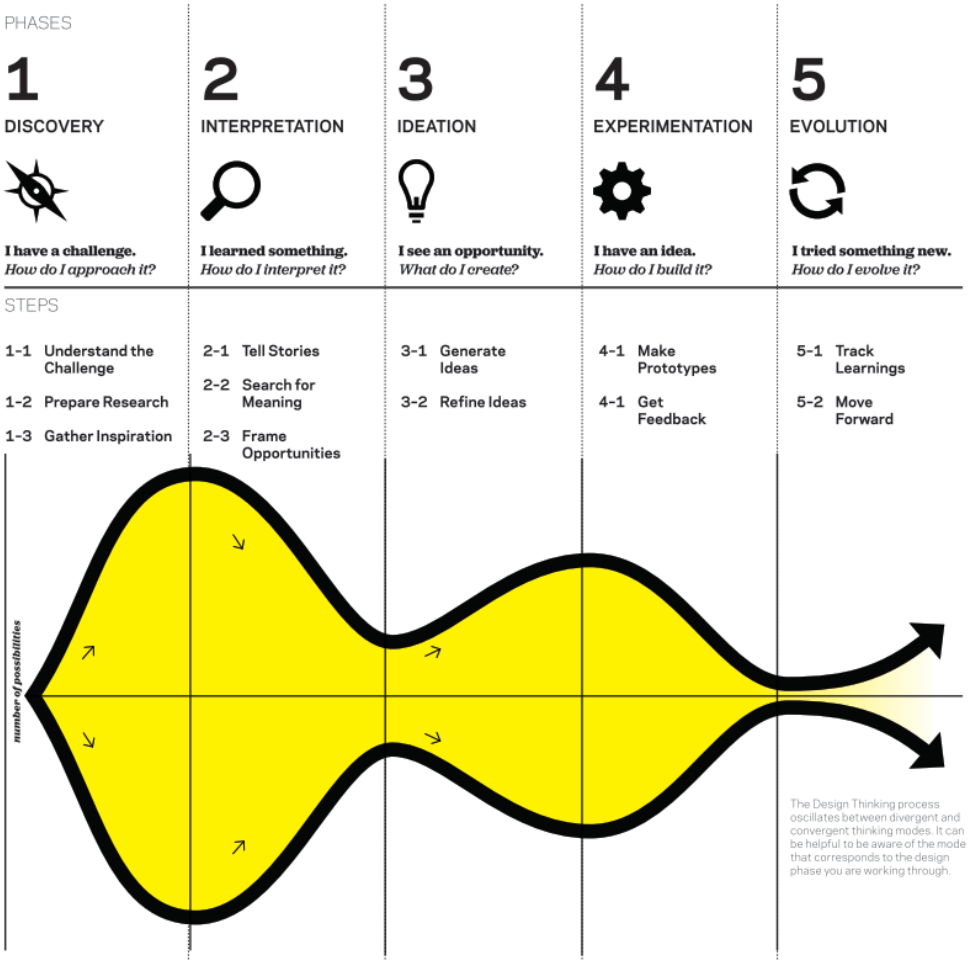


Figure 42 -Design thinking process – IDEO

Mindshake Design Thinking Model Evolution 6²

Mindshake Design Thinking Model Evolution 6² (Tschimmel, 2015) was developed by Katja Tschimmel between 2012 and 2015 when the latest version was registered in Creative Commons. The model is used in the development of projects, workshops, coaching sessions, research projects, methodology classes, among others (Figure 43).

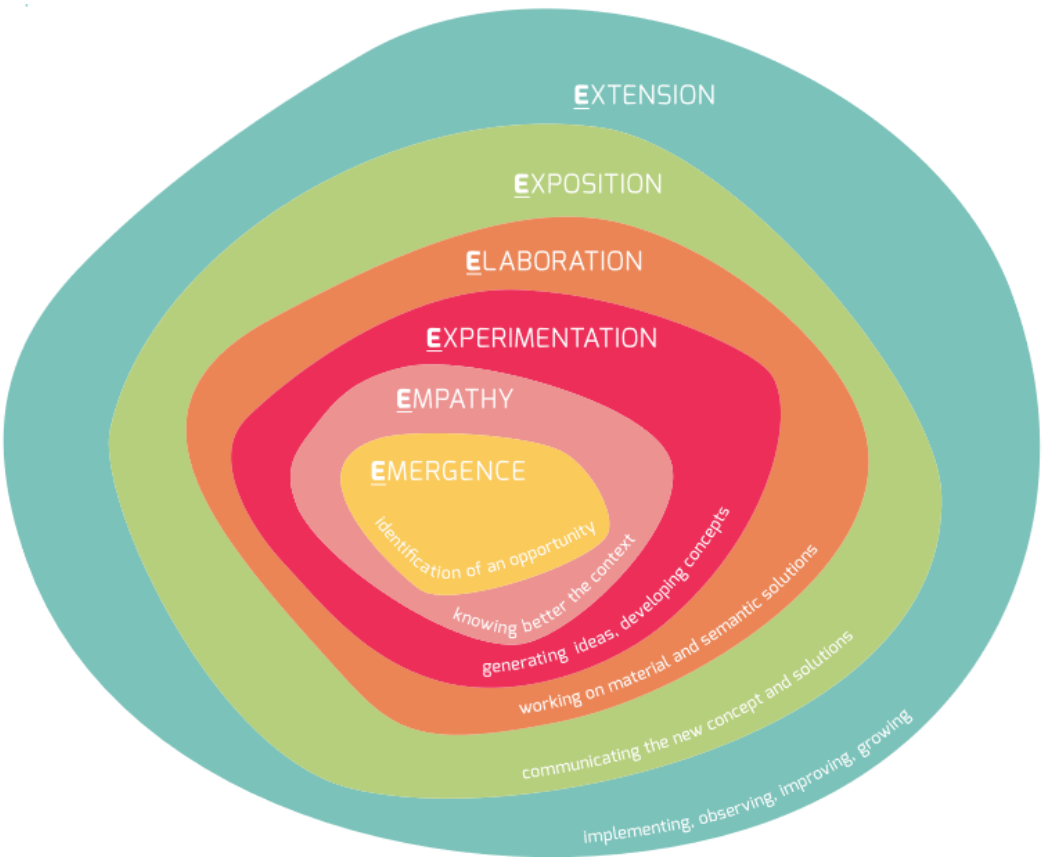


Figure 43 – Mindshake Design Thinking Model

The Design method by Eric Karjaluoto

In this Design Method, (Karjaluoto, 2014) the activities are organized into four broad stages defined quite generally

To highlight the core activities which must be adjusted and detailed according to specific needs and objectives of the project. Following these stages will help to structure and guide the Design and development process (Figure 44).

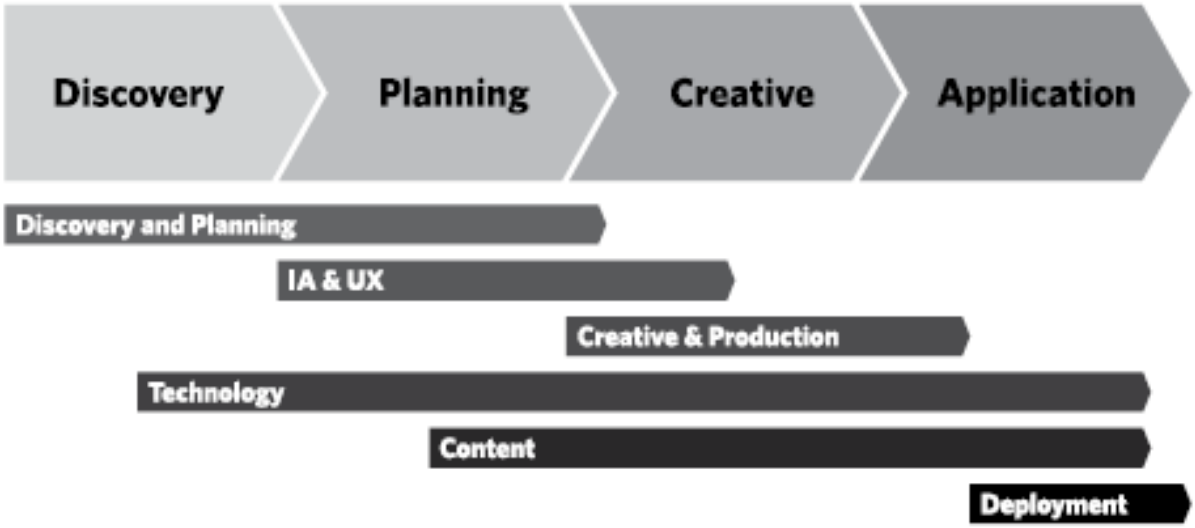


Figure 44 – Design method by Eric Karjaluoto

KATCH_e Circular Design process

The KATCH_e project (Rocha et al. 2020) proposes a step-by-step methodology for Product-service development based on eight general steps that should be adjusted to each particular project (Figure 45).

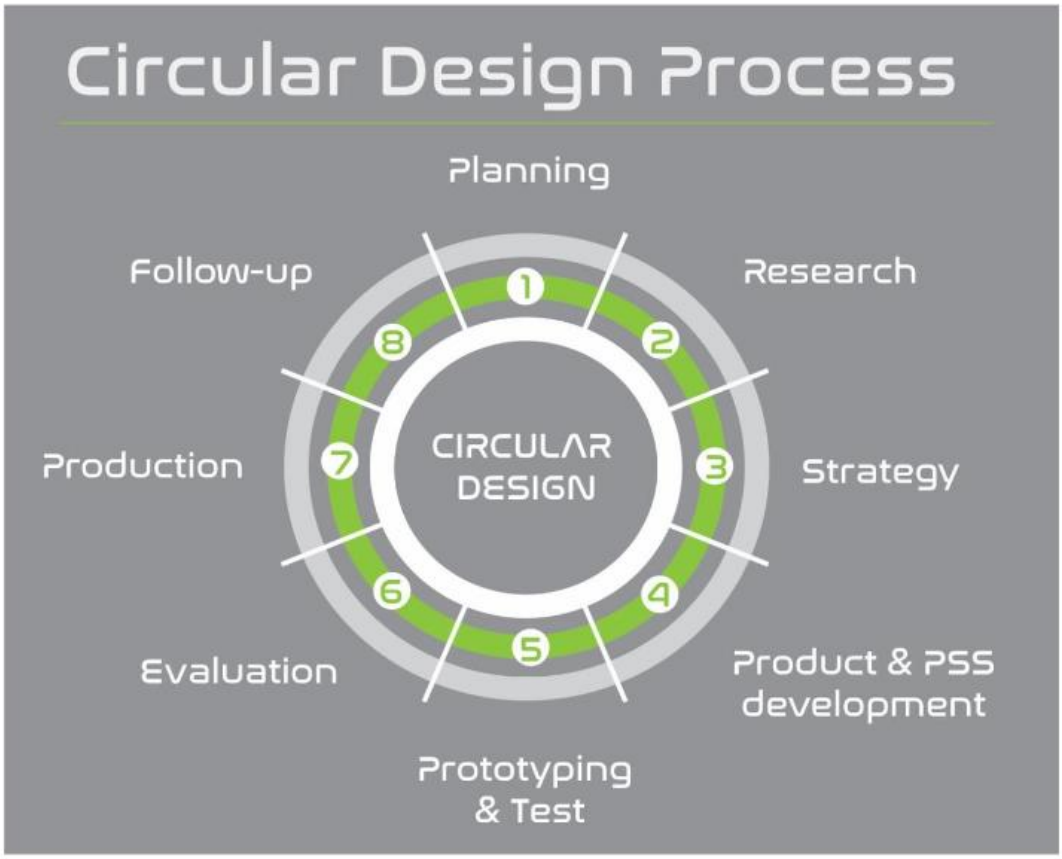


Figure 45 – Circular Design process – KATCH_e

Aiming to Innovative and circular Design solutions, the processes start on a full understanding of the context of intervention by creating abstractions and conceptual models that help to reframe the problem in new ways and follows an approach aligned with the Design methodology and the sustainable and circularity perspectives.

Chicago architecture centre – Design process

The Design Process (Discover Design, n.d.) is an approach for breaking down a large project into manageable chunks to solve a variety of problems. This process is useful to define the steps needed to tackle each project, guiding the Design process (Figure 46).

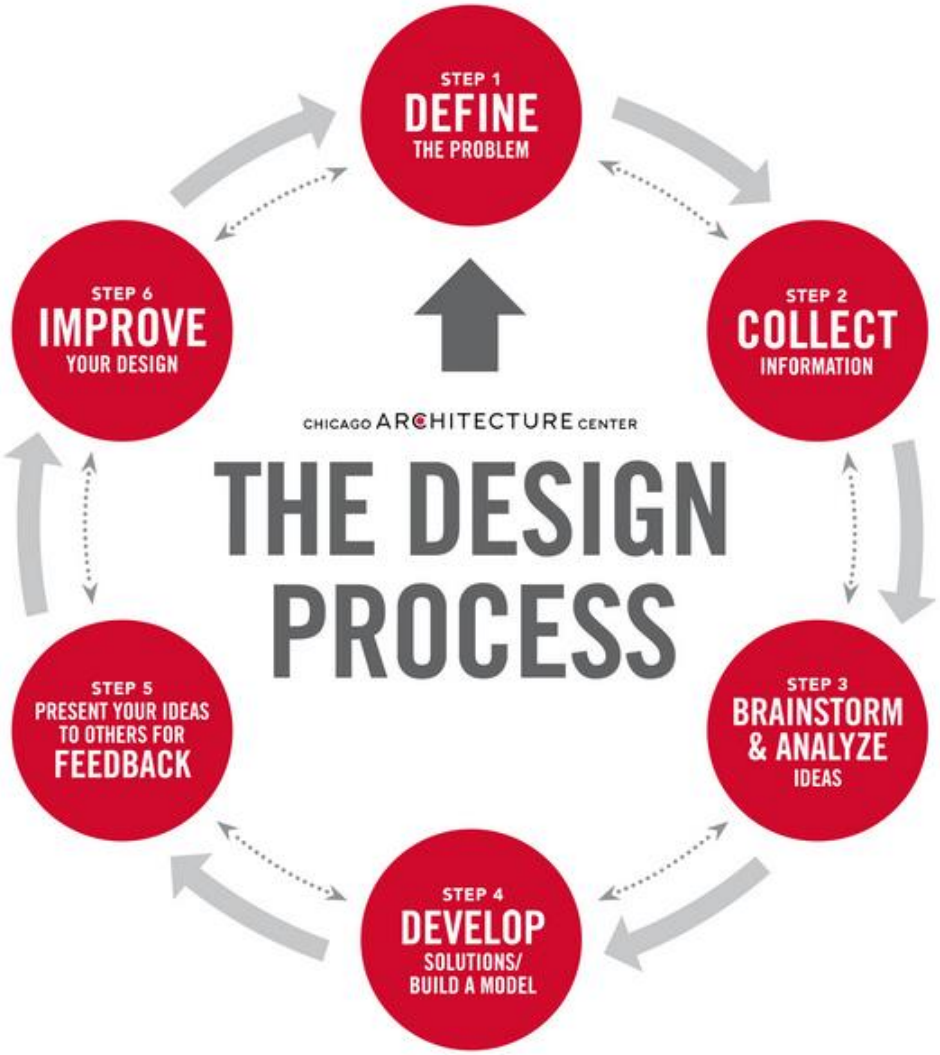


Figure 46 – Design process – Chicago architecture centre

The identified models are quite similar in terms of structure and their main aspects were compiled in a matrix to allow a systematised comparison and analysis (Annex 7).

6.1.2 Basis and rationale for the development of the Design model for a Circular Economy

As mentioned previously, within the production and consumption approach within our current society there is still a huge gap between theory and practice (Camocho et al, 2019), between what is being developed in research and development projects and what is applied in practice for the development of new solutions that re produced and reach the market.

In order to narrow this gap and provide designers, with interdisciplinary practices supported by synthetic methods, tools and guidelines that promote the development of sustainable solutions contributing towards an environmentally efficient future, fair from a social point of view and that creates value and wealth for business and the society.

In this sense, this research project developed a synthetic method that supports the Design practice and integrates the project development perspective, the management and orientation of the Design project and the perspective of the business, as presented in (Figure 47) The implementation of these perspectives in the early phases of the project (Hassi & Wever, 2010) increases the potential for innovation and circularity.

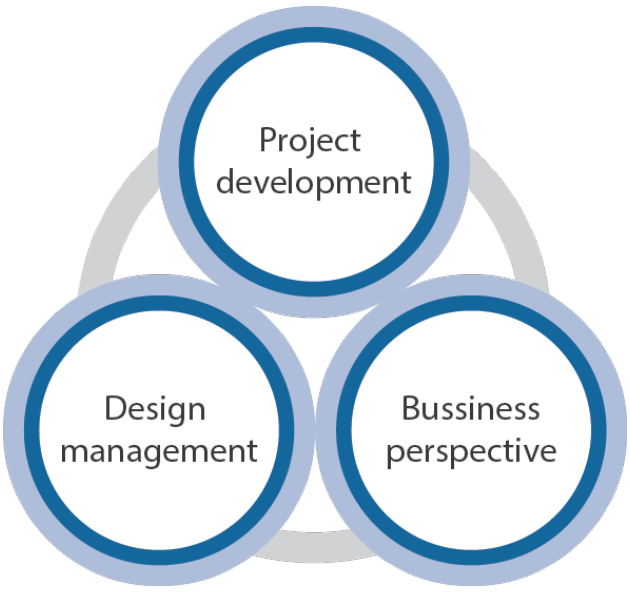


Figure 47- The 3 dimensions of the circular Design model

The model, resulting from the work and research carried out aims to systematize and guide the Design process by integrating aspects of circularity and Sustainability and respecting the intrinsic needs of the Design process and its related activities, is based on four main sources

of information (Figure 48): a) the literature review developed within the research, b) the practices applied in the development of products that are available in the Portuguese market; c)the perspective of consumers and d)the perspectives of a group of international experts that were consulted within the process.

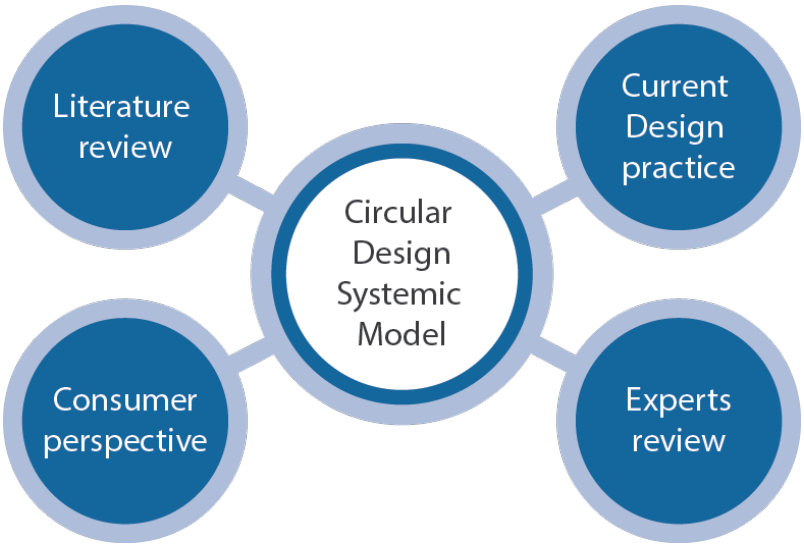


Figure 48 – Circular Design systemic model – sources.

Literature review

The Design model was developed having as a starting point the literature review carried out within the scope of the investigation and included the identification and analysis of the main national and international sources available. This analysis provided an overview of the state-of-the-art in the areas of Design, Sustainability and the Circular Economy focusing on the identification of methodologies, tools, definitions and case studies relevant to the model under development (Camocho et al., 2018).

Identification of national products with Sustainability criteria

Despite the efforts and initiatives to integrate circularity and Sustainability in practice, the research activities include the creation of a database of national products available in the market. The identification and selection of national examples aimed to identify products that have Sustainability or circularity allegations provided by their producers. The main idea was

to create a database and map sustainable and circular Design practices and to analyse how the Sustainability and circularity aspects are being integrated into product development and communicated to the user.

The database available in annex 4 was developed and a collection of national examples was done to support the identification of the Design professionals and companies linked to the products identified. The products were analysed and in a few cases, interviews were performed to identified and analyse how the products were developed and which are the needs, drivers, barriers on the Design practice towards a Circular Economy.

Despite the high expectations in the identification of national products from the start, the results demonstrated that despite all the efforts that are being done by research institutions, the Portuguese government, academia, associations, organizations, NGO's, there is a very limited number of Portuguese products placed in the market. There are examples of products available in Portugal. However, the majority is imported from abroad (Camocho et al, 2020).

Analysis of consumer perspectives

The consumption patterns and the needs and perceptions of consumers are crucial for the transition to a Circular Economy. Currently, the availability and dissemination of more sustainable and conscious products and services are increasing worldwide and there has been a growing trend in communicating to consumers about the environmental aspects to take into account when buying products (Young et al, 2008). Today's consumers are more aware of societal and environmental problems and challenges and demand more efficient and sustainable products and services. However, the information and solutions delivered by producers could be misleading in some cases having adverse results in the perception of Sustainability from the consumers. The communication included in products, the labels used that for most users who do not understand these topics are not perceived, need to be designed in a more efficient way (Camocho et al, 2019c).

In the transition to Circular Economy, it is important to have a holistic and integrated approach. On the one hand, there is the need to supply innovative and sustainable products that meet the needs of consumers. On the other, sustainable consumption behaviour is needed. For this purpose, the products and services must include features that allow informed choices and efficient use by consumers. In the development process, designers need to better

understand the consumers, their habits, perceptions and general knowledge regarding the Sustainability aspects of products and services.

Having it in mind, a consumer's analysis was developed within the research,

Expert's survey

As explained in chapter 3.1 Perspectives of Circular Economy: Expert's review, the survey developed within the current research supplied relevant information that supports the development of the Design model and guided their development in line with the needs and perception of these professionals that collaborated in sharing their experience in the field as a contribution to the development of new resources to empower Design professionals.

As mentioned before, the survey aimed to collect feedback to understand the views and perspectives of the experts in the field on what concerns the practical implementation of Circular Economy within the following aspects:

- In what sense do the experts consider that Circular Economy is the way to achieve a sustainable society in the future?
- What is considered the novelty that the concept and approach can bring to society,
- What are the main drivers and motivations to adopt Circular Economy in practice?
- What are the main barriers?
- How should we overcome the current obstacles and promote the Design practice towards innovative and sustainable solutions?
- What lessons can we learn from the past?

The results attained, the inputs collected, and all the analysis performed were crucial to support the adequacy and the development of the Design model and related resources.

Development of the Circular Design Model and toolkit

A Design model describing, in detail, the structure of the system and how the system will be implemented was developed aiming to support and promote the Design practice and the relation to a Circular Economy.

Aiming to support the Design practice towards circularity and Sustainability, the multilevel Circular Design Model (Figure 49) was structured based on the results of the research, the above-mentioned reviews, the analysis of strategies, tools and methods, and other relevant information collected and analysed.

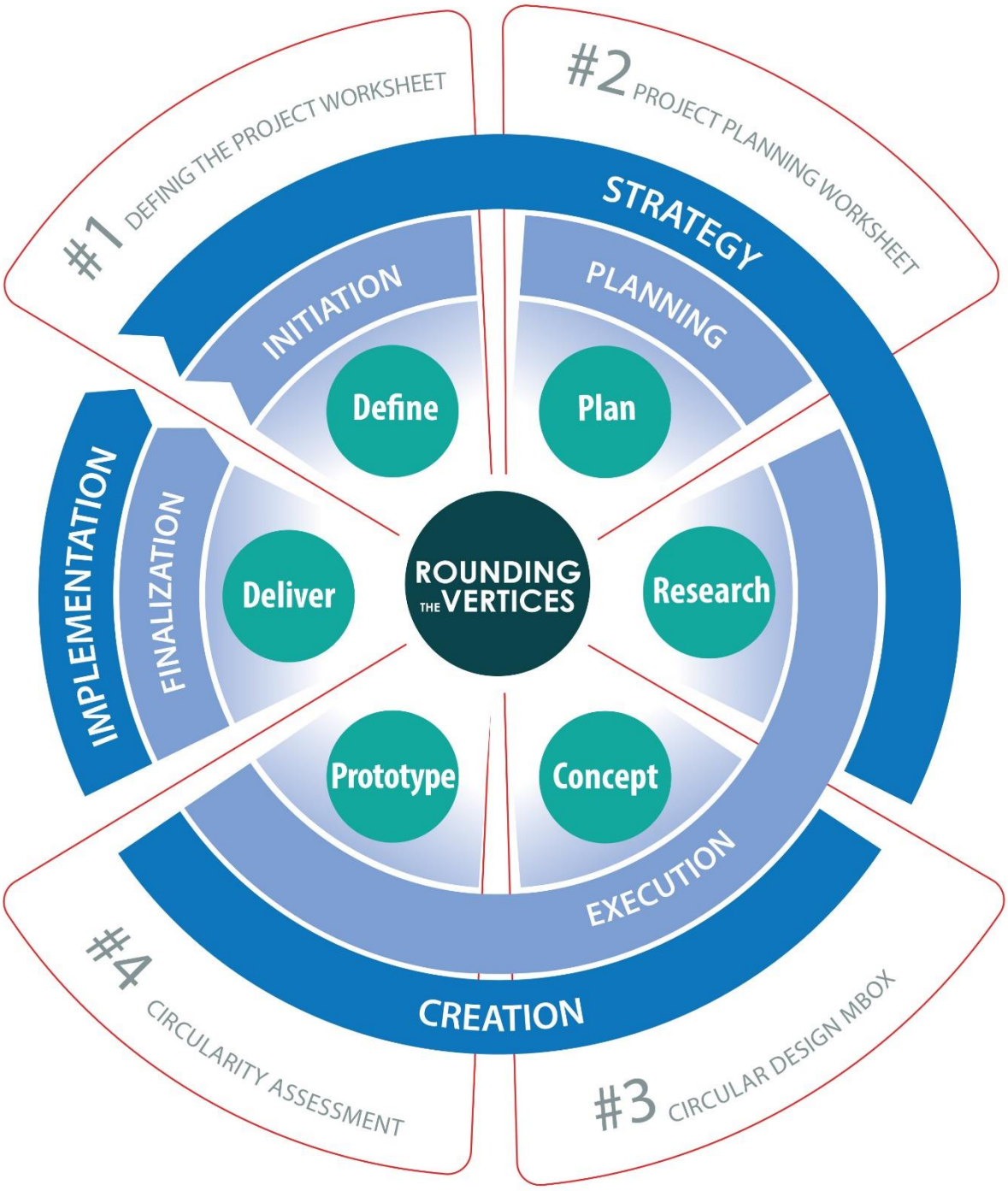


Figure 49 – Circular and Sustainable Design model

The model derives from the main stages of a Design project and relates the activities of the process in 3 levels that complement and supports each other:

- The Project management level supports the definition, organization of the project, promoting an efficient integration of circularity in the different phases and aspects of the Design management process
- The business level to align the development of the project with the strategy and considerations of the business, promoting the efficiency and Sustainability of the system.
- The Design project level, to support the practice and the integration of the circularity and Sustainability considerations, methods and tools in the development of new and innovative products, services and systems.

The multilevel model establishes the relation of the Circularity goals and the Design thinking process to define how the resources/tools can guide the Design process to promote Sustainability and circularity in practice.

The information related to each activity in, the definitions of the goals and objectives, how circularity should be addressed, which sub-activities are included and which are the inputs (resources, time, human resources, etc) and the outputs needed, are the basis for the systemic definition, the planning and the development of the Design and development project.

The model, which aims to reduce the gap between theory and practice, was developed with an orientation towards the project, considering the needs of the various stakeholders. It was aligned with the characteristics and needs of project management and development is translated into practice through a Design for circularity and Sustainability toolkit. The toolkit is composed of a set of tools, guidelines and practical knowledge that can be applied by practitioners in their daily activity.

The toolkit, improving the role of Design in the transition towards a circular and sustainable economy supports the development of new projects that will result in new products and services. This toolkit is full presented and explained further on, in chapter 6.3.

6.1.3 Rounding the vertices concept.

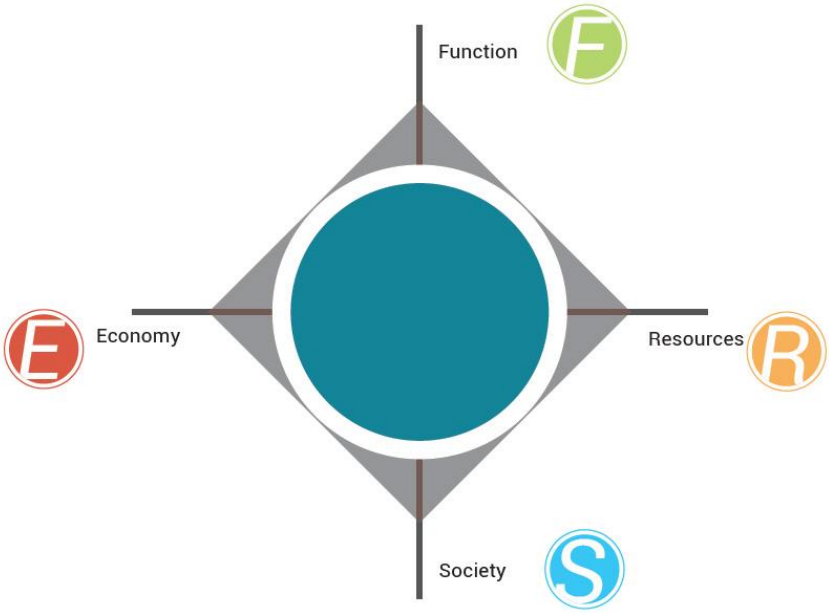


Figure 50 – Rounding the vertices concept

The transition from the linear economy to the Circular Economy relies on an improvement in the efficiency and effectiveness of the product and service systems. This transition, based on the maintenance of the materials in use in multiple cycles and the elimination of the production of waste through Design options is seen as the potential path toward Sustainability.

The Rounding the vertices is a Design concept that aims to illustrate the Design practice towards circularity that is based on the transition from a square shape, an analogy to the current linear approach, to a circular shape by increasing the performance of products and services system requires less area (Figure 50). This means that to achieve circularity, we need to improve the system by reducing the consumption of material and energy as well as improving the efficiency of the life cycle.

The method is based on the improvement of the efficiency of an entire product or service system in a holistic approach, operating at various levels and improving the product's Sustainability and the relation to the needs of the users. Only a concerted approach achieves

an effective improvement, taking into account the implications of the Design process in the various dimensions as well as the trade-offs that result from the development process.

In the concept, the improvements in the transition to circularity are demonstrated by improvements in the 4 vertices, each one referring to a dimension that must be considered in a holistic and harmonized approach, resulting in a new shape and ideally reaching the circle that represents the achievement of circular solutions.

The four dimensions of the model

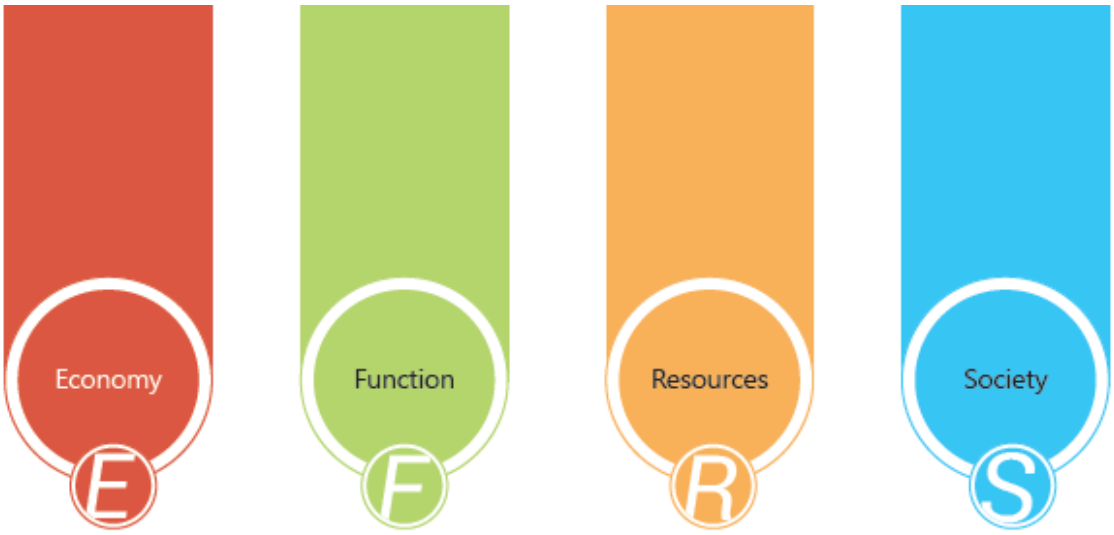


Figure 51- Rounding the vertices dimensions

Economy

The aim is to optimize the economic aspects related to the system creating sustainable value and wealth for all actors in the value chain through the Design approaches and measures adopted in the project

Function

The project should put into question the current solutions and rethink the system focusing on the function. Through a function approach, the Design team has more levels of freedom to innovate and attain higher circularity and Sustainability performance which can lead to out-of-the-box solutions.

Resources

The resources needed to fulfil the function should be optimized. The optimization and the efficiency of the consumption of materials, such as energy and water, in the product or service systems, has the potential to improve the circularity and Sustainability aspects of the systems.

Society

Design for a better society should be also the motto for the Design project. The creation and promotion of welfare, safety and good working conditions are an added value for the society that can be achieved through Design.

6.2 Development of the Circular Design Model

In the development of the Design model for the Circular Economy, in order to guarantee a holistic approach to the process and a greater suitability for the various stakeholders, 3 layers of action were defined. Next, we present the Business, Management and Design Project approaches.

6.2.1 The business approach

The business level to align the development with the strategy and considerations of the business, promoting the efficiency and Sustainability of the system.

“Applying Circular Economy principles could unlock up to EUR 1.8 trillion of value for Europe’s economy” (Ellen MacArthur Foundation, n.d.)

The Circular Economy is a source for creating value in business. The Circular Economy has transformed the way of doing business, the way of creating products and services and the way of organizing society (Acaroglu, 2020). The transition from the linear economy to circularity has a direct impact on the business and its value chain and requires a reconfiguration of the business structures. The European Union needs to reinvent the business structure that derives from the linear path of the past. Attractive investment opportunities are being created through innovative approaches and new ways to attend to the needs of society. The investment in

Circular economic offer resilience and transformation of those assets that otherwise might face being stranded or becoming redundant. However, the investments in the practice of Circular Economy are being difficult to realize (Ellen MacArthur Foundation & Systemiq, 2017). According to the report "Achieving Growth Within (Ellen MacArthur Foundation & Systemiq, 2017) companies and investors are engaged in the shift towards circularity due to the perceived benefits, however, there are still barriers in this transition due to the lack of investment. Currently, the Circular Economy is not a mainstream investment area for private businesses and the lack of funds puts at risk the achieving of generalized benefits. However, the Circular Economy offers an attractive innovation and investment opportunity that must be integrated into a holistic approach to circular product and service development.

Circular business models defined as:

"Circular business models represent fundamentally different ways of producing and consuming goods and services. They have the potential to drive the transition towards a more resource-efficient and Circular Economy and, in doing so, significantly reduce the environmental pressure resulting from economic activity" (Re-Circle, 2018 p.2)

"*A Sustainable Business Model is a business model that creates competitive advantage through superior customer value and contributes to a sustainable development of the company and society*".

Lüdeke-Freund, 2010 p.23

In the circular model we have 3 stages in the business approach:

Table 3 – Circular business models approach

Business approach	
Strategy	Definition of the strategy for the Circular Economy Design project. Definition of the goals and objectives for the project Identifying and defining the business model.
Execution	Supporting the development of the project. Aligning the strategy developed with the circularity needs and project development nee ds
Implementation	Implementation of the project. Monitoring the development of the project.

Defining the strategy for the business

To reach successful results the project should meet the needs of the entire system. The circular Design project must integrate the needs of the consumers, the markets and the needs of the business. For this, a clearly defined strategy, to meet the goals of the business will guide the process. Defining the business strategy helps you make the most of the available resources to achieve the goals.

The result of a good strategy promotes a profitable business over the long run, avoid making common mistakes, and stay ahead of the competition (Business.govt.nz, n.d.). And the integration of circularity and Sustainability consideration in this step ensures that the entire system has the same understanding and clear objectives.

Creation phase

In the creation phase, the top management, responsible for the business should support and monitor the creation phase, in which, the Design team is developing the solutions to meet the challenge and requirements of the project. In this phase, the concepts must be validated and tested in order to check if the results are matching with the requirements defined according to the strategy of the business.

Implementation

After the conclusion of the Design for the circularity project, the business has to implement it, produce the new solution and place it in the market.

6.2.2 The project management approach

As defined by the Project Management Institute, (2017) a project “It's a temporary endeavour undertaken to create a unique product, service or result”, meaning that it has a beginning and an end with a specific scope and allocation of resources defined with specific operations designed to achieve the goal of producing deliverables which can be tangible or intangible (Project management institute [PMI], 2017). Projects, which vary in their structure, lasting from minutes to hours, days, weeks, months or years, are carried out to develop or create products or services that haven’t existed before (Watt, 2014).

Circular Design projects are a key to creating circular and sustainable value and benefits in organizations and for society, and these projects have to be managed in order to attain the desired goals defined.

Project management enables individuals or project teams to carry out projects effectively and efficiently and this consist of the application of knowledge, skills, tools, and techniques to project activities to meet the requirements defined. Project management is accomplished through the appropriate application and integration of the project management processes identified for the project (PMI, 2017) and is completed when its goals and objectives are accomplished (Watt, 2014).

Driven by the Circular Economy, circular Design projects have to be managed to accomplish the Sustainability goals and objectives defined, integrating the project and stakeholders needs with the circularity principles and strategies and balancing the different project constraints that affect s the quality of the project and its results.

The overall quality of a project is influenced by the "triple constraint" which consists in attaining a balance between time, cost and scope (Figure 52).

Figure 52 – Triple constrain triangle, adapted from Watt 2014

The relationship between the scope/quality, schedule/time, and cost/resource has to be balanced, and variations in one aspect can influence the others in a non-proportional way, jeopardizing the results and the success of the project.

6.2.2.1 The life cycle of project management

As defined by the APM – Association for Project Management, (APM, n.d.) “A project management life cycle is a framework comprising a set of distinct high-level stages required to transform an idea of concept into reality in an orderly and efficient manner.

Life cycles offer a systematic and organised way to undertake project-based work and can be viewed as the structure underpinning deployment”.

Disregard of the project size, budget or business and Design goals, the project management life cycle is essential for the success of any project.

The project life cycle is usually structured in a framework of four steps designed to support project managers in guiding their projects successfully from start to finish. The purpose of the project life cycle is to create an easy-to-follow framework to guide projects.

Regardless of the project under development, the project management life cycle can assist the management and circular Design teams in narrowing the project's focus, keeping its objectives in order and finishing the project on time, within the planned budget, with minimum surprises and aligned with the defined strategy in which the project is integrated (Orangescrum, n.d.).

All projects are influenced by their context, structure, organization, industry, goals, constraints, development method, technology employed etc. The life cycle provides the basic framework for managing the project, regardless of the specific work involved.

Though projects vary in size, structure and complexity, a typical project can be mapped and structured according to the following project life cycle phases (see Figure 53):

- Initiation – Starting the project,
- Planning – Organizing and preparing,
- Execution – Carrying out the work, and
- Finalization – Closing the project.

Figure 53 – Project life phases

6.2.2.2 Initiation – Starting the project and defining what needs to be done

The life cycle of a project starts with the initiation phase, which is usually the shortest phase but the most important because it sets up the foundation of the project.

In this phase, the project management team or project manager defines what needs to be done within the development of the project (Astor, n.d.).

The goal in this phase is to systematize how to process the initial information, which derives from the strategic approach led by the business, and make sure that the development team always getting the information needed (Project Central 2022).

The first step is defining the project through the following activities (Venngage, 2019):

- Identifying a need or a problem that the project will solve,
- Identifying opportunities to solve the problem,
- Outlining project risks, dependencies, constraints, and priorities,
- Understanding whether the project is feasible and will solve the problem,
- Defining the scope of the project and the deliverables,
- Defining success criteria for the project,
- Identifying the stakeholders and defining the necessary resources.

After fulfilling these requirements, the project manager will be able to create a project layout containing all the information on purposes, objectives, resources and other aspects needed to develop the project.

The analysis conducted in this phase of the project life cycle will help in understanding how the project will be progressing in the future, as well as organize and assemble all the necessary people and resources.

6.2.2.3 Planning – Organizing, preparing and defining how to do what needs to be done

Planning is where the project management team defines the work to be done and create the roadmap and guidelines to follow for the remainder of the project to meet the objective (Aston, n.d.). Planning is the main function of any project manager and requires undertaking a rigorous process of developing plans to ensure the achievement of project objectives in line with the strategic planning and objectives.

The planning of a project requires diligence, investment of time, and gathering and systematizing sufficient information to enable the development of a detailed plan that helps avoid as many mishaps as possible and guide the entire process in a path for success.

The planning phase of the project life cycle involves, and it's focused on 3 key areas:

- Scoping of the project – by determining and agreeing on the activities to meet and complete the requirements of the project,
- Scheduling the project – involves placing the necessary activities into a time frame for completion,
- Planning requires an estimation of the cost of undertaking the project. Cost considers the time and resources required to complete the project within the planned schedule.

Once the project team has identified and defined the work, prepared the schedule, and estimated the costs, the three fundamental components of the planning process are complete.

6.2.2.4 Execution – Carrying out the work and making the project happen

This phase is about developing the specific and defined deliverables that are required to meet the scope and objectives of the project by turning the plan and strategy into action. The project manager's job in this phase of the project management life cycle is to monitor and control the process, keeping the work on track, organizing team members, manage timelines and milestones, and make sure the work is done according to the original plan (Lucid n.d).

During this phase, to ensure the success of the project, progress is continuously monitored and appropriate adjustments are made and recorded as variances from the original plan (Watts, 2014). For measuring project progress and performance and ensuring that everything is aligned with the project management plan, project managers will use Key Performance Indicators (KPIs) to determine if the project is on track.

6.2.2.5 Finalization – Closing the project

It is in this phase that the outcomes are achieved, and the benefits of the completed project are experienced and accepted by the clients and stakeholders. The closure of a project requires obtaining feedback from clients, stakeholders and the development team. In this phase, it is important to evaluate what went well in the project and identify project failures. This is especially helpful to understand lessons learned so that improvements can be made for future projects (Eby, 2018). In this step, it is important to analyse the project performance, by determining whether the project goals and objectives were met, and the initial problem was solved, and analysing the team performance, evaluation how the team members performed according to the needs and objectives (Lucid n.d).

In Circular Economy projects, and within in a continuous improvement approach, closing a project, collecting and documenting feedback, experiences, knowledge, could be a starting point for a new project, improving the circularity potential and innovate towards the transition for Circular Economy and Sustainability.

6.2.3 The Design project approach

The design approach to the project is the more operational layer of the model in wish the design practice is put into action. At this stage, the design team, establishes the link between

the business strategy and the need of the users with the support of the management activities underlined.

In this context, several activities are carried out in the creation of new solutions. It is at this stage that designers have the opportunity and responsibility to integrate circular economy aspects into the procedural methodology related to the design activity.

6.2.3.1 Definition – Initiation of the project

In the initiation phase, the aim is to define the project and establish a solid foundation to support the management and development of a circular and sustainable project.

Within the definition of the project the following activities which are interlinked must be performed:

- Identify the problem – All Design projects have the goal of solving a problem or a set of problems. In this step, the problem which will be solved through the Design practice with a sustainable and circular approach must identify, understood, and defined clearly.
- Investigate the problem – In this step, the aim is to investigate and research the problem addressed. This includes the collection and analysis of relevant data that will allow a better knowledge about the problem and will support the planning and definition of the project.
- Defining objectives. A clear definition of the objectives for the project must be performed in this phase. For a particular problem, several approaches could be done, and different objectives can be defined according to several factors such as the strategy of the company, the context, the aims of the Design team, the budget available, technologies available, time frame, etc.

According to the maturity of the company in terms of Sustainability, different levels of circular and Sustainability could be addressed. From a beginner's level to an expert and more radical level, the project can have different objectives, methodologies, tools, resources, etc. This aspect must be analysed at the beginning of the project, and the palling of the project must be structured accordingly.

In this step, success criteria should be defined according to the objectives of the project. These success criteria are important in the definition of the project functioning as guides for the project and are key elements to validate the results and assess the level of success attained.

Based on the problem identified and analysed, and the definition of the objectives or goals for the project, a Design challenge is formulated. The challenge will be the driving force and motivating support for the development of the Design project. It should be clear, approachable, understandable and actionable, and it should be clearly scoped— and well balanced in terms of length and complexity (Riverdale & IDEO, 2011).

A good definition of the challenge improves the Design process and the potential results of the process leading the project in the right direction focusing on the expected results. (Dam & Teo, 2019.)

We can consider some questions to be addressed:

- What is the circular and sustainable problem we need to solve with the project?
- What is the product to be developed?
- Is the product really needed? Needed for me, needed for the company? Needed bey the society?
- What are the functions of the project?
- What is the background or context of the project?
- What are the main objectives of the project?
- What is the circularity level addressed according to the 4 types of Circular Economy Design projects to be defined?
- What are the requirements of the project?
- Who will be involved in the project?
- Which are the main barriers and risks for the project?
- Which are the success factors for the project?

6.1.3.2 Planning

From a Design perspective, the planning of the project is a crucial stage in the process and provides a shared vision for what the project aims to accomplish. Align with the Design

management activities, in this stage, the team has to plan the activities needed to ensure that the project meets the desired objectives. It is an early phase of the project where a project's key features, structure, and major deliverables are all planned out. In this stage is also defined the role of the team according to the needs of the project and the resources needed. This stage should also define the success criteria and methods for assessing quality to ensure the project's success (WBDG, 2017).

The shared understanding and clarity on the responsibilities of each team member, provided by the planning stage keeps the team working together to achieve the project's objectives and deliver the desired results (Udoawu, 2022). A successful project requires the implementation of a planning system to control changes in the scope of the project, schedule, budget, resources, risks (WBDG, 2017).

Aiming to Design for a Circular Economy, the planning of the project must guide the process and foresee the integration of circularity criteria and goals in the development process.

6.2.3.3 Research

The research phase should aim to collect reliable and useful information from various sources to support the development of the project.

Research has always been the way towards finding the unknown. Research it’s a collection and compilation of information and data that includes critical and relevant information in an organised way (Leverage Edu, 2021) aiming to support the Design project and its activities according to the needs and objectives defined. The researcher should have a clear understanding of how the project will use the information collected

The research has two different perspectives, Quantitative Research and Qualitative Research and four main characteristics are related to both perspectives, reliability, neutrality, validity as well as a generalization (Leverage Edu, 2021).

In research we can consider two main approaches:

A Qualitative one based on the collection and analysis of non-numerical data to understand concepts, opinions, or experiences (Leverage Edu, 2021). It is used to understand how people

experience the world (Bhandari, 2020), being an explanatory approach and always seeks answers to “What’s” and “How’s” through diverse methods such as:

- **Observations –** recording what is seen, heard or encountered in detailed field notes,
- **Interviews –** asking people questions in one-on-one conversations,
- **Focus groups –** asking questions and generating discussion among a group of people,
- **Surveys –** distributing and analysing questionnaires filled in by defined groups,
- **Secondary research –** collecting existing data in the form of texts, images, audio or video recordings, etc. this data available could be gathered for other purposes.

A Quantitative approach of collecting and analysing data through various variables while including numbers as well as statistics in a project to analyse its findings. The use of graphics, Figures, pie charts is the main form of data collection measurement and meta-analysis and can be used to find patterns and averages, make predictions, test causal relationships, and generalize results to wider objectives.

Quantitative research can be attained through several methods, such as:

- Experimentation – By controlling and manipulating independent variables to measure the relation and effect on dependent variables,
- Surveys – distributing and analysing questionnaires filled in by defined groups,
- Systematic observation – Identification of a behaviour or occurrence and monitor it in its natural conditions,
- Secondary research – collecting existing data available that could be gathered for other purposes.

According to some authors, quantitative and qualitative research can be also divided into 5 main types (Leverage Edu, 2021):

- Descriptive Research – the most generalised form of research consists of the explanation or description of the situation or case. It is a theoretical basis where the data is collected, analysed, prepared and then presents it in an understandable manner,
- Correlational Research – looks into correlations between variables without allowing the control or manipulation of any of them. Correlational studies reveal the magnitude and/or direction of a link between two (or more) variables,

- Experimental Research – is a type of research Design in which the study is carried out utilising a scientific approach and two sets of variables, one used as a constant against which the variations in the second set are measured,
- Diagnostic Research – is a type of research Design that investigate the underlying cause of a certain condition or phenomenon. It can assist in learning more about the elements that contribute to certain difficulties or challenges experienced,
- Exploratory Research – a method established to explore a phenomenon that has not before been researched or adequately explained. It is a type of research Design that is responsible for finding the *why* of the events through the establishment of cause-effect relationships done through literature research, In-depth interviews, focus groups, case studies, etc.

6.2.3.4 Concept and development

The development of the concept for a new product or service that meet the needs and the strategy defined is an essential and critical stage in the Design process.

Concept development includes a set of activities that are carried out early in the project life cycle to collect and prioritize operational needs and challenges, develop alternative concepts to meet the needs, and select a preferred one as the basis for subsequent development and implementation. (*Concept Development*, 2017). It is a phase to explore the boundaries, conceptual options and potential Design directions (Karjaluoto, 2014), and explore different answers to the defined problem, seeking inspiration from different sources (Design Council, 2004)) and understand how the data and information collected in previous stages will impact the Design solutions (Discover Design, n.d.)).

Once an idea is generated, validated and tested for its quality and adequacy to the goals and objectives set, then the concept development stage follows. The development of the concept is carried out by keeping in mind the needs of the users, the business as well as the nature of the product (Basin, H., 2020) and the circularity and Sustainability goals.

The orientation towards circularity and Sustainability, as a guiding objective, must integrate into this stage a set of strategies, principles and criteria that support the Design and development teams to systematize the process and attain better solutions with higher potential. The Design teams must have the knowledge of the circularity methodologies and

tools and integrate them with a life cycle approach aiming to reduce the environmental impacts in all stages and increase the circularity and innovation potential.

The knowledge and experience of the Design teams are also crucial in managing the trade-offs that usually arise in any project of this nature. Trade-offs, in this context, are a balance or a compromise achieved between two desirable but incompatible or not attainable features at the same time.

After the development of the concept, the new solution should be tested and validated in the prototype phase.

6.2.3.5 Prototype

Prototyping is an experimental phase aiming to identify the best possible solution for each of the problems identified and to validate the concept developed according to the goals and objectives defined for the project. Prototyping offers designers the opportunity to bring their ideas and concepts to life to test the practicability, features and function of the current Design.

This stage includes 2 main activities:

- Prototypes development: A prototype aims to demonstrate the product features and explores all possibilities before investing in product complete development. It can range from a detailed drawing with pen and paper to a fully working version of the product.
  Prototypes can be classified into 4 categories with different characteristics developed for different purposes (Huang, 2021):
  - Working Prototype
  - Functional Prototype
  - Visual Prototype
  - User Experience Prototype

- Test and validation of the prototypes: With a prototype, the Design and development team can test and validate the solution attained using methods and criteria defined according to each project. The results of the testing phase are often used to redefine the solution (Interaction Design foundation, n.d.). In this stage, the circularity aspects

of the product must be analysed through Life cycle assessment methods and tools. This assessment can be done through qualitative or quantitative methods according to the needs and resources of each project. The effectiveness and procedural aspects of the project should also be analysed in this stage (Rocha et al. 2020).

6.2.3.6 Deliver

Delivery is the final stage of the process and involves the completion of the project and its delivery to the project recipients, such as client, contractor, company.

In this stage, in which the project of the new product or service is finalized, 2 main steps are involved:

- The communication of the results, in particular, the circularity and Sustainability aspects that should be part of the project in order to promote its success, inform the client, company and the users of the features and their added value. For this purpose, communication tools and reliable information are crucial, such as – Environmental Product Declarations – EPD, certifications, labels, – Life cycle assessment -LCA reports,
- Follow-up activities. Activities such as collecting feedback from users, analysis of the use and consumption, impact assessment, etc, will promote the spreading and wider integration of the circular Design approach to project development based on a continuous improvement concept (Rocha et al. 2020) for the company and the Design team responsible for the project development.

6.3. Rounding the vertices Design toolkit

6.3.1 Overview of the four tools

The Rounding the Vertices Circular Design Toolkit, (Figure 54) is composed of a set of 4 tools that can support the Design practice towards circularity and Sustainability.

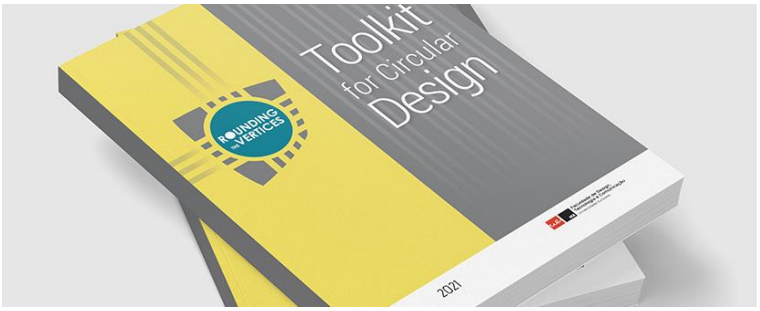


Figure 54 – Toolkit for circular Design

The tools (Figure 55) are used according to the Design process and are interlinked in order to guide the Design process and help the Design and development teams in the definition and planning of the project. It helps also in the identification of improvement measures and ideas to develop new solutions, and the validation and demonstration of the circularity performance of the Design process undertaken and the results of the project (Annex 8).

Figure 55 – Tools included in the toolkit

6.3.2 Tool #1 – Defining the project worksheet

6.3.2.1 Explanation of the tool

The first tool is focused on supporting the initiation of the project and the definition of what needs to be done. The goal in this phase is to systematize the process of the initial information, based on the strategic approach led by the business, and make sure that the development team always gets the information needed and guidance for the project development.

6.3.2.2 Structure of the tool

This tool includes a set of worksheets that supports the team in reflecting and compiling information to structure the project and define its strategy.

In order to define and initiate the process the tool includes 7 worksheets (WS):

WS 1 – Defining the needs of the project

This worksheet aims to identify the current needs and motivations of the business for the development of a Circular Economy Design project.

The definition of the needs of the project supports the definition of the problem that the project will address. In this stage, the Design and development team should identify why there is the need to develop a new Design project with a Circular Economy approach, what are the motivations for the company, what moves the company towards circularity and what are the known barriers for the project.

For this purpose, the user of the tool must reflect and answer 3 questions:

- Why does your business need to enrol in a Design for a Circular Economy project?
- What are the company's motivations for a Circular Economy Design project?
- What are the known barriers to a Circular Economy Design project?

WS 2 – Defining the market

This worksheet aims to identify the current and potential market for the business and their Sustainability and circularity concerns.

Based on market analysis, in this stage, the team must define the market for the product or service under development. This supports the guidance and definition of the project objectives and boundaries.

In this worksheet, the Design team must identify the current market, the market that is already covered by the company and the current products, the potential market that can be achieved with the development of the new product and the opportunities for the project.

In this stage, the team must also understand what the market is demanding in terms of Sustainability and circularity and how the business can meet these needs.

For this purpose, the user of the tool must reflect and identify the following aspects:

- Identify the market opportunities
- Identify potential markets for the business
- What are the barriers of the business to meet the needs of the market?
- What are the Sustainability and circular demands of the market?

WS 3 – Defining the business model

After the analysis of the market, the user is led to define and describe the current business model related to his product or service.

The business models define how the company creates value with its products or services. It outlines the structure and boundaries of the system in which the company operates and the relation with customers or users and the market.

Circular and sustainable business models focus on the value generated of a product or a service and try to capture value throughout its life, aiming to close resource loops and minimize the impacts over the life cycle.

In this stage, the Design team must understand the current business model and how the company can innovate and increase its value.

For this, the user has 2 tasks:

- Describe the current business model, determine how value is created and define the structure of the business
- Identify and describe the main Sustainability and circularity aspects of your business

WS 4 – New business models

If the company has the flexibility to explore and adopt different business models the users should analyse a set of circular business models and identify the potential of each model for his case.

The 8 business models included in the tool were defined (Bocken et al., 2014; Gerholdt, 2015):

- Circular supplies – The circular supplies business model is particularly relevant for companies dealing with scarce commodities, in which scarce resources are replaced with fully renewable, recyclable or biodegradable resource inputs.
- Resource recovery – The resource recovery business model leverages technological innovations and capabilities to recover and reuse resource outputs that eliminate material leakage and maximize economic value.
- Product life extension – The product life extension model helps companies to extend the lifecycle of their products and assets to ensure they remain economically useful. Material that otherwise would be wasted is maintained or even improved, such as through remanufacturing, repairing, upgrading or re-marketing.
- Sharing models – The sharing platform model is centred on the sharing of products and assets that have a low ownership or use rate. Companies that leverage this model can maximize the use of the products they sell, enhance productivity and value creation.
- Dematerialization from product to services – Through the product as a service BM, customers use products through a lease or pay-for-use arrangement versus the conventional buy-to-own approach. This model is attractive for companies with high operational costs and the ability to manage the maintenance of that service and recapture residual value at the end of life.

- Stewardship role in stakeholders' engagement – Proactively engaging stakeholders to ensure their long-term health and well-being and promotion of co-development, cocreation and synergies.
- Encourage sufficiency and efficiency – Solutions that seek to reduce consumption and production by eliminating superfluous features and improving the efficiency through Design.
- Develop Scale-up solutions – Delivering sustainable solutions on a large scale to maximise benefits for society and the environment.

WS 5 – Innovation level

The project can be oriented for a specific level of innovation according to the objectives and strategy of the company and the Design team. However, the level of innovation has a direct relationship between the financial resources needed, the development time, the know-how, human resources, technologies, etc. In this step, the users should analyse the four innovation levels and indicate the level expected for the project:

- **Level 1** – An incremental level defined by product improvement solutions. At this level, the project is focused on the development of a new product adding new features or characteristics to existing ones. This level has low investment, low risk, low payoff.
- **Level 2** – An incremental level defined by product redesign solutions. Redesign the product, add new features and advance based on the existing product. This level has medium investment, medium risk, medium payoff.
- **Level 3** – A Breakthrough by function innovation. Aiming to Design the function and develop evolutionary products or services, this level has large investment, medium risk and high payoff.
- **Level 4** – A transformational approach and radical system innovation. Aiming to innovate and Design the system, revolutionary and radical solutions of products, services and systems, this level has large investment, big risk, and limitless payoff

WS 6 – Project definition

Based on the previous analysis, this worksheet aims to systematize and define the project under development.

This worksheet will support the team in defining the strategy, goals and characteristics for the circular Design project and will guide the Design project.

The definition of the project is systematized and structured by filling in information related to:

- What product or service has to be developed? Or what is the function or problem addressed?
- Circularity and Sustainability goals for the project?
- Main motivations for the project,
- Target group. for whom the product or service will be developed,
- The business model expected for the solution to be developed,
- Expectations in terms of innovation level for the new solutions according to the context in which the new project is based,
- Resources available,
- Indication of the project ream and their role within the project,
- Time available to develop the project.

WS 7 – Rounding the vertices

Define the strategy for the project aiming to improve the efficiency in each area aligned with the rounding the vertices framework, already presented.

Having in mind the project definition and the requirements identified, the Design and development team should indicate in this stage which are the objectives and the strategy towards the four levels of the rounding the vertices concepts. Here, the team will indicate how to improve the function of the product or service, how to improve the efficiency in terms of resources used within the life cycle, and how to improve the economic and social aspects of the product or service system:

- Function – How can the function of the product be improved?
- Physical resources – How can the resources efficiency be improved?

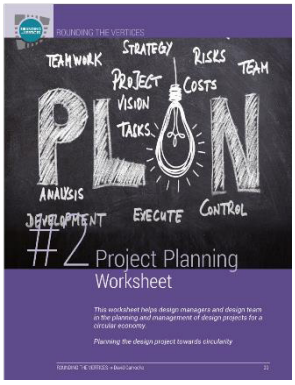
- Economic resources – How can the costs and revenues be improved?
- Social dimension – How can the project improve society?

6.3.2.3 Outputs of the tool

The result of the tool is a systematized definition of the strategy, goals and characteristics for the circular Design project structured to improve the innovation and efficiency of the solutions according to the Function, Resources, Economy and Social levels.

6.3.3 Tool #2 – Project planning worksheet

6.3.3.1 Explanation of the tool



The project Planning worksheet helps the team in defining the work to be done and creates the roadmap and structure to follow within the project to meet the objectives defined previously.

The tool organizes the project through the identification of the activities to be held, the resources needed and the duration of the task within the project.

6.3.3.2 Structure of the tool

This tool, aiming to plan the project under development, includes a set of worksheets that supports the team in systematizing and planning the activities to be carried out. This tool doesn't aim to be an extensive Design management tool and was created to be as simple as possible in supporting the project.

Resulting of a process of simplification and minimization of the workload, the tool is composed of 4 worksheets:

1. Defining the scope and deliverables for the project worksheet. In this, the user should define the scope of the project, define the deliverables that are planned for the project and define the boundaries of the project. In this, the users must also describe what

should result from the project by identifying the expected deliveries (e.g. technical drawings, renderings, mock-ups, prototypes, etc).

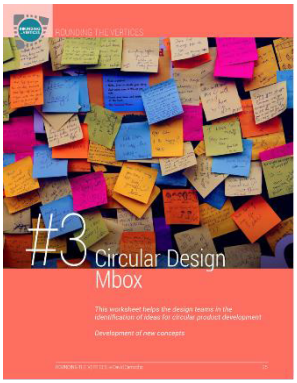
2. Identification of the project stakeholders. In this worksheet, the user indicates the main stakeholders for the project, their purpose based on what will be the involvement of the stakeholder and what is the need to involve it. The importance of the stakeholder in the process is also analysed allowing a hierarchization within the project.
3. Defining the activities and tasks for the project. This worksheet helps Design managers and Design teams in the planning and management of Design projects for a Circular Economy. In this sheet, the management team should identify the main activities and their related subtasks in order to develop the circular Design project. These must reflect the needs identified and the goals of the current project.
4. Allocating resources and time. In this step, the management team should identify the resources and time needed to perform the main activities and their related subtasks.

6.3.3.3 Outputs of the tool

The results of the tool are a list and characterization of all the activities and tasks needed to undertake the current project with an allocation of resources and time needed, the identification of the project stakeholders and the planned deliverables that should be developed within the project.

6.3.4 Tool #3 – Circular Design Mbox

6.3.4.1 Explanation of the tool



The circular Design morphological box combines the concept of the morphological box tool Fritz Zwicky (1999), widely used by designers in the identification of Design solutions, with the 10 Design principles for circularity and Sustainability.

The 10 principles that compose the Rounding the Vertices Approach were developed based on a research process in which several methodologies, tools and different approaches were analysed.

These principles, developed for designers, are project-oriented and through their analysis and implementation, the Design teams can, in a holistic approach, identify Design opportunities that result in more circular and sustainable solutions.

With the support of the tool, Design teams can implement the Design principles in a systematized approach, leading to innovative and circular solutions for product and service development.

6.3.4.2 Structure of the tool

The tool, based on the concept of the morphological box is composed of 10 sections, each one related to one Design principle developed earlier.

The morphological analysis, developed by Fritz Zwicky, (Figure 56) allows a multidimensional assessment of several variables and by using the technique of cross consistency assessment, the system and the selection and linking variables allows the creation of different solutions,

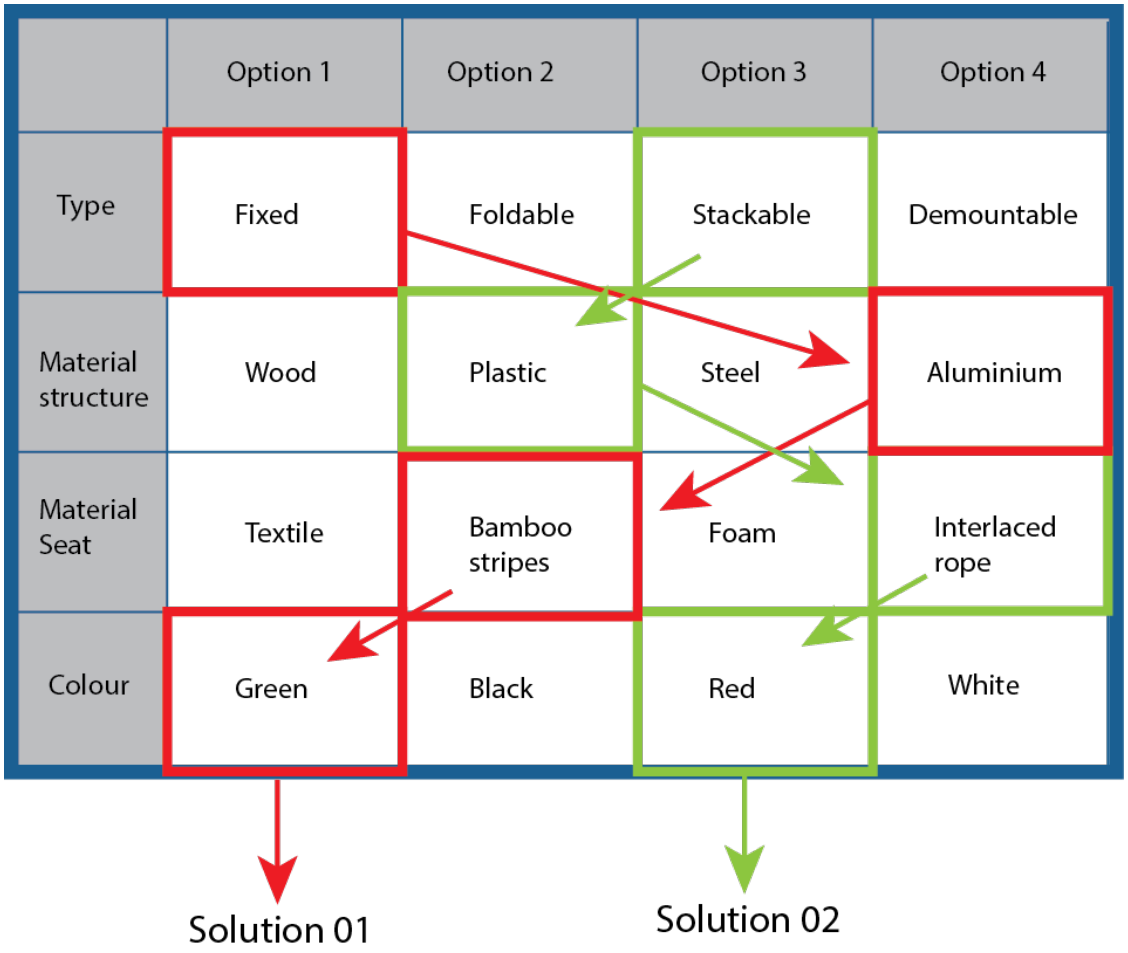


Figure 56 – Morphological box – Development of a chair (example)

Within the Mbox tool, in each section, the user will find the description of the related principle. This content aims to increase the knowledge of the designers in the files of Design for circularity. After the explanation, the user will find two questions for reflection. In the first he should indicate the current situation, explaining how the principle was reflected in the reference product, and in the second question define the objectives for the project under development related to the principle under analysis.

The analysis of the principle is done by the analysis through a set of criteria. These are what should be considered in the Design phase. The number of criteria in each principle varies.

To apply the tool, each principle has a table (Figure 57) where the user, by analysing the criteria will indicate several improvement options. In the end, the establishment of links or paths with several options, will lead to the identification of different Design solutions and finally, the definition of a new concept for the problem addressed.

	HOW CAN YOU CREATE AND DEVELOP A MORE DURABLE PRODUCT? (2)		
	WEAR-RESISTANT DESIGN SOLUTIONS	PRODUCT/USER RELATION	SIMPLICITY PRINCIPLE
	Identify ideas to improve the resistance to wear and loss of properties of your product	Identify ideas to create products with a stronger emphatic relation with the user	Identify ideas in order to simplify your product and promote efficient usage
01			
02			
03			
04			

Figure 57 – Design durable products – table

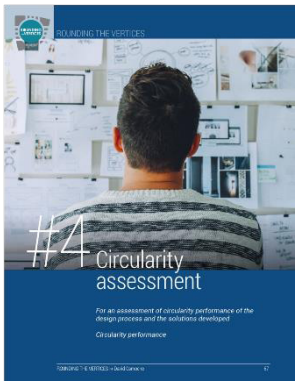
6.3.4.3 Result of the tool

The tool, by leading the user to reflect on the principles and the identification of several options in each criterion will result in a large set of individual variables that can be combined in different ways leading to different solutions for the problem addressed.

This systematization of a large number of options could lead to more innovative solutions for products, services and business models.

6.3.5 Tool #4 – Circularity Assessment

6.3.5.1 Explanation of the tool



The Design process Circularity Assessment tool aims to evaluate the performance of the Design project and its results, and how it contributes to the transition to circularity.

Within the Rounding the Vertices Concept, with the tool, the user can assess how much the process led to a circular approach and how much the vertices of the initial square shape which represents the reference product was improved towards a more circular process and results.

The assessment relates the performance of the 10 Design for Circularity principles, which covers the entire Design process, and reflects their impact in the 4 levels for circularity defined; the economic level, the function level, the resources level and the social level.

The tool results in a set of information, presented through chats, in which the user can:

- Identify the overall performance of the project, meaning how much the vertices "were rounded",
- The performance of each principle, and to what extent the principle was adopted in the process,
- The performance of the project according to the four levels for circularity,
- The impact of the performance of the 10 principles in the transition to circularity.

These results are useful to demonstrate and communicate the results of the Design for circularity and Sustainability project, indicating where the improvements were performed and pointing out the potential for further improvement through a new Design process.

6.3.5.2 Structure of the tool

The tool is composed of an introductory spreadsheet, 10 spreadsheets to evaluate the 10 designs for circularity principles and a final spreadsheet with the results of the assessment.

In the evaluation spreadsheets, the user should rate the level of integration of the principle in the project on a scale from 01 to 05 and explain how it was implemented.

In each spreadsheet (Figure 58), there is also a brief explanation of why the principle is important in the Design process.

In the final spreadsheet, the results of the assessment are displayed in a set of charts and a final table with the evaluation of the principles and their impact on the four levels. Since each principle has a different impact on each circularity level, their importance was weighted based on literature and in consultation with experts.

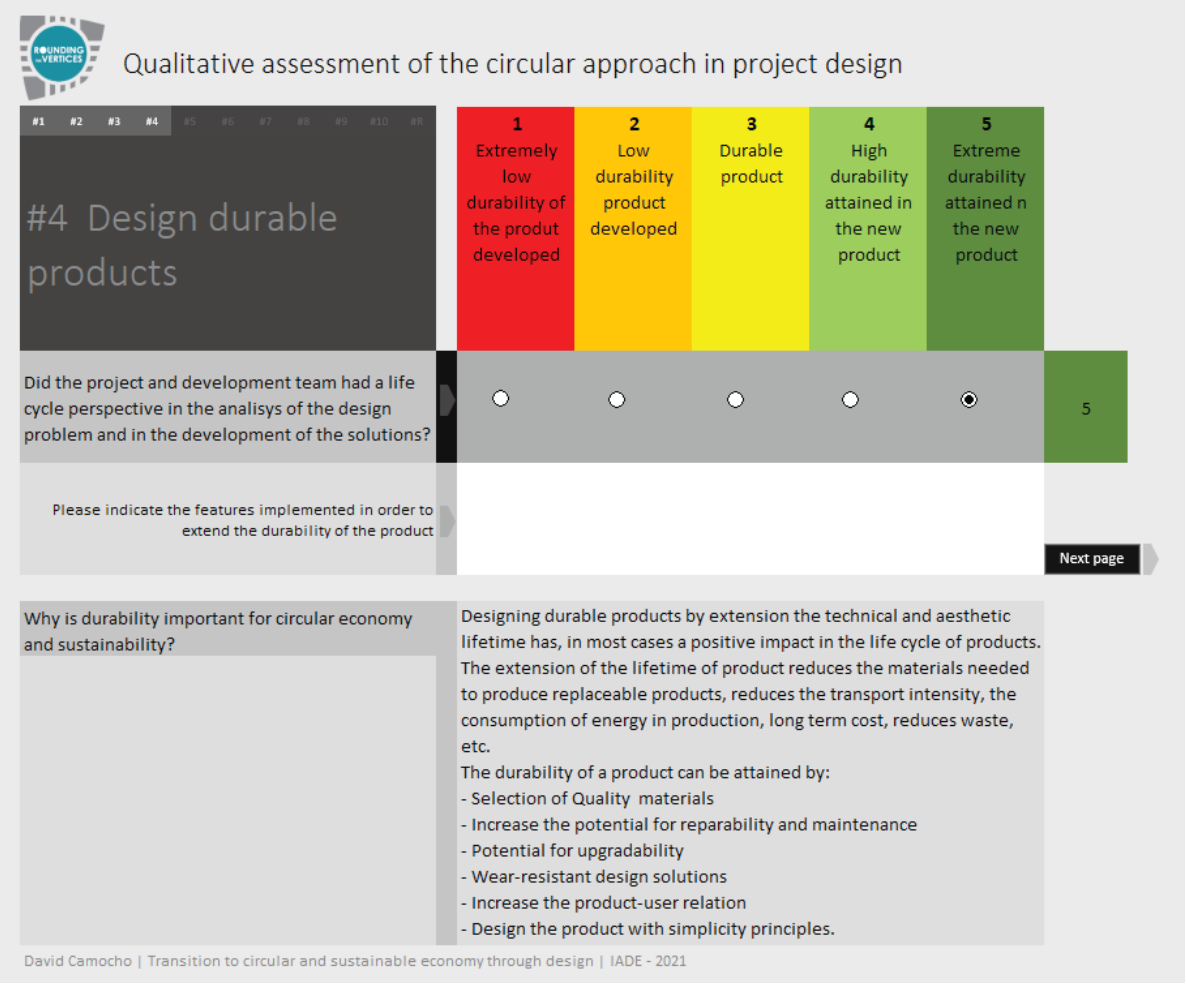


Figure 58 – Design durable products – Assessment spreadsheet – Example

6.3.5.3 Outputs of the tool

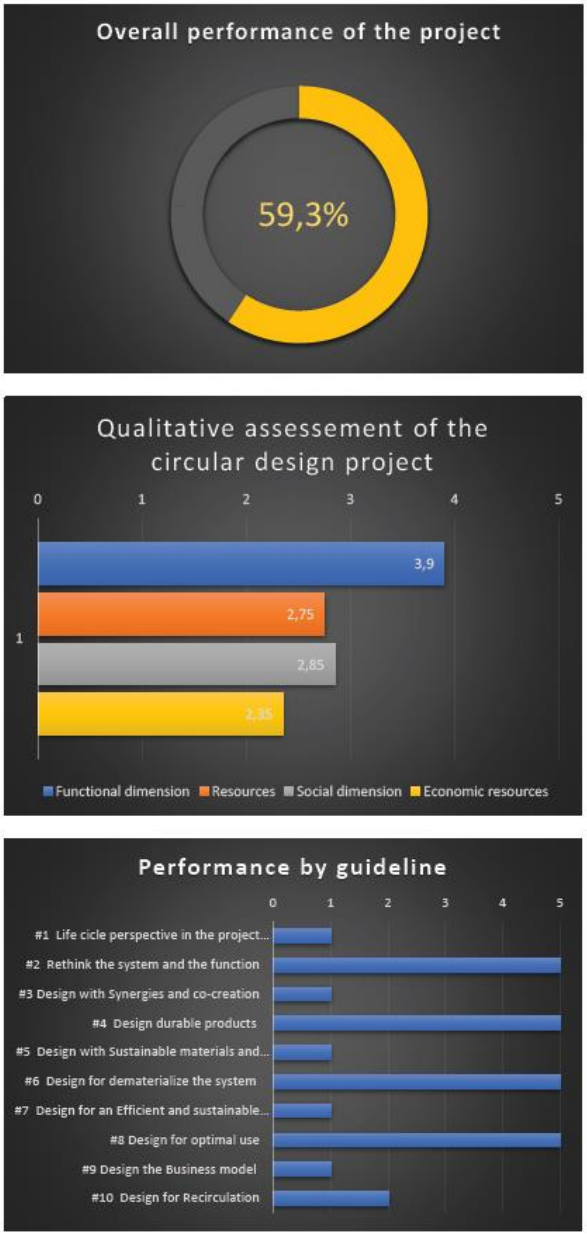


Figure 59 – Circularity assessment tool – Results

Through the inputs and the assessment of the performance in the implementation of the 10 circular Design principles, the tool calculates (Figure 59):

• **The overall performance of the project,** indicating in which percentage the project fulfils the aim of rounding the vertices. In order to reach the maximum score, the project has to implement all the principles scoring 5 on the assessment scale from 1 to 5.

• **The performance of the 4 levels**, how the project and the results are performing in terms of the function of the product, the resources used within the life cycle, the social aspect and the economic aspects of the product or service. To reach the full potential in the transition for circularity, the project must address these four aspects and improve them in all stages of the life cycle.

• **The performance of each principle**. This detailed scoring allows a brief demonstration of where the product is performing better and where there is the need to improve the process towards circularity.

6.4 Rounding the Vertices publication – toolkit printed version and excel based tools

The toolkit provides four tools to systematize the integration of circularity aspects in the Design process. The tools were developed to be used to support the four stages of the Design process, namely:

- The strategic definition of the project,
- The management of the project,
- The creation of new concepts, and
- The assessment of the Design process and its results.

There are 2 versions of the tools that should be used according to the needs and

experience of the Design teams.

The e-book version – a comprehensive resource with the theoretical content (Figures 60-62). The 3 initial tools are composed of a set of worksheets in which the Design team needs to reflect and fill in the tables. The assessment tool, due to the calculation features, is to be used only in the excel version. In the e-book, an explanation of this tool (Figure 64) is presented. The ebook can be found in Annex 8)

Figure 60 – Toolkit for circular Design

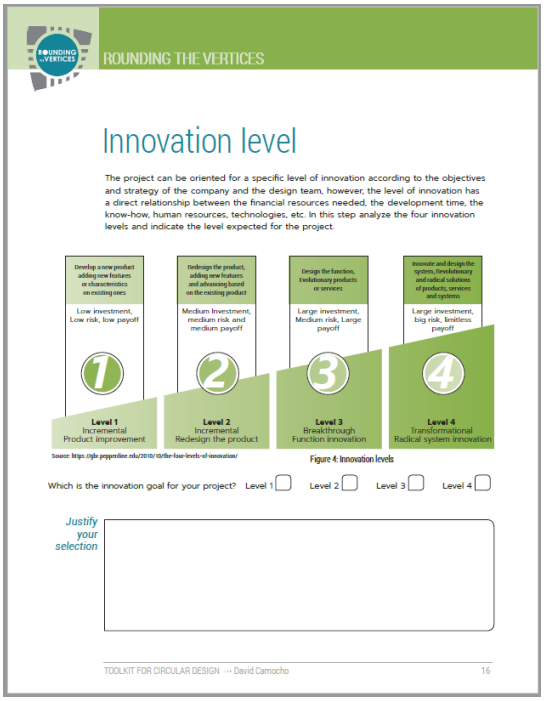


Figure 61 – Example of content pages in the toolkit

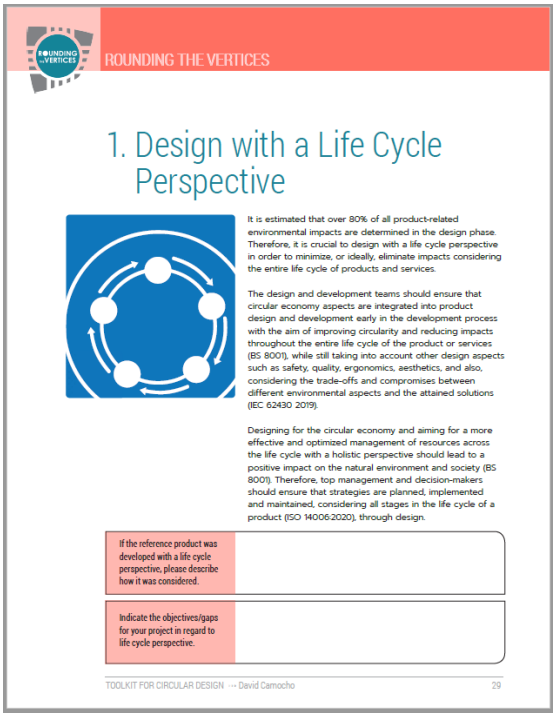


Figure 62- Example of content pages in the toolkit 2

Excel-based tools – (Figures 63-66) These versions of the tools were developed in excel so that the Design team can fill in the spreadsheets in a more systematized way. These versions include the possibility to perform calculations and features to simplify the filling-in process, however, it does have the limitations of the Excel software.

The Excel versions of the tools are available in annexes 9 to 13.

Figure 63 – Defining the project worksheet

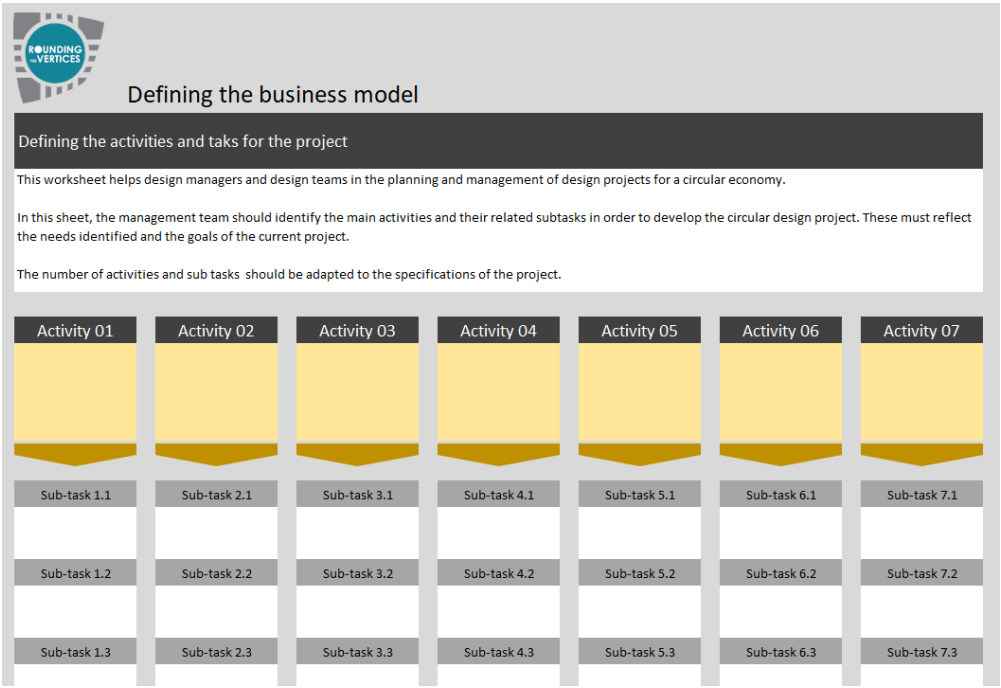


Figure 64 – Project planning worksheet – example

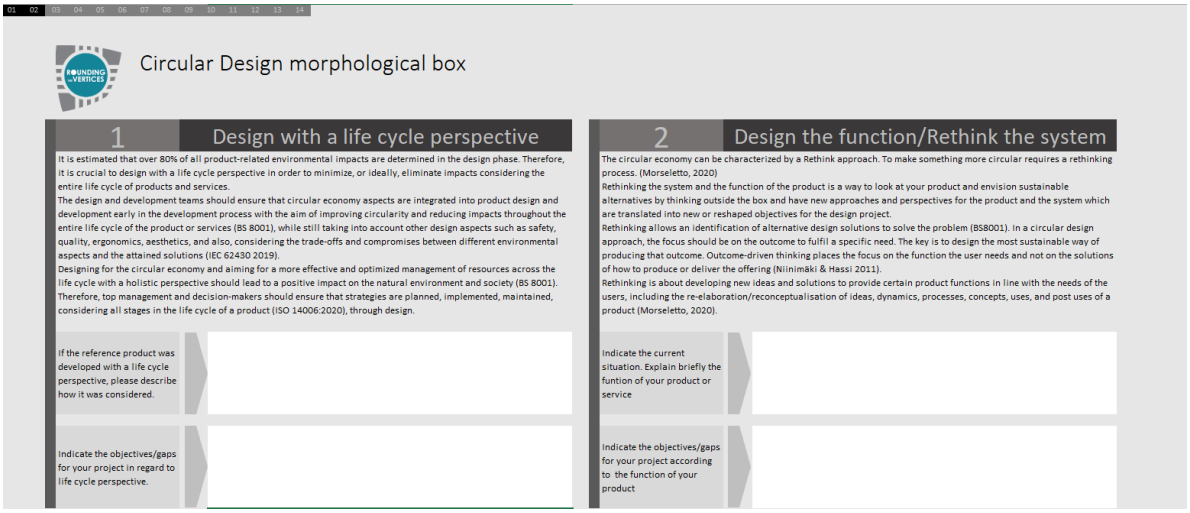


Figure 65 – Circular Design MBox – example

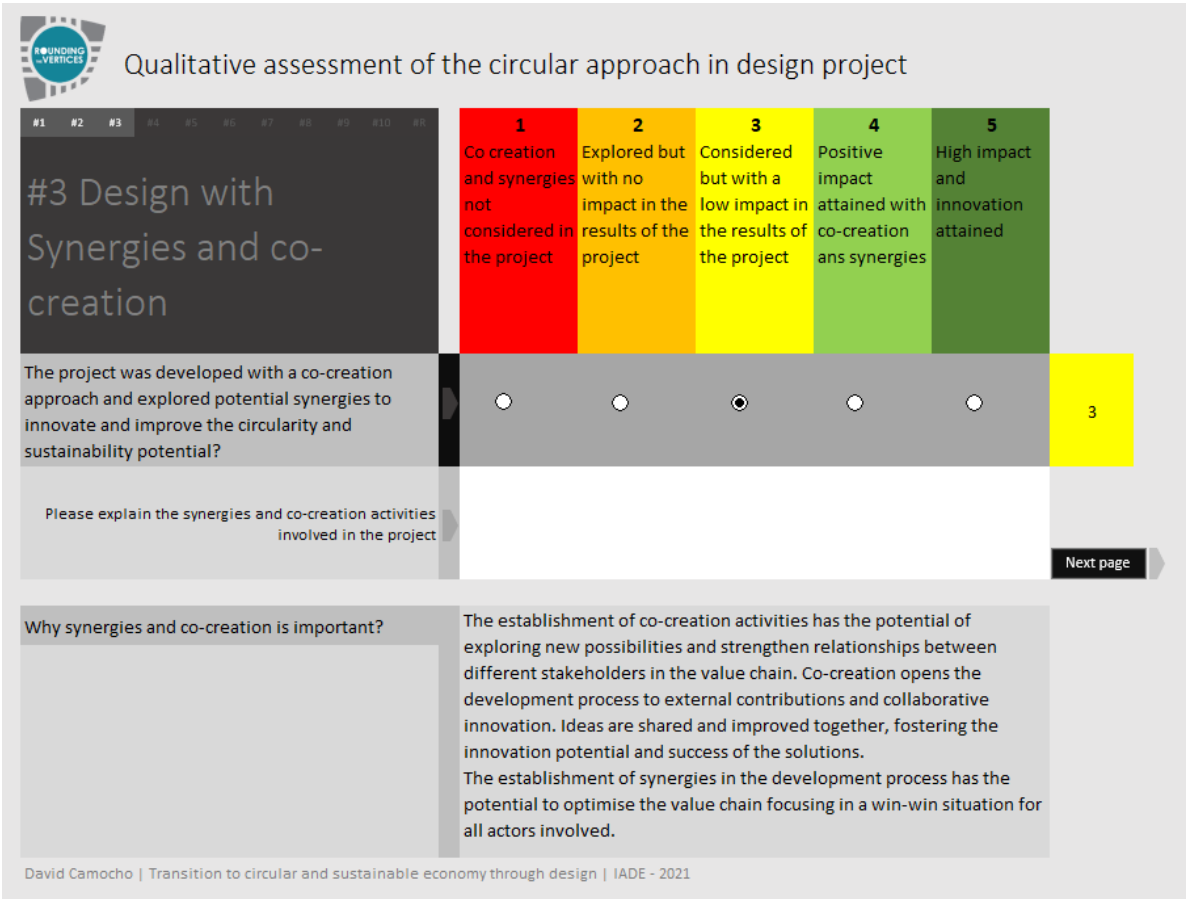


Figure 66 – Circularity Assessment tool

7. Validation of the Circular Design Model and Toolkit

7.1 Introduction

With the aim of providing designers with tools to support their practice in the development of new solutions and in order to respond to the hypothesis “Design, through its specific methods and tools, is an important factor for an effective transition to a Sustainable Circular Economy”, formulated as a guideline for the investigation, at this stage, the model and toolkit were tested and validated.

After the development of the model and toolkit composed of the four tools described previously, in the context of research under development and due to the current restrictions in the face of the COVID 19 pandemic situation and the challenges that companies and professionals suffered, it was validated by international experts of reference in the areas of Design, Sustainability and Circular Economy during the pandemic COVID 19. This analysis allowed the collection of perceptions, feedback and analysis that allowed testing and validating the resources developed in order to align them with the needs and expectations of designers and product developers in practice.

The validation included 3 main steps:

a) Evaluation through Focus group 1. This focus group, developed within the Design research and innovation week, aimed to be a pre-test of the methodology to validate the materials.
b) Evaluation by international experts (focus group 02) identified by their relevance in the areas of Design, Sustainability and Circular Economy,
c) Analysis of the feedback collected through questionnaires, discussions in the online sessions and face-to-face meetings.

Focus groups method used to collect data from experts.

Focus groups is a method widely explored and applied in Design research and practice in which participants interact freely with co-participants as well as with a moderator. This allows and promotes diverse interactions focusing on the topic and subject of the research.

This method also allows collecting opinions and ideas on a topic in depth from different participants with their own perspectives and perceptions. In focus groups, a selected group of people, often experts in the area of discussion, are grouped together to discuss opinions about a specific topic (Jung & Ro, 2019).

7.2 Focus group 1 – Expert's validation – pre-test

7.2.1 Method

Figure 67 – DRIW logo

Pre-test held within the Design Research and Innovation Week, June 2021.

The DRIW'21, organized at IADE, included several workshops, a colloquium and DDC'21 (Design Doctoral conference) which offered to the designers, students and the community lectures by international speakers, along with the discussion of the research work of PhD students in Design and workshops. The events were open to the community.

The event was seen as an opportunity to proceed with a pre-test for the validation of the Rounding the vertices toolkit before the session to validate the resources by a focus group composed of experts in the field.

The session had the title: "Rounding the vertices. Design for Circular Economy" and was held on Friday, 25th June 2021, targeting Design students, researchers and companies with a duration of 2 hours. The session was held by Zoom, organized by the authors.

7.2.2 Structure of the session

The workshop was structured in the following topics:

- Introduction to the research project
- Rounding the vertices – The concept
- Rounding the vertices Design model
- Toolkit for Circular Design:
    - Tool #1 Defining the project worksheet
    - Tool #2 Project planning worksheet
    - Tool #3 Circular Design Mbox
    - Tool #4 Circularity assessment tool
- Presentation | Reflection | Debate

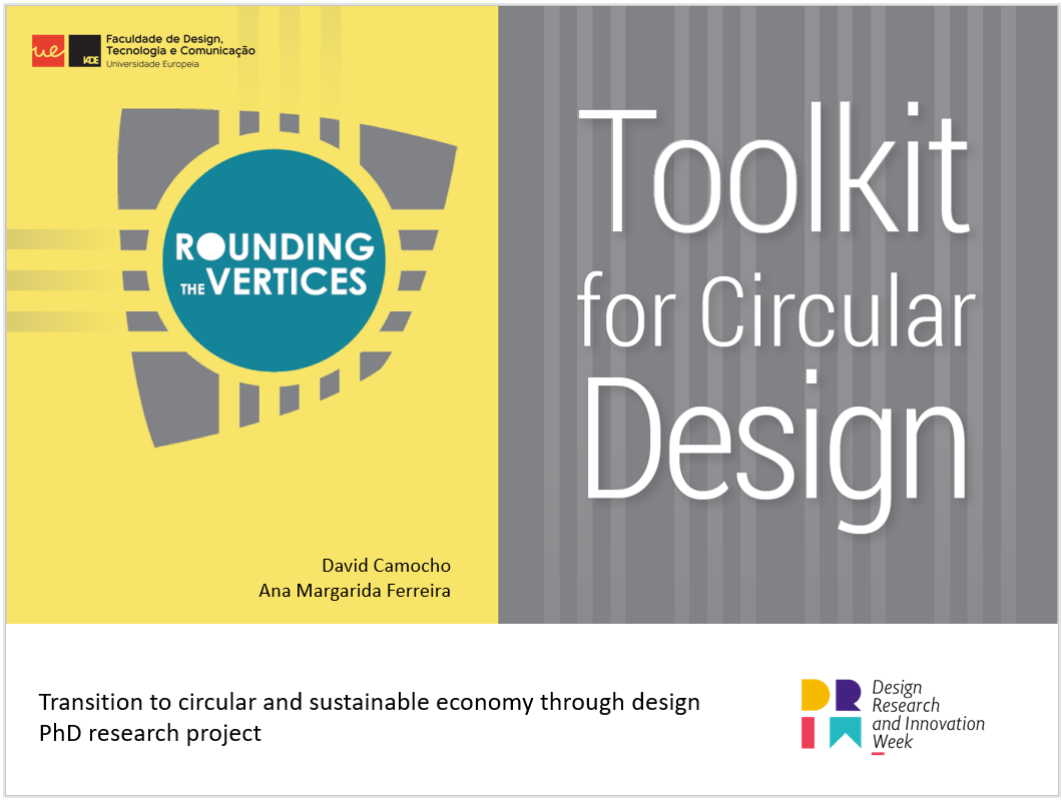


Figure 68 – Cover of the presentation

The participation, due to the fact that the session was organized at the end of the afternoon on Friday, didn't have as many researchers as expected. However, the discussion was fruitful and allowed the testing of the structure and method to present the toolkit for validation (Figure 69).

Figure 69 – Zoom – Participation in the session

The workshop was based on the presentation of the toolkit with debates and feedback collection through several questionnaires. After the presentation of each part, the participants were invited to fill in a small questionnaire, followed by a debate.

The method allowed the collection of useful feedback and the identification of improvement opportunities to apply in the session with the focus group.

7.2.3 Questionnaire for the assessment

After the presentation of each part, a small questionnaire (Figures 70 and 71) developed in google forms software was sent through the chat functionality of the ZOOM platform and the participants filled in. In the initial pages of the questionnaire are presented and the complete questionnaire is available in annex 14.

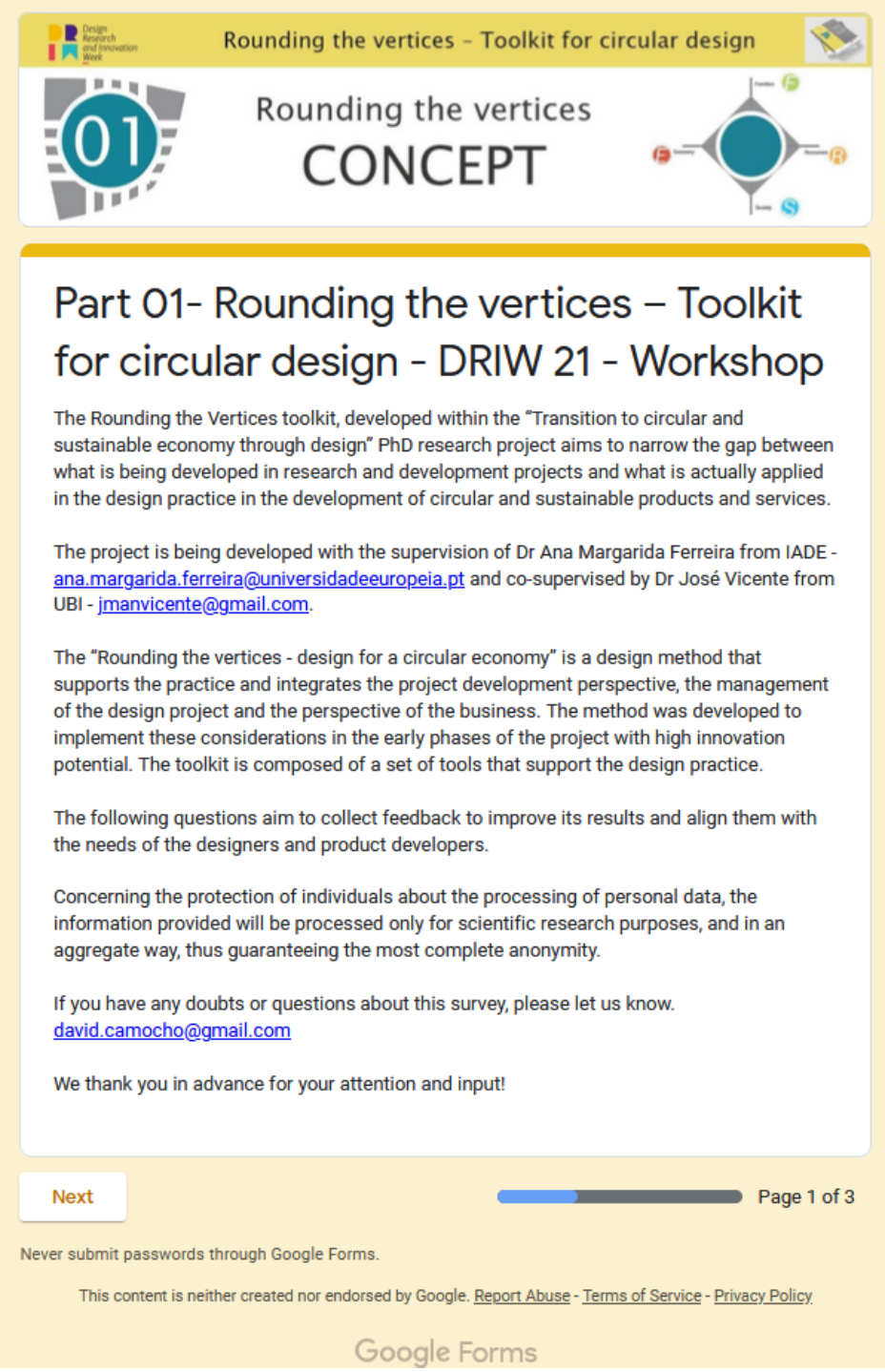


Figure 70 – Rounding the vertices DRIW workshop questionnaires – introduction.

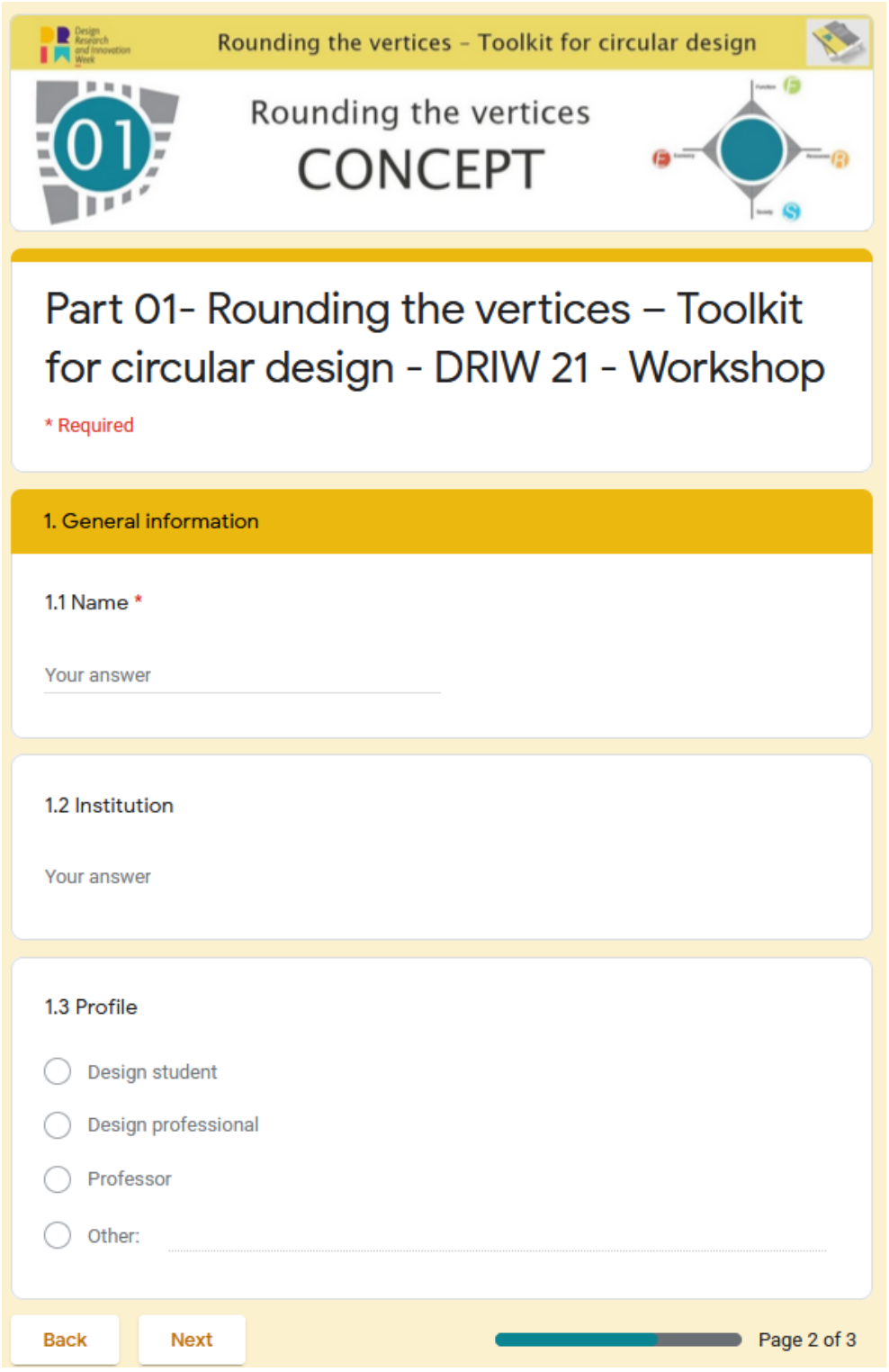


Figure 71 – Rounding the vertices DRIW workshop questionnaires – part 01.

7.2.4 Results

The session had six active participants who contributed to the success of the event by providing valuable feedback and collaboration in the debates.

The participants were dived by one Design professor, one professor and PhD student, one Design researcher and 3 Design students (Figure 72).

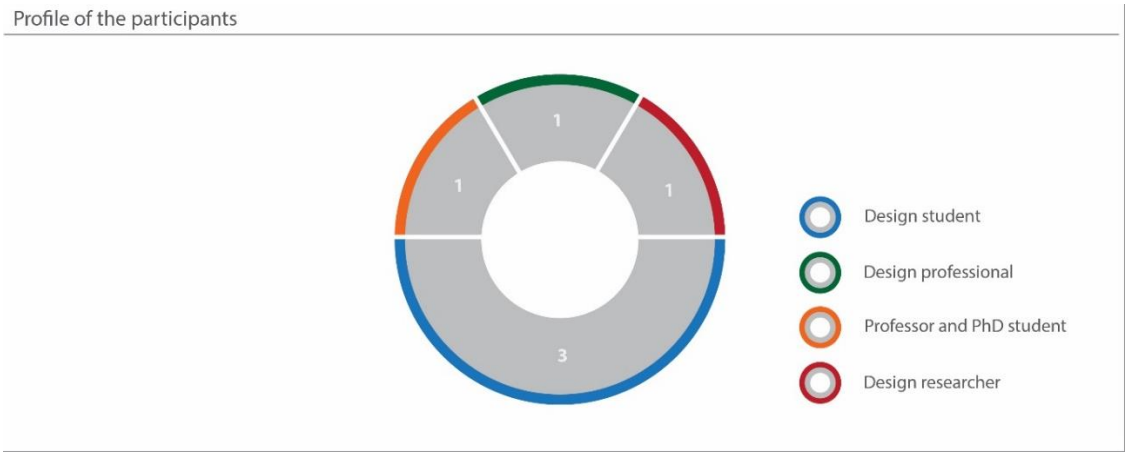


Figure 72- Profile of the participants

7.2.4.1 Rounding the vertices Concept

The Rounding the vertices concept, as the firt part was presented and explained in detail to the participants (Figure 73).

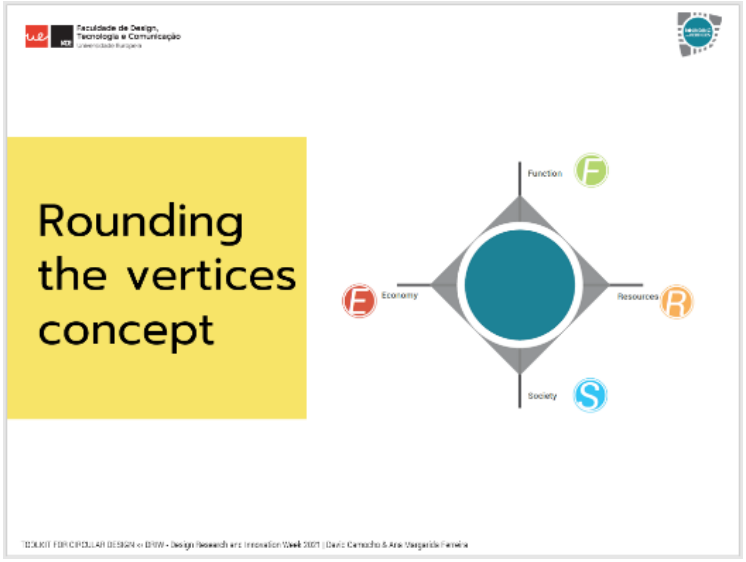


Figure 73 – Rounding the vertices concept

The concept was well accepted as well as the way it will be used to promote the toolkit

The evaluation of the four dimensions that compose the concept, using a Likert scale had an average score of 4.3 (Figure 74)

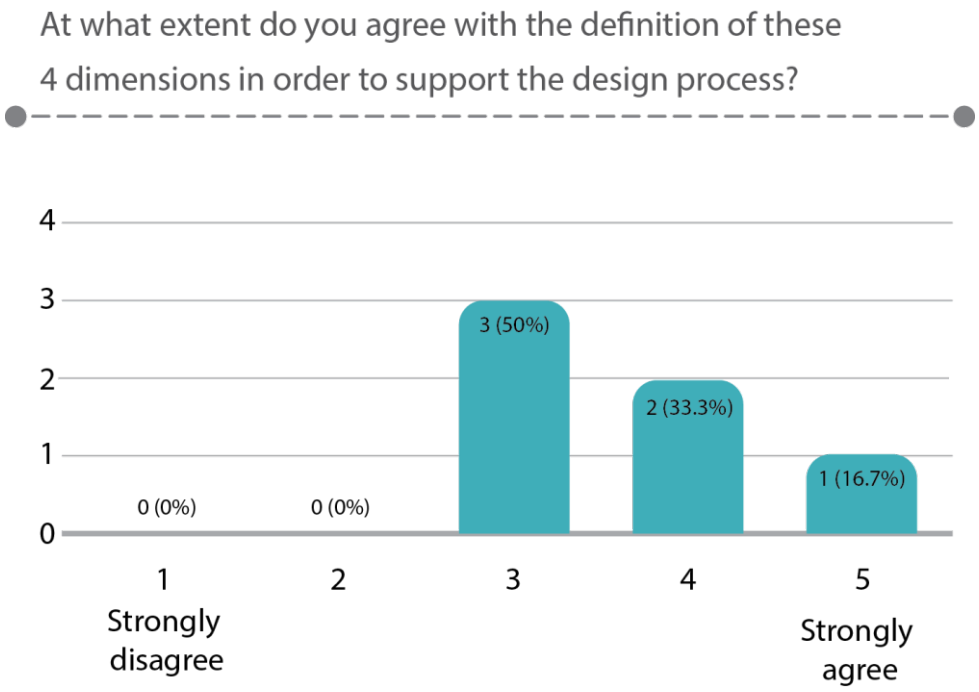


Figure 74 – Concept evaluation

As for the relevance of the concept, using a scale from 1 to 6, the evaluation was also positive, with an average score of 4.8 (Figure 75). Only one participant considered that the relevance was considerably low.

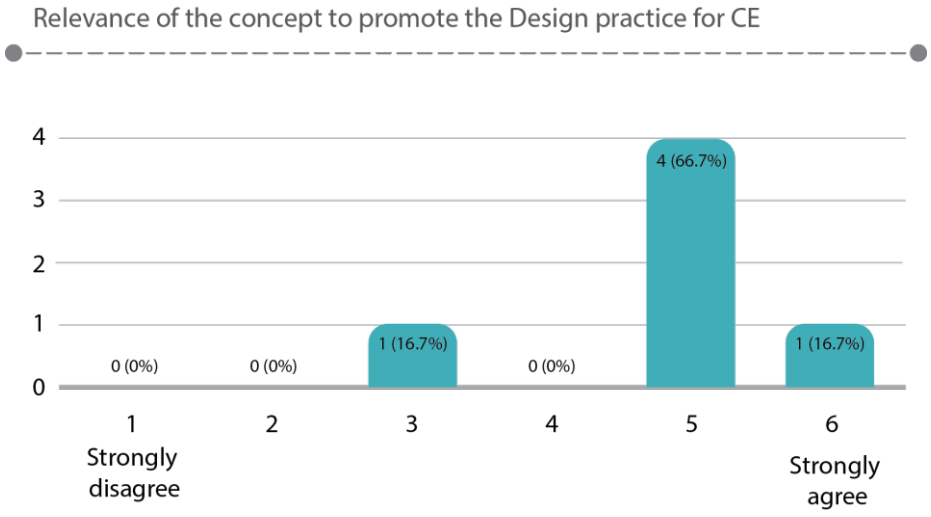


Figure 75 – Relevance of the concept evaluation

In terms of suggestions, the participants mentioned that would be preferable to explain better the aspects/axis of the concept since the terms are general. The user or target group is not identified in the concept and rationale of the conversion from the square to the circle could be further explored and presented.

7.2.4.2 Rounding the vertices Design model

The second presentation issue was dedicated to the presentation and discussion of the Design model (Figure 76).

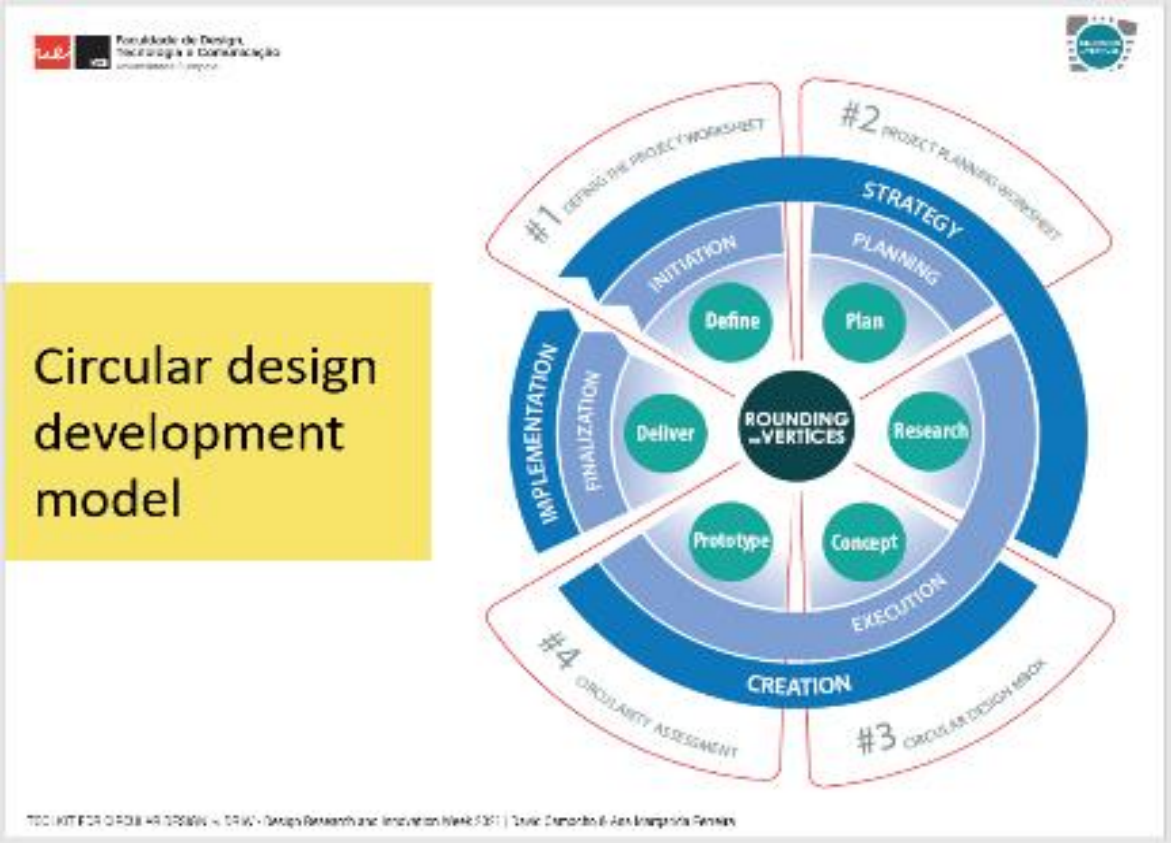


Figure 76 – Presentation of the model

From the discussion, the participants mentioned that more time and more in-depth explanation would be good to fully understand the model. However, the general perception is good.

The evaluation of the usefulness of the model to structure the Design practice had an average score of 4,5 (Figure 77).

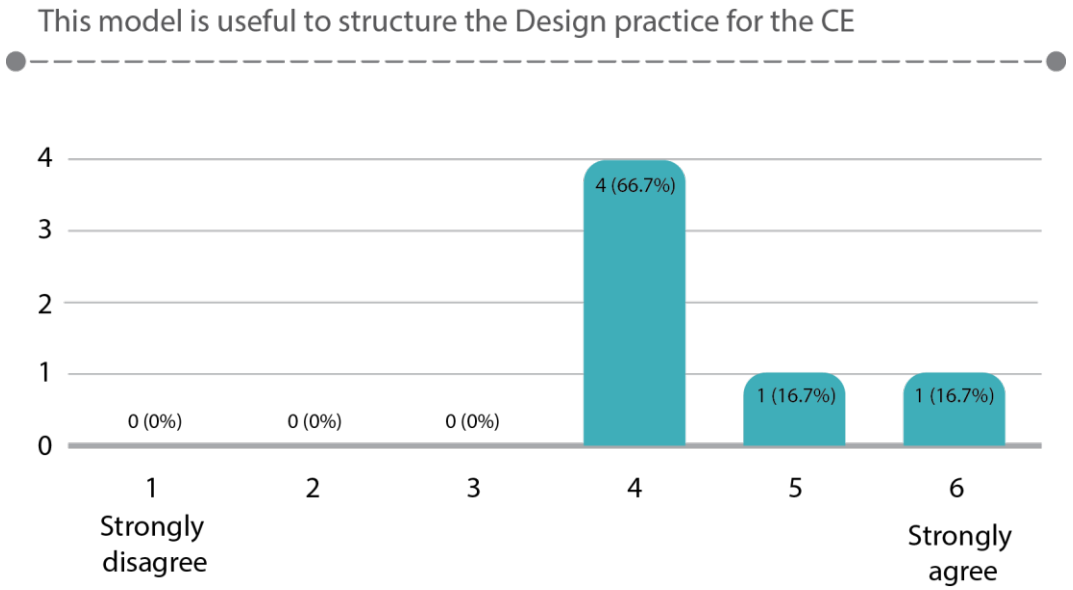


Figure 77 – Usefulness of the model

Regarding the importance of the 3 levels, Strategic, Management and Operational, to organize the project, the evaluation had an average score of 5, which is a good indication of the acceptance of the model by the participants (Figure 78).

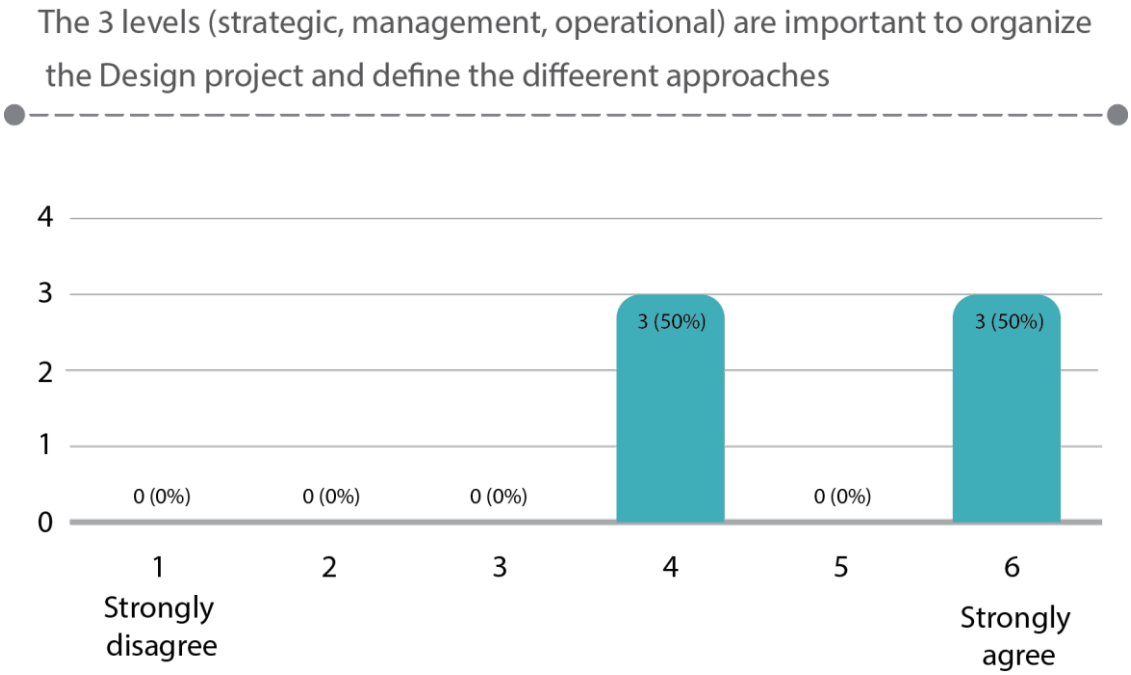


Figure 78 – Importance of the 3 levels

The suggestions for improvement, indicated in the questionnaire and from the debate held after the presentation, were mostly related to communication and the way of presenting the model. An animated solution could be a solution to improve communication.

The relation of the model with the Rounding the vertices concept was not clear enough. Perhaps the model could be presented in different stages with a clear identification of the link between the model, the tools and the relation with the four dimensions of the concept. This relation and link to the concept can also improve the generalist approach to the project and establish the link to the Circular Economy.

7.2.4.3 Rounding the vertices toolkit

After the introduction of the concept and the Design model, the 4 tools were presented, followed by short debates and the filling in of the questionnaires according to each tool.

Tool#1 Defining the project worksheet.

All participants consider the tool useful in the definition of the project and based on the perception of the tool, the main weaknesses identified were that from the presentation, the tool does not deal with circularity enough and the tool seems to be a bit complex.

As for the main strengths identified, it was mentioned that it covers the whole process. It gives the possibility to think and to understand what are the problems around the circular economic subject, and how the user can solve them, it gives options to define a new business model based on Circular Economy and It actually uses the concept of Circular Economy on each part of the process.

Some ideas to improve the tool considering the improvement of the graphic layout to consume less paper, inks and optimize the tool itself and the possibility to have a more abstract approach.

Tool #2 Project planning worksheet

Regarding the second tool presented, all participants consider that the tool is useful to help in the definition of the project.

Based on the perception of the tool explained within the session the main weaknesses and improvement opportunities identified by the participants are a certain risk of lacking flexibility regarding the stakeholders involved in the process. Another remark was related to the structure. In the first chapter one idea was to organize the tool according to the goals, objectives, outputs, background, end-users, etc thus facilitating the definition of the objectives for the project. Co-design is not reflected in the tool and can be an added value for project development also.

The flexibility and the way it will be used in different projects by users that have different approaches and objectives (project team, designer, clients, etc) was also highlighted.

As for the strengths identified, it was considered a simple structure, which was considered hard to achieve and helpful for the Design process, it was considered that the tools assure that circularity is taken into account at the beginning of the Design process. The structure, which provides room to identify activities, tasks resources and stakeholders was also considered a strength in the toolkit.

Tool #3 Circular Design Mbox

The tool was presented and explained in the session. The participants didn't have the opportunity to explore the functionalities and the content of the tool, which is a large tool with an extensive set of information that was developed in order to support the integration of circularity principles and criteria for the definition and identification of circular solutions for the project.

All participants consider that the tool is useful for the development of circular Design projects. The main remarks were related to the dimension of the tool. Some parts were considered very intensive and might influence the process of integrating the tool in the system of the company because people get not interested or consider it is too complex.

However, it was a common perspective that the tool is well developed and structured and has a lot of information that is very helpful before making decisions and taking conclusions.

Tool #4 Circularity assessment tool

The circularity assessment tool was briefly explained to the participants

Also in the session, the participants did not have the opportunity to explore the tool in detail. However, from the discussion held after the presentation, the reaction of the participants was good. For them, the tool seemed attractive and very useful to support the Design project and validate the options and activities undertaken in the process.

The discussion and analysis of the circular assessment tool did not have the expected results in terms of feedback and would be good to have more time to discuss it.

7.2.4.4 Main conclusions of the session

Being a pre-test held with a small group of participants and integrated into the DRIW workshop held at IADE, the results of the session were very useful to structure the main session with the international experts to a final validation of the toolkit.

As for the structure of the session, with presentations followed by short debates and filling in of small questionnaires need sessions with longer duration and with a sharp moderation in order to maintain the discussion and control of the time available in each slot.

For validation purposes, this type of session is not feasible, since the participants do not have enough time to explore and understand fully the toolkit. A mixed approach was considered the best approach to be applied in the validation with the international experts. An online session to introduce and explain the toolkit with debate to clarify the objectives of the toolkit, its structure and concept, followed by the distribution of the toolkit to the participants to explore, test, and validate the resource individually.

As for the perceptions of the participants regarding the toolkit presented, the reactions were good. The participants considered that the toolkit is useful to support the Design process towards circularity and the information available is important to guide the Design teams in the identification of solutions to integrate into the process.

Several ideas to improve were discussed which were considered in the definition of the final version of the toolkit.

7.3 Focus group 2 – Expert's validation

7.3.1 Method

Aiming to validate the toolkit and the approach developed within the project a second focus group of international experts was organized and involved in the process. The validation by international professionals from different areas, who have experience in research, development and implementation of Sustainability, circularity and Design in practice is an important step in order to improve the material developed and promote their adequacy to the users.

The validation process carried out had the following steps:

- **Identification of international experts** – The authors of the research, through their knowledge and experience in the fields of Sustainability, the participation and collaboration in international projects and networks, and through the literature review undertaken during the project were able to identify and select an international group of professionals who can analyse the materials and provide valuable feedback base on their knowledge and experience in the field.
  For this purpose, a database of experts was created including the name, expertise, institution, country, and contacts. This can be used in the future to establish a network of experts and to promote and disseminate the results of the research.
- **Invitation of experts to participate in the validation workshop** – all experts were invited through email. In the email, the authors addressed the invitation to participate in the workshop held online through zoom in July 202. The communication included also an explanation of the objectives and a brief explanation of the session.
- **Presentation of the research concept, background and toolkit** – The presentation of the resources was done in the online meeting. In the session, the concept of the research, the background and the toolkit were presented and explained to the participants. At the time, the participants were able to understand and get acquainted with the materials. Based on the presentation, a debate and discussion were promoted in order to collect initial feedback from the participants.
- **Questionnaire in the session** – During the online session, the participants filled in a short questionnaire to collect initial feedback and the initial perceptions. The questionnaire was developed in an online form that was distributed to all participants.

- **Sharing of the toolkit for in-depth analysis by the experts** – aiming to collect a more accurate and in-depth analysis and be considering that the presentation of the resources and debate in the session was not enough to validate them, the participants that received a beta version of the materials. They were asked to explore the materials according to their availability and interest.
- **Feedback** – the collection of feedback from the experts was done through several means. An online questionnaire was sent to all, but some experts did a more accurate analysis and gave their feedback through direct contacts and annotations and comments in the documents, which gave more useful support in the update of the materials.
- **Extra meetings** – To complement the feedback received, the authors decided to directly contact some experts in the field of Design and held extra meetings to validate the materials and collect feedback of the resources, especially in the adequacy to Design professionals in practice.
- **Analysis** – After the gathering of all feedback, an analysis was carried out to support the improvement of the toolkit.

7.3.2 Structure of the session

The session, based on the lessons learnt in the pre-test held at the DRIW'21 had an improved structure and content aimed to attain the desired results (Figure 79).

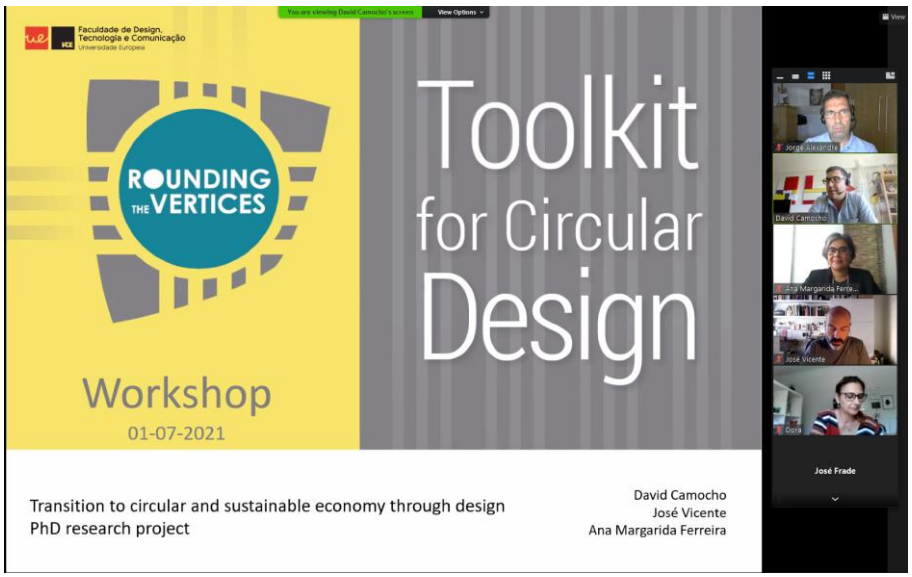


Figure 79 – Focus group 2 – workshop

The program (Table 4) of the session was divided into two blocks. In the first, the research project and the main concepts were presented and discussed.

Table 4 – Program of the workshop

Workshop – Program	
First block	• Welcome to participants • Introduction to the research project • Rounding the vertices – Design model • Rounding the vertices – The concept • Reflections and debate

Second block	• Toolkit
	  ○ #1 Defining the project worksheet
	  ○ #2 Project planning worksheet
	  ○ #3 Circular Design Mbox
	  ○ #4 Circularity assessment tool
	• Reflections and debate
	• Feedback collection – Online questionnaire

In a second block, the toolkit was presented and explained by the author (Figure 80) followed by a debate and filling in the feedback questionnaire (Figure 81).

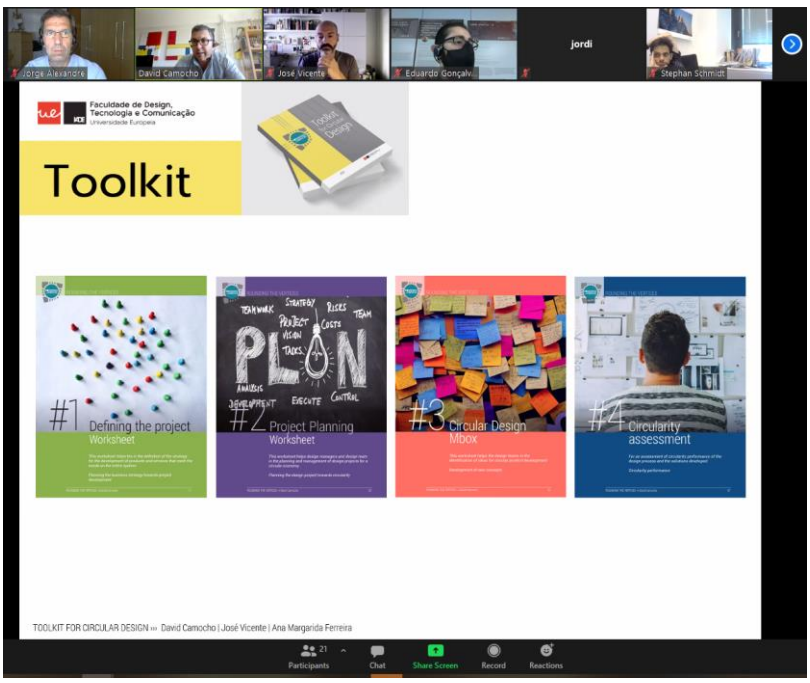


Figure 80 - Presentation of the toolkit – Experts workshop

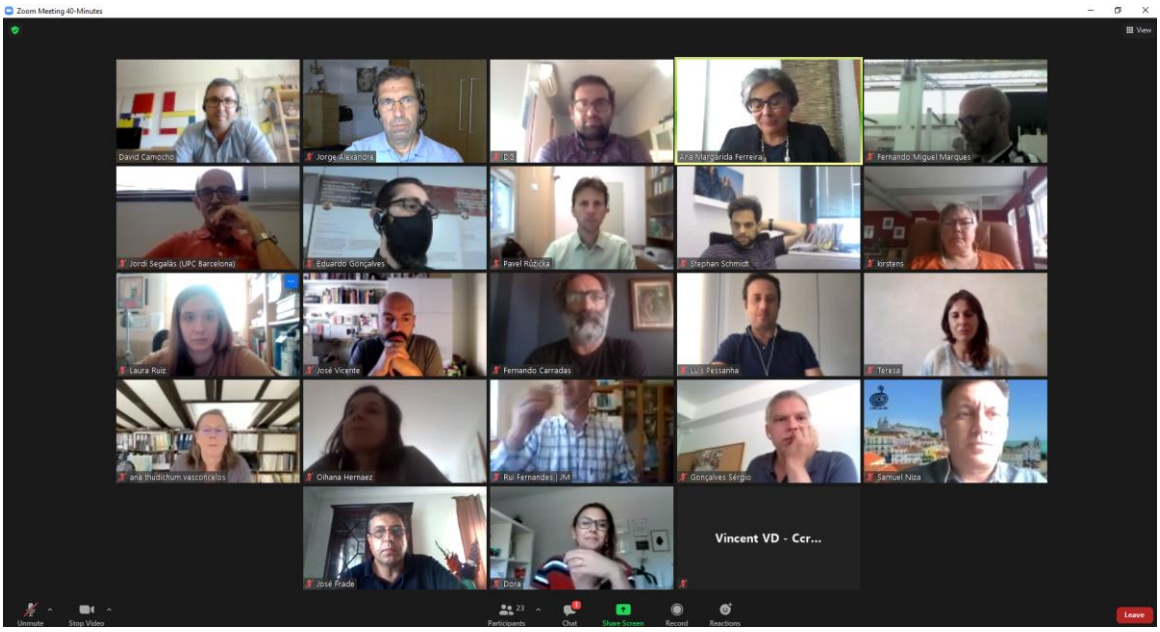


Figure 81 – Participants in the zoom meeting

7.3.3 Focus group composition.

As mentioned before, a group of experts was identified based on their relevance in validating the results achieved. The main criteria defined for their selection were their expertise in Design, Sustainability and Circular Economy and their experience in applied research, education, practical implementation and Design practice. Most of the specialists identified and invited to the focus group brought together several of the aforementioned expertise.

The presentation of the research concept, background and toolkit had the participation of 25 international experts from Portugal, Brasil, Spain, Italy, Austria, Denmark, Czech Republic.

From the 25 experts participating in the project, 14 are designers, and from them, 11 have experience in ecodesign and Design for Sustainability. 15 have higher education expertise, 22 have Sustainability and Circular Economy expertise and 16 are involved in research projects and activities. All participants have relevant experience with companies and project development.

7.3.4 Questionnaires for the assessment

As mentioned in the previous chapter, the experts that formed the focus group 2 had two evaluation moments. For each moment, a specific questionnaire was developed using Google forms software and distributed online (Annex 15).

The first questionnaire (Figure 82), distributed and filled in during the workshop aims to collect feedback and the initial perceptions from the toolkit presented in the workshop. The idea behind this approach was to collect feedback from a wider group of experts during the session. This allowed collecting the initial ideas that were raised based on the explanation and presentation of the toolkit.

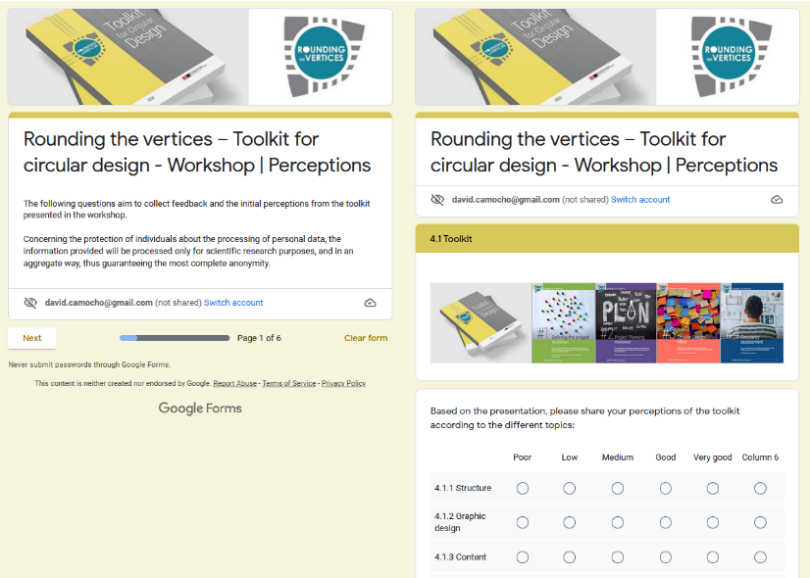


Figure 82 – Experts Focus group 2 – Workshop perceptions questionnaire

The perceptions questionnaire with 6 sections has developed to be short, simple and designed according to the structure of the workshop and included simple questions to score the resources on a Likert scale followed by open questions to collect specific feedback.

In the first section a simple introduction to the questionnaire, explaining their objectives followed by a second section to collect general information about the participant, the name and the main field of expertise.

The third section was based on the evaluation of the Design model presented and the objective here was to analyse the usefulness and importance of the model and its structure based on the three levels, Strategic, Management and Operational levels.

The fourth section was linked to the analysis of the Rounding the vertices concept and tits relevance in promoting the transition to a Circular Economy in practice.

In the next section, the participants were asked to share their perception of the toolkit according to different topics, structure, graphic Design, content, length, usability, language, adequacy to Design professionals and users.

In all sections, suggestions and improvement options were requested.

The questionnaire ended with a final field to collect feedback related to other comments, suggestions, and remarks.

The second questionnaire developed to support the validation by experts was developed and structured in nine sections to collect more in-depth feedback (Figure 83) and (Annex 16).

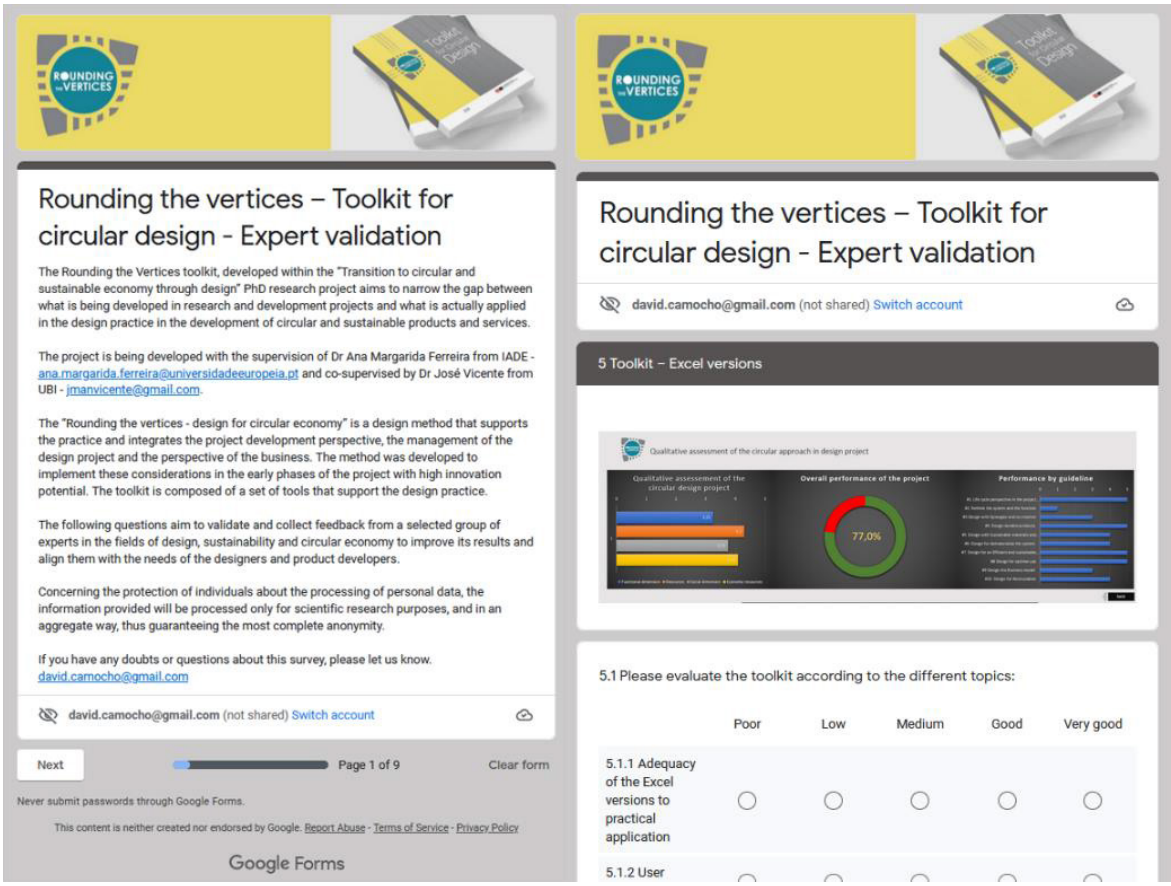


Figure 83 – Expert's validation questionnaire

Both questionnaires had the same structure. However, the number of questions, the data collected, and time need to fill in and the level of detail was more extensive in the expert's validation questionnaire.

In the expert's validation questionnaire all the sections, as explained above, were more extensive and included specific sections to evaluate each tool that compose the toolkit in its two versions, the e-book version and the excel-based version.

7.3.5 Results

The results attained with the focus group are divided into two groups. Firstly, we explore the results attained during the workshop, where the materials were explained and discussed with the entire group of participants, and secondly, the reduced group composed by the experts that received the materials and had the opportunity to perform an in-depth analysis and share their views, remarks, improvement ideas and evaluation.

Group 1 – Evaluation received in the workshop.

The questionnaire distributed during the session had 18 responses which represents a response rate of 72%.

The evaluation of the Design and development model was composed of 3 parts:

1- Evaluation of the statement "This model is useful to structure the Design practice for the Circular Economy" using a Likert scale from 1 (strongly disagree) to 6 (strongly agree.
2- Evaluation of the statement "The 3 levels (Strategic, Management and Operational levels) are important to organize the Design project and define the different approach", using the same Likert scale as in the previous statement,
3- An open question asking the expert to reflect If he could change something in the model, what would be a proposal for change?

In the first statement as we can see in Figure , the majority of experts agree with the statement, 88.4 % had scored it with classifications 4, 5 and 6, which represent that they agree that the model is useful and only two, representing 11,6% gave a lower classification, indicating that there is no agreement.

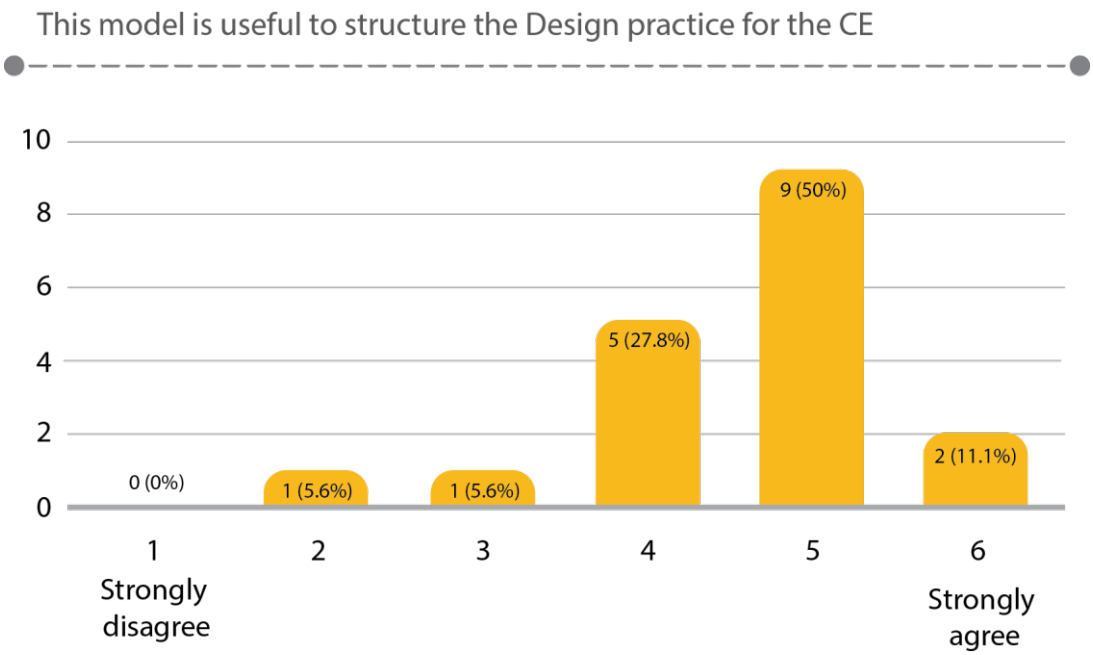


Figure 84 – Expert questionnaire results – Design model

Regarding the second statement, in which the 3 levels of the Design model were analysed, the classification is more distributed across the scale as we can see in Figure 85. However, the majority, 77,8 % of the experts consider important the levels, 38.9% strongly agree with the statement, having scored it with 6 and 27.8% with a classification 5. Only 23.3 % consider it less important, 16,7% had given a classification 2 and 5,6 % classified it with 3, meaning that they consider it of lower importance.

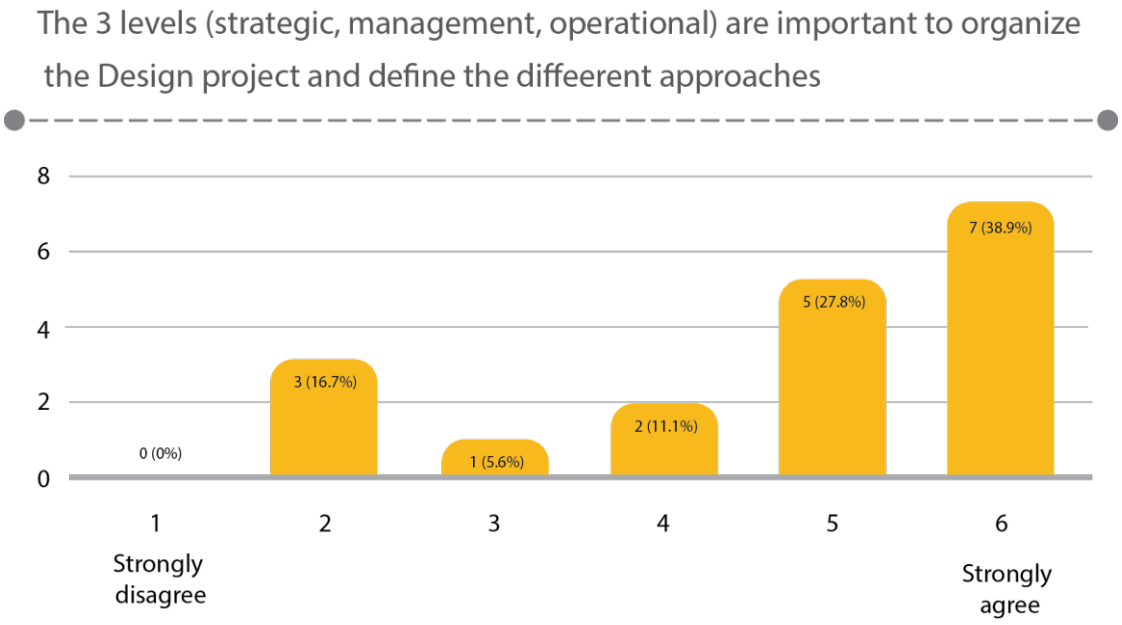


Figure 85 – Expert questionnaire results – Design model – distribution in the 3 approach levels

In the third part, in which proposals for change in the model were asked, several ideas for improvement and comments were shared which constitute a set of valuable information to improve the model and update it towards a more effective approach for the Design practice for a Circular Economy.

From the answers received, the main remark from the analysis is the need to include the validation stage in a more explicit way. The validation is part of the prototyping stage, however, is not explicit in the model.

Ideas such as the improvement of the link between the levels, the integration of new stages, focus on collaboration in a life cycle perspective and across the three levels to reach more radical solutions were mentioned.

In section 3, the Rounding the Vertices concept was analysed by the participants. For this purpose, two questions were available.

The first aimed to analyse the relevance of the concept in promoting the transition to a Circular Economy in practice on a Linkert scale from 1 (not relevant) to 6 (highly relevant).

In the results attained, shown in Figure 86, it is clear that the concept is considered relevant with a high classification of most respondents, 44.4% scored it as 5 and 38.9% as 6, meaning highly relevant. Only one respondent had scored it with 3 and 11,1 with 4, which is still a positive score on the scale.

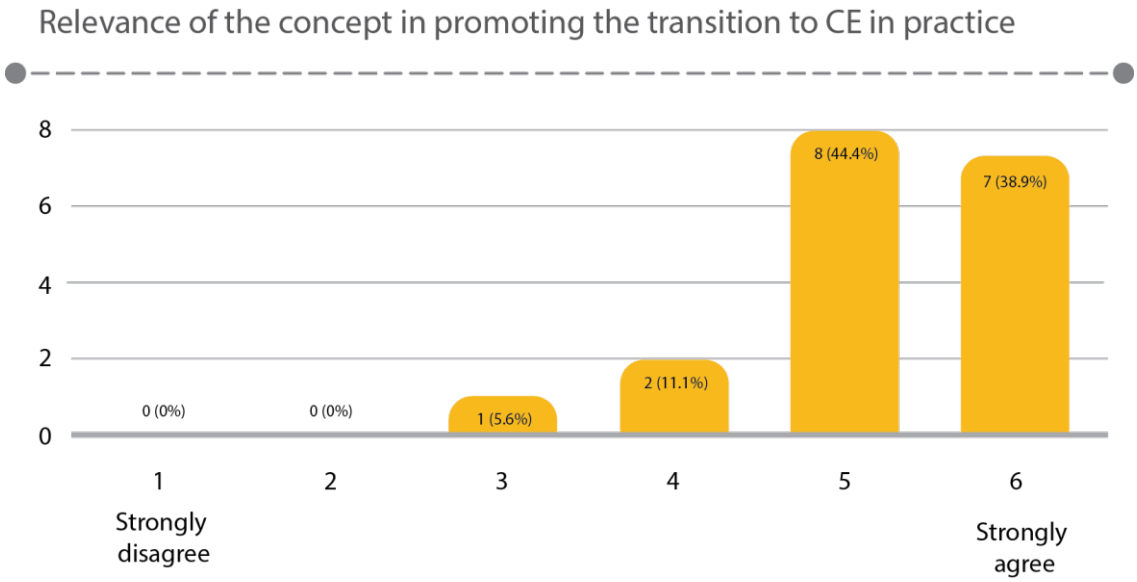


Figure 86 – Expert questionnaire results – Relevance of the concept Rounding the Vertices

The following question was an open question, in which suggestions for other levels or ideas that should be represented in the concept were promoted.

Only a few comments or ideas were shared. The missing elements that were suggested were to include collaboration as a specific focus, governance, life cycle of the product, which is implicit, but maybe in a more specific way. As other suggestions, one referred that it should look at Design as part of the transition of the business model and not the other way around and why one vertice is identified with resources and not environment?

Another comment reinforced the importance to consider the function level from a consumer perspective.

Section 4 aimed to explore the expert's perceptions on the toolkit based only on the presentation and discussion during the workshop session.

The analysis included different topics such as the structure of the toolkit, the graphic Design, the content, the length, usability, language and adequacy to the Design professionals, using a Linkert scale from “poor” to “very good” with 5 levels (figure 87).

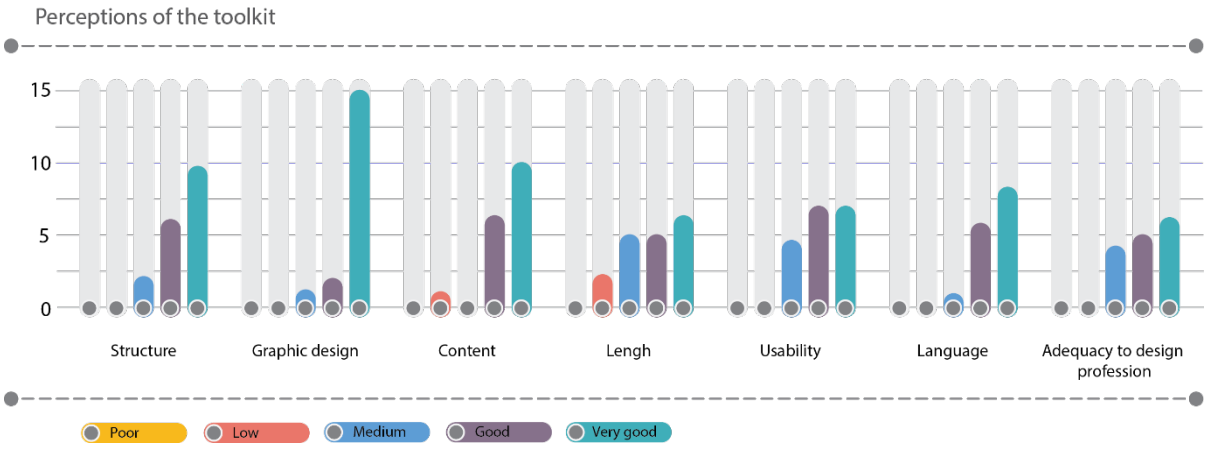


Figure 87 – Expert’s questionnaire results – Toolkit

As presented in figure 87, the classification achieved in all topics was considered good, being the level “very good” the most achieved in 6 from the 7 topics. The one with higher classification were the structure, graphic Design and content, and the one with lower classification was the length of the toolkit.

Alike the previous section, this one ended with an open question to collect ideas and suggestions to improve the toolkit. From the feedback received, several valid, useful and important ideas were shared by the experts.

The most relevant ideas were:

- To include a “how to do” in the reflections needed in the toolkit
- Explain how can the toolkit be used to contribute to a further Environmental Social and Governance development
- Add continuous feedback (validation) in the first 3 tools, as has been done in the 4th.
- Some phases seem too qualitative. Quantifications could give information to an overall evaluation in the first three tools
- The introduction of a link/canvas between/with the final results achieved by all tools
- To include examples with pictures would be useful.
- A lot of resources and toolkits such as this often tend to overextend. Some of the tool contents which do not directly relate to Circular Economy could be reduced.
- For the description of the business model in the toolkit, maybe more than a textbox can be offered.
- Specific strategies or steps (especially in tools 1- Defining the project worksheet, 2- Project planning worksheet, and 3 – Circular Design Mbox) not only for reflecting about what the user has and could improve but also helping to act in a more specific way.
- An additional document with examples of good practices related to strategies of the Circular Economy could be helpful for users.

The final section available in the questionnaire was again an open field to include other comments, suggestions and remarks not addressed in the above-mentioned sections.

In this section, only a few comments were identified and are related to:

- The need to stress that ”resources” is not only about efficiency/economy but also about renewable resources, nature-based solutions,
- The length of the toolkit, with high demand for the designers, sometimes with demands beyond the designer's responsibilities,
- Explore possibilities to find a less descriptive and a more interactive approach, as in the last tool,

- The need to explore further and more radical approaches detached from the sustainable/ ecodesign and linear economy mindset,
- The importance of having the toolkit in Portuguese.

Final remarks and considerations

The perceptions and feedback collected in the course of the session were highly relevant to the validation of the resources developed. From the discussion and analysis of the data collected is clear that the toolkit is considered a relevant tool to support the Design practice towards Sustainability and circularity and the suggestions received constitutes a set of quality information to improve the toolkit promoting a better alignment with the needs of the target group.

Group 2 – Evaluation by focus group – in-depth analysis

After the presentation in the workshop session, a beta version of all materials was distributed to the experts for further analysis. With full access to the materials, a restrict group of experts had the opportunity and willingness to collaborate and support the research by proving new feedback to validate and improve rounding the vertices materials.

This restrict group was composed by 10 international experts with a wide experience and knowledge in fields considered relevant, as presented in the table 5.

Table 5 – Focus group – composition

Expert reference	Country	Design expertise	Circular Economy and Sustainability	Education	Research
Expert 01	Portugal	✔		✔	
Expert 02	Portugal	✔	✔	✔	
Expert 03	Portugal	✔		✔	
Expert 04	Brasil		✔		✔
Expert 05	Denmark		✔	✔	✔
Expert 06	Czech Republic		✔		✔
Expert 07	Austria		✔	✔	✔
Expert 08	Spain	✔	✔	✔	✔
Expert 09	Portugal	✔	✔		✔
Expert 10	Portugal	✔	✔	✔	✔

To collect the feedback, a new questionnaire was distributed by the participants. This version was based on the structure used in the workshop session. However new and more detailed questions were included. The experts had the possibility to use the questionnaire or to give their feedback through other means considered by them. From the 10 participants, 8 chose to provide their feedback through the questionnaire. The remaining 2 chose to do a more in-depth analysis and entered comments directly into the resources and held a meeting to present their ideas.

Feedback to the Design and development model

All experts consider that the model is useful to structure the Design practice for the Circular Economy and its structure developed within the 3 levels proposed, namely the strategic, management and operational, are important to organize the Design project and define the different approaches.

On what concerns the improvement of the model, the main ideas received were linked:

- To introduce in concept-prototype a "client perception or feedback analysis" to take into account the market impact of the project,
- An initiating activity before even entering the model: The open (semi-structured) brainstorming session. The model seems to be most suited when designers have an idea of what to develop, what the potentials and challenges could be, etc. Some of the elements that are included in the Design step on functionality and rethinking the system should be considered much earlier – e.g. in the semi-structured brainstorming session,
- There should be a step further to ensure ‘continuous improvement’ of the design/product or service. In line with PDCA thinking, there should be a regular checking of whether the Design is still appropriate or could be improved.

Feedback to the Rounding the Vertices concept

The Rounding the Vertices Concept is based on system optimization to support the transition to a Circular Economy through Design as explained in section 6.3.1.

The feedback received is positive regarding the concepts. The experts consider it relevant and agree with the four dimensions and their relevance to promote the transition to a Circular Economy in practice.

Regarding ideas of other levels that could be represented in the concept, a few ideas were shared:

- Function level could be changed to Design or Design solution,
- Co-design and collaboration as an extra vertice, since collaboration is fundamental at all levels to reach radical innovation and real transformation into circularity,
- Creativity and innovation.

One remark to the concept is that throughout the Design process, it has to be ensured that 'resources' cover not only their consumption/use but also negative effects such as emissions to air and water, waste generation. At the same time, the focus should be on both resource efficiency as well as the use of renewable resources and nature-based solutions, and it should be adequately covered mainly in the M-box.

Feedback to the toolkit – e-book version

The overall evaluation was positive. As presented in Figure 88, on what concerns the structure of the toolkit, their layout and content the evaluation was good or very good. The topics that had a lower classification were length and usability, in which, one expert had scored it as low. The remaining topics, such as language and adequacy had also a positive evaluation.

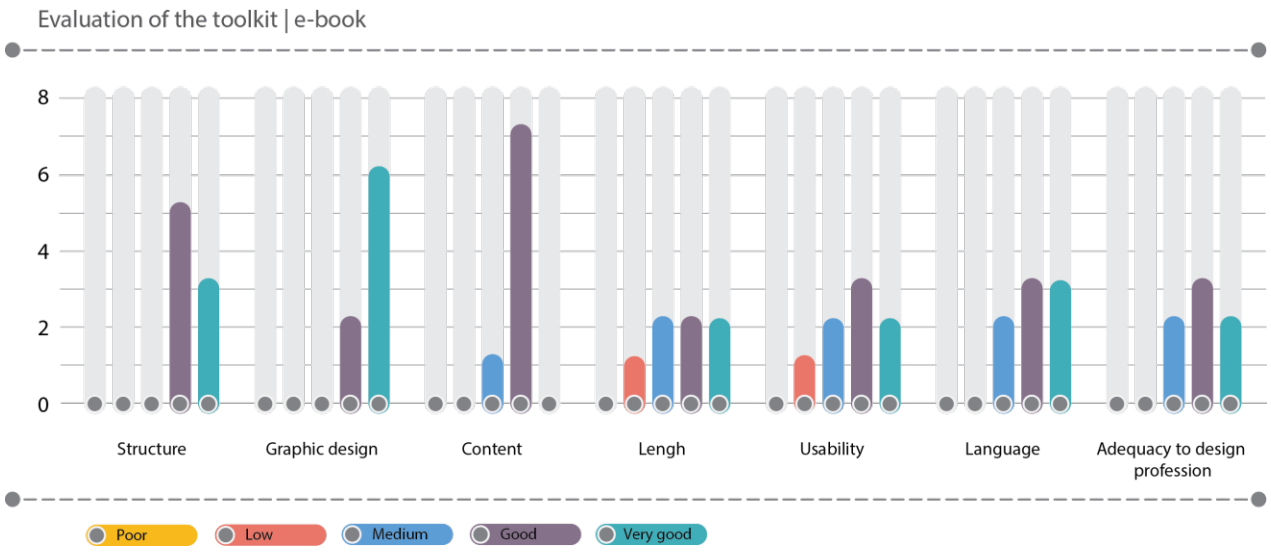


Figure 88 – Evaluation of the toolkit – ebook version

Based on the analysis, the experts were invited to indicate the main areas of improving and strengths of the e-book.

Main areas for improving identified:

- Length – A bit exhausting for the application of day-to-day projects for small and medium-sized companies,
- Knowledge needed to fill in some reflections,
- Much of the material is based on the development of products. However, services as a potential solution are also referred to. But the decision on product/services should be taken early, maybe even in the brainstorming session,
- The materials seem to mostly support the optimization of existing solutions. Not so much real changes on a larger scale,
- The structure, having theory and space for practice may impair usability.

Main strength identified:

- Functional but complex,
- The idea of having multidisciplinary teams,
- Easy to apply in most projects; contribute to a business plan, establishment of industrial symbiosis solutions, easy query and validation during the process,
- Appealing graphic Design that takes you by the hand from A to Z,
- Good overview of the process,
- It shows the expertise of the author, and at the same time it uses simple language understandable not only to professionals,
- Clear structure and contents.

Regarding the improvement of the toolkit a few ideas were identified:

- Reduction in length to improve the usability,
- A how-to-do the reflections
- Integration a possibility to reflect on products or services in an initial phase of the process,
- Include the possibility and features to compare the reference product or service with the new solution developed.

Feedback to the toolkit – Excel version

The excel version of the toolkit was also distributed for testing and validation.

In the evaluation of this version, the experts were asked to reflect on the adequacy of these versions to practical applications, user-friendliness of the tools, the graphic layout and length. As presented in figure 89, the overall evaluation is considered good, in the four topics covered. The only negative evaluation was related to length however, in this topic, most experts rated it as "good". The topic with higher evaluation was the graphic layout, despite the fact that the tools were developed in excel, which has several limitations in this regard.

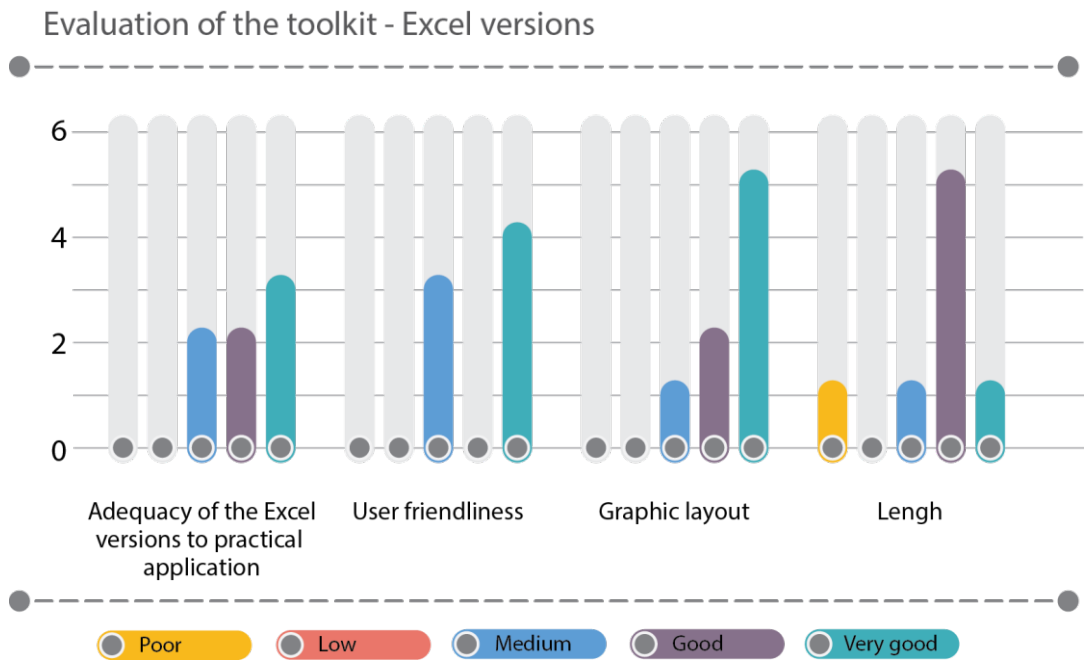


Figure 89 – Evaluation of the toolkit – excel version

The tools had a good evaluation with good usability. However, some comments and feedback on how to improve it were received such as other software's to use.. Examples are also referred to as a feature to include on the tools in order to demonstrate to the user the filling-in process. Examples and case studies n Sustainability and circularity can also be linked to the tools in order to motivate and inspire the Design teams in applying the tools in their own projects.

Specific feedback and improvement ideas on each tool

To conclude the evaluation, the experts shared ideas, remarks and improvement options for each tool. These ideas, as well as all the feedback received, are analysed and complied within a table in order to systematize the update of the materials and their improvement.

Conclusions on the evaluation by experts

The evaluation of research results was carried out by consulting European experts with recognized skills both in the areas of Design and in the fields of Sustainability, Circular Economy, education and research. The option to use a focus group allowed to bring together a set of experts that through online sessions for presentation and discussion of the results, complemented by an in-depth analysis of the materials made available in a beta version, allowed the validation of the results, and their relevance to the proposed objectives of providing the Design teams with tools and methodologies to implement in practice the transition to the Circular Economy. The feedback collected also allowed the integration of ideas and suggestions for improvement that supported the increase in the quality and adequacy of the materials developed.

7.4 Adaptations and improvement of the method and toolkit

As previously mentioned, the analysis and feedback from the experts provided a set of ideas and suggestions for improvement, the identification of some errors and the indication of the most relevant aspects of the materials developed. In order to systematize all the information collected, a table was developed where all the feedback collected was analyzed and classified in order to define a way of acting in the update of the materials according to the requirements and needs of research development. In this way, the feedback was classified into short-term aspects, indicating options that were implemented in the materials and medium-long-term aspects, which constitute relevant options but, due to their complexity or lack of information, are considered for a new version. Finally, errors identified by the specialist were immediately corrected in the respective materials.

In this context, the materials presented in this work, are the improved version based on the evaluation phase by the international group of experts.

Conclusions and Future Research

The main objective of this research was to provide designers and professionals directly involved with the development of products and services with knowledge and resources to work towards Sustainability and a Circular Economy. The Design professionals should act in a conscious and innovative way, promoting their practice and their legacy as efficient as possible and with added value for the creation and development of a society that thrives today and for future generations.

The evolution of society and the increase in the production and consumption of products to satisfy the growing needs of users based on the consumption of natural resources, is taking society to a breaking point that, if surpassed, will hardly have a return, jeopardizing the future of society.

Since the mid-1970s, it has been realized that production and consumption patterns are unsustainable and that a new approach is needed towards a more sustainable society with more value for all stakeholders in the value chain.

In this context, and as seen from the research developed, the importance of Design in this transition is undeniable. However, given the constant evolution of the needs of the various players in the value chain of products and services, it is essential to train and equip Design professionals with methodologies, tools and guidelines that enhance its activity giving rise to more efficient and sustainable products that result in increased value for users, society, business and Design professionals, among others.

The focus on the development of products and services with improvements in the Sustainability profile and with fewer impacts is not new. In recent decades, designers and other professionals have developed their activity aiming to achieve Sustainability through the development process, aiming to increase efficiency and innovation, and exploring different approaches, from cleaner production, ecodesign, Design for Sustainability, to the development of product-service systems. However, although there are numerous good examples, the results are far from being globalized and widely integrated into society.

Currently and globally, in response to growing pressures from economic and social crises, scarcity of resources and increased pollution, among other aspects, the orientation towards the Circular Economy, strongly promoted by governments, research centers, education and training institutions, associations and many other stakeholders, asserts itself as a new way to

achieve the Sustainability of society with the potential to increase prosperity, wealth and well-being, reducing dependence and pressure on raw materials and energy.

The Circular Economy is seen as an approach with great potential for success and which is being the subject of numerous research and development projects and initiatives, of practical application in companies, public funding and education, and Design is one of the main agents in the paradigm shift. The success is achievable through Design, through conscious and effective actions, through a Design centered on the user and their real needs and through the search for innovative solutions that allow the flow of resources, solutions in which products can be used for longer with a reduction in the consumption of material resources and energy, with the adoption of a systemic approach and new business models.

This research carried out in the last 5 years in line with the professional background of the author with more than 20 years of experience in the area, is intended to respond to the hypothesis initially defined as the backbone of the work developed and the 4 research questions defined initially. The hypothesis "Design, through its specific methods and tools, is an important factor for an effective transition to a Sustainable Circular Economy" was clearly confirmed and validated by the work developed. The Design practice and the way designers act in the transformation of the society by supplying solutions for the needs of users in terms of products and services has been clear, and the translation of the new needs in terms of Sustainability and Circularity that can only be attained by Design has been tested and explored by the current work and its validation is confirmed by the results attained and the feedback received from international experts.

The four questions initially defined set the tone for the development of the research and defined the framework in terms of needs for the designers:

- How will Design support the transition from the linear economy to the new model of Circular Economy?
- Which tools can designers apply to support an effective Design practice for a successful transition to a Circular Economy in the real world?
- How can designers overcome the barriers in the implementation of a Design practice that effectively result in more sustainable products and services aligned with the European policies for Circular Economy?
- How can the Design practice and the role of the Design professionals be promoted in a Circular Economy context?

To answer these questions the literature review was fundamental by analysing the state of the art in different aspects related to Design, Sustainability and Circular Economy, but was also important to understand the importance of the topic. The topic is being explored in such a way, that is impossible to have a complete picture since, new publications, resources, platforms, websites, events, are released frequently, almost on a daily basis.

Within the review, and in order to clarify how Circular Economy is being addressed and perceived, an expert's review was conducted. The surveys aimed to understand if a) Circular Economy is considered the solution to attain Sustainability; b) which is the novelty that the Circular Economy approach brings; c) which are the main drivers, motivations and barriers in its implementation; d) how to overcome the current obstacles and promote the Design practice towards innovative and sustainable solutions? and finally, e) lessons learnt from the past. What and why the ecodesign, Design for Sustainability, and other Sustainability approaches did not have the expected impact on society. The survey resulted in a good set of data that were important in the development and orientation of the model and toolkit developed within the research.

The users, their needs and expectations were also a focal point in the development of the resources. For this purpose, another survey was carried out to assess the consumer's perception of Sustainability in products. The survey included a sample of more than 100 individuals and explored their perceptions regarding the Sustainability and circularity characteristics of products and the influence on their consumption choices.

The review carried out has been important in collecting and analyzing tools and methods that are available to support the integration circularity in practice. This resulted in an extensive collection of data regarding the structure, concepts, principles and strategies that are being developed and implemented internationally in the field. The analysis resulted also in the definition of a group of 10 main Design principles for a Circular Economy that were explored in the research to support the integration of Circular Economy in the Design practice in a more efficient and practical way.

These principles, complemented by a set of criteria were the background for the development of a new Design model for Circular Economy and the toolkit. The work developed based on the analysis of emerging needs and opportunities resulted in the development of the "Rounding the Vertices" concept. It can be translated as rounding corners of a square transforming it into a circle, and which is based on improving the efficiency of the system by

optimizing four priority axes/vertices. The economy vertice, the environment, society ones and the increase and improvement of the function of the created products and services.

Based on the Rounding the Vertices Concept, an action model was developed defined by three distinct layers that are interconnected resulting in a holistic approach. This comprises 1) a layer related to the development of the business, integrating the needs to create wealth and value in the strategy of the business, 2) a layer related to project management, acting in the transposition of the identified needs for the companies and the needs of the customers/users, and 3) an operational layer, linked to the practical development of the Design project.

This model is operationalized through a toolkit that was also developed and validated by an international group of research experts. This Design toolkit for the Circular Design includes a set of practical tools, aligned with the Design process and which is also a didactic tool to support designers in the Design project and the identification and development of innovative and circular solutions.

The Rounding the Vertices – Toolkit for Circular Design was developed for use in accordance with the Design process in order to guide the project and assist project teams in defining and planning the project, in identifying improvement spaces and identifying ideas to develop new solutions. It also helps in the validation and demonstration of the circularity performance, both of the Design processes carried out and the project results. This resource is composed of four tools that complement each other, namely the Project definition worksheet, the Project planning worksheet, the Circular Design Mbox and the Circularity Assessment Tool.

The work developed within the scope of this investigation was validated by a group of international experts who, through workshops and exploration of materials, had the opportunity to evaluate and test the resources developed. The materials resulting from this project constitute a tool to support the practice, which guides the Design process and the integration of strategies and principles of Sustainability and circularity in the development of new solutions, as well as the training of designers and other professionals through the didactic contents that complement the tools.

To conclude, it was possible to show, through the evaluation of the model and toolkit that design can support an effective transition to a sustainable circular economy through its specific methods and tools. This is supported by the several resources developed and made

available to designers and companies and the set of papers that were developed and published during the research:

- **TRANSition to circular and sustainable economy through design –** Presented at DDC'18 Transgression – 5Th Design Doctoral Conference, IADE 2018 – Portugal (Camocho et al. 2018) (Annex 17)
- **Circular Economy – Tools for designers –** *Presented at* DDC'19: Transformation – 6Th Design Doctoral, IADE 2019 – Portugal (Camocho et al. 2019d) (Annex 18)
- **Circular and sustainable products. From theory into practice –** Presented at 19th European Roundtable for Sustainable Consumption and Production, 209, Barcelona, Spain (Camocho et al. 2019a) (Annex 19)
- **Meeting the Circular Economy Agenda: Supporting Tools for a New Strategic Design Practice –** Published in the Convergences – Journal of Research and Arts Education, 2019 (Camocho et al. 2019b) (Annex 20)
- **The Common-Sense Assessment of Sustainability –** Presented at *AHFE 2019, International Conference on Social and Occupational Ergonomics.* Washington D.C., USA (Camocho et al. 2019c) (Annex 21)
- **Circular and Sustainable Design: a systemic design model for the transition to a circular and sustainable economy –** Published ant Discern: International Journal of Design for Social Change, Sustainable Innovation and Entrepreneurship, 2020 (Camocho et al. 2020) (Annex 22)

Further research and activities

The work developed and results achieved, raised numerous questions and allowed the identification of new research opportunities but the issue constitute a baseline to continue the development of the Design practice towards a more Sustainable and Circular society.

As further research opportunities to be explored in the future, the following activities were identified:

- **Database of circular and sustainable national products.** The structure and testing of a reliable and relevant database for identification of national products were defined within the project, however, there are opportunities and the need to further develop it, identify examples and made them available in a new platform accessible to all, to be used as a source of examples, bests practices and an inspiring tool for designers and companies.
- **Further development of the tools.** Within the Thesis, the aim was to develop new tools to support designers in their daily practice. The tools that results were tested and validated and their relevance is clear, however, for wider and more effective use, the programming of the tools in a more user-friendly platform is an added value that should be explored, as well as an wider exploration of the services component in these resources.
- **Data base of examples.** Aligned with the previous idea, based on the application of the tools by designers and companies, a database to collect and share the examples resulting from the application of the Rounding the vertices methodology should be developed.
- **Circular Design website.** Currently, there are several resource centres and platforms with relevant information available. The creation of a website with information on Design for a Circular Economy with resources available and specific for designers can be an added value.
- **Radical Design for circularity.** The methodology and tools developed aim to the creation of new solutions of products and services, however, aiming to radical solutions and completely out-of-the-box solutions, the improvement of the methodology and approach is seen as the next step for research.

References

Acaroglu, L. (2020). *Quick Guide to Circular Economy Business Strategies*. Medium. Retrieved October 1, 2021, from https://medium.com/disruptive-design/quick-guide-to-circular-economy-business-strategies-b3d6a000facf

Agência Nacional de Inovação (2018). *Economia Circular em projetos de I&D cofinanciados*. Retrieved from https://www.ani.pt/media/3826/2_economia_circular.pdf

Alves, D., Ferreira, A., & da Silva, C. (2011). *O designer como mediador na construção da responsabilidade = The designer as mediator in the construction of the ambiental responsability culture*. Redige, 2(2), 276–304.

Ameta, G. (2009). *Design for Sustainability: Overview and Trends*, International Conference on Engineering Design, ICED'09, Stanford university, Stanford, Ca, Usa

Association for Project management. (n.d.) What is Life cycle. Definition from APM body of kanowledge7th edition. Retrieved https://www.apm.org.uk/resources/what-is-project-management/what-is-a-life-cycle/

Aston, B. (n.d). *What Is The Project Life Cycle: The 5 Phases & Why It's Important.* DMP. Retrieved February 2022 https://thedigitalprojectmanager.com/project-management-life-cycle/

Astor, B. (n.d.). *What Is The Project Life Cycle: The 5 Phases & Why It's Important*. The Digital Project Manager. Retrieved May 1, 2021, from https://thedigitalprojectmanager.com/project-management-life-cycle/

Bakker, C., den Hollander, M., van Hinte, E.& Zijlstra, Y., 2014. *Products that Last: Product Design for Circular Business Models*. TU Delft Library

Basin, H. (2020). *Concept Development – Definition, Meaning and 6 Stages*. Marketing91. Retrieved form https://www.marketing91.com/concept-development/, 3 January 2022

Bhamra, T., & Lofthouse, V. (2007). Design for Sustainability: A Practical Approach. (Aldershot, Ed.). UK: Gower Technical Press.

Bhamra, T., Lilley, D. & Tang, T., (2015) *Design for Sustainable Behaviour: Using Products to Change Consumer Behaviour,* The Design Journal 427-445.

Bhandari, P. (2020). An introduction to qualitative research. Scribbr. Retrieved October 10, 2021, from https://www.scribbr.com/methodology/qualitative-research/

Bocken, N., de Pauw, I., Bakker, C., & van der Grinten, B. (2016). Product design and business model strategies for a Circular Economy. *Journal of Industrial and Production Engineering*, 33(5), 308–320. https://doi.org/10.1080/21681015.2016.1172124

Bocken, N., Short, S., Rana, P., & Evans, S. (2014). A literature and practice review to develop sustainable business model archetype*s*. *Journal of Cleaner Production*, 65, 42–56. https://doi.org/10.1016/j.jclepro.2013.11.039

Braungart, M., & McDonough, W. (2009). Cradle to Cradle: Remaking the Way We Make Things. London: Vintage Books.

British Standard Institution. (2005). Design management systems: Part 6: Managing inclusive design guid (BS 7000-6:2005).

British Standard Institution. (2017). Framework for Implementing the Principles of the Circular Economy in Organizations – Guide (BS 8001:2017).

Brown, T. (2009). *Change by design: how design thing transforms organizations and inspires innovation* (1st ed.). HarperCoollins.

Brundtland, G. H. (1987). Our Common Future: Report of the World Commission on Environment and Development. *United Nations Commission*, 4(1), 300. https://doi.org/10.1080/07488008808408783

Business.govt.nz. (n.d.). *An introduction to business strategy*. Retrieved October 10, 2021, from https://www.business.govt.nz/business-performance/business-strategy/introduction-to-strategy/

Cambridge Dictionary. (n.d.). Cambridge Dictionary. Retrieved January 10, 2022, from https://dictionary.cambridge.org/pt/dicionario/ingles/greenwashing?q=Greenwashing

Cambridge University, (n.d). Inclusive design toolkit, retrieved February 2021 http://www.inclusivedesigntoolkit.com/whatis/whatis.html

Camocho, D. Vicente, J. Ferreira, A.; (2019a) Circular and sustainable products. From theory into practice, Proceedings of the 19th European Roundtable for Sustainable Consumption and Production (ERSCP 2019) Institute for Sustainability Science and Technology, Universitat Politècnica de Catalunya, Barcelona, 15−18 October 2019, ISBN: 978-84-09-16893-4

Camocho, D. Vicente, J. Ferreira, A.; (2019b) Meeting the Circular Economy Agenda: Supporting Tools for a New Strategic Design Practice. Convergências - Revista de Investigação e Ensino das Artes, VOL XII (24): http://convergencias.esart.ipcb.pt

Camocho, D., Ferreira, A. M., & Vicente, J. (2019c). The Common-Sense Assessment of Sustainability, Advances in Social and Occupational Ergonomics. *Proceedings of the AHFE 2019, International Conference on Social and Occupational Ergonomics*, July 24–28, 2019, Washington D.C., USA doi.org/10.1007/978-3-030-20145-6

Camocho, D., Vicente, J., & Ferreira, A. M (2019d). Circular Economy – Tools for designers. Presented at the DDC'19: Transformation – 6Th Design Doctoral Conference, Lisbon, Portugal: IADE Universidade Europeia.

Camocho, D., Vicente, J., & Ferreira, A. M. (2018). TRANSition to circular and sustainable economy through design. Presented at the DDC'18: Transgression – 5Th Design Doctoral Conference, Lisbon, Portugal: IADE Universidade Europeia.

Camocho, D.G., Vicente, J., & Ferreira, A.M. (2020) Circular and Sustainable Design: a systemic design model for the transition to a circular and sustainable economy, Discern: International Journal of Design for Social Change, Sustainable Innovation and Entrepreneurship, 1(1), 1-11. https://www.designforsocialchange.org/journal/index.php/DISCERN-J

Campbell, B., Khachatryan, H., Behe, B., Dennis, J., Hall, C.: Consumer perceptions of eco-friendly and sustainable terms. Agricultural and Resource Economics Review, 44(1), 21–34. (2015)

Carbon Clear. (2012). Disposable cups vs. reusable cups: Solving the carbon intensity question, 1–3. Retrieved may 2017 from http://www.carbon-clear.com/files/Reuseable_vs_Disposable_Cups_2012.pdf

Catarino, J., Henriques,J., Maia, A., Alexandre, A., Camocho, D., Rodrigues, F., (2007). *Manual valor sustentável*, INETI. Isbn 978-972-676-202-7

Centres (2013). European network of ecodesign. *Motivations for and Barriers to Ecodesign in Industry*, 1–20

Chesson, D. (2018). *Meeting 21st century organizational challenges with design thinking*. Organization Development Journal, 36(3), 73–81.

Circle Economy, 2018. The circularity gap report, https://www.circularity-gap.world/2018

CIRCO Hub Portugal. (2021). *CIRCO Hub Portugal*. CIRCO Hub Portugal – Criar Negócios Através do Design Circular. Retrieved from https://circohubportugal.lneg.pt

Circular Design Project. (n.d.). Circular Design Project, Learning for Innovative Design for Sustainability. Retrieved February 1, 2019, from https://circulardesigneurope.eu/about/about-project/

Circularity Check. (n.d.). Ecopreneur.eu.WeSustain and MV. Retrieved from https://ecopreneur.eu/circularity-check-landing-page/

Click.NL. (2015). *CIRCO | Creating business through circular design*. CIRCO. Retrieved September 1, 2021, from https://www.circonl.nl/

Concept Development. (2017). The MITRE Corporation. Retrieved from https://www.mitre.org/publications/systems-engineering-guide/se-lifecycle-building-blocks/concept-development

Cradle to Cradle Products Innovation Institute. (n.d.). *What is Cradle to Cradle Certified? – Get Certified*. Cradle to Cradle Certified. Retrieved February 2019, from https://www.c2ccertified.org

Cross N. (2001). Designerly Ways of Knowing: Design Discipline Versus Design Science. *Design Issues* 2001; 17 (3): 49–55. doi: https://doi.org/10.1162/074793601750357196

Cross, N. (2011). *Design Thinking: Understanding How Designers Think and Work*. Bloomsbury Visual Arts.

D.school (n.d.) Hasso Plattner Institute of Design at Stanford University. Retrieved May 2020. https://dschool.stanford.edu/resources/getting-started-with-design-thinking

Dam, R. & Teo, Y. (2019). *Design Thinking Process: Define the Problem and Interpret the Results*, Retrieved May 2020 from https://www.interaction-design.org/literature/article/stage-2-in-the-design-thinking-process-define-the-problem-and-interpret-the-results

De los Rios, I., & Charnley, F. (2017). Skills and capabilities for a sustainable and Circular Economy: The changing role of design. *Journal of Cleaner Production*, 160, 109–122. https://doi.org/10.1016/j.jclepro.2016.10.130

de Wit, M., Verstraeten-Jochemsen, J., Hoogzaad, J., & Kubbinga, B. (2019). *The Circularity Gap Report* 2019 . Circle Economy

Dekoninck, E., Domingo, L., O'Hare, J., Pigosso, D., Reyes, T., & Troussier, N. (2016). Defining the challenges for ecodesign implementation in companies: Development and consolidation of a framework. *Journal of Cleaner Production*, 135, 410–425. https://doi.org/10.1016/j.jclepro.2016.06.045

Design Council. (2004). *Design Council's framework for innovation*. Retrieved may 2020 https://www.designcouncil.org.uk/news-opinion/what-framework-innovation-design-councils-evolved-double-diamond

Designing for a Circular Economy: Lessons from The Great Recovery 2012-2016. RSA Retrieved from: http://www.greatrecovery.org.uk/.

DESIS Network. (2019). DESIS Network. Retrieved January 10, 2022, from https://www.desisnetwork.org/about/

Dieter Rams (1976). *10 Principles of good design*;VITSOE. Retrieved from https://www.vitsoe.com/gb/about/good-design

Discover Design, (n.d.). Chicago architecture centre. Retrieved https://discoverdesign.org/handbook

Disposable Cups vs. Reusable Cups: Solving the Carbon Intensity Question, Retrieved form www.carbon-clear.com

Duarte, C., (2013). *Measuring Design Simplicity*, Advances in Industrial Design Engineering, http://dx.doi.org/10.5772/54753

Eberhardt, L., Birkved, M. & Birgisdottir, H., (2020*): Building design and construction strategies for a circular economy, Architectural Engineering and Design Management*, DOI: 10.1080/17452007.2020.1781588

Eberhardt, L., Birkved, M., & Birgisdottir, H. (2020). Building design and construction strategies for a circular economy. *Architectural Engineering and Design Management*, 18(2), 93–113. https://doi.org/10.1080/17452007.2020.1781588

Eby, K., (2018). *Demystifying the 5 Phases of Project Management*. Smartsheet. Retrieved may 2022 https://www.smartsheet.com/blog/demystifying-5-phases-project-management

EduZWACE – Education for Zero Waste and Circular Economy, 2020. Erasmus+ project, Retrived https://www.eduzwace.eu

Elizabeth B.-N. Sanders & Pieter Jan Stappers (2008) Co-creation and the new landscapes of design, Co-Design, 4:1, 5-18, DOI: 10.1080/15710880701875068

Ellen MacArthur Foundation & IDEO. (2017). The Circular Design Guide. The Circular Design Guide. Retrieved 2018, from https://www.circulardesignguide.com/

Ellen MacArthur Foundation & IDEO. (n.d.). *The Circular Design Guide*. Circular Design Guide. Retrieved March 12, 2018, from https://www.circulardesignguide.com/

Ellen MacArthur Foundation, & Systemiq. (2017). *Achieving "Growth" Within*. Ellen MacArthur Foundation, 1–29. Retrieved from https://www.ellenmacarthurfoundation.org/assets/downloads/publications/Achieving-Growth-Within-20-01-17.pdf

Ellen MacArthur Foundation. (2013). Towards the Circular Economy. *Ellen MacArthur Foundation,* 1, 1–96. https://doi.org/10.1162/108819806775545321

Ellen MacArthur Foundation. (2015). Growth within: A Circular Economy vision for a competitive Europe. *Ellen MacArthur Foundation,* 100. https://doi.org/Article

Ellen MacArthur Foundation. (n.d.). *Business and the circular economy*. Retrieved October 1, 2021, from https://ellenmacarthurfoundation.org/resources/business/overview

ENEA – Estratégia Nacional de Educação Ambiental. (2017). Agência Portuguesa Do Ambiente. Retrieved September 10, 2021, from https://enea.apambiente.pt/content/apresentacao?language=pt-pt

Environmental Services Association [ESA]. (2013). Going for growth: A practical route to a circular economy.

Estaregue, D. & Ferreira, Ana M. (2008a) *"Environmental Communication".* SIGDOC 2008 – ACM International Conference on Design of Communication, Lisbon, 22-24 September.

Estaregue, D. & Ferreira, Ana M. (2008b) "*The (Un) Sustainability of Corporative Marketing",* New Views 2: Conversations and Dialogues in Graphic Design – International Symposium Defining Graphic Design for the Future, London, 9-11 July.

European Commission, (2019)b, *Report from the Commission to the European parliament, the council, the European economic and social committee and the committee of the regions on the implementation of the Circular Economy action plan,* Retrieved from https://op.europa.eu/en/publication-detail/-/publication/ade8c7de-3e8f-11e9-8d04-01aa75ed71a1/language-en

European Commission, Directorate-General for Research and Innovation, Amodio, A., Malyska, A., Markouli, C. (2021). *Mapping study for the development of sustainable-by-design criteria*, Publications Office. https://data.europa.eu/doi/10.2777/109081

European Commission. (2015). *Closing the loop – An EU action plan for the Circular Economy*. Com, 614, 21. https://doi.org/10.1017/CBO9781107415324.004. Retrieved from http://eur-lex.europa.eu/resource.html?uri=cellar:8a8ef5e8-99a0-11e5- b3b7-01aa75ed71a1.0012.02/DOC_1&format=PDF

European Commission. (2018). Industrial Symbiosis. European Green Capital Award. Retrieved May 2021 https://ec.europa.eu/environment/europeangreencapital/wp-content/uploads/2018/05/Industrial_Symbiosis.pdf

European Commission. (2019)a. *Communication from the Commission to the European Parliament, the European Council, the Council, the European Economic and Social Committee and the Committee of the Regions- The European Green Deal.* European Commission. https://eur-lex.europa.eu/resource.html?uri=cellar:b828d165-1c22-11ea-8c1f-01aa75ed71a1.0002.02/DOC_1&format=PDF

European Commission. (2020). *Circular Economy Action Plan*. #EUGreenDeal, 4. Retrieved from https://ec.europa.eu/environment/circular-economy/pdf/new_circular_economy_action_plan.pdf

European Commission. (n.d.). *EU Ecolabel* – Environment – European Commission. EU Ecolabel. https://ec.europa.eu/environment/ecolabel/

European Environment Agency. (2017). Circular by design – Products in the Circular Economy, *EEA Report*, No. 6/2017. European Environment Agency. https://doi.org/10.2800/860754

Evans J. (n.d.). Circular Economy Toolkit, Retrieved from: www.circulareconomytoolkit.org

Ferreira, A. (2003). "*Design e Inovação: Valores para o Século XXI", Idade da Imagem*, Revista de Arte, Ciência e Cultura do IADE, Ano III, 8, Maio/Agosto, pp. 52-56. Lisboa: CEIADE.

Ferreira, A. (2008a). *Caracterização e Quantificação da Inovação no Processo Evolucionista do Design: análise de um século da prática médico-cirúrgica em Portugal*, Dissertação para a obtenção do Grau de Doutor em Engenharia de Produção. Covilhã: Universidade da Beira Interior

Ferreira, A. (2008b). *Evolução do Conceito e da Prática do Design*, Prova Complementar à Dissertação para obtenção do Grau de Doutor em Engenharia de Produção. Covilhã: Universidade da Beira Interior.

Finisterra Do Paço, A., Barata, M., & Filho, W. (2009). Identifying the green consumer: A segmentation study. *Journal of Targeting, Measurement and Analysis for Marketing, 17*(1), 17–25. https://doi.org/10.1057/jt.2008.28

Gerholdt, J. (2015). *The 5 business models that put the circular economy to work*. Greenbiz. Retrieved May 2021, from https://www.greenbiz.com/article/5-business-models-put-circular-economy-work

Goal 12: Ensure sustainable consumption and production patterns. (n.d.). United Nations Sustainable Development Goals. Retrieved January 10, 2022, from https://www.un.org/sustainabledevelopment/sustainable-consumption-production/

Godinho, R. (2019). *Understanding the why, what and how of business model innovation*, Porti Business School, Center for Business Innovation, Retrieved from https://www.pbs.up.pt/pt/artigos-e-eventos/artigos/understanding-the-why-what-and-how-of-business-model-innovation/ (12 Abril 2021)

Goleman, D. (2009). *Ecological Intelligence – The coming age of radical transparency*. Broadway Books.

Haigh, L., De Wit, M., Daniels, C., Colloricchio, A., Hoogzaad, J., (2021). *Circularity Gap Report*. Circle economy. Retrieved from https://www.circle-economy.com

Hassi, L., & Wever, R. (2010). *Practices of a " green " front end of innovation; A gateway to environmental innovation*. Knowledge Collaboration & Learning for Sustainable InnovationERSCP-EMSU conference, Delft, The Netherlands, October 25-29, 2010

Huang, L. (2021). P*rototype Development: All You Need to Know About Making a Prototype.* RapidDirect. Retrieved from https://www.rapiddirect.com/blog/prototype-development/

Hummels, C., & Frens, J. (2012). *Designing Disruptive Innovative Systems, Products and Services: RTD Process*. Industrial Design – New Frontiers. https://doi.org/10.5772/22580

Ideia Circular. (n.d.). *O que é Cradle to Cradle?* Retrieved February 2019, from https://www.ideiacircular.com/o-que-e-cradle-to-cradle/

IDEO. (n.d.). *IDEO Design Thinking*. IDEO | Design Thinking. Retrieved March 2020, from https://designthinking.ideo.com

Idil Gaziulusoy, A. (2015). A critical review of approaches available for design and innovation teams through the perspective of sustainability science and system

innovation theories. *Journal of Cleaner Production*, 107, 366–377. https://doi.org/10.1016/j.jclepro.2015.01.012

InEDIC – Innovation and ecodesign in the ceramic industry (2011). Manual de Ecodesign.

Interaction Design Foundation (n.d.). *Design thinking*. Retrieved February 2020 https://www.interaction-design.org

International Electrotechnical Commission. (2019). Environmentally conscious design – Principles, requirements and guidance. (IEC 62430:2019).

International EPD System | EPD International. (n.d.). The International EPD System. Retrieved January 10, 2022, from https://www.environdec.com/about-us/the-international-epd-system-about-the-system

International Organization for Standardization. (2016). Environmental management — Life *cycle assessment — Principles and framework (ISO 14040:2006)*

ISO, 2000. *Environmental labels and declarations — General principles*. ISO 14020. ISO, Geneva, Switzerland.

ISO, 2006a. *Environmental labels and declarations — Type III environmental declarations — Principles and procedures.* ISO 14025. ISO, Geneva, Switzerland.

ISO, 2006b. *Environmental management — Life cycle assessment — Principles and framework.* ISO 14040:2006. ISO, Geneva, Switzerland.

ISO, 2015. *Environmental management systems – A practical guide for SMEs*. ISO 14001. ISO, Geneva, Switzerland.

ISO, 2015. Environmental management systems Requirements with guidance for use. ISO 14001. ISO, Geneva, Switzerland.

ISO, 2016. *Environmental labels and declarations — Self-declared environmental claims* (Type II environmental labelling). ISO 14021. ISO, Geneva, Switzerland.

ISO, 2018. *Environmental labels and declarations — Type I environmental labelling — Principles and procedures*. ISO 14024. ISO, Geneva, Switzerland.

ISO, 2020. *Environmental management systems — Guidelines for incorporating ecodesign*. ISO 14006:2020. ISO, Geneva, Switzerland.

Jung, H., & Ro, E. (2019). Validating common experiences through focus group interaction. *Journal of Pragmatics*, 143, 169–184. https://doi.org/10.1016/j.pragma.2019.02.019

Karjaluoto, E. (2014). The design method: a philosophy and process for functional visual communication. *Choice Reviews Online* (Vol. 51). https://doi.org/10.5860/choice.51-4820

KATCH_e (2019) (a), *Modules and tools overview*, Retrieved from www.katche.eu/wp-content/uploads/2019/02/KATCH_Modules_Tools_OVERVIEW.pdf

KATCH_e, (2019a), *Knowledge Alliance on Product-Service Development towards Circular Economy and Sustainability in Higher Education*. Retreived from www.katche.eu

KATCH_e, (2019b), *Situtation analisys report*. Retrived from www.katche.eu

Kirchherr, J., Reike, D., & Hekkert, M. (2017). Conceptualizing the Circular Economy: An analysis of 114 definitions. **Resources, Conservation and Recycling**, 127(April), 221–232. https://doi.org/10.1016/j.resconrec.2017.09.005

Leverage Edu. (2021). *Research Design: Definition, Types & Characteristics*. https://leverageedu.com/blog/research-design/

Liedtka, J. (2018). *Why Design Thinking Works*. Harvard Business Review, (September-October).

Life Cicle Initiative. (n.d.). Life Cycle Initiative. Retrieved January 10, 2022, from https://www.lifecycleinitiative.org/

Lockwood, T. (2010). Design thinking – Integrating innovation, customer experience and Brand value. T. Lockwood, Ed.. Allwoth Press.

Lucid. (n.d). The 4 phases of the project management life cycle. Lucidchart. Retrived May 2022 https://www.lucidchart.com/blog/the-4-phases-of-the-project-management-life-cycle)

Lüdeke-Freund, F. (2010). *Towards a Conceptual Framework of 'Business Models for Sustainability'.* Knowledge Collaboration & Learning for Sustainable Innovation, R. Wever, J. Quist, A. Tukker, J. Woudstra, F. Boons, N. Beute, eds., Delft, 2010, ERSCP-EMSU Conference 2010, The Netherlands, October 25-29, 2010, Available at SSRN: https://ssrn.com/abstract=2189922

Luttropp, C., & Lagerstedt, J. (2006). EcoDesign and The Ten Golden Rules: generic advice for merging environmental aspects into product development. *Journal of Cleaner Production*, 14(15–16), 1396–1408. https://doi.org/10.1016/j.jclepro.2005.11.022

Manzini, E., & Vezzoli, C. (2010). *Design for Environmental Sustainability*. London: Springer.

MARGOLIN, V. (2014). *Design e Risco de Mudança*. Caldas da Rainha: ESAD.

Marlien, R., Priyanto, S., Andadari, R., & Ihalauw, J. (2019). *Co-synergy and Cocreation Value on Customer Behavioural Outcomes*, 86(Icobame 2018), 83–86. https://doi.org/10.2991/icobame-18.2019.18

Material Circularity Indicator (MCI). (n.d.). Ellen MacArthur Foundation. Retrieved April 5, 2019, from https://ellen bmacarthurfoundation.org/material-circularity-indicator

Material circularity indicator, Ellen MacArthur foundation, Retrieved from:https://www.ellenmacarthurfoundation.org/resources/apply/circularity-indicators

Mcaloone, T., & Pigosso, D., (2017). *Sustainable Manufacturing*, 99–111. https://doi.org/10.1007/978-3-319-48514-0

McDonough, W., & Braungart, M. (2002). *Cradle to Cradle: Remaking the Way We Make Things* (1st ed.). North Point Press.

Medkova, C., Fifield, B., (2016). *Circular Design – Design for CE*. Retrived from: www.researchgate.net/publication/313771263

Merriam Webster. (n.d.). The Merriam-Webster.Com Dictionary. Retrieved June 10, 2021, from https://www.merriam-webster.com/dictionary/downcycling

Ministério do Ambiente e Ação Climática. (n.d.). *Portal Economia Circular. Eco.Nomia.* Retrieved May, 2018, from https://eco.nomia.pt/

Moreno M, Ponte O. & Charnley F. (2017). *Taxonomy of design strategies for a circular design tool*. In: Conference Proceedings of Plate 2017, 8-10 November 2017, Delft, the Netherlands

Moreno, M., De los Rios, C., Rowe, Z., & Charnley, F. (2016). A conceptual framework for circular design. *Sustainability* (Switzerland), 8(9). https://doi.org/10.3390/su8090937

Morseletto, P. (2020). Targets for a circular economy. *Resources, Conservation and Recycling*, 153. https://doi.org/10.1016/j.resconrec.2019.104553

Muratovski, G. (2015). *Research for Designers: A Guide to Methods and Practice*. SAGE Publications.

Niinimäki, K., & Hassi, L. (2011). *Emerging design strategies in sustainable production and consumption of textiles and clothing*. Journal of Cleaner Production, 19(16), 1876–1883. https://doi.org/10.1016/j.jclepro.2011.04.020

Nike Circular Design Guide. (n.d.). Nike Circular Design. Retrieved January 10, 2022, from https://www.nikecirculardesign.com

Orangescrum, (n.d) Project Management Life cycle. Retrieved https://www.orangescrum.com/tutorial/introduction-to-project-management/project-management-life-cycle

PAEC – Liderar a transição – Plano de ação para a economia circular em Portugal 2017-2020 (2017). Presidência do Conselho de Ministros, Grupo Interministerial Economia Circular, Resolução do Conselho de Ministros n.º 190-A/2017, Retreived from https://eco.nomia.pt/contents/ficheiros/paec-pt.pdf

Papanek, V. (1971). *Design for the Real World: Human Ecology and Social Change*. Thames & Hudson Ltd. ISBN**:** 9780500273586

Pereira, R. (2021). *O sistema de Economia Circular e a Agenda 2030: análise da evolução em Portugal*. *E3*, *7*(1), 097–124. https://doi.org/10.29073/e3.v7i1.381

Pigosso, D., Rozenfeld, H., & McAloone, T. (2013). Ecodesign maturity model: A management framework to support ecodesign implementation into manufacturing companies. *Journal of Cleaner Production*, 59, 160–173. https://doi.org/10.1016/j.jclepro.2013.06.040

Portugal 2020 program, Retrived from www.portugal2020.pt

Potting, J., Hekkert, M., Worrell, E., & Hanemaaijer,. (2017). *Circular Economy: Measuring innovation in the product chain*. PBL Netherlands Assessment Agency

Prendeville, S., Niemczyk, M., Sanders, C., Lafond, E., Elgorriaga, A., Mayer, S., & Kane, D. (2013). *Motivations for and Barriers to Ecodesign in Industry*. Retrieved from http://edcw.org/sites/default/files/resources/ENEC Motivations & Barriers 2013.pdf

Product Discovery: product-service systems and the future of products. (2021). MJV Technology & Innovation. Retrieved October 10, 2022, from https://www.mjvinnovation.com/blog/product-discovery-process/

Project Central (2022). What Are The 4 Phases Of The Project Management Life Cycle?. Retried February 2022 https://www.projectcentral.com/blog/project-management-life-cycle/)

Project Management Institute | PMI. (n.d.). Project Management Institute. Retrieved January 10, 2022, from https://www.pmi.org/

Project Management Institute. (2017). A Guide to the Project Management Body of Knowledge (Pmbok(r) Guide)-Sixth Edition (6th ed.). Newtown Square, Pennsylvania: Project Management Institute.

Quadro de Referência Estratégico Nacional (QREN), Retrived from www.qren.pt

Re-Circle. (2018). Business Models for the Circular Economy. *Opportunities and Challenges for Policy*. OECD publishing. https://doi.org/10.1787/g2g9dd62-en

Resolução de Conselho de Ministros nº 190A/2017, de 11 de dezembro. Diário da República n.º 236/2017, 2º Suplemento, I Série. Presidência do Conselho de Ministros. Lisboa

Riverdale & IDEO (2012). Design Thinking for Educators. http:// designthinkingforeducators.com/

Riverdale, & IDEO. (2011). Design Thinking for Educators, Retrieved April, 2019, from http://designthinkingforeducators.com/

Rocha, C., Camocho, D., Alexandre, J. (2019). *KATCH_e Design for Circular Economy module*. KATCHE_e Project.

Rocha. C., Camocho, D., Sampaio., Alexandre, J. (editores) (2020). *Product-Service Development for Circular Economy and Sustainability Course*, KATCH_e project. LNEG – Laboratório Nacional de Energia e Geologia, I.P., ISBN: 978-989-675-063-3

Romero, D., & Rossi, M. (2017). *Towards Circular Lean Product-Service Systems*. Procedia CIRP,64, 13–18. https://doi.org/10.1016/j.procir.2017.03.133

Rousseau, J., Loureiro, A., Rosa, C.A.: (2016). *Relatório de 2015-16 do Observatório do Consumo Consciente*, Fórum do Consumo, Universidade Lusófona, IADE-Universidade Europeia & GFK

Schumann, B. (2019). Design for Recycling. Retrieved from https://ecodesign-packaging.org/en/guidelines/strategies/design-for-recycling/

Shahbazi, S., (2020). *Design guidelines for circular strategies*. CIRCit Norden. Technical University of Denmark. Retrieved from https://circitnord.com/wp-content/uploads/2020/04/Guidelines-for-circular-product-design-and-development.pdf

Simeone, L., van Dam, K., & Morelli, N. (2019). *A preliminary review of the concept of circular economy in design research.* Cumulus Conference Rovaniemi 2019 Around the Campfire: Resilience and {IntelligenceCumulus} Conferences.

SInnDesign – Sustainable Innovation through Design (2016). Manual de Ecodesign. Retrieved from http://sinndesignproject.eu

Stahel, W. (1994). *The utilization focused service economy: Resource efficiency*, B. R. Allenby and D. J. Richards (eds), The Greening of Industrial Ecosystems, National Academy Press, 178–190.

SurveyMonkey. (2018). *3 Best Practices for Planning Expert Surveys*. Retrieved from https://www.surveymonkey.com/

Sustainable consumption and production policies. (n.d.). UNEP – UN Environment Programme. Retrieved January 10, 2022, from https://www.unep.org/explore-topics/resource-efficiency/what-we-do/sustainable-consumption-and-production-policies

Sustainable Product Policy. (n.d.). EU Science Hub. https://joint-research-centre.ec.europa.eu/scientific-activities/sustainable-product-policy_en

The 17 Goals | Sustainable Development. (n.d.). United Nations. Retrieved January 10, 2022, from https://sdgs.un.org/goals

Tischner, U. (2016). *Change by Design (or by Disaster).* ökoRAUSCH. Retrieved March 18, 2022, from https://www.oekorausch.de/en/change-by-design-or-by-disaster/

Tschimmel, K. (2015). *Evolution 6 Design Thinking*. MindShake www.mindshake.pt/design_thinking

Udoagwu, K. (2022). *10 Essential Elements for the Perfect Project Plan*. Wrike. Retrieved from https://www.wrike.com/blog/essential-elements-perfect-project-plan-infographic/

United Nations. (2016). *Responsible consumption & production: three planets. Responsible consumption & production: three planets,* (responsible consumption & production: why it matters)

United Nations. (n.d.). *Transforming our world: the 2030 Agenda for Sustainable Development | Department of Economic and Social Affairs*. United Nations, Department of Economic and Social Affairs, Sustainable Development. https://sdgs.un.org/2030agenda

Value Analysis Canada. (n.d.). *About Value Analysis*. Retrieved May 2020, from https://valueanalysis.ca/aboutva.php

Vasantha, G., Roy, R., Taylor, P., Lelah , A., , Brissaud, D. (2012). A review of product – service systems design methodologies. Journal of Engineering Design, 23(9), 635–659. https://doi.org/10.1080/09544828.2011.639712

Venngage, (2019). The 4 Project Life Cycle Phases. Retrieved February 2022 https://venngage.com/blog/project-life-cycle

Vicente, J. (2012). *Contributos para uma metodologia de design sustentável aplicada à indústria do mobiliário: o caso português*.

Vicente, J., Frazão, R., Silva, F. (2011). *Ecodesign Tools: One basis to operationalize Sustainable Design;* In Proceedings of VI International Congress on Design Research, Lisboa, Portugal.

Vicente, J., Frazão, R., Silva, F. (2012) – *The evolution of design with concerns on Sustainability.* Convergências: Revista de Investigação e Ensino das Artes. ISSN 1646-9054. N.º 10.

Vringer, K. Vollebergh, H., Soest, D., Heijden, E., Diets, F. (2015). *"Sustainable consumption dilemmas"*, OECD Environment Working Papers, No. 84, OECD Publishing, Paris.

Watt, A. (2014). *Project Management*. Victoria, B.C.: BCcampus. Retrieved from https://opentextbc.ca/projectmanagement/

Watts, A. (2014). *Project Management*. Victoria, B.C.: BCcampus. Retrieved from https://opentextbc.ca/projectmanagement/.ISBN 978-1-77420-013-1

WBDG, (2017). Project Planning, Delivery, and Controls. Whole Building Design Guide. Retrieved May 2022 from https://www.wbdg.org/project-management#ip

Witkowski, J. (2017) *The Evolution of Design Tools*. Retrieved from www.lullabot.com/articles/the-evolution-of-design-tools.

World Business Council for Sustainable Development. (2018). Circular Economy Practitioner Guide. Circular Economy Guide. Retrieved 2019, from https://www.ceguide.org/Strategies-and-examples

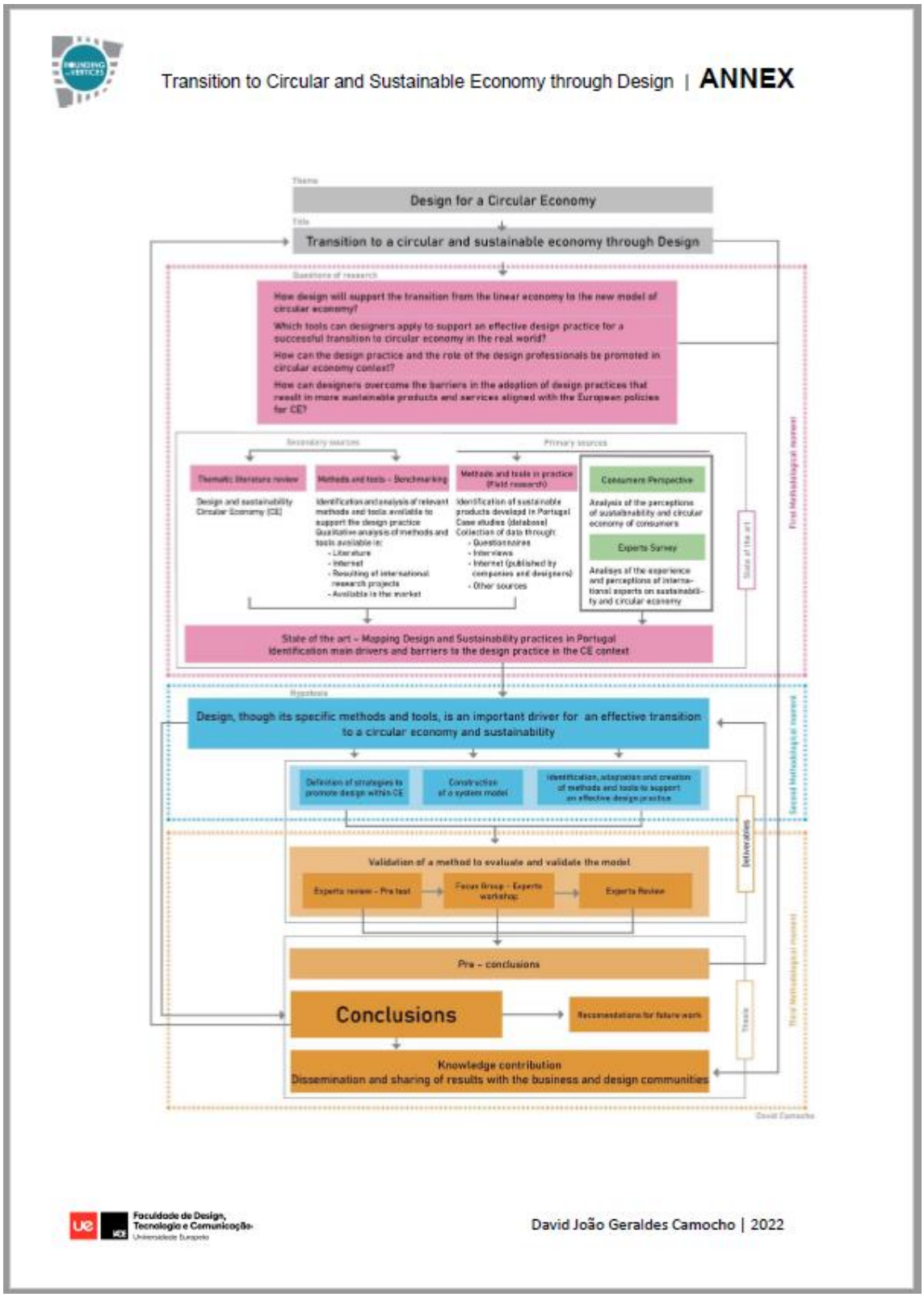
Young, W., Kumju, H., Seonaidh, M., Caroline, J. O. (2008). *Sustainable consumption: green consumer behaviour when purchasing products*. Sustainable Development Journal, 31(July), 20–31

Zwicky, F., (1969). *Discovery, Invention, Research – Through the Morphological Approach*, The Macmillan Company

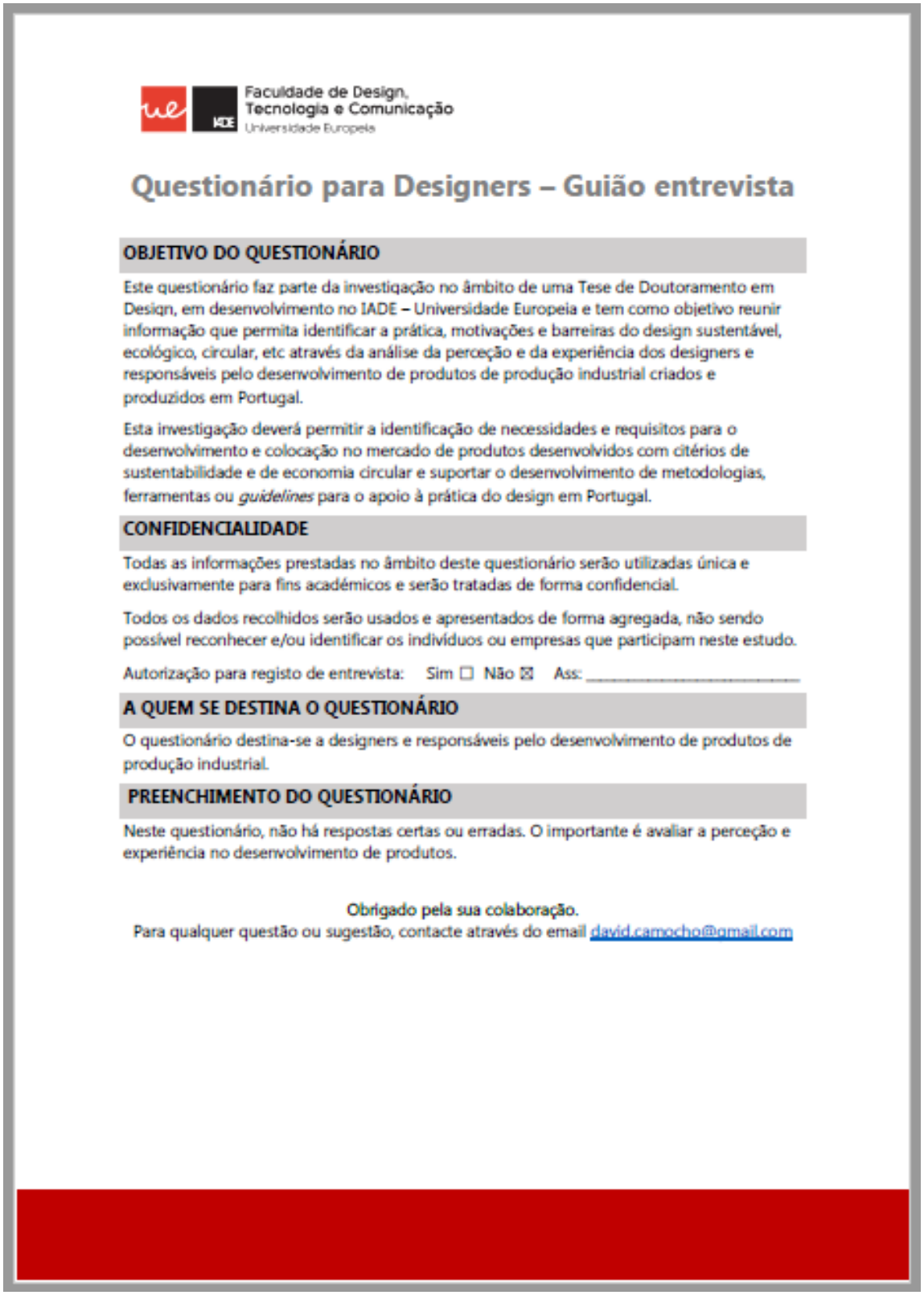
Annexes

List of annex files illustrated. The full versions of the in annex.

Annex 1 – Research Design



Annex 2 – Questionnaire Designers Practice



Faculdade de Design, Tecnologia e Comunicação
Universidade Europeia

Questionário para Designers – Guião entrevista

OBJETIVO DO QUESTIONÁRIO

Este questionário faz parte da investigação no âmbito de uma Tese de Doutoramento em Design, em desenvolvimento no IADE – Universidade Europeia e tem como objetivo reunir informação que permita identificar a prática, motivações e barreiras do design sustentável, ecológico, circular, etc através da análise da perceção e da experiência dos designers e responsáveis pelo desenvolvimento de produtos de produção industrial criados e produzidos em Portugal.

Esta investigação deverá permitir a identificação de necessidades e requisitos para o desenvolvimento e colocação no mercado de produtos desenvolvidos com citérios de sustentabilidade e de economia circular e suportar o desenvolvimento de metodologias, ferramentas ou *guidelines* para o apoio à prática do design em Portugal.

CONFIDENCIALIDADE

Todas as informações prestadas no âmbito deste questionário serão utilizadas única e exclusivamente para fins académicos e serão tratadas de forma confidencial.

Todos os dados recolhidos serão usados e apresentados de forma agregada, não sendo possível reconhecer e/ou identificar os indivíduos ou empresas que participam neste estudo.

Autorização para registo de entrevista: Sim ☐ Não ☒ Ass: _____

A QUEM SE DESTINA O QUESTIONÁRIO

O questionário destina-se a designers e responsáveis pelo desenvolvimento de produtos de produção industrial.

PREENCHIMENTO DO QUESTIONÁRIO

Neste questionário, não há respostas certas ou erradas. O importante é avaliar a perceção e experiência no desenvolvimento de produtos.

Obrigado pela sua colaboração.
Para qualquer questão ou sugestão, contacte através do email david.camocho@gmail.com

Annex 3a – Questionnaire international experts Survey – Paper version

Faculdade de Design, Tecnologia e Comunicação
Universidade Europeia

International experts review - Survey

Purpose of the survey

This questionnaire is part of a research project within the scope of a Doctoral Thesis in Design under development at IADE - European University in Portugal and aims to collect the views and perceptions of a group of international experts on the fields of circular economy, sustainability and design.

The collected information will allow the identification of an international overview of the practice, motivations and barriers in the transition to circular economy through design, and will support the research and development of methods, tools and guidelines to promote an improved design practice.

Consent to process personal data

By agreeing to participate in this survey you give your consent to have your relevant personal data collected and processed by the authors for the purpose of the current PhD research project.

Your answers to this survey, including any personal data collected, will be treated and presented in aggregated form and it will not be possible to recognize and/or identify the answers and opinions expressed in the questionnaire.

For whom the questionnaire is intended

The questionnaire is intended for international experts in the field of Circular economy, sustainability and design.

Filling in the questionnaire

In this questionnaire, there are no right or wrong answers. The importance is to identify and explore the perceptions and experiences related to the circular economy, sustainability and design.

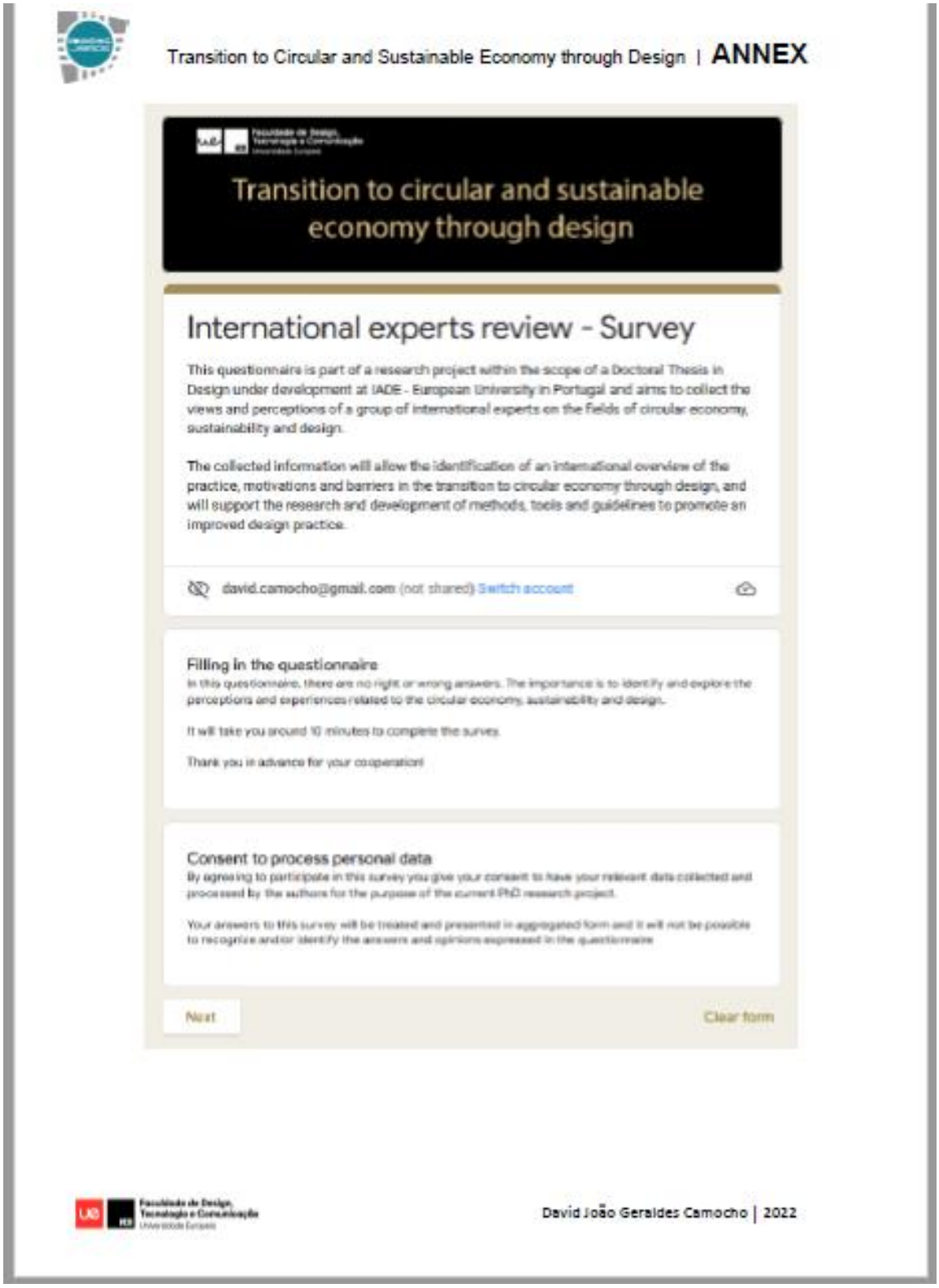
It will take you around 10 minutes to complete the survey.

Thank you in advance for your cooperation!

For any questions or suggestions, please contact via email to: david.camocho@gmail.com

Section 1 – General data

Annex 3b – Questionnaire international experts Survey – Online



Transition to circular and sustainable economy through design

International experts review - Survey

This questionnaire is part of a research project within the scope of a Doctoral Thesis in Design under development at IADE - European University in Portugal and aims to collect the views and perceptions of a group of international experts on the fields of circular economy, sustainability and design.

The collected information will allow the identification of an international overview of the practice, motivations and barriers in the transition to circular economy through design, and will support the research and development of methods, tools and guidelines to promote an improved design practice.

david.camocho@gmail.com (not shared) Switch account

Filling in the questionnaire

In this questionnaire, there are no right or wrong answers. The importance is to identify and explore the perceptions and experiences related to the circular economy, sustainability and design.

It will take you around 10 minutes to complete the survey.

Thank you in advance for your cooperation!

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Your answers to this survey will be treated and presented in aggregated form and it will not be possible to recognize and/or identify the answers and opinions expressed in the questionnaire

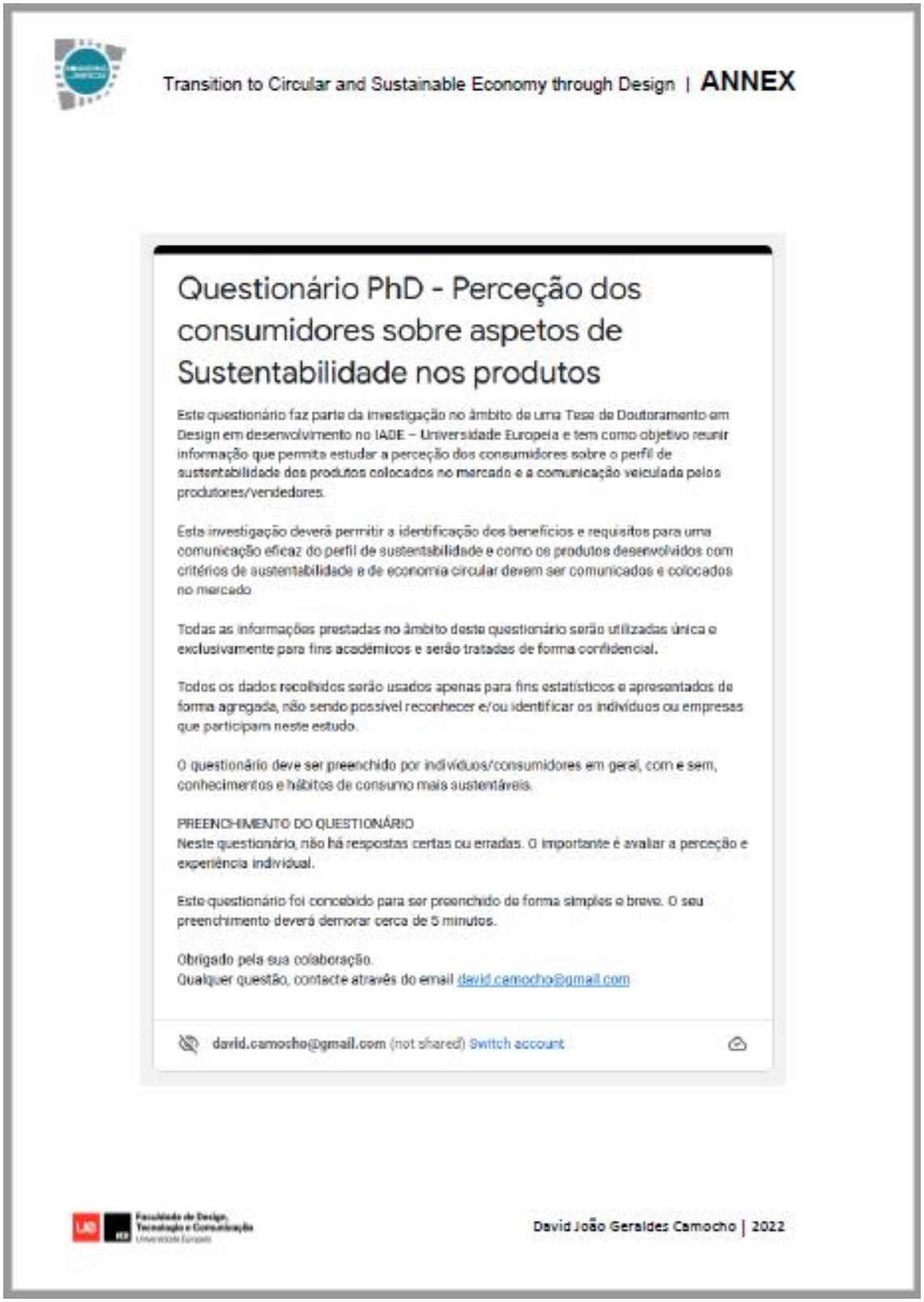
Next

Clear form

Annex 4 – Products database_structure and examples

product name	image	discription
Ecotiles Revigres - Saturno - Ecompact - Ecotech - Ecompact Estruturado	 	Gama de paviementos eco
Reviconfort		Pavimento desmontável reutilizável e aplicado sem colas
NAZ-		Roupa Sustentáveis
EPAL Fill Forever		Garrafa PET reutilizável
SunCook		Forno Solar

Annex 5a – Questionnaire consumers perceptions – Online version



Annex 5b – Questionnaire consumers perceptions – Paper version

Universidade Europeia

IADE

QUESTIONÁRIO

OBJETIVO DO QUESTIONÁRIO

Este questionário faz parte da investigação no âmbito de uma Tese de Doutoramento em Design, em desenvolvimento no IADE – Universidade Europeia e tem como objetivo reunir informação que permita estudar a perceção dos consumidores sobre o perfil de sustentabilidade dos produtos colocados no mercado e a comunicação veiculada pelos produtores/vendedores.
Esta investigação deverá permitir a identificação dos benefícios e requisitos para uma comunicação eficaz do perfil de sustentabilidade e como os produtos desenvolvidos com critérios de sustentabilidade e de economia circular devem ser comunicados e colocados no mercado.

CONFIDENCIALIDADE

Todas as informações prestadas no âmbito deste questionário serão utilizadas única e exclusivamente para fins académicos e serão tratadas de forma confidencial.
Todos os dados recolhidos serão usados apenas para fins estatísticos e apresentados de forma agregada, não sendo possível reconhecer e/ou identificar os indivíduos ou empresas que participam neste estudo.

A QUEM SE DESTINA O QUESTIONÁRIO

O questionário deve ser preenchido por indivíduos/consumidores em geral com e sem conhecimentos e hábitos de consumo mais sustentáveis.

PREENCHIMENTO DO QUESTIONÁRIO

1. Neste questionário, não há respostas certas ou erradas. O importante é avaliar a perceção e experiência individual.
2. O questionário está estruturado em 5 secções:
   - Secção 1 – Dados gerais sobre o inquirido
   - Secção 2 – Conhecimentos gerais
   - Secção 3 – Hábitos de consumos e influencia da rotulagem ambiental
   - Secção 4 – Perceção do perfil de sustentabilidade dos produtos
   - Secção 5 – Observações e acompanhamento do projeto
3. Este questionário foi concebido para ser preenchido de forma simples e breve. O seu preenchimento deverá demorar cerca de 10 minutos.

Obrigado pela sua colaboração.
Qualquer questão, contacte através do email david.camocho@gmail.com

SECÇÃO 1 – DADOS GERAIS

01 Idade: _____

02 Sexo: Masculino [ ] Feminino [ ]

03 Habilitações literárias:
Inferior a 12º ano [ ] 12º ano [ ] Licenciatura [ ] Mestrado ou superior [ ] Outro [ ] _____

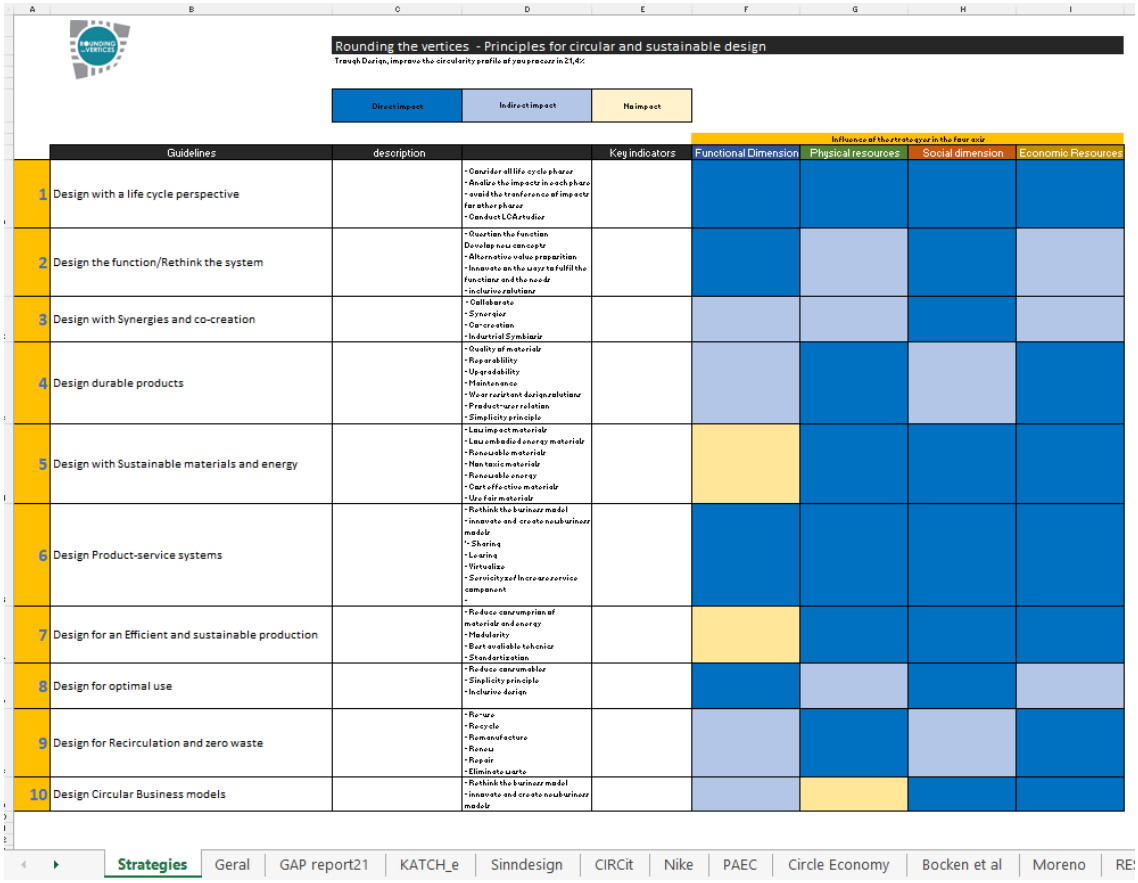
04 Atividade profissional: _____

SECÇÃO 2 – CONHECIMENTOS GERAIS

05 **Indique o seu nível de conhecimento nas seguintes áreas:**

	1 Não sei o que é	2 Já ouvi falar	3 Sei o que é –Noções básicas	4 Conhecimento elevado	5 Especialista na área
Design	○	○	○	○	○
Ecodesign	○	○	○	○	○
Sustentabilidade	○	○	○	○	○
Economia circular	○	○	○	○	○

Annex 6 – Rounding the Vertices_ Strategies review



Rounding the vertices - Principles for circular and sustainable design

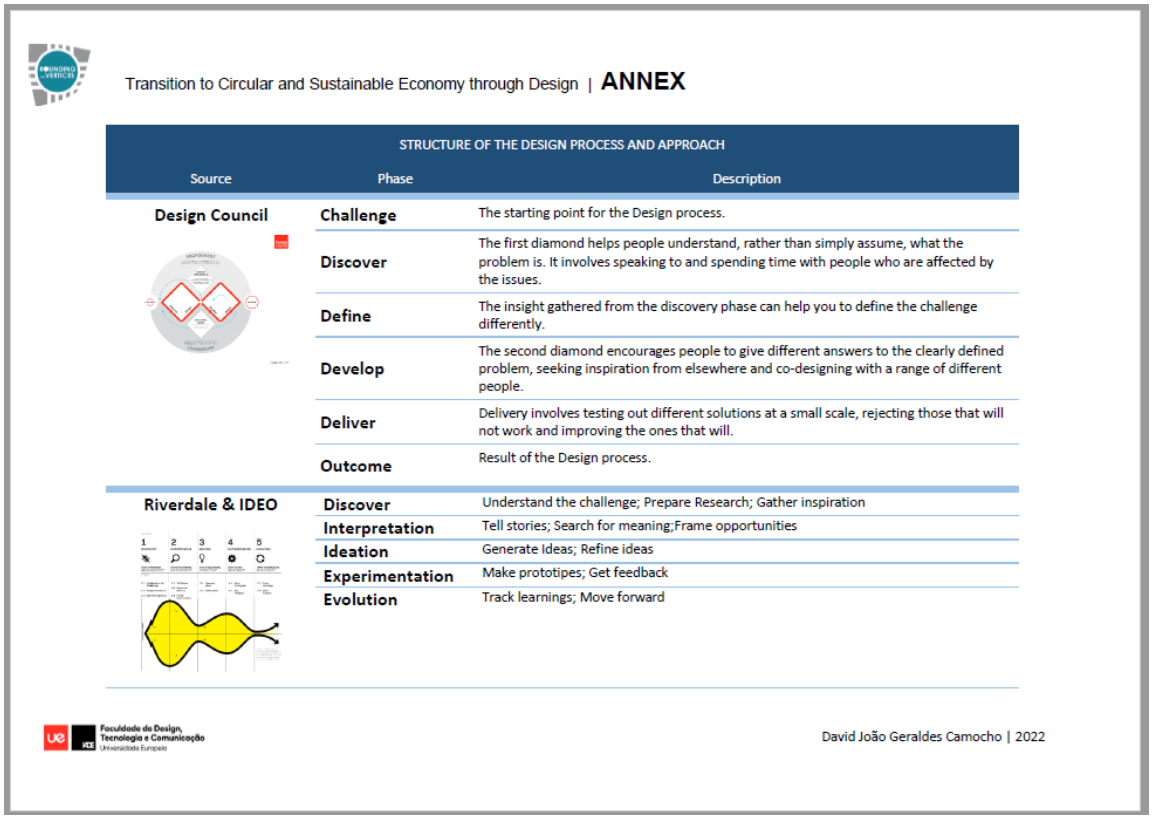
Trough Design, improve the circularity profile of you process in 21,4%

	Direct impact	Indirect impact	No impact

	Guidelines	description		Key indicators	Influence of the strategy in the four axis: Functional Dimension	Physical resources	Social dimension	Economic Resources
1	Design with a life cycle perspective		- Consider all life cycle phase - Analize the impacts in each phase - avoid the transference of impacts for other phase - Conduct LCA studies					
2	Design the function/Rethink the system		- Question the function Develop new concepts - Alternative value proposition - Innovate on the ways to fulfil the functions and the needs - inclusive solutions					
3	Design with Synergies and co-creation		- Collaborate - Synergies - Co-creation - Industrial Symbiosis					
4	Design durable products		- Quality of materials - Reparability - Upgradability - Maintenance - Wear resistant designs solutions - Product-user relation - Simplicity principle					
5	Design with Sustainable materials and energy		- Low impact materials - Low embodied energy materials - Renewable materials - Non toxic materials - Renewable energy - Cost effective materials - Use fair materials					
6	Design Product-service systems		- Rethink the business model - innovate and create new business models '- Sharing - Leasing - Virtualize - Servicitys of Increase service component -					
7	Design for an Efficient and sustainable production		- Reduce consumption of materials and energy - Modularity - Best available technics - Standartization					
8	Design for optimal use		- Reduce consumables - Simplicity principle - Inclusive design					
9	Design for Recirculation and zero waste		- Re-use - Recycle - Remanufacture - Renew - Repair - Eliminate waste					
10	Design Circular Business models		- Rethink the business model - innovate and create new business models					

Strategies | Geral | GAP report21 | KATCH_e | Sinndesign | CIRCit | Nike | PAEC | Circle Economy | Bocken et al | Moreno | RE

Annex 7 – Design process approaches review



Transition to Circular and Sustainable Economy through Design | **ANNEX**

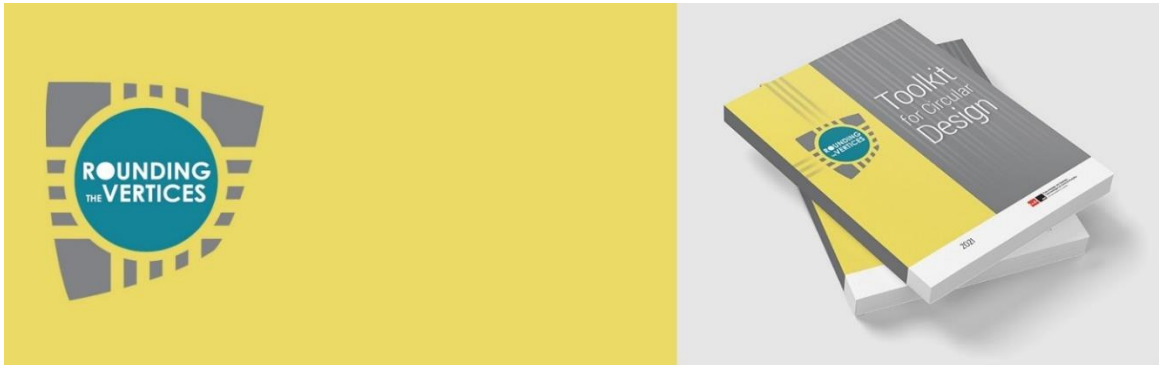
STRUCTURE OF THE DESIGN PROCESS AND APPROACH

Source	Phase	Description
Design Council	**Challenge**	The starting point for the Design process.
	Discover	The first diamond helps people understand, rather than simply assume, what the problem is. It involves speaking to and spending time with people who are affected by the issues.
	Define	The insight gathered from the discovery phase can help you to define the challenge differently.
	Develop	The second diamond encourages people to give different answers to the clearly defined problem, seeking inspiration from elsewhere and co-designing with a range of different people.
	Deliver	Delivery involves testing out different solutions at a small scale, rejecting those that will not work and improving the ones that will.
	Outcome	Result of the Design process.
Riverdale & IDEO	**Discover**	Understand the challenge; Prepare Research; Gather inspiration
	Interpretation	Tell stories; Search for meaning;Frame opportunities
	Ideation	Generate Ideas; Refine ideas
	Experimentation	Make prototipes; Get feedback
	Evolution	Track learnings; Move forward

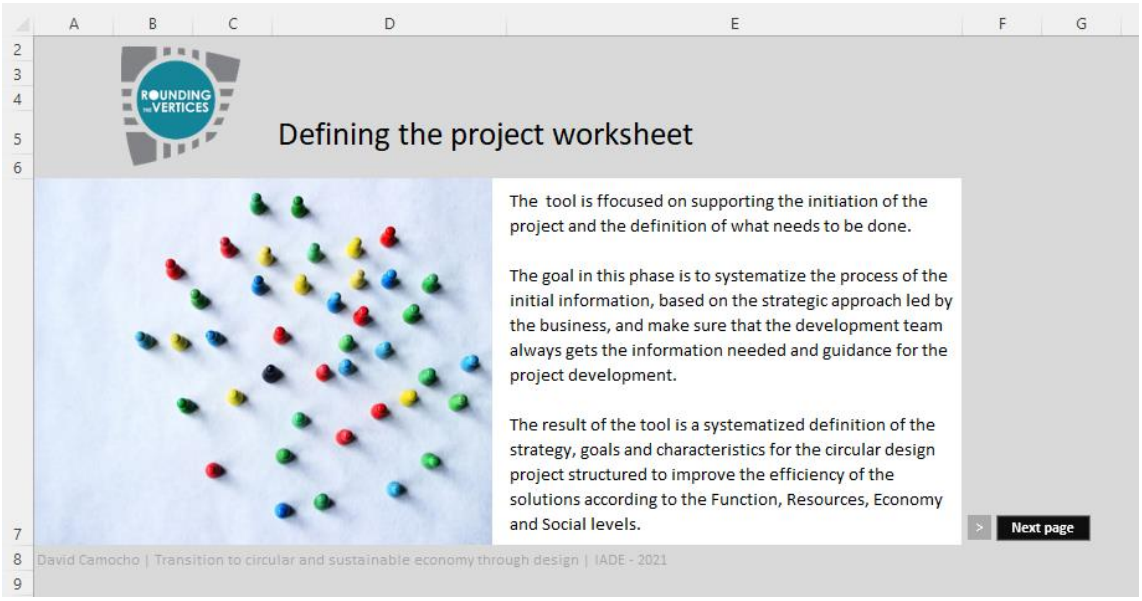
Faculdade de Design, Tecnologia e Comunicação

David João Geraldes Camocho | 2022

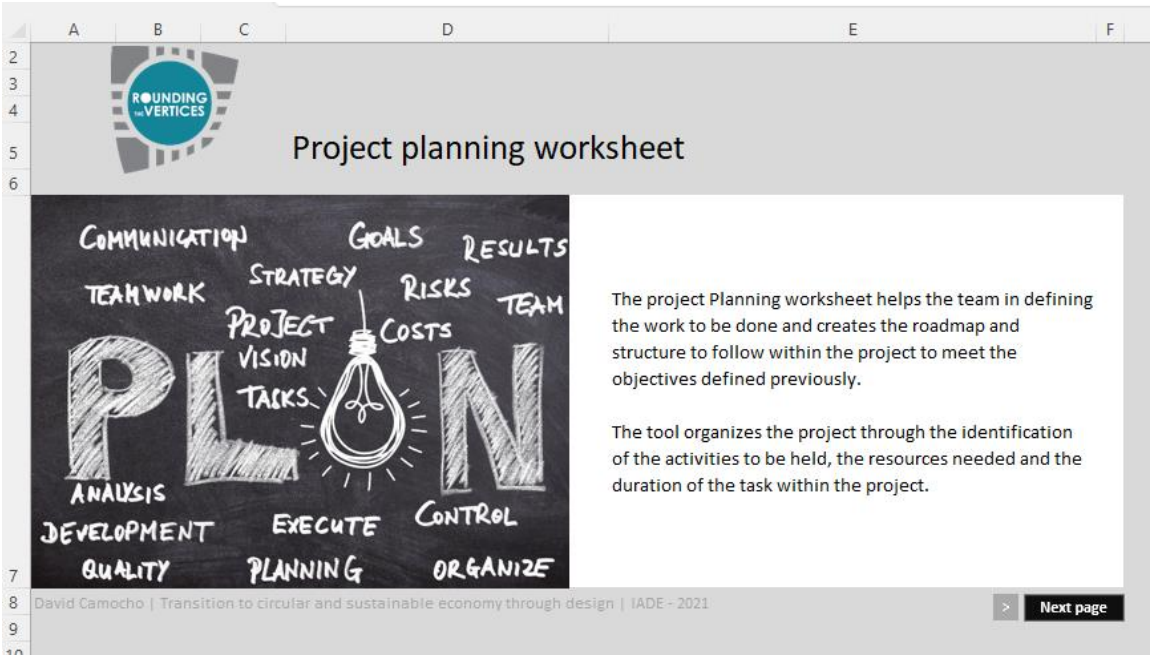
Annex 8 – Rounding the Vertices Toolkit – e-book version



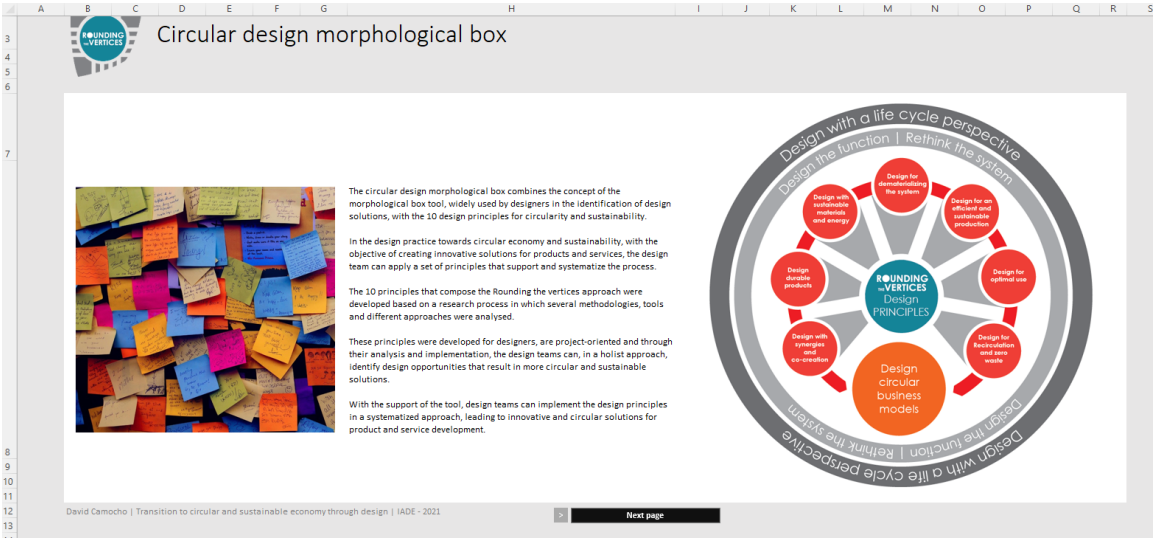
Annex 9 – Tool 1_Defining the project_excel version



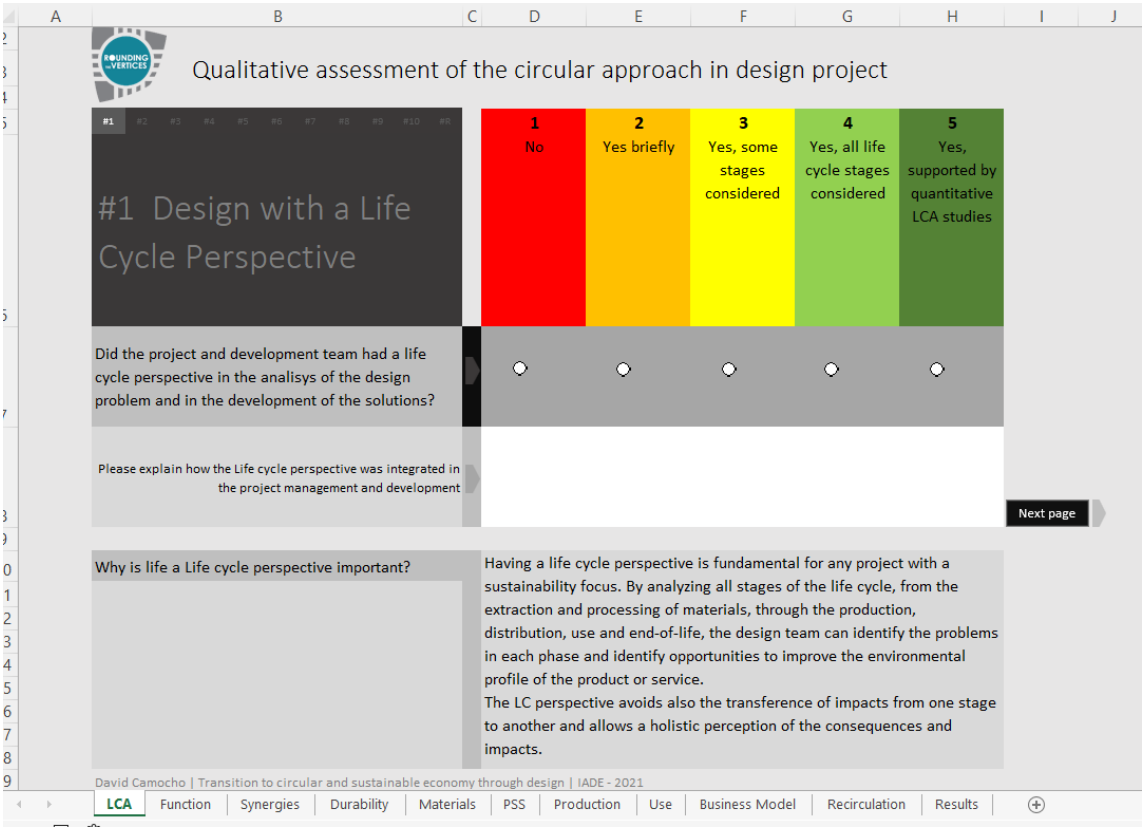
Annex 10 – Tool 2_project planning_Excel version



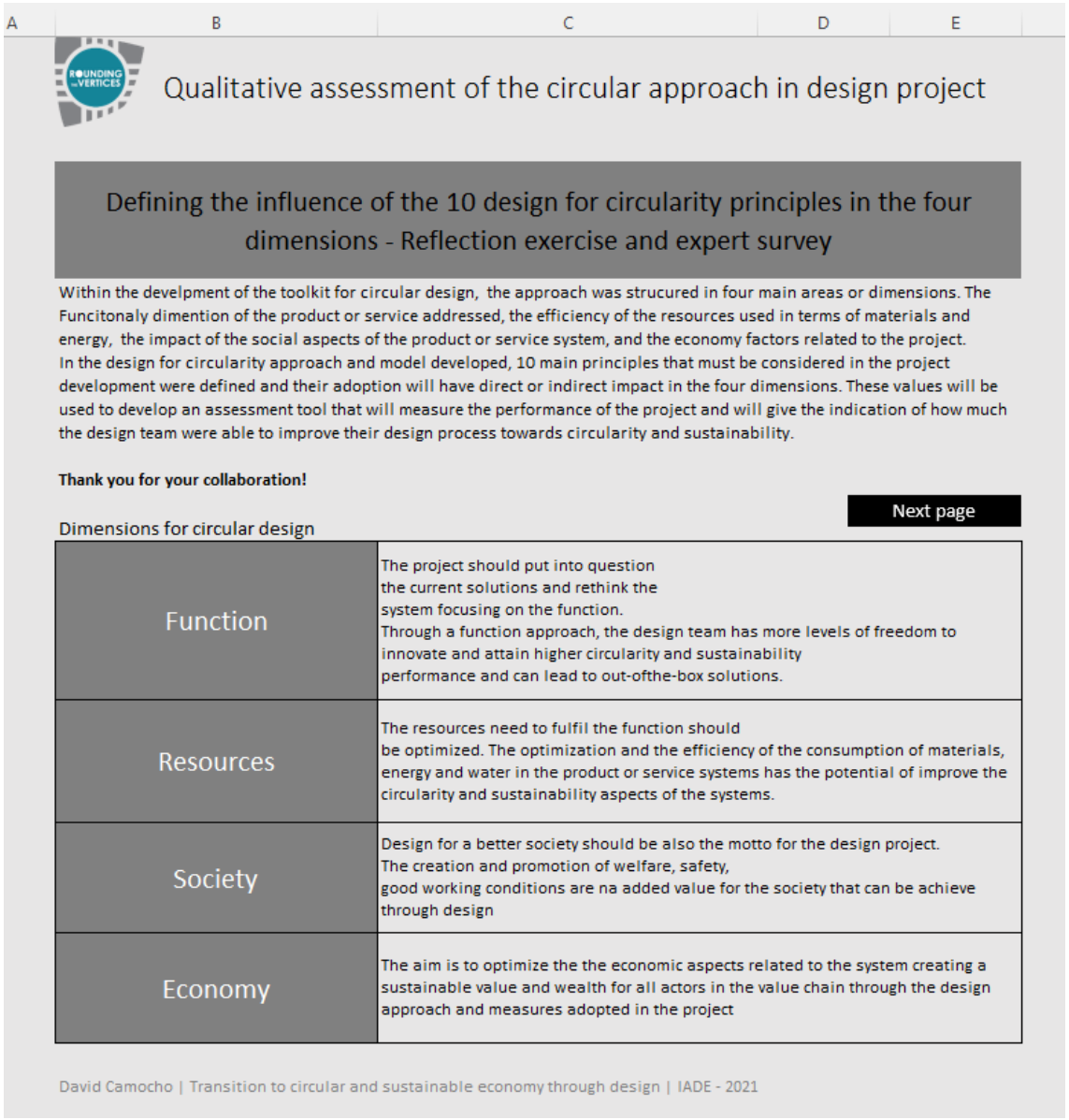
Annex 11 – Tool 3_Circular Design MBox_Excel version



Annex 12 – Tool 4_Assessent_Excel version



Annex 13 – Assessment Criteria definition



A B C D E

Qualitative assessment of the circular approach in design project

Defining the influence of the 10 design for circularity principles in the four dimensions - Reflection exercise and expert survey

Within the develpment of the toolkit for circular design, the approach was strucured in four main areas or dimensions. The Funcitonaly dimention of the product or service addressed, the efficiency of the resources used in terms of materials and energy, the impact of the social aspects of the product or service system, and the economy factors related to the project.
In the design for circularity approach and model developed, 10 main principles that must be considered in the project development were defined and their adoption will have direct or indirect impact in the four dimensions. These values will be used to develop an assessment tool that will measure the performance of the project and will give the indication of how much the design team were able to improve their design process towards circularity and sustainability.

Thank you for your collaboration!

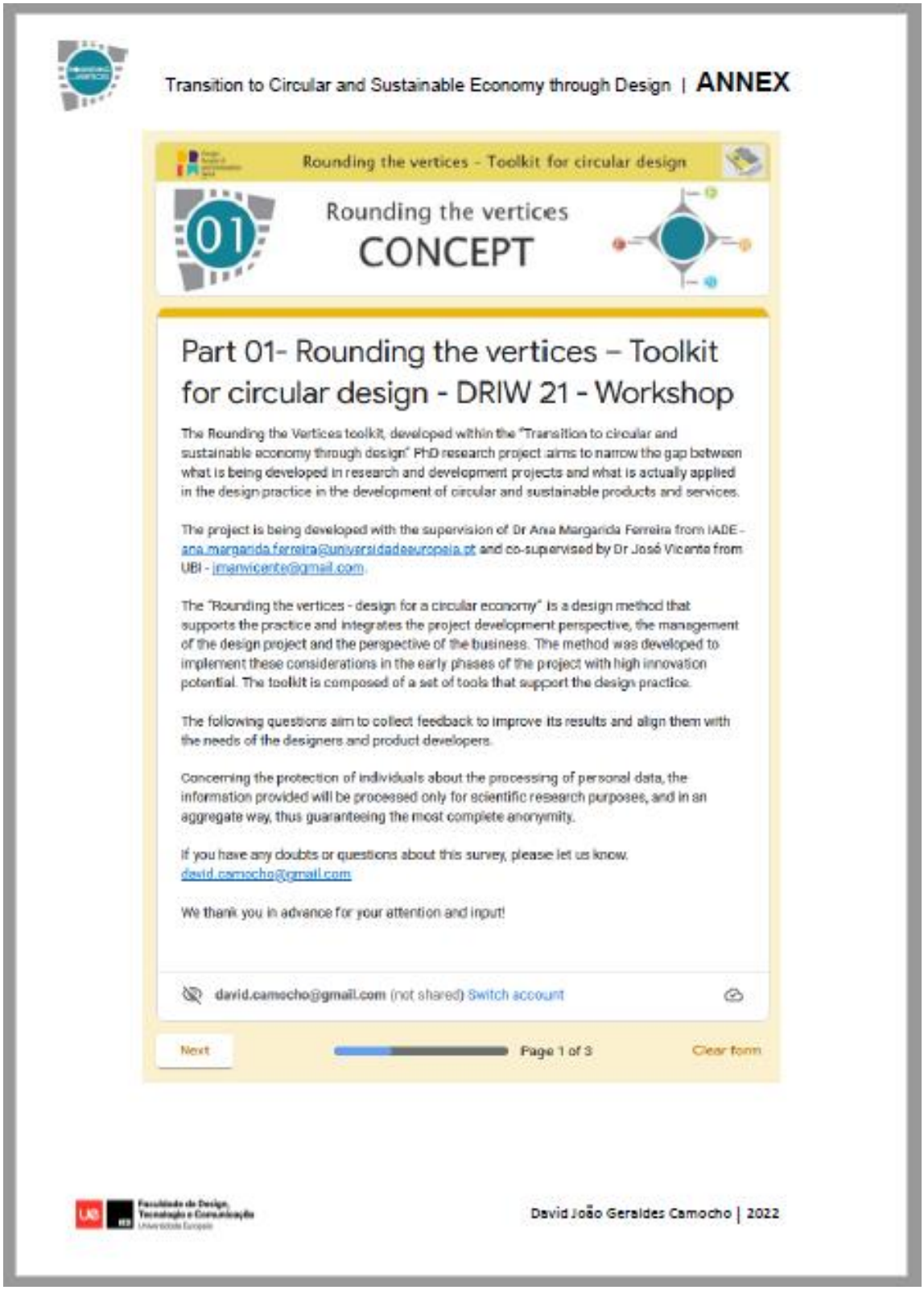
Next page

Dimensions for circular design

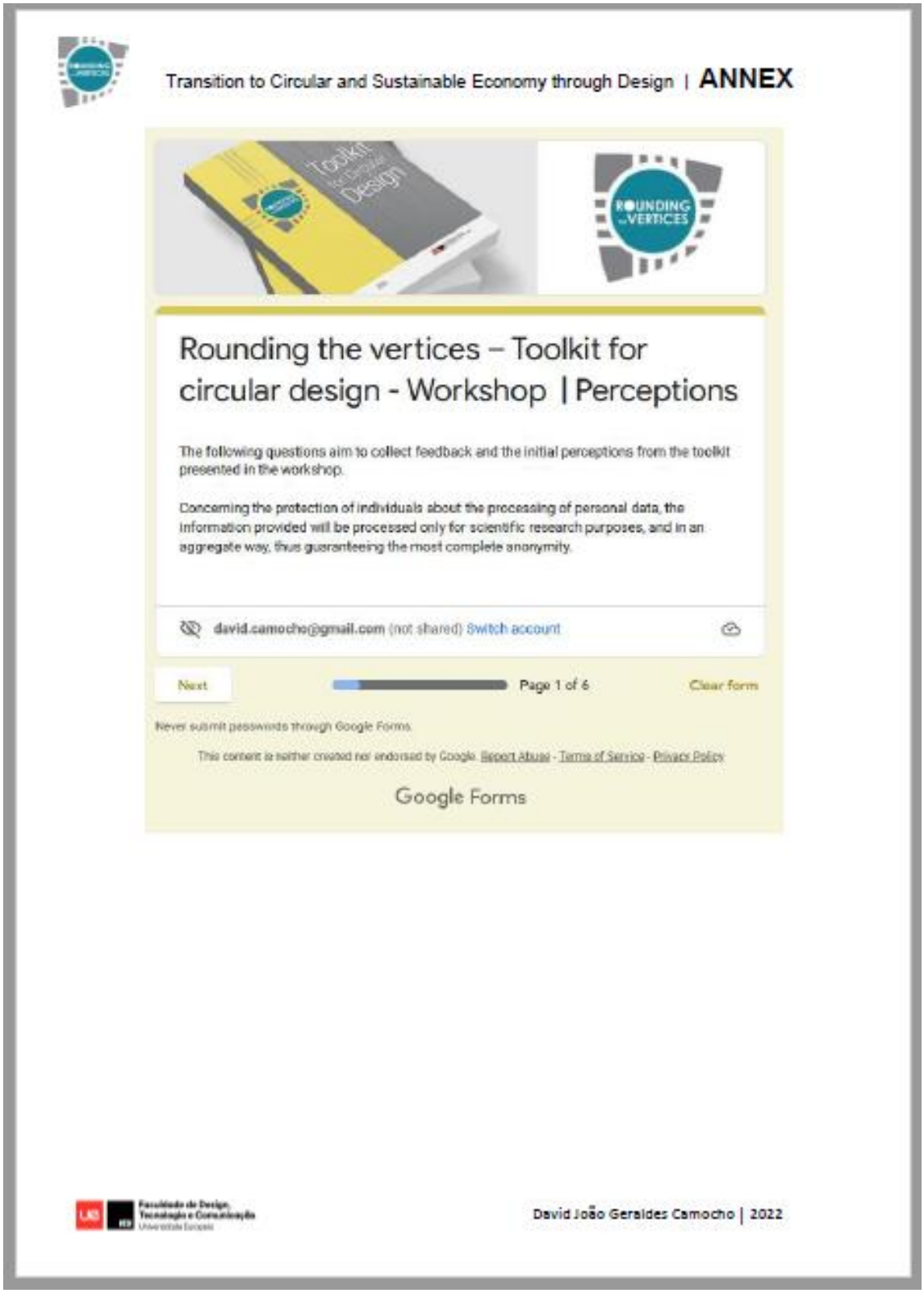
Function	The project should put into question the current solutions and rethink the system focusing on the function. Through a function approach, the design team has more levels of freedom to innovate and attain higher circularity and sustainability performance and can lead to out-ofthe-box solutions.
Resources	The resources need to fulfil the function should be optimized. The optimization and the efficiency of the consumption of materials, energy and water in the product or service systems has the potential of improve the circularity and sustainability aspects of the systems.
Society	Design for a better society should be also the motto for the design project. The creation and promotion of welfare, safety, good working conditions are na added value for the society that can be achieve through design
Economy	The aim is to optimize the the economic aspects related to the system creating a sustainable value and wealth for all actors in the value chain through the design approach and measures adopted in the project

David Camocho | Transition to circular and sustainable economy through design | IADE - 2021

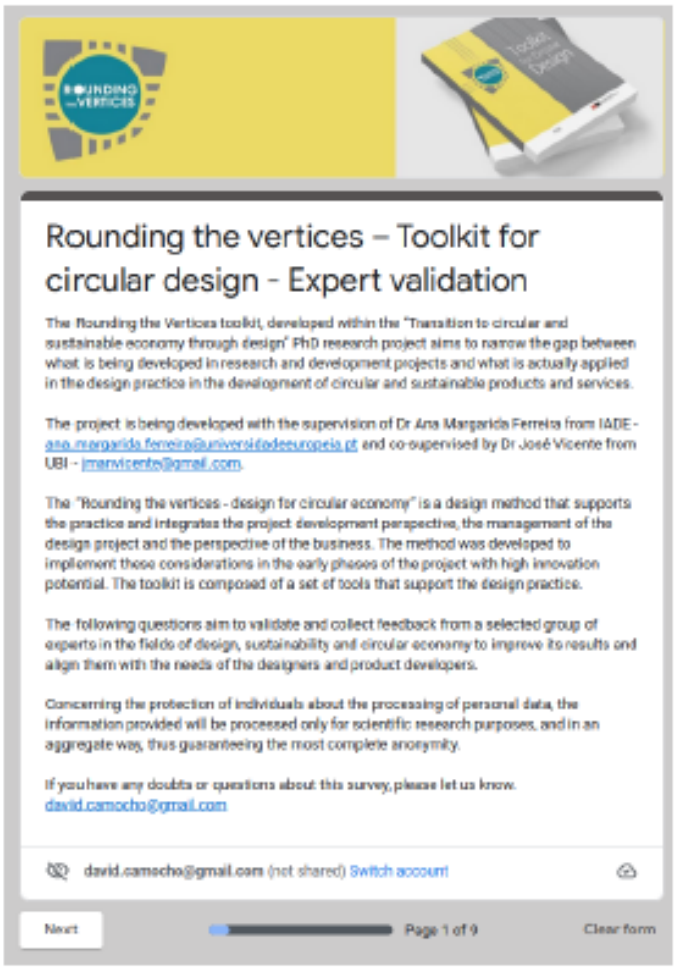
Annex 14 – Questionnaire Validation _pre test DRIW



Annex 15 – Questionnaire experts review WS Perceptions- Online



Annex 16 – Questionnaire experts review – Online



Rounding the vertices – Toolkit for circular design - Expert validation

The 'Rounding the Vertices toolkit, developed within the "Transition to circular and sustainable economy through design" PhD research project aims to narrow the gap between what is being developed in research and development projects and what is actually applied in the design practice in the development of circular and sustainable products and services.

The project is being developed with the supervision of Dr Ana Margarida Ferreira from IADE - ana.margarida.ferreira@universidadeeuropeia.pt and co-supervised by Dr José Vicente from UBI - jmarvicente@gmail.com.

The "Rounding the vertices - design for circular economy" is a design method that supports the practice and integrates the project development perspective, the management of the design project and the perspective of the business. The method was developed to implement those considerations in the early phases of the project with high innovation potential. The toolkit is composed of a set of tools that support the design practice.

The following questions aim to validate and collect feedback from a selected group of experts in the fields of design, sustainability and circular economy to improve its results and align them with the needs of the designers and product developers.

Concerning the protection of individuals about the processing of personal data, the information provided will be processed only for scientific research purposes, and in an aggregate way, thus guaranteeing the most complete anonymity.

If you have any doubts or questions about this survey, please let us know.
david.camocho@gmail.com

david.camocho@gmail.com (not shared) Switch account

Next Page 1 of 9 Clear form

Annex 17 – Paper_ TRANSition to circular and sustainable economy through design

TRANSition to circular and sustainable economy through design

ABSTRACT

This paper aims to present the research under development whose main objective is to support an effective and practical transition to a more circular and sustainable economy through design.

Currently, circular economy (CE) is gaining attention in Europe and around the world as a potential way for our society to increase prosperity and sustainability by reducing the dependence on primary materials and energy.

In this transition towards CE, numerous research projects and activities have and are being developed at distinct levels of society and design has a crucial role, however, there are still several limitations and barriers in its implementation. To implement the model, designers, product developers and companies need to be able to apply the CE principles and criteria in practice in a simple and efficient way.

The Ph.D. research project that underlies this paper was designed with the objective of supporting the creation of added value for the design professionals and for the society. Focusing on supporting the transition to the CE, the expected results will strengthen the role of design by providing professionals a strategy supported by effective methods and tools for an innovative and effective design practice.

Keywords: Design, Design tools, Design Management, Circular Economy, Sustainability

Annex 18 – Paper_ Circular economy – Tools for designers

Circular economy - Tools for designers

***David Camocho*[a]**
***José Vicente*[b]**
***Ana Margarida Ferreira*[c]**

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ABSTRACT

The circular economy is seen as a new concept and a new way of responding to the needs of society in a more sustainable and efficient way. The transition from the traditional linear model to a more innovative and circular approach in the development of the economy implies the design of new products, services, and systems, supported, in most cases, by the re-thinking and creation of innovative business models.

To achieve a successful and wide implementation, the concept must be accepted and applied in practice by businesses along the whole value chain and meet the current and future needs of consumers through design.

Several methods, principles, practices, tools, training initiatives, and many resources are being developed globally, but there is still a large gap between what is available to companies and designers, and what is applied in practice on product and service development.

This paper, aligned with a Ph.D. research project focused in the promotion of Circular Economy through design, explores results of an in-deep review of main circular economy tools available that can be used by designers to systematize and guide their development process. The analysis will be a basis for the future development of a toolkit oriented to the practical implementation of the circular economy in the design. (Camocho, Ferreira, & Vicente, 2018)

Keywords: Circular Economy, Tools, Design Practices and Principles, Innovation, Sustainability

INTRODUCTION

The Circular economy approach to the development of the society is seen as a potential solution to attain a sustainable future by increasing prosperity while reducing the critical dependence on primary materials and energy (Ellen MacArthur Foundation, 2015). In the past, during many decades, designers and other professionals have been working to achieve sustainability in the development process, aiming to increase the efficiency and innovation exploring several approaches, from cleaner production, eco-design, design for sustainability through product services systems, however, despite several good examples, mainly linked to niche markets, the results were far from been globalized and integrated widely in the society. Nowadays, Circular Economy claims to

Annex 19 – Paper_ Circular and sustainable products. From theory into practice.

Proceedings of the 19th European Roundtable for Sustainable Consumption and Production (ERSCP 2019)
Institute for Sustainability Science and Technology, Universitat Politècnica de Catalunya, Barcelona, 15-18 October 2019

Circular and sustainable products. From theory into practice.

David Camocho[1], José Vicente[2], Ana Margarida Ferreira[3]

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Abstract

Circular economy is seen as an innovative path with the potential to achieve a more sustainable society. In this context, and, facing high pressure and motivation from governments, many research projects and initiatives are being developed all over the world. However, we still have a long road ahead in translating the theory and research outputs into practice. For example, in the recently launched report "The circularity Gap report" published by Circular economy in January 2019, our society is only 9% circular and the trend is still negative, the circularity gap is not closing and the upward trend in resource extraction and greenhouse gas emissions has continued in the past 12 months (Circle economy, 2019).

In the circular approach to product and service development, which entails fundamental changes in production and consumption systems, where it is necessary to go beyond resource efficiency and recycling (European Environment Agency, 2017), it's clear the importance of design as an integrating agent in the process. Design professionals, through a redesigned approach to the design practice, applying efficient tools and comprehensive life cycle methods, have the challenge and the potential to transform products, services, and business models.

The work presented in the current paper is part of a research project (Camocho, Ferreira, & Vicente, 2018) which aims to support the transition to circular and sustainable economy through design where the authors will explore the current practice, methods, tools and communication elements applied in the development and placement in the market of products claiming to be sustainable and/or circular. The pilot study presented in the paper aims to demonstrate and validate the procedure for the analysis of the process that underlays a representative sample of Portuguese products. The research aims to identify which are the real needs, drivers and barriers faced by designers and product developers in the circular design and development process. The results of the work will underpin a holistic approach, sparking critical thinking and supporting a more efficient design practice for a circular production and consumption.

Keywords: Design, Circular Economy, Life Cycle Assessment, Sustainable Products, Sustainability

ISBN: 978-84-09-16892-7

Annex 20 – Paper_ Meeting the Circular Economy Agenda Supporting Tools for a New Strategic

Meeting the Circular Economy Agenda: Supporting Tools for a New Strategic Design Practice

Rumo aos desafios da economia circular: Ferramentas de apoio a uma nova estratégia na prática de design

Camocho, D. Vicente, J. Ferreira, A.

UNIDCOM/IADE - IADE, Universidade Europeia
UBI - Universidade da Beira Interior
UNIDCOM/IADE - IADE, Universidade Europeia

ABSTRACT: The circular economy is a new strategic concept to meet society's needs in a more efficient and sustainable manner based in decoupling the economic growth and welfare from the increase in the consumption of natural resources. It implies the transition from the traditional linear model to a more innovative and circular approach in the development of the economy by designing new products, new services, and new systems, supported, in most cases, by the re-thinking and creation of new business models.

Designers and product developers have an important and crucial role to achieve a successful and wide implementation of the concept which has to be accepted and applied in practice by businesses along the whole value chain and meet the current and future needs of consumers and the society.

Currently, several methods, principles, practices, tools, training initiatives, and many resources are being developed globally as a result of the wide exploitation of the concept, but there is still a large gap between what is available to companies and designers, and what is applied in practice on product and service development.

This paper reflects part of the PhD research project under development by the authors which is based on the promotion of the design practice within Circular Economy. It explores the results of the review of circularity tools available that can be used by design professionals to systematize and guide their development process. The analysis will support the development of a toolkit and guidelines oriented for the practical implementation of the circular economy in the development of innovative and efficient products and services. (Camocho, Ferreira, & Vicente, 2018).

KEYWORDS: Circular Economy, Design Tools, Design Practices and Principles, Innovation, Sustainability.

RESUMO: A economia circular é um novo conceito estratégico que visa responder às necessidades da sociedade de uma forma mais eficiente e sustentável que se baseia na dissociação entre crescimento económico e bem-estar do aumento do consumo de recursos naturais. Esta transição, do modelo linear tradicional para uma abordagem mais inovadora e circular no desenvolvimento da economia implica o desenvolvimento de novos produtos, novos serviços e novos sistemas, apoiados, na maioria dos casos, no repensar e na criação de novos modelos de negócio.

Os designers e os responsáveis pelo desenvolvimento de produtos têm um papel importante e crucial para alcançar uma implementação ampla e bem-sucedida do conceito. Este deve ser aceite e aplicado na prática pelas empresas ao longo de toda a cadeia de valor atendendo às necessidades atuais e futuras dos consumidores e da sociedade.

Atualmente, vários métodos, princípios, práticas, ferramentas, iniciativas de formação e outros recursos têm sido desenvolvidos globalmente como resultado da ampla exploração do conceito, no entanto, ainda existe uma grande lacuna entre o que está disponível para empresas e designers e o que é aplicado na prática no desenvolvimento de produtos e serviços.

Este artigo reflete parte do projeto de investigação de doutoramento em desenvolvimento pelos autores, o qual se baseia na promoção da prática de design no âmbito da Economia Circular. Explora os resultados da revisão de ferramentas de circularidade disponíveis que podem ser aplicadas pelos profissionais de design na sistematização e orientação do processo de desenvolvimento. Esta análise irá apoiar o desenvolvimento de um conjunto de ferramentas e orientações para a implementação prática da economia circular no desenvolvimento de produtos e serviços mais inovadores e mais eficientes. (Camocho, Ferreira & Vicente, 2018).

Annex 21- Paper_ The Common-Sense Assessment

The Common-Sense Assessment of Sustainability

David Camocho[1,2,3(✉)], José Vicente[2], and Ana Margarida Ferreira[1,2]

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Abstract. Products claiming sustainability benefits have been spreading all over the world in response, manly, to the consumer's behavior change towards a healthier and more sustainable way of life.

However, what guarantee do consumers have that the products they are consuming are in fact more sustainable? Apart from certified products, the consumer believes in a common-sense assessment of sustainability supported in part by self-declarations and allegations from designers, producers, and retailers focusing only in few aspects of the life cycle, and in some cases, misleading consumers through greenwashing approaches.

This paper is part of a Ph.D. research aiming to support a transition to circular economy and sustainability through design. The authors explore in this article the consumer perceptions of sustainability in products and communication strategies adopted. The results will support the development of guidelines to promote a more effective design practice for the development of sustainable and circular economy-based products.

Keywords: Design · Circular economy · Consumer perception · Common-sense assessment · Sustainability assessment · Sustainability

1 Introduction

The paper presents the research under development which aims to help the transition to a more sustainable and circular economy through design. The authors believe that design practice has a crucial role in defining the characteristic of the products and services that fulfill the needs of society. Also, that their impacts in the life cycle are defined in the design and development phase. In order to promote design and the practice of design, it is important to understand how eco and sustainable products and services are developed and placed on the market, how they communicate to users their

R. H. M. Goossens and A. Murata (Eds.): AHFE 2019, AISC 970, pp. 114–125, 2020.
https://doi.org/10.1007/978-3-030-20145-6_11

Annex 22 – Paper_ Circular and Sustainable Design A systemic design model for the transition to a circular and sustainable economy

Circular and Sustainable Design: A systemic design model for the transition to a circular and sustainable economy

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Abstract

Successful and innovative design practices towards the development of more circular and sustainable products and services that are aligned with the current and future needs of our society rely on efficient practices that combine three main levels in the design and development process. The design management level which is responsible for establishing, planning and managing the development of design projects. The business level, which is focused on the feasibility and effectiveness of the project and its results in the short and long term. Lastly, the design level that is responsible for the implementation and development of circular design projects. This paper is part of a PhD research focused on supporting an innovative and efficient transition to a circular economy and sustainability through design. It describes the basis of a design model under development based on the design thinking process and an expert's survey carried at an international level and the research activities undertaken. It integrates the three levels in a systemic perspective, guiding the process and establishing the link between the needs of the design and development teams in terms of the definition of circularity and sustainability considerations and strategies, objectives and the activities, resources and practical tools needed to support the circular design projects.

Keywords: Design, Circular economy, Sustainability, Design systemic model

Introduction

To achieve sustainability and the transition to a Circular Economy (CE), we need to shift to a more innovative and effective way to fulfil the needs of the society and change the paradigm of production and consumption of products and services. The way we design, produce, use, distribute and discard products has a strong impact on the economy, the society and the environment (European Commission, 2019) and design practice are seen as a catalyst to shift from the traditional model of take-make-dispose to achieve a more restorative, regenerative and circular economy (Moreno, De los Rios, Rowe & Charnley, 2016). However, the approaches proposed so far in the field of design and innovation have not addressed and promoted significant changes at the system level (Idil Gaziulusoy, 2015) and designers who have the function of translating the strategies and concepts of circularity in the development of products and services that promote the closing of cycles, the efficiency, and sustainability of the systems, are challenged by new environmental, social and economic needs must adopt a holistic approach to problem-solving (Bocken, de Pauw, Bakker & van der Grinten, 2016) taking into account that most of the characteristics of the entire life cycle of a product are defined in the design stage.

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