

# Exploring Circularity Toolkits for SMEs Learning Ecosystems.

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**Abstract.** This research explores the role of Circular Design and education in facilitating the transition to a Circular Economy for SMEs and start-ups. Despite accessible resources in Circular Design, the extent of their adoption by businesses—and especially SMEs, who face resource limitations and lack scientific access—remains uncertain. Circular Design operates at a systemic level, requiring consideration of economic, social, and environmental aspects in innovation processes. This study analyzes existing tools and their alignment with SME needs, identifying critical areas for Circular Design adoption. The analysis reveals an emerging and diverse set of resources supporting circular transitions. Learning Ecosystems for the Circular Economy are characterized by multi-sectoral partnerships, flexible learning approaches, and digital advancements. Three key directions emerge for developing Learning Ecosystems: assessing companies' circular maturity, integrating circular design into company culture, and fostering collaboration with innovation ecosystems. In conclusion, this research lays the groundwork for implementing targeted Learning Ecosystems to advance circularity within SMEs, emphasizing the importance of collaboration and innovative approaches in circular innovation.

**Keywords:** Circular Economy, Circular Design, Design Thinking, Sustainable Entrepreneurship, Learning Ecosystems

## 1 Introduction

This contribution investigates the relevance of Circular Design and the development of circular capabilities for Small Medium Enterprises (SMEs). It primarily focuses on the study, mapping, and analysis of tools and toolboxes for Circular Design with the objective of understanding and identifying the strategic elements to consider in designing learning ecosystems for SMEs that have the will or need to implement circular approaches. The first part of the contribution explores the scientific literature understanding the relevance of the Circular Economy (CE) and Circular Design for SMEs and framing the development of circular capabilities within SMEs' ecosystems. This is a critical aspect of the transition to a circular economy, particularly crucial for SMEs. The second part of the contribution explores a repertoire of online tools for Circular Design selected through desk research with the aim of verifying and understanding whether and how they operate in developing skills related to circular

transition and innovation for SMEs. The analysis of the case studies aims to verify and comprehend the actions taken and those left undone by entities engaged in supporting SMEs in acquiring skills for transitioning to circular innovation. The third part of the contribution, starting from the results of the mapping and analysis of Circular Design tools, identifies several elements to be considered when designing Learning Ecosystems for SMEs to better participate in Circular Economy.

The present document has been developed within the framework of the Circuloop Project, a research initiative funded by the Lithuanian government (2022-2023) aimed at developing a digital platform to support Lithuanian SMEs in designing circular product-service offerings. The original contribution of this work lies in mapping and analyzing online tools dedicated to developing skills for Circular Design. The results of this study have been used to verify both the alignment and originality of the Circular Design tools implemented by a digital platform. The development directions identified in this contribution can be considered and used by organizations intending to design online tools to support the development of Circular Design skills within a specific territorial or sectoral context.

## **2 Relevance of the Circular Economy and Circular Design for SMEs**

In the emerging Circular Economy paradigm, Circular Design represents a strategic resource for fostering the circular transition and innovation of SMEs (and start-ups). There is a growing body of literature related to training — in terms of methods and tools — to transfer Circular Design knowledge and skills to businesses (especially SMEs). In parallel, there is also a growing body of tools (often online, often free) dedicated to Circular Design training, learning, and education that are easily accessible by SMEs. These tools are developed or endorsed by global organizations such as the Ellen MacArthur Foundation and, locally and nationally, by a growing number of universities, research centers, and innovation advisory agencies that are quickly developing training resources dedicated to this topic. Why is it important for SMEs to gain knowledge and skills in Circular Design? According to 2021 Organization for Economic Cooperation and Development (OECD) data, SMEs account for about 90 percent of enterprises in all OECD countries. In addition, according to 2020 World Bank research, SMEs make up 90 percent of enterprises worldwide and provide 50 percent of global employment. While large enterprises can attract a lot of attention to environmental issues and act very quickly on the circular transition front thanks to their visibility and size, SMEs represent most enterprises worldwide and play a vital role in the global economy and, thus, the Circular Economy. The Circular Economy requires all companies to make systemic changes, which are more complex and difficult for smaller organizations to implement. Limited human and economic resources, hard-to-access competitive research systems, and fewer opportunities for investment in technology and production processes represent barriers for many SMEs. This argument also applies to start-up organizations. Generally, they have greater sensitivity to circular issues but often lack the on-the-ground experience needed to operate effectively in circular economic systems.

Circular Design is closely connected with the ability to operate at the scale of the systems and manage the complexity of innovation processes characterized by the involvement of multiple actors. It means that designers and entrepreneurs must organize, systematize, and evaluate various data and information balancing economic, social, and environmental aspects. The complexity of the Circular Economy, therefore, requires the development of new visions on how to train designers and entrepreneurs to address systemic problems and define innovation challenges from conceptual and operational perspectives. Interesting approaches and tools have already been developed to use Design Thinking in a Circular Economy framework. However, these tend to be self-taught or very academic and might not provide the proper support to entrepreneurs, especially SMEs, that want to ideate, develop, and distribute their circular products and/or services. In particular, this contribution aims to understand: i) what are the main circular capabilities that SMEs need to develop; ii) what emerges from previous studies that have addressed this topic and what are the existing tools for Circular Design that have already been developed and are in use; iii) how these tools address circularity issues for SMEs' innovation and how they can contribute to implementing an SMEs Learning Ecosystem focused on circularity.

### **3 Development of the circular capabilities of SMEs' ecosystems**

The Circular Economy and Circular Design are related, complementary, and interconnected concepts that contribute to the same overarching goal of sustainability and resource efficiency. Both concepts aim to minimize environmental impact, maximize resource utilization, and foster a shift away from the traditional linear economy. A Circular Economy is an economic system that seeks to eliminate waste, reduce resource consumption, and promote the regeneration of natural systems. It operates under three main principles: designing out waste and pollution, keeping products and materials in use, and regenerating natural systems. In it, the value of products and materials is maintained for as long as possible, leading to resource optimization and reduced environmental impact. As Del Vecchio et al. (2021) say: "...Circular Economy (CE) is a topic trend of growing interest in the public debate (Urbinati et al., 2017; Lahti et al., 2018; Centobelli et al., 2020; Ferasso et al., 2020). Aimed to promote sustainable production and consumption models able to close resource loops (Ghisellini et al., 2016; Moggi et al., 2018), CE has been recently proposed as an alternative paradigm for socio-economic development and a promising base for achievement of sustainable development goals (Schaltegger and Wagner, 2011; Centobelli et al., 2020). Companies, universities and research centers, institutions and citizens are called to contribute to the transition process of production, distribution, and consumption systems toward a circular configuration..."

On the other hand, Circular Design is a design approach that focuses on creating products, services, and systems that support the principles of the Circular Economy. Circular Design aims to develop innovative solutions that extend product life cycles, enable easy repair and maintenance, and facilitate efficient recycling and reuse of materials. It also considers the environmental and social impacts throughout the entire life cycle of a product-service system. Suárez-Eiroa et al. (2019) think that design is one of the most important enablers for the success of the CE operational principles

(among those we want to highlight closing the system through the so-called “Reduce, Reuse, Recycle philosophy” (3R philosophy), reducing the system's size, maintaining resource value within the system):

"...There is a total consensus in the scientific literature about the importance of design within the CE framework (Kalmykova et al., 2018; B. Suarez-Eiroa et al., 2019; Korhonen et al., 2018). Design covers multiple perspectives of the CE model. For instance, a product can be designed to be easily recovered and recycled, easily repaired, or easily removable into modules, among other possibilities. These actions take part in the eco-design concept, an essential key to guarantee the success of CE (Sauve et al., 2016; Elia et al., 2017). Innovation is also needed in social, organizational, financial, or political issues. These necessary actions can be located under the scope of eco-innovation, what according to Kemp and Pearson (2007), is 'the production, assimilation or exploitation of a product, production process, service or management or business method that is novel to the organization (developing or adopting it) and which results, throughout its life cycle, in a reduction of environmental risk, pollution and other negative impacts of resources use (including energy use) compared to relevant alternatives'. Toxopeus et al. (2015) emphasize the idea that innovation is a driving process toward the new paradigm, in contraposition to the simple optimization of processes. Designing for a CE covers fundamental issues to lead the transformation process from a linear production-consumption model into a circular one (de Jesus et al., 2016; Prieto-Sandoval et al., 2018) ...".

**Table 1.** Practical strategies of Circular Economy grouped by the proposed operational principles. Synthesis of the table presented in Suárez-Eiroa, B., Fernández, E., Méndez-Martínez, G., & Soto-Oñate, D (2019) *Journal of Cleaner Production*. 214, pp.952-961.

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*Practical strategies of Circular Economy grouped by the proposed operational principles*

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*Principle 1: Adjusting inputs to the system to regeneration rates*

- Substituting non-renewable with renewable inputs.
- Substituting renewable materials with low regeneration rates with others with faster regeneration rates.
- Adjusting taxes and subsidies of technology, products, and materials based on their resource regeneration rates.
- Saving energy and materials.
- Fostering renewable mobility.

*Principle 2: Adjusting outputs from the system to absorption rates*

- Substituting materials and processes which produce technical outputs with those which produce biological outputs.
- Substituting processes with higher waste generation rates for those with lower waste generation rates.
- Adjusting taxes and subsidies of technology, products, and materials based on waste generation rates.

*Principle 3: Closing the system*

- Separating biological and technical wastes properly.
- Re-manufacturing products and components.
- Promoting and improving downcycling, recycling, and upcycling of wastes.
- Promoting energy recovery by converting waste into heat, electricity, or fuel.
- Promoting Extended Producer Responsibility.

*Principle 4: Maintaining resource value within the system*

- Interconnecting stages.
- Promoting industrial symbiosis.
- Increasing durability.

- Reducing obsolescence.

*Principle 5: Reducing the system's size*

- Informing consumers properly.
- Expanding the Extended Consumer Responsibility.
- Promoting functional service economy and sharing economy.
- Promoting green procurement.
- Adjusting selling doses to consumer doses.

*Principle 6: Designing for circular economy*

- Eco-design.
- Designing transparent, reproducible, and scalable products to build the same products in other places based on local resources.
- Thinking about practical utilities and consumer preferences (customization/made to order).
- Designing new business models and strategies.
- Designing new methodologies to guarantee continuous improvement.
- Designing projects to promote sustainable development and the Circular Economy.

*Principle 7: Educating for circular economy*

- Adjusting educational curricula to the current challenges.
  - Promoting knowledge, skills, capabilities, and values that ensure the proper performance of the Circular Economy.
  - Promoting habits and individual actions in favor of the Circular Economy.
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Organizations with a global or supranational scope, like the European Commission and the Ellen MacArthur Foundation, actively advocate Circular Economy (CE) strategies and concepts across various sectors, including industrial design, manufacturing, consumption, education, and training. Their guidelines and strategic plans emphasize the importance of human capital in achieving a Circular Economy. As the Ellen MacArthur Foundation (2015) states, the Circular Economy serves as a growth model that fosters more efficient resource management in economic pursuits and devises innovative and alternative solutions for waste generation and handling, resulting in both social and economic advantages. Again as Del Vecchio et al. (2021) say: "...These considerations allow us to assume that the debate on CE, therefore, can also be rooted in the paradigm of entrepreneurship as a core process to advance knowledge on technical domains for valuable and sustainable innovation. Looking at CE from the entrepreneurship perspective means investigating the dynamics related to the innovation process supporting the creation of innovative entrepreneurship as well as the competencies of human capital called to depict and implement the transition process required by the CE (Kirchherr and Piscicelli, 2019). This requires developing integrated learning programmes able to mix the different perspectives of CE to overcome fragmentation of the initiatives that until now were focused on specific aspects such as *design thinking* or engineering issues..."

## **4 Relevance of education and design for Circular Economy development**

As Suárez-Eiroa et al. (2019) suggest, education is a critical factor in ensuring the success of the Circular Economy (CE). Implementing CE strategies necessitates the integration of various values, knowledge, and skills (De los Rios and Charnley, 2017). CE aims to examine product life cycles holistically, considering the interconnectedness

of processes. It requires a paradigm shift that engages all social actors to promote collaboration (Ghisellini et al., 2016). Successful design and collaboration with other industries under this new paradigm demand enhancement of personal and social skills (EEA, 2016). From the user's standpoint, scientific literature has widely discussed establishing a new consumption culture. It is acknowledged that increased demand for sustainable products drives their production (Kirchherr et al., 2018). A consumption culture that addresses needs and avoids property accumulation is essential, and education serves as a tool to combat this mindset. Bonciu (2014) asserts that CE entails altering producers' and consumers' education, values, and behavior. In summary, education is a cross-cutting issue with the potential to drive the development and expansion of CE.

The latest European Commission Strategic document, A New Circular Economy Action Plan For a cleaner and more competitive Europe (EC, 2020), wants to address the challenges launched by the European Green Deal with "... concerted strategy for a climate-neutral, resource-efficient and competitive economy. Scaling up the circular economy from front-runners to the mainstream economic players will make a decisive contribution to achieving climate neutrality by 2050 and decoupling economic growth from resource use while ensuring the long-term competitiveness of the EU and leaving no one behind..." (EC, 2020). It might be an occasion for strengthening the EU's industrial base and developing new business models and entrepreneurship, mainly constituted by SMEs, and developing a European CE model that might build: "... high-quality, functional and safe products, which are efficient and affordable, last longer and are designed for reuse, repair, and high-quality recycling. A whole new range of sustainable services, product-as-service models and digital solutions will bring about a better quality of life, innovative jobs and upgraded knowledge and skills..." (EC, 2020). This future-oriented political agenda is a pivot for designing and co-creating with the economic actors, consumers, citizens, and civil society organizations: "...The plan presents a set of interrelated initiatives to establish a strong and coherent product policy framework that will make sustainable products, services and business models the norm and transform consumption patterns so that no waste is produced in the first place. This product policy framework will be progressively rolled out, while key product value chains will be addressed as a matter of priority. Further measures will be put in place to reduce waste and ensure that the EU has a well-functioning internal market for high quality secondary raw materials. The capacity of the EU to take responsibility for its waste will also be strengthened..." (EC, 2020). In the Action Plan, Sustainability Principles are also presented to address the design of sustainable products.

**Table 2.** Sustainability principles for the Circular Economy Action Plan. Source: European Commission (EC), 2020.

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*Sustainability principles for the Circular Economy Action Plan*

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- Improving product durability, reusability, upgradability, and reparability, addressing the presence of hazardous chemicals in products, increasing their energy and resource efficiency.
- Increasing recycled content in products, while ensuring their performance and safety.
- Enabling remanufacturing and high-quality recycling.
- Reducing carbon and environmental footprints.
- Restricting single-use and countering premature obsolescence.
- Introducing a ban on the destruction of unsold durable goods.

- Incentivizing product-as-a-service or other models where producers keep the ownership of the product or the responsibility for its performance throughout its lifecycle.
  - Mobilizing the potential of digitalization of product information, including solutions such as digital passports, tagging and watermarks.
  - Rewarding products based on their different sustainability performance, including by linking high performance levels to incentives.
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These principles might also be considered an action platform in which other influential players act. The Ellen MacArthur Foundation (EMF) is undoubtedly the global reference organization that promotes the transition to a CE, with a strong focus on the involvement of businesses and policymakers as drivers of systemic change. EMF is certainly an exemplary case to start with to frame the evolution and dissemination of methods and tools of Circular Design for organizations, including businesses. At a general level, EMF considers design a strategic resource for the CE because waste and pollution are the results of design decisions, and CE principles can be incorporated into the design process to prevent waste and regenerate nature. EMF argues that the CE requires a radical rethinking of how we design, and designers can play a crucial role in this transition by applying Circular Design practices characterized by a systemic, collaborative, and community-based approach to innovation. A key area for the EMF approach is supporting small- and medium-sized enterprises in transitioning to circularity-based innovation and business models. When faced with the challenges of systemic change and the possibility/need to adopt circular practices, SMEs may have various types of gaps to fill—organizational and (infrastructural) gaps, knowledge, and competence gaps—and limited human and economic resources. EMF has co-developed a wide range of resources and learning tools dedicated to the Circular Economy that are freely accessible to the companies. Among them is the Circular Design Guide, co-developed by IDEO and EMF, which probably represents the most famous example of a practical framework that supports designers and businesses to create sustainable and circular products, services, and systems.

The development of a tool such as the Circular Design Guide raises specific research questions: is it an exceptional and unique case, or are we witnessing a broader and emerging phenomenon? Who are the entities promoting these tools and why? How many tools for circular design are targeted at businesses, especially SMEs? How can we assess the effectiveness of these tools in transferring knowledge and skills on Circular Design to SMEs? How can we analyze these tools to understand how and in what ways they are being or can be used by SMEs?

To address these questions, the following sections focus on the development of a research project with the aim of:

- examining the state of the art regarding the presence and characteristics of studies mapping and analyzing tools for Circular Design;
- identifying Circular Design tools and assess their strengths and weaknesses in relation to SMEs, examining how businesses access these resources and how they can leverage them in the processes of designing, researching, developing, and prototyping circular product-service systems;
- identifying, based on the outcomes of the analyses, focal points for reflection and potential directions that can support institutions and organizations in the development of tools for Circular Design.

## 5 Mapping tools and toolkits for Circular Design

Circular Design is a relatively new approach based on applying CE principles to the design of products and services. Its profile has been raised in recent years due to the increased awareness of environmental and social crises. Designers, entrepreneurs, companies, and institutions started using Circular Design as a strategy for developing sustainable solutions to emerging challenges. The use of Circular Design tools, toolkits, and toolboxes can be traced back to the development of the CE concept. Some of these tools comes from the field of management and are derived from Design Thinking methods. For example, one of the first and most well-known circular design tools is the Cradle to Cradle (C2C) certification, which was introduced in 2005. These tools declare to provide designers and businesses with practical guidance and helpful resources for applying circular design principles to their processes.

A recent body of scholarly publications (Moreno et al., 2017; Camacho-Otero et al., 2018; Kravcenko et al., 2019; Lidgreen et al., 2020; Butkovic et al., 2023;) start to analyze the tools for Circular Economy. The emerging themes range from defining the processes for evaluating the use and effectiveness of these tools to developing conceptual frameworks and suitable Circular Design strategies to be employed in the development of the tools. Systematic Literature Review studies conducted over a decade of scientific literature on the CE (Kondala et al., 2023) highlight among the main barriers to SMEs' adoption of CE the lack of know-how, financial resources, dedicated policies and regulations, collaboration, and support from academic institutions. The adoption of CE practices in SMEs is linked to self-motivation and the activation of organizational learning, influenced by policymakers and customers (Dey et al., 2022; Scipioni et al., 2021). Much of the literature analyzes circularity by attributing significance to the reorganization of companies' supply chains, while it is often overlooked during the product design phases, especially the initial ones (Saidani et al. 2020). This is confirmed by the analysis of Scopus database publications containing systematic studies dedicated to circular design tools. The results reveal only publications that analyze parameters about useful life extension in 70 tools and methods related to eco-design and circular economy (Royo et al., 2023).

There are another four publications regarding the development of specific circular design toolkits, including one dedicated to product design (Tetiana and Cluzel, 2023), two focused on user-centered design of products and services (Rexfelt and Selvefors, 2021), and one on behavioral design (Chu et al., 2021). In Royo et al.'s contribution, it is revealed that studies on tools for eco-design date back to the early 2000s and were focused on the analysis of eco-design processes (Baumann et al., 2002; Byggeth & Hochschorner, 2006; Ritzén, 2000). More recent studies, however, have shifted their focus to the challenges of businesses adopting these tools (Tyl et al., 2014; Rossi et al., 2016; Rousseaux et al., 2017; Bovea and Pérez-Belis, 2012). Furthermore, only 6 out of the 55 tools analyzed concentrate on indicating multiple circularity parameters. These tools are more recent, starting from 2014 onwards. The literature analysis indicates that there is room to conduct an original study updating the mapping of the most recent and widely used tools for circular design, considering the latest developments in the concepts of circular economy and circularity. Additionally, it



considers the role of digital transformation in facilitating the release of these tools online for broader access and use.

A study aimed at mapping and subsequently analyzing exemplary cases of circular design tools and toolkits utilized a methodology based on *desk research* and structured in three phases: i) first selection of cases; ii) second selection and brief description of exemplary cases; iii) mapping circular innovation toolkits for Learning Ecosystems.

### 5.1 First selection of cases

The first phase of case selection was carried out through desk research based aimed at identifying and selecting a broader set of cases of tools designed by scholars, designers, and organizations of various types.

The basic criteria adopted for the initial identification of cases are:

- adherence of the tools to the principles and practices of the CE;
- accessibility of the tools for businesses, especially SMEs, ensuring they can access and use/apply the tools;
- adaptability of the tools to different contexts and sectors.

The first selection phase identified a set of 20 different cases of tools, toolkits, and toolboxes related to Circular Design and Circular Innovation has been identified (See Tab.3).

**Table 3.** First set of exemplary cases of tools, toolkits, toolboxes and platforms for Circular Design and Circular Innovation.

Tool name (link)	Authors / Organizations	Scope of the tool
1. <i>Circular Design Guide</i> ( <a href="http://circulardesignguide.com">circulardesignguide.com</a> )	A collaboration between Ellen MacArthur Foundation and IDEO	Toolkit to support designers, entrepreneurs, policymakers in designing sustainable and regenerative solutions for a circular economy.
2. <i>Cradle to Cradle certification</i> ( <a href="http://c2ccertified.org">c2ccertified.org</a> )	Cradle to Cradle Products Innovation Institute	Holistic approach to product certification ensuring sustainability and circularity.
3. <i>Scale360° Playbook</i> ( <a href="http://weforum.org">weforum.org</a> )	World Economic Forum	Multi-media toolkit for circular innovation for technologists, researchers, entrepreneurs, and governments.
4. <i>Circulytics</i> ( <a href="http://ellenmacarthurfoundation.org">ellenmacarthurfoundation.org</a> )	Ellen MacArthur Foundation	Measuring tool to support a company's transition towards the circular economy.
5. <i>Systemic Design Toolkit</i> ( <a href="http://systemicdesign toolkit.org">systemicdesign toolkit.org</a> )	A collaboration between Namahn and shiftN	Toolkit to design interventions for creating impact in complex systems.
6. <i>Circular Design Toolkit - Ecodesign Circle Project</i> ( <a href="http://circulardesign.tools">circulardesign.tools</a> )	German Environment Agency (Project Coord.)	EU Project (Interreg) to develop tools, methods and communication strategies for designers, eco-experts, and every organisation or

		individual dedicate to make a change by design.
7. <i>Circular Design Praxis</i> ( <a href="http://circulardesignpraxis.org">circulardesignpraxis.org</a> )	Collaboration between Keio University, RMIT University, and University of Melbourne	Think tank that promotes circular projects rooted in local cultures and vernacular practices.
8. <i>Circular Design</i> ( <a href="http://circulardesign.it">circulardesign.it</a> )	IUAV Venezia (The project is the output of a PhD Research)	Open-source collection of systemic design strategies to accelerate the circular economy.
9. <i>Circular Design Journey and Circuloop Platform</i> ( <a href="http://circuloop.lt/app/#/">circuloop.lt/app/#/</a> )	Kaunas Technology University	Toolkit and digital platform to support Lithuanian professionals and companies in designing circular product-services.
10. <i>Design for Planet</i> ( <a href="http://designcouncil.org.uk/our-mission">designcouncil.org.uk/our-mission</a> )	Design Council UK	An initiative promoting design-led solutions for environmental sustainability and a greener future implemented by designers, entrepreneurs, and policymakers.
11. <i>Circular Toolbox</i> <a href="http://Openresearch.amsterdam">Openresearch.amsterdam</a> ( <a href="http://openresearch.amsterdam">openresearch.amsterdam</a> )	Municipality of Amsterdam	An online set of tools and knowledge to foster the transition to a circular economy.
12. <i>Designing Your Circular Transition Toolkit</i> ( <a href="http://ddc.dk/tools/designing-your-circular-transition">ddc.dk/tools/designing-your-circular-transition</a> )	Danish Design Center	A toolkit to support organizations in the process of transitioning towards a circular economy.
13. <i>Circular Innovation Lab</i> ( <a href="http://circularinnovationlab.com">circularinnovationlab.com</a> )	Circular Innovation Lab (non-profit organization)	Danish think tank that collaborates with national governments, UN agencies, and international organizations to create circular economy solutions. (from the ideation to implementation and monitoring).
14. <i>Circle Lab</i> ( <a href="http://circle-economy.com">circle-economy.com</a> )	Circle Economy (non-profit organization)	An online platform for cities, businesses, and citizens to explore, brainstorm, and implement circular business models and strategies.
15. <i>Blue City</i> ( <a href="http://bluecity.nl">bluecity.nl</a> )	Rotterdam Circular – Municipality of Rotterdam	An incubator and Innovation Lab for circular companies established in Rotterdam and its Region.

16. <i>Centre for Circular Design</i> ( <a href="http://circulardesign.org.uk">circulardesign.org.uk</a> )	University of Arts London	Research and thinking tools to help designers develop their understanding of the challenges and opportunities that circular design offer.
17. <i>Circular Design Network</i> ( <a href="http://circinnovation.com">circinnovation.com</a> )	Aalto University, GTK, Luke, SYKE, and VTT	Project to create a research network and community supporting data-driven circular economy in Finland.
18. <i>Use2Use Design Toolkit</i> ( <a href="http://use2use.se/toolkit">use2use.se/toolkit</a> )	Chalmers University of Technology and RISE	Set of tools to design circular products and services adopting a user perspective.
19. <i>Circularity Deck</i> ( <a href="http://circularitydeck.com">circularitydeck.com</a> )	Delft University of Technology (Dr. Jan Konietzko)	A learning and organizing tool for the circular economy. For sustainability managers, entrepreneurs, and designers.
20. <i>Circular Design Toolbox</i> ( <i>Circulab Academy</i> - <a href="http://circulab.com">circulab.com</a> )	Circulab (independent design studio and strategy consulting agency)	A toolbox to rethink projects – from the business model to partnerships and value chains, considering the social, economic, and natural context. Circulab Academy is a digital platform for learning.

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The diagram shown in Figure 1 provides a final comparative overview of the 20 selected tools in the initial desk research phase. For each of the 20 cases, the following aspects were examined:

- the type of entity/entities that developed the tool;
- the types of beneficiaries of the tool;
- whether the tool has local, national, and/or international reach;
- whether the tool offers one or more resources and services facilitating the transfer of knowledge on circular design.

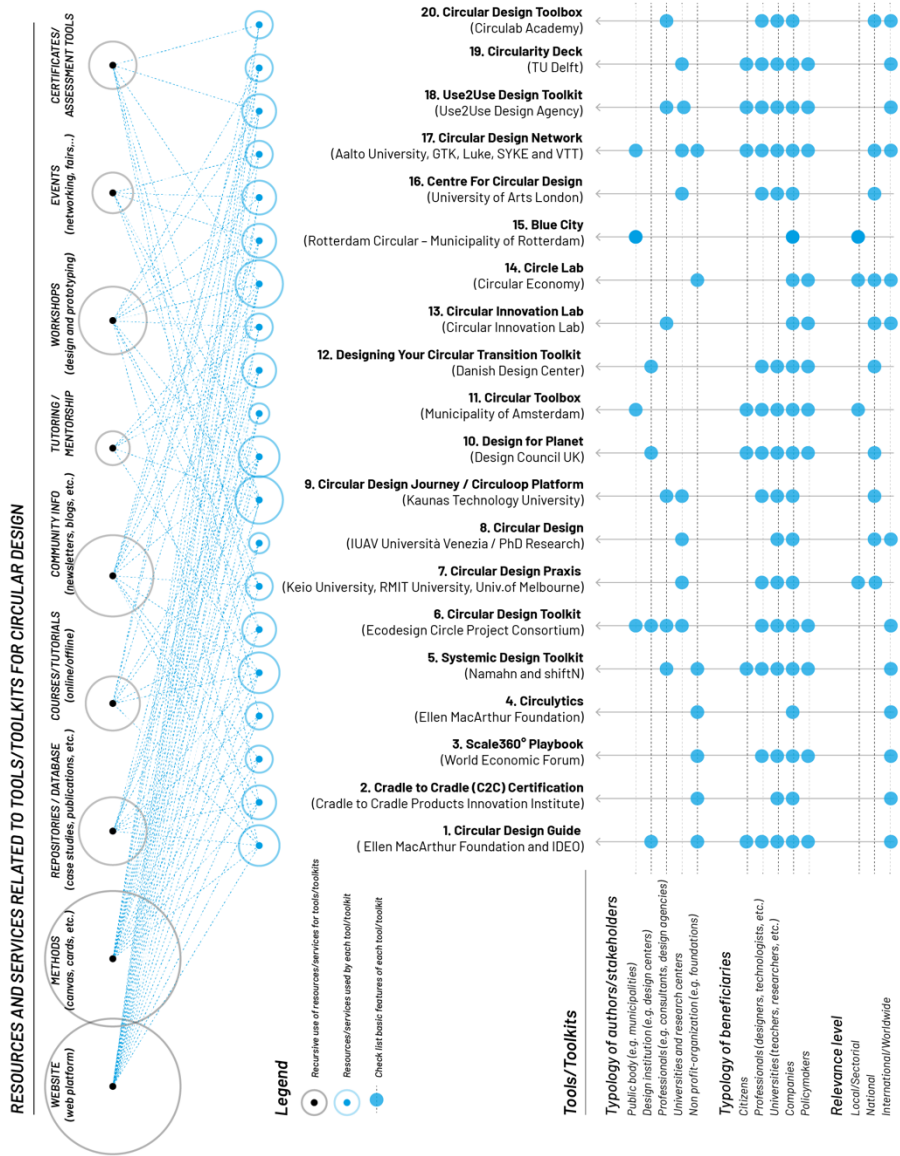
From the initial list of exemplary cases, a diverse range of tools, resources, and services developed by various organizations emerges, united by their interest in the development of the CE. Overall, these tools support designers (professionals, students, and enthusiasts), businesses, and policymakers in the different stages of ideation and definition of circular product and service solutions. In some cases, advanced services such as certification of circular products, start-up support for circular businesses, strategic data management in circular economy processes, and the organization of dedicated circular economy events are highlighted.

The website/web platform is an indispensable tool for promoting the transfer of knowledge on Circular Design because it allows the dissemination of tools and methods (e.g., canvas, maps, cards, etc.) closely aligned with the culture of design thinking. These tools are easily accessible and can be used independently.

At a second level of importance, we find resources to promote the tools within user communities. At a third level of importance, there are resources that require a more active and engaged participation from beneficiaries, such as consulting repositories and

databases and participating in workshops. At the last level, there are more specific, personalized, and paid resources, such as tutoring or certifications.

**Figure 1.** Visual map of the analyzed cases based on indicators and selection criteria defined in the research methodology (source: Politecnico di Milano)



## 5.2 Analysis of best practices in tools for Circular Design

From the mapping, 8 cases of tools and toolkits designed for businesses stand out as the most comprehensive in terms of quantity and variety in offering resources, methods, and tools for Circular Design. These cases can be considered as best practices to be analyzed.

For each of the 8 cases selected the following are the analysis elements used to understand how and in what ways Circular Design and Circular Innovation tools are or could be useful and applicable to SMEs:

- positioning of the tool/toolkit in a specific stage or within the entire circular design process or whether it places circular design in a broader design framework;
- nature of the stakeholders involved in the design and development of the tool/toolkit, identifying the types of organizations, professionals, and communities of practice that participated in the design and development activities;
- typology of beneficiaries and users of the tool/toolkit understanding whether it is designed for a large audience (individuals and organizations) or focuses on categories such as design professionals and SMEs;
- check if the tool/toolkit is designed for being disseminated via digital platforms, i.e., if and how they are accessible and usable;
- check the kind of resources and related services that are used by the tool/toolkit, the presence of instructions, guidelines, practical examples, online/on-demand support from experts, or specific events where these tools can be used (e.g., workshops);
- check of the existence of channels and ways of promoting the use of the tool/toolkit.

**Table 4.** Summary description of the tools/toolkit's cases analyzed according to the defined investigation criteria.

<i>Tool name</i>	<i>Description</i>
<i>1. Cradle to Cradle (C2C) certification<sup>1</sup></i>	The Cradle to Cradle Certified® product standard positions itself as a comprehensive framework for enhancing product and manufacturing processes, certifying items aligned with circular economy principles. Managed by the Cradle-to-Cradle Products Innovation Institute (C2CPII), it involves collaboration with various stakeholders, emphasizing global engagement with businesses, governments, and NGOs. Beneficiaries range from large corporations to SMEs, with over 500 brands from 40+ countries, including SMEs, utilizing the standard for innovation. Accessible through the institute's web platform, the toolkit provides guidance documents, case studies, and a public comment period, ensuring user-friendly integration of circularity principles. Funding for C2CPII's work comes from program fees, community contributions, and related services, including training

<sup>1</sup> See <https://www.c2ccertified.org/get-certified>

programs and case studies, supporting the application of circular design principles. Promotion is achieved through the web platform, disseminating resources, and fostering global collaboration to encourage the widespread adoption of circularity principles.

## 2. *Circular Design Guide*<sup>2</sup>

The Circular Design Guide, a collaboration between IDEO and the Ellen MacArthur Foundation, positions itself as a practical toolkit guiding designers and businesses to align with circular economy principles throughout the entire design process. Stakeholders, including designers, businesses, and experts, contribute to its development, catering to a broad audience with a focus on empowering SMEs. The guide's user-friendly design facilitates seamless integration of circular design principles. Additional resources, such as worksheets, complement the guide, with the Ellen MacArthur Foundation offering services like training programs and case studies. Promotion occurs through diverse channels, leveraging comprehensive resources, case studies, and insights shared via the foundation's services. The LinkedIn group, with nearly 38,000 members, serves as a networking platform, connecting users with experts, mentors, and practitioners, promoting the widespread adoption of circular design.

## 3. *Design for Planet - Design Council UK*<sup>3</sup>

Design for Planet, led by Design Council UK, positions itself as a platform for the UK design economy, targeting nearly 2 million stakeholders. Its focus is on stimulating regenerative design practices to address the climate crisis. The initiative involves collaboration with diverse stakeholders, including creative individuals, designers, businesses, governments, and communities actively engaged in climate action. While not explicitly stated, there's an implicit emphasis on empowering SMEs within the UK design economy through tools and knowledge for circular design. Access to the initiative, particularly the Skills & Innovation Hub and the Systemic Design Framework, is facilitated through the Design Council website. Resources include a showcase of tools and best practices. Promotion occurs through various channels, including the Design Council's website, newsletters, podcasts, films, and integration into broader programs like Inclusive Environments and the annual Design for Planet Festival, fostering sustainable design partnerships and participation.

## 4. *Circular Toolbox*<sup>4</sup>

Openresearch.amsterdam is a digital platform focused on research, knowledge, and innovation in Amsterdam. The Built Environment Toolbox, integral to the platform, initiates circular construction processes by offering articles, examples, and best practices. Stakeholders, including municipalities, universities, and entities in the Amsterdam metropolitan area, collaborate on research projects, forming part of the sustainable knowledge infrastructure. While beneficiaries encompass various stakeholders, SMEs in construction may particularly benefit from the Toolbox's insights. Access through the user-friendly Openresearch.amsterdam platform ensures simplicity and

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<sup>2</sup> See <https://www.circulardesignguide.com/>

<sup>3</sup> See <https://www.designcouncil.org.uk/our-mission/>

<sup>4</sup> See <https://openresearch.amsterdam/en/page/63802/circular-toolbox>

navigability. The Toolbox provides resources like articles, examples, and best practices, emphasizing circular design potential, encouraging stakeholders to explore and implement circular construction practices. Promotion occurs through the platform, updating information periodically to enhance awareness and adoption of new circular construction standards.

5. *Designing Your Circular Transition Toolkit*<sup>5</sup>

The "Designing Your Circular Transition" toolkit from Danish Design Center serves as a resource for companies and organizations seeking to implement collaborative design methods in their circular transition efforts. Developed collaboratively by Danish Design Center (DDC), the toolkit targets a broad audience involved in the circular economy, with potential benefits for Small and Medium-sized Enterprises (SMEs). Accessible online and freely available, the toolkit incorporates eight tools designed by DDC and integrates the MIRO platform for downloading tools and accessing guidelines. Continuous updates, based on insights from a practical testing phase with companies and organizations, ensure the toolkit remains current. Promotion occurs through the Danish Design Center's website, emphasizing its role in supporting Denmark's circular transition.

7. *Circular Design Journey and Circuloop Platform*<sup>6</sup>

Circular Design Journey (CDJ) program and the Circuloop platform, outcomes of the Circular Design Tools research project by Kaunas Technology University (KTU), are positioned as key components in KTU's broader circular economy initiative. Aimed at fostering collaboration among academia, industry, and government, the tools address challenges in transitioning to a circular economy, emphasizing a cultural shift, knowledge exchange, and product integrity. Stakeholders involved in design and development include KTU and the Department of University B. Beneficiaries include businesses, creative professionals, SMEs, and start-ups seeking to implement circular product-service systems. Accessible through the Circuloop platform, CDJ is a four-month program with two cycles focusing on concept design, rapid prototyping, and refining circular solutions. Resources include a circular design toolkit, business model canvas, and knowledge base. Promotion occurs through workshops, mentorship, and tools custom-designed for program activities, fostering the integration of circular design principles. The pilot edition in 2023 involved 16 teams, with eight high-potential projects receiving additional resources for prototyping solutions.

8. *Circle Lab*<sup>7</sup>

Circle Lab positions itself as an online platform for global exploration and implementation of circular business models. Managed by the Circular Economy Foundation, involving over 60 experts, it collaboratively designs circular strategies. Benefitting a global audience, including SMEs, Circle Lab offers enhanced accessibility and a knowledge hub with 1,500 practical circular economy applications. The platform fosters co-creation and innovation, breaking information silos. Collaborating with businesses and governments, the Circular Economy Foundation provides services such as consultancy and research. Promotion

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<sup>5</sup> See <https://ddc.dk/tools/designing-your-circular-transition>

<sup>6</sup> See [circuloop.lt](https://circuloop.lt) (the website is under construction)

<sup>7</sup> See [www.circle-economy.com](https://www.circle-economy.com)

occurs through the Circle Lab website, featuring the circular economy concept. The platform empowers cities and businesses with online challenges, encouraging collaboration and addressing global circularity issues. The foundation's inclusive approach targets entrepreneurs and major brands, urging their active contribution to circular economy realization.

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## 6 Reflections on the development of circular design toolkits for Learning Ecosystems

From the research analysis phase, some reflections emerge that frame and characterize the relationship between Circular Design tools, the need for circular capabilities by SMEs, and the development of Learning Ecosystems. At a general level, there is a lack of scientific literature exploring the relationship between Learning Ecosystems and Circular Design and CE. In parallel, the scientific literature that discusses Learning Ecosystems in relation to SMEs is very limited. Similarly, there is scientific literature dedicated to the development of specific circular design tools, but the literature that analyzes tools and toolkits for Circular Design is very limited.

The mapping and analysis of the tools for Circular Design reveals a significant interest towards businesses but not a specific focus on SMEs. Although these tools attribute importance to the themes of education and digitalization, they do not specifically mention Learning Ecosystems. This means that there is an area of study and innovation to explore that is based on the connection between the discipline of design with the disciplines related to CE and Circular Innovation, and the disciplines that are concerned with and involved in Learning Ecosystems from a social, technological, and economic perspective.

The eight exemplary case studies mentioned earlier —Cradle to Cradle (C2C) certification, Circular Design Guide, Design for Planet - Design Council UK, Circular Toolbox, Designing Your Circular Transition Toolkit, Circular Design Toolkit, and Circular Design Journey, Circuloop Platform and Circle Lab — form an integral part of a possible future Learning Ecosystem. The analyzed cases highlight the presence of some "basic ingredients" that are necessary to configure Learning Ecosystems dedicated to the learning of Circular Design processes by SMEs. Particularly, these tools might provide SMEs with various insights, practical tools, and collaborative opportunities to adopt circularity principles, improve product design, and transform their internal systems and value chains. From the analysis of the cases, it was possible to map and extract a set of more specific indications that are useful for connecting Circular Design tools with the development of Learning Ecosystems dedicated to the circular innovation and transition of SMEs.

***Collaboration and partnerships.*** A Learning Ecosystem involves collaboration and partnerships among various stakeholders, such as educational institutions, businesses, government agencies, community organizations, and learners. The analyzed cases show that these categories of entities are all involved in the development of these tools. Among them, universities are the most active subjects in both the design and the use of



or experimentation with these tools. However, entities such as design centers, municipalities, and institutions have a greater capacity to aggregate various stakeholders at the national or local level. For example, the Circular Design Toolkit developed by the Ecodesign Circle project aims to strengthen the application of design to the circular economy in the Baltic Sea region. The Designing Your Circular Transition Toolkit, developed by the Danish Design Centre, supports Danish SMEs in the introduction of collaborative design methods for their circular transition processes. It is not surprising, therefore, that many of the analyzed tools have been developed in Nordic countries. In these contexts, it may be easier to activate or develop this type of partnership. Therefore, Learning Ecosystems for SMEs could potentially develop through a key axis that involves collaboration between an educational institution and an institution rooted in the local territory, or through a connection among businesses.

***Holistic approach.*** A Learning Ecosystem takes a holistic approach to learning, recognizing that education and skill development can happen in formal and informal settings. It goes beyond traditional educational institutions and includes non-traditional learning spaces such as workplaces, community centers, online platforms, and other experiential learning environments. Some of the cases analyzed offer interesting suggestions. Circular Design Toolkit (Ecodesign Circle) and Circular Design Journey (KTU) attach great importance to the organization of design workshops or the use of makerspaces as places that support the prototyping phases. Design Council UK through the Design for Planet Festival proposes a model of an event that facilitates aggregation networking and dissemination of knowledge generated in partnership with universities and research centers. These examples highlight the importance of building Learning Ecosystems that can connect and dialogue with activities related to experiential learning or interaction that take place in physical locations.

***Flexible and customized learning opportunities.*** A Learning Ecosystem places the learner at the center and can adapt learning experiences to different interests, goals, and learning needs. This means diversifying learning opportunities on one hand and supporting personalized learning pathways and encouraging self-directed learning on the other. The set of analyzed cases covers a wide range of learning opportunities including, mentorship programs, online courses, workshops, and hands-on experiences. It recognizes that different individuals have different learning styles and preferences. The Circular Design Journey program by KTU is designed to allow participants to develop a personalized learning path based on the type of business, industry sector, and the level of circular maturity of the idea (and the company). The Designing Your Circular Transition Toolkit by the Danish Design Centre, with its diverse resources, is suitable for guiding businesses through every phase of the innovation process, promoting a systematic approach to circular innovation.

***Technology and digital tools.*** A Learning Ecosystem leverages technology and digital tools to enhance learning experiences, facilitate access to resources and information, and support communication.

Most of the analyzed cases place great emphasis on the development of platforms. Among the most advanced cases (in a servitization logic), there is the Cradle to Cradle

(C2C) platform, which offers a range of resources that enable companies to assess and improve the circularity and sustainability of their products and services. The Circular Design Guide by IDEO and EMF undoubtedly represents the reference platform when it comes to communicating resources and tools to help organizations understand and apply the principles of Circular Design. Lastly, the Circular Toolbox constitutes the only example of an open-source platform that provides businesses in Amsterdam and its metropolitan area with complete accessibility to resources for Circular Innovation.

## **7 Designing Learning Ecosystems for SMEs to implement circular economy**

SMEs are crucial in fostering sustainable and circular practices, mainly in the European context. They represent an essential part of the economy and contribute significantly to job creation, innovation, and growth. However, transitioning to a circular economy model requires a profound shift in traditional business models and practices. To navigate this transition effectively, SMEs need to be an active part of a Learning Ecosystem that provides them with the necessary knowledge, skills, and tools.

The research phase has allowed us to identify aspects of interest for the implementation of learning ecosystems dedicated to SMEs to promote the circular economy through circular design. SMEs that effectively leverage these resources can enhance their sustainability performance, improve resource efficiency, and make a significant contribution to the broader societal shift towards a circular economy (Bocken, Short, Rana, & Evans, 2014; Stahel, 2016; Lewandowski, 2016). Therefore, the synergy between the Learning Ecosystem and circular tools is essential to guide SMEs' transition towards a circular economy. The learning ecosystem serves as a nurturing ground where SMEs can acquire the knowledge and skills necessary for this transition, while circular tools provide the means to implement these learnings in a tangible and effective manner (Bocken et al., 2014; Lewandowski, 2016).

In general, the mapped cases provide interesting examples of what we mean by a Learning Ecosystem for SMEs. In the context of the circular economy, it involves the systematization, combination, and integration of resources, platforms, and networks that provide SMEs with the knowledge, skills, and tools necessary to transition to a circular model. At the same time, the analysis has highlighted that, currently, these aspects are not all found in a single tool or experience. This implies that there is a design opportunity for implementing a learning ecosystem model based on circular design that can integrate the lessons learned from the analysis and research phase and better align with the needs of SMEs. Below, we present a set of reflections that form the basis of an organic proposal to implement an SMEs Learning Ecosystem characterized using circularity toolkits.

The first direction of implementation concerns the tools and resources to identify and map the diverse learning needs regarding circularity for SMEs. The analyzed cases partially or implicitly include processes to understand the specific needs of SMEs regarding circular design and innovation. The central theme thus becomes the development of accessible processes, tools, and resources that provide SMEs with the concrete opportunity to establish both their initial competencies (assessment of the

circular maturity level of the company) and identify the learning needs to be acquired based on the development of a specific circular innovation project or a general transition of the company towards circular business models (definition of training objectives on circularity). This could be achieved through access to online tools designed for this purpose, the organization of events and initiatives to engage with networks of experts and mentors from various disciplines and sectors, and ultimately through the creation of collaboration networks among the SMEs themselves.

The second implementation direction concerns the tools and resources to stimulate forms of experimental and peer-to-peer learning among SMEs. The analyzed cases have highlighted a predominant use of online tools for circular design. These tools serve as tangible applications of knowledge disseminated within learning ecosystems. They translate theoretical principles into practical actions and solutions that SMEs can implement. The usefulness and user-friendliness of these tools can be enhanced with other modes of experimental learning based on hands-on experimentation such as tinkering, hacking, and making, which involve the realization of proof-of-concept through design-prototyping processes. These processes can use enabling technologies like digital fabrication and enabling environments like Fab Labs and makerspaces, which foster community-based collaborative and peer-to-peer learning to a greater extent.

The third implementation direction concerns the evaluation and monitoring processes of learning through Learning Ecosystems. The analyzed cases do not demonstrate the presence of explicit processes and dedicated tools for the evaluation or self-assessment of learning. It is therefore relevant to implement mechanisms to assess the effectiveness of Learning Ecosystems and those dedicated to circularity, enabling the measurement and monitoring of SMEs' progress in transitioning to circular business models. This will allow for continuous improvements and adaptation of the learning ecosystem to the evolving needs of SMEs.

Some analyzed toolkits allow for the verification of progress made by following the proposed learning processes, but, except for C2C, there are no platforms, for example, capable of certifying the consolidation of learning on circularity.

The fourth and final direction pertains to the development of a culture of collaborative learning that is suitable for SMEs, applied to the theme of circular transition, and adaptable to the specific territorial and local contexts in which businesses operate. Collaboration and networking among SMEs within the Learning Ecosystem are key elements in accelerating the learning processes of circular system dynamics. However, collaboration has always been a complex issue for SMEs to address. Many SMEs operate in sectoral and territorial contexts (e.g., industrial districts) characterized by competitive and cooperative dynamics, while others operate in contexts such as cities or sectors like digital where collaborative dynamics are culturally more accepted. However, the circular economy requires the development of collaborative cultures based on more distributed production models and value networks, territorial collaboration with local businesses and stakeholders, and engagement of user-citizens. For this reason, the development of circular design tools can be oriented towards the implementation of circular projects with territorial relevance or impact that enable collaborative learning processes.

The analysis of the cases leads to a final reflection on the philosophy of implementing circular design tools for SMEs.

A particularly relevant theme concerns the relationship between the current and future role and contribution of human intelligence and the emerging role of artificial intelligence in the development of Learning Ecosystems and tools for Circular Design and Circular Innovation.

Currently, while this article discusses circular design, "linear design" is still a resource that is difficult to access for many SMEs. Circular Design is indeed a complex process that requires a broader design culture often extending beyond the boundaries of the company, systemic involvement of the organizational structure, and genuine motivation because circular design incorporates a set of values that go beyond the firm itself.

The risk for SMEs is that they may use these tools more as an educational exercise or as an opportunity to obtain "training credits" rather than as a true learning process or an activity applied to a real project. In fact, simply transitioning from one tool to another or applying a tool in a "school-like" manner does not guarantee the consolidation of organizational knowledge or the achievement of a design outcome. Therefore, in the logic of creating learning ecosystems, the involvement of individuals becomes relevant, which is even more crucial for SMEs where the centrality of human skills is widely supported by scientific literature. Engaging in dialogue with experts, professionals, and scholars, as well as the opportunity to connect with institutions and even citizens and their associations when circular innovation concerns them, is essential. The contribution of experts and professionals—acting as facilitators and mentors—promotes the humanization and personalized use of tools for circular design. It enhances and maximizes the learning process, facilitating their proper use according to the company's needs. At the same time, it is interesting to explore the real and potential contribution of Artificial Intelligence to the development of Learning Ecosystems for circular SMEs (the scientific literature on the relationship between AI and Learning Ecosystems is currently limited). It is hypothesized that artificial intelligence can play a significant role in accelerating the development and diffusion/adoption of learning ecosystems for SMEs by working on automation and personalization of circular learning processes, advanced forms of virtual tutoring and support for continuous learning, and advanced analysis of data and learning outcomes. The combination of human skills and artificial intelligence would enable SMEs to speed up and enhance their learning processes, focusing immediately on applying circularity to their business models.

## 8 Conclusions

The research work has identified a potential area of research and innovation concerning the development of Learning Ecosystems for Circular Design and Innovation and the CE with a focus on learning for SMEs. The analysis of the cases of tools for Circular Design has highlighted the presence of an emerging and diversified set of resources that individually stimulate and support the circular transition of individuals and organizations. From the analysis, it has emerged that Learning Ecosystems for the CE will increasingly be characterized by the activation of multisectoral and territorial partnerships and collaborations, by a holistic, flexible, and customized approach to learning, and by facilitated access to design resources thanks to the development of digital and Artificial Intelligence.

Finally, three relevant directions have emerged in the development of Learning Ecosystems to stimulate circularity in SMEs. The first concerns the dialogue of companies with the ecosystem to assess their circular maturity and define access to the resources and tools of the Learning Ecosystems. The second concerns the evolved interaction with the various resources and tools of the ecosystem to learn and experiment with circular design and incorporate it into the company's culture and processes. The final one concerns the integration between Learning Ecosystems and Innovation Ecosystems to facilitate SMEs in developing circular innovation together with other companies, communities of innovators, and stakeholders.

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