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Review

Implementing sustainable design theory in business practice: A call to action

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ABSTRACT

The intensification of industrial activity within an unsustainable development paradigm caused an alarming environmental crisis intertwined with societal problems on a global scale. Sustainable design theory contains an extensive body of knowledge on how these environmental and societal issues can be addressed by rethinking industrial products, processes and, more broadly, how organizations operate in the context of a more sustainable socio-economic system. Nevertheless, evidence shows that implementing these ideas is a problematic yet under addressed aspect, resulting in a gap between abstract speculations and concrete action. In this study, we focus on this critical gap by looking at how existing theory of sustainable design is implemented in business practice. To this end, we conduct a literature review followed by interviews with twenty international experts, to uncover their knowledge related to relevant project experiences. The outcome is a framework that integrates existing sustainable design theory with important business concepts, clustering it into four literature streams:ecodesign, product service system design, sustainable business model design and collaborative ecosystem design. These streams correspond to four levels of design for sustainable innovation. The framework also encompasses a set of themes related to the implementation of sustainable design theory in business practice across the aforementioned four levels. Based on this, we outline our contributions to theory and practice, and pinpoint recommendations for academic researchers, industrial designers and business managers who want to leverage their professional position to play an active role in the transition toward sustainable development.

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1. Background and research question

The concept of sustainable development is not new. It emerged in the 1960s with the rise of ecological concerns and the fear of resource scarcity (Carson, 1962; Hardin, 1968). The United Nations defined it as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Brundtland, 1987). Sixty years later, these good intentions have not been complemented with sufficient efforts and adequate measures to steer the course of action in the correct direction (Allwood, 2018; Grafton et al., 2019). As a result, we are now facing an alarming environmental crisis that is intertwined with societal problems on a global scale. The climate is changing, bringing along severe consequences, including sea-level rise and more frequent extreme weather events that escalate the risk of food scarcity, massive migratory flows and conflicts around the world, both in developing and industrialized countries (IPCC, 2019). For example in the past Australian summer across 2019 and 2020, the country has been literally "on fire" due to extremely dry conditions, causing 18 million hectares of land burning to ashes, the destruction of over 6000 buildings, the loss of around 1 billion animals, as well as some human fatalities (UNEP, 2020). While natural resources are being depleted (Rockström et al., 2009), Europe is particularly concerned about the dependency of its economy from critical materials imported from overseas (European Commission, 2018). Science policymakers have started to metaphorically compare freshwater to gold (Borgomeo, 2020). In order to address these problems, the United Nations have already drafted an agenda based on specific sustainable development goals (United Nations, 2015). The discipline of design can, and should, play a role in addressing these goals by helping to rethink industrial products, processes and, more broadly, how business takes place around them (Dobers and Strannegård, 2005; Papanek, 1971).

The expression "sustainable design" refers to a rational and structured process to create something new (Simon, 1968) for solving sustainability-related problems (Manzini, 2009; Papanek, 1971). Sustainable design emerged in the 1960s along with the concept of sustainable development. Back then, the American visionary architect and philosopher Richard Buckminster Fuller stated that "a comprehensive anticipatory design science" should be adopted to create an "operating manual for spaceship Earth", in order to guide human development while preserving the environment, optimizing the use of resources, and ensure their fair distribution (Fuller, 1957, 1969). In the 1970s Victor Papanek leveraged these ideas in his book *Design for the Real World* (Papanek, 1971), which can be considered the seed of sustainable design theory (Bhamra and Lofthouse, 2016; Ceschin and Gaziulusoy, 2016). Over time, sustainable design theory has discussed how this creative yet rational process can be applied to address an increasingly broader spectrum of issues, ranging from crafting a pair of shoes that can be recycled (McDonough and Braungart, 2002) to managing the waste streams of a large city (Prendeville et al., 2018). Recent work by Ceschin and Gaziulusoy (2016, 2020) provides a comprehensive and up to date mapping of this body of knowledge.

Sustainable design theory is functional to advance the understanding of how the sustainability transition may be realized (Gaziulosoy and Oztekin, 2019) by transforming products, people's behaviors, commercial services, cities and eventually the entire socio-economic system (Ceschin and Gaziulusoy, 2016). However, these theoretical speculations on sustainable design will not go to great lengths, unless they are tied to solid business considerations (Baldassarre et al., 2019a; Dobers and Strannegård, 2005). Indeed, evidence shows that sustainable design ideas can be implemented successfully only when they are grounded into the objectives and operations of organizations (Baldassarre et al., 2017; Ceschin, 2013). Although this issue has been identified almost two decades ago (Manzini and Vezzoli, 2003; Tukker, 2004), most ideas still fail to reach the market (Tukker, 2015) and the knowledge gap on how to implement sustainable design theory in business practice remains (Baldassarre et al., 2020; Pigosso et al., 2013; Vezzoli et al., 2015). Addressing this gap is essential to achieve a positive impact on society and the environment that sustainable design theory promises (Tukker, 2004, 2015). Thus, we pose the following research question:

How is sustainable design theory implemented in business practice?

In addressing this question, we integrate existing sustainable design theory with complementary business concepts. In this paper, the expression "business concepts" is used to indicate theoretical principles and constructs used in the literature to explain and discuss how business organizations operate. We focused specifically on integrating those business concepts that are relevant from a sustainability standpoint. For example, "green product development" is a set of principles that provide business organizations with normative guidance for the creation of new products

with a lower environmental impact (Baumann et al., 2002). Another example is represented by the constructs of "sustainable business model" (Bocken et al., 2014) and "circular innovation ecosystem" (Konietzko et al., 2020), which are used to describe how one or multiple business organizations can achieve competitive advantage while addressing social and/or environmental issues. Consequently, we develop a framework (Fig. 4) that integrates existing sustainable design theory with such business concepts, and clusters it into four literature streams—*ecodesign, product service system design, sustainable business model design, collaborative ecosystem design*—corresponding to four levels of design for sustainable innovation. In addition, the framework comprises a set of themes—*the strategic objective of sustainable design, the perspective and terminology of sustainable designers, the key stakeholders, core activities, and main challenges in the sustainable design process*—related to the implementation of sustainable design theory in business practice across the aforementioned four levels. Through this framework, our contribution to sustainable design theory is providing a synthetic yet insightful overview of research streams at the boundary with business literature, while identifying a set of themes related to its implementation in business practice and highlighting language differences across literature and practice. Relatedly, we put forward three recommendations to inform future work of sustainable design scholars. Furthermore, the framework contributes to business practice by clarifying that implementing sustainable solutions requires operating simultaneously on multiple design levels. Relatedly, we put forward two recommendations for actors in business practice, more specifically for industrial designers and business managers. Altogether, we hope that these contributions may serve as a "call to action" targeted to scholars, designers and managers, for getting ideas implemented into reality, and achieving a tangible impact for a more sustainable development.

The remainder of this paper is structured as follows. In section 2, we explain in detail the research design we used to address the research question. In section 3 and 4, we present the results of our research. In section 5, we answer the research question by introducing our framework (Fig. 4) and discussing in detail the contributions of our work to sustainable design theory and business practice. In section 6, we highlight the limitations of our study, indicate directions for future research, and close with some brief, conclusive remarks.

2. Research design

To address the research question, we adopted a two-step approach (Fig. 1). Step A consisted of a literature review. The objective of this step was to integrate existing sustainable design theory with business concepts, in order to lay the foundations for further investigating how it can be implemented in business practice. The outcome of the review was a categorization of sustainable design theory into four literature streams, corresponding to four levels of design for sustainable innovation. Step B consisted of an empirical investigation based on expert interviews. Building on the conceptual outcomes of the previous step, the objective of this step was gaining deep insights into how sustainable design theory can be implemented in business practice. The outcome was a set of themes, describing how sustainable design theory can be implemented in business practice across the four levels previously identified. Empirical investigations represent an important follow up after a literature review as they ensure that theoretical assumptions on sustainable design remain consistent with real-world developments (Pigosso et al., 2013). The research process within step A and B is visualized below (Fig. 1) and further detailed in the coming paragraphs. Finally, we combined the outcomes of Step A (Fig. 2) and Step B (Fig. 3) resulting into our framework of implementing sustainable design theory in business practice (Fig. 4).

2.1. Step A

Step A of our research process consisted of a literature review, aimed at integrating existing sustainable design theory with business concepts.

2.1.1. Data collection

Our data collection process started with the identification of a comprehensive and up to date overview of sustainable design theory. We identified a review on the subject proposed by Ceschin and Gaziulusoy (2016), recently published in *Design Studies*, the academic journal with the highest impact and reputation in the field of design (Gemser et al., 2012). The authors develop a four-level framework that maps sustainable design approaches from a technical and product-centered focus toward large-scale system-level changes. This work is based on the systematic review paper of Adams et al. (2016), recently published in the *International Journal of Management Reviews.* The authors develop a three-level framework that categorizes sustainable innovation in terms of operational optimization, organizational transformation and systems building, discussing sustainable design in the broader business context. Together, these two papers provided us with a starting point for identifying and integrating additional literature on sustainable design and business. We opted for this choice—instead of a pool of articles derived from a systematic search—because of our aim to combine the research findings of two broad research fields over several years, which posed objective difficulties in identifying a comprehensive and focused enough pool of relevant and influential articles. Consequently, we decided to start from two literature reviews with high relevance and impact on the research domains on which this paper is focused. Both reviews were recently published in high-quality journals, and they both have a significant impact within their respective domains, with respectively 117 and 205 citations (Scopus search performed on March 1, 2020).

After identifying the two review papers, we leveraged them to engage in an iterative literature search based on a snowballing approach (Wohlin, 2014). Snowballing is useful for gathering comprehensive data on established and emerging concepts within and across research domains (Blomsma and Brennan, 2017; Geissdoerfer et al., 2017). Thus, it was a suitable approach to integrate sustainable design theory with business concepts. In line with this approach, we created a literature database by selecting articles cited by (backward snowballing) and citing (forward snowballing) the two review papers mentioned above. To mitigate the bias during snowballing, two authors engaged in this process independently. They selected the articles separately, and eventually discussed and integrated their individual results first with each other, and then with the other three authors (Silverman, 2013). More specifically, for snowballing backwards two authors independently screened the titles in the reference list of the two review papers (a total of 454 articles) and selected relevant articles. To this end, they first checked the type of the publication and included only the peer-reviewed papers published in scientific journals. Next, they checked the keywords and abstracts of the articles to identify those that are useful for the integration of sustainable design theory with business concepts. Since backward snowballing only allows identifying established concepts, the authors simultaneously engaged in forward snowballing, working independently to identify new concepts emerging from the two review papers. Accordingly, on Scopus, they identified articles that cite these two papers (in total 345 articles). Similar to backward snowballing, forward snowballing was based on a screening of title, type of

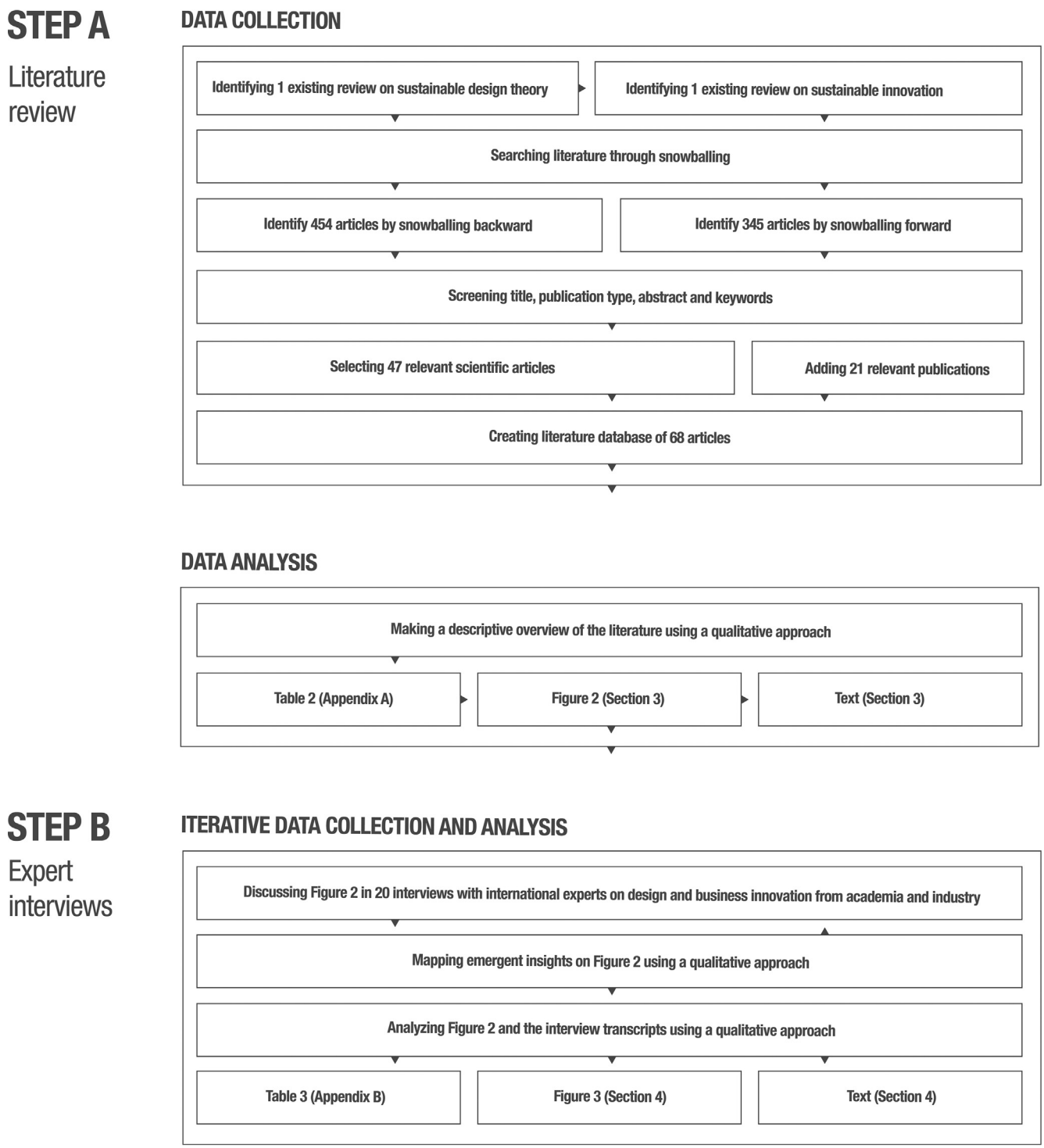

Fig. 1. Overview of the research design employed in this research.

publication, keywords and abstract. Throughout this process, articles were selected according to the following four criteria. First, a relevance criterion: selected articles focus explicitly on both sustainable design and business. Second, a content variety criterion: selected articles range in focus from product to systemic innovation—building upon focus areas found in the reviews of Ceschin and Gaziulusoy (2016) and Adams et al. (2016). Third, a pragmatic criterion: selected articles are fairly distributed in number across the range of focus. Fourth, a quality criterion: selected articles are peer-reviewed scientific publications. This resulted in the selection of 47 articles. Finally, all authors, as experts on the investigated subject, were aware of a number of important publications—including scientific and grey literature—that did not emerge from the snowballing process. These were included in the literature database, which resulted in a sample of 68 articles.

2.1.2. Data analysis

After data collection, we used the database of articles to provide

a descriptive overview of the identified literature. Using a qualitative approach for data analysis (Silverman, 2013), the first author scanned the articles in the database, in order to identify core concepts in the text across the multiple documents. In this process, he used the frameworks developed by Ceschin and Gaziulusoy (2016) and Adams et al. (2016) as a source of inspiration to structure the emergent concepts. This resulted in a set of written and visual notes (Silverman, 2013) categorizing the articles in the database according to their focus. In order to reduce subjectivity and avoid bias, such written and visual notes were eventually revised in series of face-to-face discussions with all members of the author team and with two independent researchers, who are also experts in the investigated subject (Silverman, 2013).

The outcome of this process is a list in which all the articles in the database are categorized into four clusters corresponding to four literature streams and four levels of design for sustainable innovation: *ecodesign, product service system design, sustainable business model design, collaborative ecosystem design.* For each article in the list, we include the authors, year of publication, journal and title, indicating as well how we have identified the source (Table 2 in Appendix A). Based on this outcome, in section 3, we present our literature review and a graphic visualization of four levels of design for sustainable innovation (Fig. 2).

2.2. Step B

Step B of our research process consisted of an empirical investigation based on twenty expert interviews, aimed at gaining insight into how sustainable design theory is implemented in business practice.

2.2.1. Iterative data collection and analysis

The starting point of our empirical investigation was a qualitative data collection based on individual interviews with 20 international experts. The interviews were conducted with an informal conversation approach (Patton, 2002) leveraging the visual developed in Step A (Fig. 2). The visual was used to facilitate an open and interactive discussion with the experts around the implementation of sustainable design theory in business practice. Specifically, the experts were asked to elaborate upon their knowledge and project experiences on design projects for sustainable innovation across the four levels previously identified. While no specific interview protocol was followed, probing the experts to describe their real experiences was functional to explore the gap between theoretical speculations and their implementation in business practice. Some of the interviews were conducted face-to-face, while others as video calls, by the first author and a research assistant. All interviews were digitally recorded and transcribed by the research assistant. In line with our focus at the boundary between theory and practice, sustainable design and business, respondents included both academics and industry professionals with a different mix of expertise. Despite background and profile differences, all of them have relevant knowledge and real project experiences related to the investigated subject. All experts operate at an international level, working within and across different European countries and types of organizations, including prestigious universities, small and large multinational manufacturing companies, and consultancy firms. Furthermore, attention was paid to ensuring age diversity in the sample of respondents. This was needed to integrate fresh and unbiased insights from the younger experts into the more consolidated ideas of the more senior experts. Table 1 contains the list of all the respondents indicating their profile next to their years of experience.

Data analysis took place iteratively and in parallel with data collection, using a qualitative approach (Silverman, 2013). Specifically, while the interviews took place, written and visual notes were taken to map emerging insights directly upon a printed copy of the visual (Fig. 2). This allowed collecting on the same template multiple layers of data, which were gradually analyzed and integrated into new versions of the visual informing the following interviews. Continuously re-discussing and re-shaping emergent insights with the cumulative views of multiple experts allowed reducing subjectivity in analyzing the qualitative data (Silverman, 2013). The last version of the visual was then used in combination with the transcripts as the input for a second analysis. At this stage the first author went through the transcripts in order to identify and categorize key passages and quotes, making a first thematic categorization of all the findings (Silverman, 2013). In order to break again through subjectivity and avoid bias, this categorization was progressively improved through a series of separate face-to-face discussions with the other authors (Silverman, 2013).

The outcome of this process is a set of five themes related to the implementation of sustainable design theory in business practice across the four levels previously identified: *the strategic objective of sustainable design, the perspective and terminology of sustainable designers, the key stakeholders, core activities, and main challenges in the sustainable design process*. To illustrate the connection with the respondent's knowledge and project experiences, we include a list with some of the most insightful interview quotes categorized according to the five themes and four levels (Table 3 in Appendix B). In section 4, we present a descriptive text of our empirical findings, based on quotes and the combined inputs of multiple experts.

3. Literature review

In this section of the paper, we present our literature review aimed at integrating existing sustainable design theory with business concepts. According to the outcomes of our review, the section is divided into four parts, corresponding to four literature streams matching four levels of design for sustainable innovation (Fig. 2).

3.1. Ecodesign

Ecodesign literature discusses strategies, methods and tools for developing sustainable—also referred to as "green"—products, in order to balance economic and environmental benefits (Baumann et al., 2002). Business concepts in *ecodesign* are thus largely related to product development.

Ecodesign scholars argue that by addressing both *eco*logic and *eco*nomic aspects, *ecodesign* minimizes the negative environmental impact of products, while simultaneously offering financial benefits and other business advantages (Dangelico and Pujari, 2010; Hallstedt et al., 2013; Huang and Wu, 2010). Indeed, *ecodesign* gives to the environment the same status as traditional industrial values such as profit, functionality, aesthetics, ergonomics and quality (Brezet and van Hemel, 1997). The intention is eliminating the conflict between environmental criteria and business success (Baumann et al., 2002; Brezet and van Hemel, 1997). Instead of considering environmental responsiveness as a compliance issue—involving expenses, and trade-offs with other corporate goals—*ecodesign* frames it as a business opportunity (Braungart and McDonough, 2002; Pujari et al., 2003). Such opportunity rests upon the identification of internal and external drivers that could result into win-win situations (Tariq et al., 2017; van Weenen, 1995). This literature specifically highlights the external drivers as particularly important for business to adopt an *ecodesign* approach. These include restrictive policies and laws punishing environmental harmful behavior. However, in the case of new ventures, internal drivers and the motivation of innovators in developing

Table 1
Profile and experience of the experts selected for the interviews.

Expert #	Profile	Experience
Expert 1	Full professor of Sustainable Design	38 years
Expert 2	Full professor of Sustainable Design	27 years
Expert 3	Associate professor of Sustainable Design	23 years
Expert 4	Associate professor of Sustainable Business	15 years
Expert 5	Full professor of Sustainable Business	12 years
Expert 6	Assistant professor and practitioner of Sustainable Design	13 years
Expert 7	Assistant professor and practitioner of Sustainable Business	8 years
Expert 8	Researcher and practitioner of Sustainable Design and Business	8 years
Expert 9	Professor and corporate manager of Sustainable Business	38 years
Expert 10	PhD researcher and consultant of Sustainable Business and Design	5 years
Expert 11	PhD researcher and practitioner of Sustainable Design and Business	15 years
Expert 12	Postdoctoral researcher and practitioner of Sustainable Business	12 years
Expert 13	Consultant of Sustainable Business and Design	23 years
Expert 14	Consultant and researcher of Sustainable Design and Business	6 years
Expert 15	Designer and corporate management trainee of Sustainable Business	3 years
Expert 16	Corporate designer and strategist of Sustainable Business	6 years
Expert 17	Corporate manager of Sustainable Business	8 years
Expert 18	Product Design manager and lead of Sustainable Business	8 years
Expert 19	Lead Designer and director of Sustainable Business	19 years
Expert 20	Corporate manager and consultant of Sustainable Business	23 years

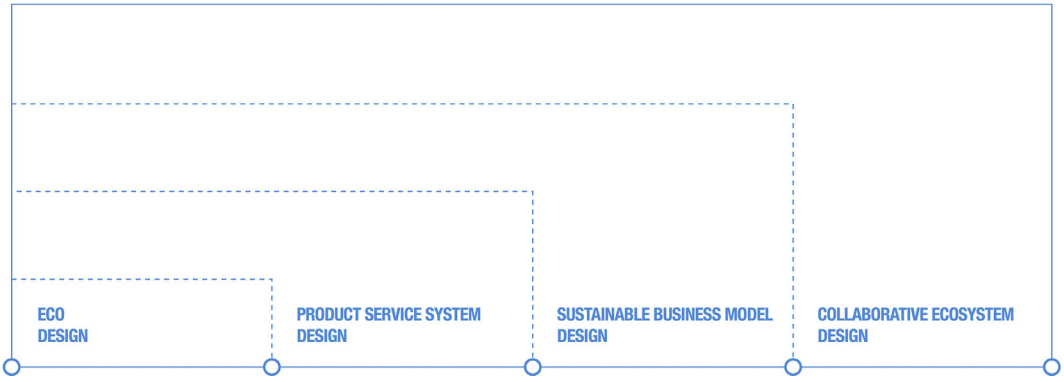

Fig. 2. Literature streams matching four levels of design for sustainable innovation. Based on the results of our literature review and inspired by the work of (Adams et al., 2016; Ceschin and Gaziulusoy, 2016).

sustainable products is crucial as well (van Hemel and Cramer, 2002). A central aspect of *ecodesign* is the concept of product life cycle. In the *ecodesign* manual for the United Nations Environment Programme (UNEP), Brezet and van Hemel (1997) introduce important thoughts around product life cycle phases—production, distribution, use and end-of-life. The argument is that adopting environmental criteria in the design of products allows reducing the environmental impact in these phases, and thus along the entire lifecycle (Pigosso et al., 2013). *Ecodesign* also considers consumer awareness and behavior, and explored consumers' willingness to reduce their environmental impact as a driving force for creating new market opportunities (Aschehoug et al., 2012; De Marchi, 2012; De Medeiros et al., 2014). Several scholars argue that there is a lack of integration between *ecodesign* and the broad context of product development, management, business development, and corporate strategy (Baumann et al., 2002; Pigosso et al., 2013). In particular, the strategic role of *ecodesign* within companies is underexplored and the connection with business activities is still quite loose (Baumann et al., 2002; Domingo et al., 2015). For example, Baumann et al. (2002) argue that many *ecodesign* approaches do not provide practical ways on how to implement the concept in business practice. Pujari et al. (2003) conclude that in order to make *ecodesign* more successful and impactful, it has to be linked and integrated into the overall business strategy of the firm. An analysis of this work shows that in *ecodesign* literature, important connections between sustainable design theory and business concepts exist (Domingo et al., 2015). However, this often occurs with a narrow focus related to product development (Dyllick and Rost, 2017; McDonough and Braungart, 2002).

In business practice, the implementation of *ecodesign* ideas typically results in a redesigned product with a life cycle that has a lower environmental impact (Braungart et al., 2007). An example of this is the Aeron Chair by Hermann Miller, which can be fully disassembled and recycled in all its parts.

3.2. Product service system design

Product service system design literature discusses how to develop a mix of tangible products and intangible services jointly capable of fulfilling final customer needs while fostering a positive sustainability impact (Tukker and Tischner, 2006). Business concepts in *product service system design* are thus related not only to products but also to the services taking place around them.

Product service system design scholars argue that a focus only on products is not sufficient to achieve sustainability goals (Manzini and Vezzoli, 2003; Martinez et al., 2010; Oliva and Kallenberg, 2003). Indeed, they state that sustainable design should take into account not just products but also services (Cook et al., 2006;

Goedkoop et al., 1999; Morelli, 2002). These new ideas position sustainable design as a strategic competence for creating new business opportunities and new ways of fulfilling product functions through the design and novel combination of products and services (Dewberry et al., 2013; Tukker and Tischner, 2006). *Product service system design* rests upon these assumptions. For businesses, it is an excellent vehicle to enhance competitiveness and foster sustainability simultaneously (Tukker, 2004). From a business perspective, product service systems offer the possibility to find new strategic market opportunities, increase competitiveness, establish a longer and stronger relationship with customers and build up barriers to entry for potential new competitors due to service component of the system, which is hard to copy (Emili et al., 2016). From a sustainability perspective, they can potentially delink profit and production volumes, reduce resource consumption and material use, motivate the inclusion of through-life and end-of-life issues, and lead to enhanced efficiency in use and product longevity (Kristensen and Remmen, 2019). Since firms become responsible not only for production and delivery of products but also for other phases in the life cycle of products, they have more incentives to adopt life-cycle thinking (Baines et al., 2007; Manzini and Vezzoli, 2003; Vezzoli et al., 2015). Compared to a traditional product sales offer, in *product service system design*, it is in the economic and competitive interest of the producer/provider to foster continuous innovation in reducing the environmental impacts and improving social equity and cohesion (Vezzoli et al., 2015). A central aspect *of product service system design* is the network of stakeholders that produce and deliver the solution to customers. Consequently, the development of partnerships is crucial, as well as the value co-production process within such a partnership (Cavalieri and Pezzotta, 2012; Ceschin, 2013; Laperche and Picard, 2013; Vezzoli et al., 2015). Design plays an important role in creating new stakeholder configurations and developing an integrated system of products, services and communications (Manzini and Vezzoli, 2003). To this end, design needs to be more business-oriented and at the same time focus on technical details, for example, when discussing the specifics of product or service elements (Ceschin, 2013). An analysis of this work shows that in *product service system design* literature, sustainable design theory establishes strong connections with broader strategic business concepts (Tukker, 2004). Nevertheless, literature concludes that while product service systems have the potential to enhance competitiveness and contribute to sustainability simultaneously, consumer acceptance and business factors remain under-addressed issues (Tukker, 2015). Successful *product service system design* thus requires adopting a stronger business perspective and the early involvement with the customer and changes in the organizational structures of the provider (Baines et al., 2007).

In business practice, the implementation of *product service system design* ideas typically results in a product - service combination, where the environmental impact of a product is potentially lower - since customers pay for using a product instead of buying it - while providing a better solution to people (Tukker, 2004). An example of this is the “OV fiets”, a bike rental service offered by the Dutch Railways. The objective of OV fiets concept is to reduce the use of cars by offering a bike rental scheme that makes public transport more functional for people.

3.3. Sustainable business model design

Sustainable business model design literature discusses how to develop new ways of doing business integrating sustainability into the objectives and operations of organizations (Stubbs and Cocklin, 2008). Business concepts in *sustainable business model design* are thus related not only to products and services but also to the overall business strategy around them.

Sustainable business model design scholars argue that the business model concept can be leveraged to make design more strategic (Baldassarre et al., 2017; Esslinger, 2011; Rocha et al., 2019). Indeed, sustainable business modeling requires firms redefining the purpose of their business and operating differently, for example by reporting financial, environmental, and social outcomes, by taking a stakeholder view of the firm, by including society and the environment as stakeholders, and by taking a leading role in sustainability (Birkin et al., 2009; Stubbs and Cocklin, 2008). Design is a central aspect of sustainable business model innovation. The word design is mentioned repeatedly in some key publications as a strategic process for the creation of sustainable business models (Bocken et al., 2013; Boons and Lüdeke-Freund, 2013; Lüdeke-Freund et al., 2016). Boons and Lüdeke-Freund (2013) state that the design of sustainable business models is a key challenge of sustainable business model innovation. Bocken and colleagues explain that there are several archetypes of sustainable business models and that the “product service system” is one of them, thus reinforcing the connection with earlier literature on sustainable design and broadening the theoretical domain (Bocken et al., 2014). Esslinger (2011) argues that designers are especially well suited to implement and promote sustainable business models because they are able to connect human needs and dreams with new opportunities and inspirations from science, technology, and business. Keskin et al. (2013) study the design and innovation processes for sustainability in new ventures. There are multiple tools and methods to support the design of sustainable business models (Baldassarre et al., 2020; Bocken et al., 2013; Joyce and Paquin, 2016; Lüdeke-Freund et al., 2016). Their aim is to implement the design of sustainable business models in practice (Baldassarre et al., 2020; Joyce and Paquin, 2016). Circular Economy is a recent theme in business model research, referring to an industrial economy that is restorative and regenerative by intention and design, fostering sustainability by converting waste into a resource (Geissdoerfer et al., 2017). Some scholars focus on the design of sustainable business models from this circular angle (Guldmann and Huulgaard, 2020; Henry et al., 2020; Sumter et al., 2018). For example, Sumter et al. (2018) look at the case of refurbished strollers, and the role of design in driving circular business model innovation. Recent work by Henry et al. (2020) specifically identifies the ‘design-based model’ as a type of circular business model focused on innovating through new technology to reduce material use. An analysis of this work shows that in *sustainable business model design* literature, sustainable design theory is inextricably intertwined with business concepts, and especially with entrepreneurship, using design almost as a synonym of this word (Keskin et al., 2013; Klewitz and Hansen, 2014).

In business practice, the implementation of *sustainable business model design* ideas typically results in a (new) organization or a corporate venture driven by a social and environmental purpose (Keskin et al., 2013). An example of this is Fairphone, a social enterprise that emerged from a social movement with the core mission of developing and selling smartphones with a minimum environmental impact and a fair supply chain.

3.4. Collaborative ecosystem design

Collaborative ecosystem design literature discusses how to develop new interactions across firms in order to reshape entire markets and industries toward a sustainability transition (Talmar et al., 2018). Business concepts in *collaborative ecosystem design* are thus not anymore related to single firms, but rather to the wider industries and markets in which they operate.

Sustainable ecosystem design scholars argue for the need to

build on theories of system innovation and transitions, which call for a systemic change on an economic, institutional, socio-cultural, organizational and technological level (Gaziulusoy et al., 2013; Joore and Brezet, 2015). Geels (2005) introduces the concept of transitions as a transformation of the system across the above-mentioned levels. Loorbach and Wijsman (2013) integrate literature on corporate sustainability and transition management, exploring the role of business in transitions. They suggest that a system perspective can help firms in analyzing their societal context (e.g. mobility system or energy system) and, in turn, determining innovation opportunities and alternative business models while remaining competitive within current markets (Loorbach and Wijsman, 2013). In that respect, they coined the term 'ambidextrous management' as an approach to mediate the long-term goals required by system innovation with short-term business goals linked to existing business models (Loorbach et al., 2010). Gaziulusoy and Brezet (2015) build onto this work from a design perspective. They integrate insights from sustainability science and system innovations with the sustainable design theory. They suggest that firms can address wider-scale changes by adopting a systemic and long-term perspective and by interpreting strategically the insights emerging from this perspective. Within this process, they emphasize the role of learning-oriented networking with universities, other firms and government (Gaziulusoy and Brezet, 2015).

Indeed, the transition to new societal or economic systems, such as a circular economy, requires the intentional design of new products and services, and experimentation with new business models to deliver them (Baldassarre et al., 2019b; Bocken et al., 2019). For these new business models to work in practice and enable the changes at a system level, it is essential to establish a collaborative capacity across organizations (Brown et al., 2019). Brown et al. (2019) explore the creation of circular-oriented innovation and highlight the interdependence within diverse networks of actors, as well as collaboration across organizations and sectors as critical factors for the success of sustainable business models at the system level. On these theoretical grounds, the term ecosystem emerges as a new lens to frame such collaborations as macro business models in which multiple organizations jointly deliver a value proposition connected to environmental gains (Brehmer et al., 2018; Hellström et al., 2015; Heuer, 2011; Zucchella and Previtali, 2019). For instance, Zucchella and Previtali (2019) emphasize the crucial role of a focal actor as the ecosystem orchestrator in engaging other actors in the implementation of circular business models by building a common vision and trust and facilitating relations and forms of cooperation. Building on Jacobides et al. (2018), Konietzko et al. (2020) propose design principles for circular ecosystem innovation, which prescribe how firms should collaborate and experiment via a structured trial-and-error process. An analysis of this work shows that in *collaborative ecosystem design* literature, sustainable design theory connects with business concepts beyond a firm centric approach, in order to support the creation of coalitions of organizations working together in the transition toward sustainable development (Manzini, 2017).

In business practice, the implementation of *collaborative ecosystem design* ideas typically results in a coalition of organizations collaborating to drive the sustainable transformation of an economic sector (Konietzko et al., 2020). An example of this is the EU Horizon 2020 "Zero Brine" Project (www.zerobrine.eu), in which an international consortium formed by over 20 partners is collaborating to redesign the value and supply chain of water and minerals in the process industry.

4. Empirical investigation

This section of the paper covers our empirical investigation aimed at gaining insight into how sustainable design theory is implemented in business practice. According to the outcomes of the investigation, this section is divided into five sub-sections associated with five themes that emerged through twenty interviews with international experts. These themes provide a coherent structure to describe the knowledge and experiences of the experts working on sustainable innovation projects across the four levels of design previously identified (Fig. 2). An overarching finding is that when implementing theory into practice, the way of thinking and language related to these levels differs between academic research and business practice. Some of the experts who are closer to business practice explained that from the perspective of a company, theoretical differences between the four levels may be complex to grasp and not particularly relevant. For example, when trying to go beyond the product focus of *ecodesign*, a firm might not see any concrete difference between engaging in *product service system design* or *sustainable business model design*. What instead matters from a business practice perspective is the output of the design process, namely: a sustainable product, a sustainable product and service design, an entirely sustainable organization and a collaboration across multiple organizations driven by sustainability. Consequently, we discuss our empirical findings by adopting the terminology from the perspective of the business practice. In other words, we renamed the four design levels as illustrated in Fig. 3 and present our interview insights categorized according to these levels and the five themes that differentiate them.

4.1. Strategic objective of sustainable design

In business practice, the strategic objective of sustainable design refers to the scope of the design process when integrating environmental and/or social concerns into the objectives of organizations.

Implementing sustainable product design (*ecodesign* in academic literature) requires a major focus on reducing the life cycle impact of products while increasing their efficiency and quality and reducing cost for the organization that manufactures them (Expert 1, 2, 8, 9, 11, 19). Expert 1 explicitly mentioned that in the projects where he was involved *"ecodesign was an approach to focus on the life cycle of the product"*. Expert 9 clarified that the company he had worked with for multiple years, *"embraced ecodesign as an important contributor to the efficiency and quality of its operations"*. Indeed, at a product level, the strategic objective of sustainable design is pushing an organization to think beyond the "form and function" of their product, changing its life cycle (production, distribution, use, and end-of-life), in order to reduce its environmental footprint while making profit.

Implementing sustainable product and service design is about the exchanges of an organization with other stakeholders, and on how these affect the environmental and social impact across the supply chain (Expert 2, 3, 6, 7, 18, 19). For example, Expert 18 explained that when his/her company started a project about selling a sustainable product as a service, they *"focused a lot on the materials that were used in that product but also on the entire supply chain […] and the specific impact in the community"*. This example illustrates that at this level, the strategic objective of sustainable design is pushing an organization to think beyond the life cycle of its product, changing tangible and intangible stakeholder exchanges (e.g. knowledge, materials, energy, money, etc.), in order to foster a positive social and environmental impact while making profit.

	SUSTAINABLE PRODUCT DESIGN	SUSTAINABLE PRODUCT & SERVICE DESIGN	SUSTAINABLE ORGANIZATION DESIGN	SUSTAINABLE COLLABORATION DESIGN
Strategic objective of sustainable design	Pushing an organization to think beyond the "form and function" of their product, changing its life cycle (production, distribution, use, end of life), in order to reduce its environmental footprint while making profit	Pushing an organization to think beyond the life cycle of its product, changing tangible and intangible stakeholder exchanges (e.g. knowledge, materials, energy, money, etc.), in order to foster a positive social and environmental impact while making profit	Pushing an organization to think beyond products and services, (re)defining its purpose, how it functions from an economic and operational standpoint, in order to pursue sustainability goals while making profit	Pushing multiple organizations to think beyond their individual business, collectively (re)defining (un)sustainable market practices, in order to facilitate the transformation of existing sectors while making profit together
Perspective and terminology of sustainable designers	- Department centric (one department) - Engineering terminology	- Cross functional (multiple departments) - Commercial terminology	- Firm centric (the entire organization) - Strategy terminology	- Cross organizational (multiple organizations) - Policy terminology
Key stakeholders involved in the sustainable design process	- R&D - CSR - Marketing - Suppliers - ...	- Users - Operations - Logistics - External partners - ...	- CEO / upper management - Finance - HR - Shareholders / investors - ...	- Public officers - Civil society - Business representatives - Legal experts - ...
Core activities in the sustainable design process	- Life cycle analysis - Product development - ...	- Stakeholder analysis - Service development - Experimentation - ...	- Business modeling / case - Financial accounting - Risk assessement - ...	- Industry / sector analysis - Strategic foresight - Transformational leadership ...
Main challenges in the sustainable design process	Reducing resource and energy use, toxicity and carbon emissions	Transforming existing supply chains and assessing impact of alternative solutions	Managing stake / shareholders, and ensuring financial viability while scaling up	Creating policy frameworks and gaining stakeholder committment over time

Fig. 3. Themes and insights describing the implementation of sustainable design in business practice. Based on the results of our empirical investigation.

Implementing sustainable organization design entails questioning the purpose and reason of being of an organization, rethinking its core goals, underlying processes and how it creates value out of social and environmental issues (Expert 5, 8, 14, 16, 17, 18, 20). Expert 20 made this very clear: *"And of course, we do projects like that […] where we redesign the business model and you've got a shift toward an [economic] value focus [while solving sustainability problems]"*. Consequently, at this level, the strategic objective of sustainable design is pushing an organization to think beyond products and services, (re)defining its purpose, how it functions from an economic and operational standpoint, in order to pursue sustainability goals while making profit.

Implementing sustainable collaboration design entails broadening the scope beyond single business models in order to transform the entire socio-technical system, entire industries and/or market sectors through a collective conversation of all the parties involved (Expert 3, 5, 6) aimed at creating innovation ecosystems (Expert 10, 20). Expert 10 explained this ecosystem concept providing the example of a project where multiple organizations *"worked together for a while on a completely redesigned mobility system for the city"*. Additionally, Expert 20 clarified that in his experience, this type of project *"only works when they [the organizations] collaborate, when they have a clear joint goal and mutual benefits"* (Expert 20). At this level, the strategic objective of sustainable design entails pushing multiple organizations to think beyond their individual business, collectively (re)defining (un) sustainable market practices, in order to facilitate the transformation of existing sectors while making profit together.

4.2. Perspective and terminology of sustainable designers

In business practice, the perspective and terminology of sustainable designers respectively refer to the point of view from which designers may frame and address simultaneously sustainability and business problems to the terminology they use to communicate with different stakeholders while doing this.

Sustainable product designers often operate in Research and Development (R&D) departments. From that perspective, they strive to change the way products are made in order to reduce their life cycle impact (Expert 2, 9, 17, 19, 20). This is clearly reflected by the case of Expert 14, who explained: *"When I was working [as an industrial designer] for those two multinational companies I was into an engineering context"*. Relatedly, Expert 9 recalled on his experiences in the company he worked with, saying that within sustainable product design and development *"environmental requirements had to be communicated with a factory language"*

(Expert 9). Thus, at this level, the perspective of designers is department centric. This perspective is intertwined with a specific terminology. Indeed, within the R&D department, designers must be able to explain to engineers how products can be developed more sustainably (Expert 1, 9). To this end, they use an engineering terminology.

Sustainable product and service designers must understand how different people across departments in their organization look at sustainability issues (Expert 6, 9, 19). Expert 6 commented upon the importance of "*thinking about this from a design perspective*". Relatedly, Expert 9 stated that: *"You need a cross functional view to bring this [sustainable design] safely across the borders of departments"*. These instances show that at this level, the perspective of designers is cross functional. In other words, the designer has to work from the perspective of multiple departments, aiming to change not only how products are made but also how they are delivered to customers (Expert 9, 19). This effort entails talking with operations and logistics (Expert 14, 19, 20). This requires commercial terminology.

Sustainable organization designers are able to use the business model framework in order to take the perspective of the entire organization on sustainable innovation (Expert 7, 14, 16, 17). This is illustrated very clearly by the experience of Expert 17: *"Since I am working with business models […] and the sustainability strategy […] I use the perspective of the entire organizations […] And it is a semantic language thing […] knowing how to talk to different people. Personally, I talk very differently to a [product] designer than I speak to a financial controller [in my company]"*. At this level the perspective of designers becomes firm centric. In this regard, Expert 14 mentioned that in one of the projects he had worked on, "*it was clear that the managers [of the client organization] wanted to talk about alternatives to fossil fuels in their business model*". These examples show that when the goal is the transformation of a business model, it is important to understand and talk with the strategy function (Expert 4, 20). To this end, a strategy terminology is required, in order to effectively communicate design ideas to the upper management and the CEO.

Sustainable collaboration designers must work from many different perspectives because all the companies operating in a certain market or industry have different priorities and issues to deal with (Expert 1, 10). Expert 10 stated that *"in the end, it's just a matter of perspective"*, and that *"a systemic view, is what is unique in ecosystem [collaborative] innovation"*. As the collaboration emerges over time from the interactions and negotiations of the stakeholders involved, the designer can facilitate this process by bridging perspectives and outlining a shared vision (Expert 1, 3, 20). Expert 1 exemplified this using the metaphor of a *"spider in the web, connecting the points of view between industry, public sector and civil society"*. Consequently, at this level, the perspective is cross organizational. Since in Europe such collaborations are often funded by Circular Economy project calls as part of current policy frameworks (Expert 8, 11), it is important to be able to understand the related terminology of decision-makers (Expert 1, 10). This is apparent in the case of Expert 19, who explained: *"[As a designer] I do think I have influence by inspiring and explaining our innovation philosophy to our compliance department so they can translate again, to the policymakers"*. Thus, designers operating at this level must be familiar with a policy terminology.

4.3. Key stakeholders involved in the sustainable design process

In business practice, the key stakeholders involved in the sustainable design process refer to all those parties who need to be directly involved and/or come to play a crucial role when the integration of environmental and/or social concerns into business objectives takes place.

Product design is typically a task of the R&D department, where designers, engineers and in some cases scientists collaborate. Expert 2 explained that in the projects he was involved, *"there were designers and engineers working on [sustainable] products"*. When integrating environmental criteria in the design of products, the R&D department is (often) informed by the Corporate Social Responsibility (CSR) - or sustainability function - of the organization (Expert 9, 16, 19). Furthermore, redesigning products in order to make them sustainable normally entails changing some of their components, materials and/or production processes, requiring interactions with the related suppliers (Expert 8, 11, 18). Finally, making sure that the sustainability aspects are properly conveyed to consumers is the task of the marketing function (Expert 9, 13). These instances are exemplified by the case of Expert 9 who recalled that in the company he worked with, "*after the environmental department […] they decided to establish in their own development department an environmental strategy […] A green marketing function was needed*". The project experiences of Expert 8 highlight the importance of suppliers: *"Suppliers were also involved [in sustainable product design]"*. Thus, at this level, the key stakeholders who are most likely involved in the design process are the R&D, CSR and marketing functions of the organization, as well as suppliers to a limited extent.

Implementing services around sustainable products requires the involvement of the operation and logistic functions, which make sure that such services can be delivered as planned (Expert 16, 17, 19). The importance of this aspect was especially stressed by Expert 19, who explained: *"When we design our services, we have to understand our users, but also, we involve the service department right from the start, we work closely together with operations and logistics, marketing and sales […] explaining what the design is about […] and with external business partners"*. Indeed, sustainable service delivery often requires multilateral cooperation with external partners beyond just suppliers (Expert 14), and ultimately users as well play an active role in the delivery system when they experience the service (Expert 14, 16, 19). At this level the key stakeholders that are most likely involved in the design process, next to those previously mentioned, are operations, logistics, users and external partners in different degrees depending on the circumstances.

Integrating sustainability aspects in the business model of an organization requires the commitment of the upper management and the CEO (Expert 9, 16, 17). The finance function must be involved to assess whether the transformation is viable from a revenue perspective (Expert 16, 20). Assessing the financial aspects is essential to get the buy-in of shareholders and/or investors, who could otherwise oppose the initiative (Expert 19). The case of expert 17 exemplify these instances: *"I work on the sustainability strategy of the company […] and new business models […] So I work mostly with the CEO, with the brand managers and other departments […] and also externally of course, both with academics and with startups and interesting people and so on"*. Furthermore, Expert 20 stressed the importance of "*the people aspect […] the roles of people*". Indeed, transforming a business model toward sustainability requires putting together a team with the right mix of interdisciplinary competences, calling for a role of the Human Resources (HR) department (Expert 16, 20). Consequently, at this level, the additional key stakeholders that are most likely be involved in the process are the upper management, finance, HR and shareholders.

When multiple organizations carry out together collaborative innovation projects, for example in the context of a Circular Economy, the representatives of each business, often at the upper management level, are involved in the effort (Expert 16, 18, 20). As Expert 16 explained, in such projects "*every company has to be*

represented […] you need delegates from every organization". Legal experts are also needed, in order to make sure that collaboration takes place within clear agreements and establishes regulations (Expert 7, 13, 20). As Expert 18 explained, it is important to involve "*different stakeholder types*" including *"civil society organizations, NGOs, companies, and sometimes also public institutions"*. Expert 19 elaborated further on the need to consider policy issue thus interacting with stakeholders from latter category: *"The European Union, we sometimes have meetings with them […] discussing future policies with policymakers"*. Thus, at this level, the type of stakeholders involved in the design process diversifies to include legal experts, representatives of business working collaboratively, and also public officers, who can drive top-down change, and civil society, who can drive bottom-up change (Expert 1, 17, 19).

4.4. Core activities in the sustainable design process

The core activities in the sustainable design process are those that need to be performed to integrate environmental and/or social aspects in the development of innovation outputs.

Implementing sustainable product design primarily requires understanding the life cycle of the product to assess its environmental impact (Expert 1, 2, 8). Expert 2 recalled the importance of this activity by recalling one of his experiences: *"And then [product] designers said: if we want to make it more sustainable we need to analyze the whole life cycle"*. After the analysis of the life cycle, it becomes possible to set clear design objectives (e.g. reparability) and criteria (e.g. modularity) to lower the environmental impact of the related product, which is subsequently developed (Expert 8, 9, 14, 19). Expert 19 elaborated explicitly upon this aspect: *"I tried to set up guidelines for the product developers […] stuff like modularity and reparability […] to implement products to last longer"*. Therefore, at this level, the core activities in the sustainable design process are life cycle analysis and product development.

Implementing sustainable product and service design with a sustainability mindset entails considering social aspects, stakeholders and user interactions around the product life cycle (Expert 14, 19). While developing services, it is essential to identify the key stakeholders involved and analyze what they exchange with each other and what do they want to achieve (Expert 6, 10, 14, 15). Expert 15 mentioned the importance of going beyond life cycle analysis and performing a stakeholder analysis when designing services: *"We do life cycle analysis […] And we do stakeholder analysis when we design services. We started with plastic cups at festivals […] We contacted all the festival organizers and producers, we involved recycling agencies, cup producers, and we started to bring them together just to clarify the problem for everyone"*. Moreover, implementing new services requires a trial and error approach based on experimentation, such as demonstrations and pilots (Expert 7, 12, 18). At this level, the core activities are stakeholder analysis, service development and experimentation. These activities may occur next to those mentioned in the previous level.

Implementing sustainable organization design requires writing a business case to keep track of viability (Expert 16, 20). Expert 16 referred to the company he works with to stress the importance of this and closely related activities: *"We have this kind of value proposition design process in the company, which works on those activities […] estimating the size of the market, the willingness to pay, how much financial resources are available, calculating profit and loss and writing a business case"*. Indeed, financial accounting (e.g. forecasting a profit and loss statement) is also an essential activity to assess viability when introducing a sustainable business model (Expert 14, 19, 20), as well as the risk entailed with undertaking this effort (Expert 20). Consequently, at this level, additional core activities must include business modeling and writing a business case, financial accounting and risk assessment. These activities may occur next to those mentioned in the previous level.

Implementing sustainable collaboration design requires the analysis of the entire industry and/or economic sector (e.g. the automotive industry/mobility sector) that has to be transformed (Expert 5,17). Expert 17 explained that in this context *"it's not just about doing an industry analysis […] It's about talking to leaders and changing the future […]"*. Next to understanding who are the players involved in a certain industry and what are the power plays taking place, strategic foresight is needed to see how they can be disrupted in the long run (Expert 5, 17). Often analysis and foresight need to go beyond a single industry, since sustainably transforming business ecosystems entails synergies across industries and national states across different regions of the globe (Expert 14, 17). To this end, transformational leadership is required from key players active in the public and public sectors, who can together accelerate the change (Expert 12, 17). Again Expert 17 mentioned this activity in his/her working experiences: "*How can we integrate directly with the [directives of the] European Union? What is the future of optimization and work in Southeast Asia? How can we meet with the prime minister of [that Asian country]?"* These instances show that at this level, the innovation process often includes as core activities industry and sector analysis, strategic foresight and transformational leadership. These activities may occur next to those mentioned in the previous level.

4.5. Main challenges in the sustainable design process

In business practice, the main challenges in the sustainable design process refer to those aspects that prove to be particularly problematic when integrating environmental and/or social goals in the development of innovation outputs.

Implementing sustainable product design is ultimately about reducing the life cycle impact, normally associated with a single product (Expert 2, 8, 9, 11). Thus, at this level, the main challenges relate to technical issues, specifically reducing material use, energy flows, toxicity and carbon emissions. Expert 11 explicitly elaborated upon the difficulty to get implement new sustainable product designs due to such challenges: *"Reduction of emissions, reductions of toxicity, reduction of resource use […] these were the challenges in the project […] And it was quite drastic: 50% less. Yeah, I'd still like to see that implemented"*.

However, reducing material and energy flows has a limited impact if the broader context is unsustainable (Expert 8). In fact, if materials are not sourced responsibly and if the energy used throughout various phases of the life cycle comes from fossil fuels, a product cannot be sustainable (Expert 2, 18).

Sustainable product and service design is very challenging to implement. Expert 2 stated that: *"Designing services [next to products] allows for more radical sustainability changes but also poses new problems"*. Expert 12 elaborated further on the matter in relation to a project that he was involved in: *"We were trying to implement a [service] solution to inform customers about the impact of their mobile phone. Bringing it to market in different countries was the main challenge I encountered [in the project]"*. Indeed, delivering product-service combinations on the market most likely requires changing current ways of operating of companies and even entire supply chains (Expert 2, 6, 12, 19).

Furthermore, impact assessment beyond a focal product becomes extremely difficult (Expert 10, 14). When more radical transformations take place, unexpected rebound effects might occur (Expert 6, 19, 20). Consequently, at this level, the main challenges are transforming supply chains and assessing the impact of product-service combinations.

Sustainable organization design allows pushing forward even

more radical changes, but the new business models required to this end are difficult to implement because they must be financially viable and scalable (Expert 7, 20). Expert 20 was very clear on this aspect: *"When we design these [sustainable] business models we must also consider [financial] viability […] And then, can the organization scale it up?"* Given that shareholders and external partners are often affected by the introduction and provision of a sustainable business model, managing their wishes and expectations also becomes a major challenge (Expert 4, 13, 17, 19). Expert 13 and Expert 19 were also clear on this challenge, respectively stating that *"with new business ideas, stakeholder management is always difficult"* and that the need to "*generate shareholder value, it's often a barrier to [sustainable] innovation"*. Thus, at this level, the main challenges relate to financial and organizational aspects, specifically ensuring financial viability, scaling up, and managing stakeholders and shareholders in the process.

Implementing sustainable collaboration design is very challenging (Expert 10, 12) because it requires creating consortiums and/or coalitions of organizations (Expert 8, 10). Expert 5 explained that when multiple organizations are involved *"business models are just part of the game. You also need someone who defines the rules of the game […], policy comes into play. […] There must be interventions and frameworks that help the disruption of existing industry structure"*. A strong commitment is also required in terms of time and effort from collaborating organizations, both upfront when applying for funding and eventually to turn a temporary endeavor into a running business (Expert 1, 13, 19). Consequently, at this level, the main challenges relate to political and legal aspects, creating policy frameworks, gaining stakeholder commitment and turning a multi-stakeholder temporary project into a stable and cohesive business entity.

5. Discussion

This section is divided into three sub-sections. First, we present the framework about implementing sustainable design theory in business practice. Second, we discuss our contributions to sustainable design theory, putting forward three recommendations for future research. Third, we discuss our contribution to business practice, putting forward two recommendations.

5.1. Framework for implementing sustainable design theory in business practice

This research addresses the question of how sustainable design theory is implemented in business practice. We hereby propose a framework that provides an answer to this question through an insightful overview (Fig. 4) combining the outcome of our literature review (Fig. 2) and empirical investigation (Fig. 3).

The top part of the framework proposes an integration of existing sustainable design theory (c.f. Ceschin and Gaziulusoy, 2016) with business concepts (e.g. Adams et al., 2016; Baumann et al., 2002; Boons and Lüdeke-Freund, 2013; Konietzko et al., 2020). Here, we cluster these combined theoretical insights according to four literature streams, corresponding to four levels of design for sustainable innovation: ecodesign, *product service system design, sustainable business model design, collaborative ecosystem design. Ecodesign* requires developing of products with a life cycle that has a lower environmental impact (Brezet and van Hemel, 1997). *Product service system design* entails developing of product-service combinations that reduce the environmental impact of resource use by providing access instead of ownership along with a superior functional solution (Tukker, 2004). *Sustainable business model design* is about reshaping existing organizations or creating new ventures driven by a social and/or environmental purpose (Keskin et al., 2013). *Collaborative ecosystem design* relates to a systemic effort aimed at the creation of coalitions of collaborating organizations, working together to drive the sustainable transformation or entire markets and economic sectors (Konietzko et al., 2020).

The middle part of the framework visualizes the gap that is present between sustainable design ideas proposed by theory and their concrete implementation in business practice (Baldassarre et al., 2020; Vezzoli et al., 2015). This gap between theory and practice, already identified by researchers almost twenty years ago (Manzini and Vezzoli, 2003; Tukker, 2004), must be addressed if the desired environmental and social impacts of sustainable design are to be achieved (Tukker, 2004, 2015).

To this end, in the bottom part of the framework, we propose a set of themes related to how sustainable design theory is implemented across the four levels of design, which in business practice correspond to a specific strategy output. These themes are based on the knowledge and real project experiences of the experts. The first theme describes the *strategic objective of sustainable design*, which is about pushing organizations to change their innovation strategy with a different range of scope across the four levels of our framework, from rethinking products to shaping new systemic collaborations with other players across industries. The second theme describes the *perspective and terminology of sustainable designers*, which varies across the four levels of the framework from department centric to cross organizational, with a jargon shift from engineering to policy-related. The third, fourth and fifth themes describe respectively the *key stakeholders, core activities and main challenges in the sustainable design process*, which tend to increase in terms of number and complexity across the four levels of the framework.

5.2. Contributions to sustainable design theory

The first part of our contribution to sustainable design theory lies in integrating the body of knowledge with business concepts derived from reviewing extant theoretical (e.g. Baumann et al., 2002; Bocken et al., 2014) as well as empirical literature (e.g. Baldassarre et al., 2017; Konietzko et al., 2020; Manzini and Vezzoli, 2003). This integration is essential to advance sustainable design theory. Indeed, sustainable design emerged with the objective of aligning environmental and social benefits with economic ones (Brezet and van Hemel, 1997). Therefore, strategic business considerations should be central to it (Dobers and Strannegård, 2005; Manzini and Vezzoli, 2003). Accordingly, in this piece of work, we connect research on sustainable design with (sustainable) business research, providing a synthetic yet insightful overview of research streams at the boundary between these spaces (blue part of Fig. 4).

First recommendation: We encourage sustainable design scholars to incorporate more prominently the study of (sustainable) business literature into their research: by better understanding business concepts, and formulating their messages accordingly, they might ultimately increase the relevance of their work and disseminate it outside of the "sustainable design niche".

The second and main part of our contribution to sustainable design theory is uncovering a set of themes related to its implementation in business practice, based on the knowledge and real project experiences of multiple experts. These insights are relevant to contribute in addressing a longstanding gap of knowledge around the implementation of sustainable design theory (Baldassarre et al., 2020; Manzini and Vezzoli, 2003), which is critical to achieve impact (Tukker, 2004, 2015). Indeed, filling this knowledge gap is not an easy task because in business practice theory is confronted with multiple and diverse issues (Vezzoli et al., 2015). Nevertheless, with this research, we contribute to

Fig. 4. Framework visualizing the gap between sustainable design theory and its implementation in business practice. Insights are categorized according to four levels of sustainable design based on a literature review (top blue part/vertical columns) and five themes that emerged from expert interviews (bottom pink part/horizontal rows). Inspired by the work of (Adams et al., 2016; Ceschin and Gaziulusoy, 2016). (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

addressing this complex and multifaceted problem by identifying and describing some of its underlying variables (pink part of Fig. 4). For example, we describe who are the key stakeholders and which core activities have to be considered when attempting to translate theory into practice.

Second recommendation: We encourage sustainable design scholars to increase research efforts around the gap of knowledge concerning the implementation of theory in business practice: by diving deeper into this complex and multifaceted problem, it is possible to break it down into its underlying variables, resulting into smaller and more manageable subjects to focus on.

An additional theoretical contribution to sustainable design is stressing that the way of thinking and related language of researchers and practitioners working in this space is quite different.

Our empirical data indicate that while researchers often think and talk in terms of literature streams, practitioners do so in terms of innovation strategy and outputs. Considering that the overarching goal of sustainable innovation research is ultimately supporting practice in becoming more environmentally and socially responsible (Ehrenfeld and Gertler, 1997), the aforementioned issue becomes rather problematic if it results in raising a communication barrier between academia and industry. Logically follows the importance of developing a common language, a subject already addressed by former research (Bocken et al., 2014; Lüdeke-Freund and Dembek, 2017). To this end, the value of our framework lies in representing a visual support to see these language differences and overcome the related barrier (different naming of the four levels in the blue and pink part of Fig. 4).

Third recommendation: We encourage sustainable design scholars to acknowledge that in business practice theoretical ideas are often reframed in terms of innovation strategy outputs, using a different language: by adopting such language in their conceptual work, they might ultimately be able to better convey their message outside academia and increase the real impact of their work.

5.3. Contributions to business practice

Our contribution to business practice is clarifying the crucial role of operating simultaneously on multiple levels to implement innovation ideas that are truly sustainable. In other words, businesses should not only transform the way they make their products, but simultaneously redesign the service exchanges taking place around these products, the wider business models encompassing these services, and also reconsider the way they interact with other actors to shape markets and industrial sectors. Despite in the literature the discussion about the higher levels of sustainable business model and ecosystem innovation is ongoing (Bocken et al., 2014; Konietzko et al., 2020)—and that some new ventures are engaging with these forms of radical innovation (Hockerts and Wüstenhagen, 2010)—in practice most large incumbent firms still operate at the lower levels of product and process optimization, driven by eco-efficiency compliance (Linder and Williander, 2017; van Tulder et al., 2013). Besides visualizing these levels of change next to each other, the framework developed in this study captures the broad spectrum of objectives, perspectives, stakeholders, activities and challenges that are present across them. Such information is particularly relevant for industrial designers and business managers who want to play a role in the transition toward sustainable development.

Industrial designers have been traditionally concerned with technical and aesthetic matters (Dell'Era and Verganti, 2010). However, the need for sustainable innovation poses new environmental and societal challenges, which are complex and interdisciplinary (George et al., 2016). As general specialists, designers can give a significant contribution to solving such challenges (Manzini, 2009, 2016, 2017) and foster innovation across the four levels of the framework. Yet, doing this requires going out of the comfort zone and learning to do something new (Joore and Brezet, 2015; Manzini, 2009).

Fourth recommendation: We encourage industrial designers to leverage their general specialism to foster sustainable innovation on multiple levels, from rethinking products and services, to disrupting the business model of organizations and transforming entire industrial sectors: by daring to have broader strategic objectives, learning to work from new perspectives, becoming proficient with new terminologies across disciplines, executing new key activities and dealing with new challenges, they may ultimately become active agents of change in the transition toward sustainable development.

Business managers can use their influence inside the organization they work for, in order to elevate design above a minor function concerned solely with technicalities and aesthetics in product development (Micheli et al., 2018). Specifically, designers may play a role at a strategic level by integrating the criteria of desirability (i.e. what people want), feasibility (i.e. what is technically achievable), viability (i.e. what is financially possible) and sustainability (i.e. what is economically, socially and environmentally acceptable) when innovating (Baldassarre et al., 2020). Recent research on this subject shows that designers' ways of "thinking and doing" can indeed be leveraged to innovate at the higher levels of our framework (Baldassarre et al., 2019b; Joore and Brezet, 2015). For example, designers can facilitate participatory workshops to foster interdisciplinary dialogue and processes (Bocken et al., 2019), envision and communicate future sustainable scenarios (Gaziulusoy and Ryan, 2017), conceive and test marketing campaigns through digital platforms and prototype beyond focal products entire value propositions, service exchanges and business models (Baldassarre et al., 2020; Schuit et al., 2017).

Fifth recommendation: We encourage business managers to acknowledge that industrial designers are not just product makers: by using their influence inside the organization to employ designers' ways of "thinking and doing" at a more strategic level, they will ultimately be able to realize superior innovation outcomes that are desirable, feasible, viable and sustainable.

6. Conclusion

In this paper, we focus on the implementation of sustainable design theory in business practice. This is essential for translating intangible speculations into reality, and achieving a positive, tangible, impact on society and the environment. Former research has already highlighted the need to focus on this important, yet problematic aspect. Our intention is to contribute to this effort while laying the foundations for future research and practice in this direction. To this end, we propose a framework and five recommendations for academic researchers, industrial designers and business managers who want to leverage their professional position to play an active role in the transition toward sustainable development.

Building on our work, future research may also address the limitations of this study. The first limitation relates to our data collection. In our literature review, the included articles were not selected with a systematic approach through a keyword-based search on scientific databases. Conversely, it was initially collected from two existing literature reviews and subsequently expanded through backward and forward snowballing. In our literature search, we included articles found through the reference list of these reviews, and articles citing them found on Scopus. Despite our literature search might have been biased, our data is derived by a large number of relevant publications, which were selected with clear criteria as part of a structured process and provide adequate grounding for our findings. Furthermore, our empirical data was collected with a qualitative approach. Thus, our framework is still an exploratory outcome and further research should validate its comprehensiveness and deepen our understanding of the themes. Nevertheless, the collected data is based on 20 expert interviews with relevant and diverse background knowledge and experience on the investigated subject. As such they provide a broad overview of multiple relevant aspects, which is relevant to inform future research.

The second limitation relates to the qualitative approach that we used to interpret our literature and empirical data. Even though we conducted this analysis in a structured way and employed different measures to mitigate subjectivity, we do not exclude that different

interpretations of our data may be possible. Nevertheless, our interpretation remains valuable to inform and guide future research efforts exploring the implementation of sustainable design theory in business practice.

To conclude, this paper represents a call to action related to the implementation of sustainable design theory in business practice. We suggest that future research around sustainable design theory may build onto this call to action by focusing further implementation issues while addressing the above-mentioned limitations. A potential follow-up of this study may be to leverage the framework, related concepts and keywords as a starting point for a more systematic literature review on the subject. Another future research avenue may be to conduct a follow-up of our empirical investigation, using our results as the starting point for a survey with a larger number of experts or to set up more focused longitudinal case studies on how certain companies or industries have been going through the different phases of sustainable design.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A and B. Supplementary data

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