Bio-inspired Design: Explicating the Value of Bio-Inspiration

GARBUIO Massimo\textsuperscript{a}; MAZZOLENI Ilaria\textsuperscript{b} and EISENBART Boris\textsuperscript{c}

\textsuperscript{a} University of Sydney Business School, Australia
\textsuperscript{b} Southern California Institute of Architecture, USA
\textsuperscript{c} Delft University of Technology, Holland
\textsuperscript{*} Corresponding author: Massimo.Garbuio@sydney.edu.au
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Policymakers and stakeholders are asking corporations to innovate and synchronize their practices with that of the natural environment. In this hopefully thought-provoking position paper, we use a comprehensive review of literature and industrial practice in gradually building strong arguments that bio-inspired design is a possible pathway to achieve this. This approach is directly inspired by nature, given that it is nature that ultimately will suggest novel ways to conserve biodiversity and provide human beings with a sustainable lifestyle. We strive to show the value of bio-inspired products and services, not only by virtue of being more environmentally sustainable, but, when consolidated in a concerted business model and value chain to lead to a sustainable competitive advantage for companies.

Keywords: bioinspired design, business model, analogies, strategy

Introduction

In every industry across the globe, corporations are being asked to innovate their strategies and mind-sets to meet the rapidly evolving expectations of governments and stakeholders for environmentally conscious business practices.

However, companies tend to interpret sustainability with a patchwork of disjointed practices aimed simply at appearing socially responsible (Howe and Kramer, 2006). Buildings and cities often adopt design features that focus on discrete problems, such as energy or waste reduction, to the neglect of an overarching strategy, due to their tendency to focus on working project by project (Kahneman & Lovallo, 1993). Yet,
excessive consumption, pollution, and overpopulation cannot be addressed with a series of individual solutions. With users and their needs remaining at the forefront of contemporary design, organizations are likely to continue to overlook the need for an overarching approach to social responsibility, unless overconsumption and similar issues become urgent user problems. The need for a more integrative approach to design is becoming increasingly obvious.

As we will show in this article, nature can provide tangible inspiration and analogies to help designers address some of the challenges of our century, in an approach that we call bio-inspired design. Designers can advocate this view to managers and management scholars alike, given that managers are responsible for the marketing of such bio-inspired products and that management and strategy are disciplines that are increasingly encouraged to employ designerly ways of thinking into their practices (e.g., Garbuio et al., 2015; Martin, 2009; Brown, 2009). To facilitate the spread of bio-inspired products and services, such solutions need to be cohesively integrated with an organization’s value chain and competitive business models.

In this paper, we build on an extensive literature in making our proposition that bio-inspired design (as an adjustment or expansion, respectively, to the mechanisms of user-centered design) may spearhead a pathway to addressing the larger challenges to modern society, or at least mitigating their severity. Throughout the paper, we complement these arguments with examples of industrial success in utilizing principles of bio-inspired design to also yield competitive advantages for companies. In the next section, we first discuss the concept of “user centricity” in design and highlight some its virtues and pitfalls when it comes to tackling some of today’s most pressing challenges. We then describe bio-inspired design, which involves looking at nature as inspiration and considering the entire ecosystem during the design process rather than the individual user. This entails a shift in the perspectives taken while designing products, services and strategies. We provide arguments, based on extant research, that this may very likely be cohesively connected with prominent approaches for user-centered design and innovation, such as design thinking. Finally, we illustrate how designers can facilitate the adoption of bio-inspired products and services by business leaders through their consolidation with/into sustainable business models. We strive to provide compelling arguments that bio-inspired design may help biologists, designers, and business leaders to address many of our most pressing environmental challenges.

PROBLEMS ASSOCIATED WITH USER CENTRICITY IN DESIGN THINKING

Defining User Centricity
One design principle that is widely accepted by designers and, more recently, business scholars is the importance of observing and understanding users. User-centered design represents a general approach that brings users or consumers into the design process (Norman and Draper 1986; Norman, 1998; Veryzer & Borja de Mozota, 2005; Vredenburg, Mao, Smith, & Carey, 2002). This approach involves getting to know users’ needs and wants, and sometimes also involves broadening their participation in the design process to more intimately identify their experience with products (Von Hippel, 1988; Bate and Robert, 2007). Thus, it moves design from a focus on the function of artefacts to the
actions of users as they experience these artefacts (Margolin, 1995; Margolin, 1997). Typically, user-centricity underpins a common process in which designers engage in an iterative cycle of investigation of customers’ perceptions of products, services, and needs. At times, designers may complement such activities directly focused on a particular user through broader, ethnographic research or persona creation (e.g., Miaskiewicz and Kozar, 2011; Mariampolski, 2005; Elliot and Jankel, 2003; Kelly, 2001; Squires and Byrne, 2002; Michlewski, 2008).

The user-centered approach was spearheaded in the professional design field several decades ago (compare Dorst, 2008; Visser, 2006) and has since dispersed to appendant fields, particularly management, where user understanding has become a key element of MBA education (Dunne and Martin, 2006). The approach is also popular among designers and managers of internationally recognized design-led organizations, such as the design consultancy IDEO and Philips Design (Brown, 2009; Kyffin and Gardien, 2009). In an interview study of attitudes toward design, senior designers and managers at these firms clearly identified how the user-perspective combined with a commercial viability perspective has become ingrained among them (Michewski, 2008). IDEO CEO Tim Brown assigns particular importance to design thinking as a human-centered endeavor (Brown, 2009). According to him, a successful design outcome exists at the intersection of three concerns: what is desirable from the user’s perspective, what is technically feasible, and what is commercially viable for the organization (Brown 2009). The approach is on the one hand a claim to support conception of visionary business strategies, on the other, envisions design to have the power to influence society (Badke-Schaub et al., 2010; Lockwood 2009, Martin 2009, Verganti 2009). Adoption of design thinking and its underlying user-centered approach to design, hence, have extremely valuable implications for management and business venturing. As we will discuss more thoroughly later in this article, here is where the connection can be drawn with building a larger, overarching vision through bio-inspired design and its orchestration into organizations’ business models.

2.2 Complications associated with user centricity in design thinking

Though scholars have at times voiced criticism (see, e.g., Norman, 2010; Badke-Schaub et al. 2010; Visser, 2009) pertaining to the scientific foundation of the design thinking approach, particularly in the proliferation in which it is promoted by Brown (2009), there is a large consensus on its efficacy for user-centered design and business strategy (Martin, 2009). If a deeper understanding of customers leads to products and services that better satisfy individual needs, problems can still arise when users’ desires conflict with what is ultimately good for them or others and the environment. From reviewing extant literature, it seems there are three main problems exacerbated by overreliance on user-centricity: overconsumption, product obsolescence and counter-intentional unsustainable behavior.

1 Personas are fictitious yet specific and concrete representations of target users. More specifically, personae represent an aggregate of target users who share common behavioral characteristics (i.e., is a hypothetical archetype of real users) (Pruitt and Adlin, 2006; Miaskiewicz and Kozar, 2011).
First, overconsumption is exacerbated by people’s preferences for immediate rather than delayed gratification (Crocker, 2013; Randers, 2012). Several decades of psychology and behavioral economics experiments have confirmed that individuals discount the future more heavily than the present time: they strongly prefer to consume today rather than tomorrow, even when future benefit is larger (Bulley et al., 2016; Peters and Büchel, 2009). Behavioral economics have identified many patterns that lead to poor long-term choices, such as under-investing in 401(k) plans (Madrian and Shea, 2001), failing to stick to personal savings plans (Laibson, 1997), and failing to take advantage of long-term oriented benefit programs (Della Vigna and Malmendier, 2006).

Secondly, overconsumption is exacerbated by obsolescence, which can be either directly built into products or is triggered through deliberate manipulation of consumers into frequent substitution of older-generation products for new ones. The term planned (or built-in) obsolescence dates at least to 1932 with Bernard London’s pamphlet “Ending the Depression Through Planned Obsolescence,” which advocated government imposition of something like an expiration date on consumer items in order to stimulate further consumption, and was popularized in 1954 by the American industrial designer Brooks Stevens. The first creator of large-scale planned obsolescence was the Phoebus cartel, a group of light-bulb manufacturers that has been accused of preventing technological advances that would have produced longer-lasting light bulbs to stir sales of their product (Wells, 2002; Dannoritzer, 2010). Today, many electronic gadgets as well as cars are victim of planned obsolescence, whether of function or style. Rather than decreasing in the face of heightened awareness about sustainability, research suggests that obsolescence is strategically used by more and more companies today (Abramson, 2012). Originally dictated by commercial logic, planned obsolescence is now largely accepted and, inadvertently, even expected by consumers.

By continually introducing new functions and retargeting or discontinuing others, a manufacturer can ride fashion cycles in product categories such as automobiles, which have a strict yearly schedule for new models, and mobile phones, which endure constant minor feature enhancements and restyling. Some of these companies also adopt strategies such as annual revisions about what features to include in each year’s new models – and exclude form previous years’ models, thus making older models less desirable for no technical reason (Bellezza et al., in press). Similarly, the clothing industry is cyclical and almost entirely style-driven. Americans buy 20 billion garments a year, an average of 64 garments a person (Cline, 2012). In the last decades, clothing stores started to break up the century-old biannual cycle of fashion; now several fashion companies produce four-to-six collections each year instead of two. This type of “fast fashion” has not changed the amount of labor needed to make an item or the waste created by its production, according to Masoud Golsorkhi, editor of the London culture and fashion magazine Tank. “Sometimes it’s actually cheaper to throw away clothes than to wash them,” he noted, “that has got to be wrong” (Hansen, 2012).

Thirdly, most of the increasing demand for sustainable products appears to be an expression of a status-conscious mind-set rather than a truly environmentally conscious mind-set. The number one reason Toyota Prius owners gave for purchasing the low-emissions vehicle was that it “makes a statement about me,” namely showing the world that they care about the environment (Maynard, 2007). By contrast, environmental
conservation only ranked number five on this list. Prius sales are concentrated in geographic areas where being green is likely to be a status symbol; similarly, people are more likely to install solar panels where they will be visible to others rather than in direct sunlight (Sexton and Sexton, 2011). These studies confirm the fact that consumers are willing to pay higher prices for sustainable products that enhance their status (Griskevicius et al., 2010). Given that the design of sustainable products may not be driven entirely by sustainability concerns, user-centric design may have a limited capacity to truly improve the well-being of users. By extension, the sustainability of popularly “green” products and technologies becomes questionable due to known effects connected with behavioral consumer patterns like the rebound effect (Herring and Sorrell, 2009), which paradoxically then leads to less sustainable consumption overall. As illustration, users may end up driving their fuel-efficient cars further and more often than their gas guzzlers. Thus, solutions to environmental challenges might not require new, more efficient technologies, but rather behavioral changes in how we use the technology and reductions in our consumption of goods and services (Waltersdorfer et al., 2015; Herring and Sorrell, 2009; Owen, 2012).

A final, maybe less obvious deficit is that user-centricity is not always the best source of innovation. Famous leaders in innovation, such as the late Steve Jobs, have recognized that users often do not know or cannot articulate what they want from a product (see Isaacson, 2011, for examples of Job’s hesitation to rely on user and market research to generate new-product ideas; see also Leonard and Rayport, 1997). In addition, researchers have begun to theorize that paying too much attention to current customers, especially large, influential ones, leads companies to provide only incremental, rather than radical, innovation and fall behind new entrants that are not blindsided by these customers (Christensen, 1997). Similarly, a truly needed, overarching vision towards sustainability may become more and more distant. Distance from customers could spur leaders to search for innovation that goes deeper than mere technological or stylistic innovation (Norman and Verganti, 2012; Verganti, 2008; Bennett and Cooper, 1979).

For all these reasons, the world’s environmental issues are unlikely to be solved with current practices. The fact that user-centricity and design thinking are nowadays permeating into the business environment may accelerate this effect further. We suggest that what is needed is a more radical re-evaluation of the relationship between energy and consumption by human beings and companies alike. Our search of extant literature suggests that designers are maybe best equipped to address these problems given their tools, talents, and drive to solve challenging and often ill-defined problems (Simon 1973). Hence, in the next section we propose compelling arguments from a review of literature and practice to highlight the benefit in merging design thinking endeavors with a different, more inherently environment-oriented component, i.e. bio-inspired design.
BIO-INSPIRED DESIGN

Given the challenges of the 21st century, bio-inspired design may provide an interesting approach in a transition from a user-centered approach to one rooted in the natural world. More specifically, we propose that bio-inspiration reacts to nature in two ways:

i) Nature as inspiration: Bio-inspired design is inspired by a systematic examination of ecological processes.

ii) Nature as a design constraint: As compared to traditional design, bio-inspired design gives equal weight to all organisms rather than being anthropocentric.

Design and bio-inspired design are of course about design for human needs and wants. However, the definition of bio-inspired design goes a step further and explicates the role of nature in design. As a source of inspiration, elements of the natural environment play an active role in design, enriching the designer’s inspirations. But nature also provides constraints to designers, requiring them to consider all organisms that might be impacted by the design process during all its phases. In this sense, bio-inspired design is not based exclusively on human needs and wants — i.e. user-centricity — but rather places the design object in the context of a larger ecosystem of resources, objects, and actions that limits and alleviates the environmental stress currently imposed on our planet. Using nature as both inspiration and constraint in the design process, bio-inspired design recognizes that resources are finite, nature is vulnerable, and other organisms are as important as humans are. Arguably, this is a fairly radical change in mind-set, that some people may find somewhat confronting at first and we will use the next sections to explicate how this is to be interpreted.

Nature as inspiration

The first defining characteristic of bio-inspired design is its use of natural processes, structures and fundamental effectual relations as a source of inspiration and innovation. It distinguishes itself from bionic or biomimetic design, which directly try to mimic extraordinary design solutions found in nature into products (Nachtigall, 2002). Bio-inspired design promotes a novel, more overarching perspective, using the idea of natural equilibria as vantage point and making considerations about the orchestration of disturbances to these, e.g. through novel products and services, salient.

In general, bringing a fresh perspective to an old problem has been proven to lead to innovative solutions (Garbuio et al, forthcoming). Neuroscientific research has found that our perception of the external environment is not a product of eyes or ears, but rather of the brain (Berns, 2008). In fact, our perceptions are heavily influenced by past experiences (Jiang et al, 2007; Purves and Lotto, 2003). Commonplace perceptions feel comfortable and cost little energy to process. Conversely, uncommon perceptions force the brain into a different, more challenging mode of processing. Innovators see the world differently from others because their brains avoid many of the cognitive traps that affect most people (Berns, 2008).

2 Of course, there are other characteristics of design thinking that contribute to bio-inspired design, such as abduction, framing (e.g., Dorst, 2011), prototyping, and experimentation (e.g., Brown, 2009; Liedtka and Olgivie, 2011).
Ultimately, the ability to identify novel insights depends on the ability to view both the familiar and the unfamiliar from a new perspective. In an experimental study, Chan et al. (2011) found that senior engineering students generated more novel and higher-quality solutions during the ideation process when considering far-flung (from a different problem domain) and less-common examples than when considering more familiar ones (see also Arntz et al. forthcoming; Goldschmidt and Sever, 2011). The potential for creative insights strengthens when the two domains being compared are very different on their surface characteristics — that is, on their appearance and attributes — rather than their structural characteristics, that is, on their working relationships (Gentner and Markman, 1997; Tseng et al., 2008). Moreover, Casakin and Goldschmidt (1999) found that visual analogies can improve design problem solving by both novice and expert architects (see also Ball et al. 2004; Helms, Vattam, and Goel, 2009; and Mazzoleni, 2013).

Radical innovations often happen at the intersections of disciplines. Applying established methods from one’s own field to a novel problem, attacking problems as a beginner, and letting go of preconceptions and fear of failure are all keys to creativity (Berns, 2008; Lakhani and Jeppesen, 2010). People are predisposed to link problems that are distant from their fields with solutions they have encountered in their own work. In a study of the company InnoCentive, which posts tough R&D problems online for anyone to solve, Lakhani and Jeppesen (2010) found that problem solvers were most effective at the margins of their own fields. For example, one molecular biology problem was solved by an aerospace physicist and a small agriculture business owner. These individuals were close enough to understand the challenge, but not so close that their knowledge led them to the same stumbling blocks that held back their more expert peers. In fact, 30 per cent of posted challenges that confounded experienced corporate researchers were solved by non-employees (Lakhani and Jeppesen, 2010). When we deeply understand how organisms function in a different field, we bypass the restrictive, simplifying frameworks of our own field and see more broadly.

Looking at creativity and innovation from a psychological point of view, we see that differences in the ability to think creatively can be linked to variations in personally traits and cognitive faculties (Batey & Furnham, 2006). Cognitive strategies applied by highly creative people are related to abstraction of knowledge and semantic relation (Gilhooly et al., 2007). This entails abstraction and recombination of remotely related concepts across domains by use of analogies. Such solution finding strategies have been linked with higher originality and innovation than direct retrieval from memory (Nusbaum & Silvia, 2011; Kauman, 2009; Silvia, 2008; Runco, 2007). The idea of reconnecting concepts across domains is very similar to the process of abductive reasoning, which, in combination with analogical reasoning, is considered the lifeblood for the successful application of design thinking (see, e.g., Dong et al., 2016; Dorst, 2011; Kolko, 2010). An expansion of design thinking towards bio-inspired design, hence, not only seems inherently possible, but a seamless pathway for innovation.

3 By using analogies far from their field, the opposite is also true. That is, people are predisposed to link solutions that are distant from their fields with problems they have encountered in their own work.
One early example of nature as a source of inspiration and innovation is the study of birds in the quest for human flight. In his fruitless attempt to design a “flying machine,” Leonardo da Vinci (1452–1519) meticulously studied the anatomy and flight of birds. More recently, the seminal work of the designer Janine Benyus (1997) exemplifies biomimicry. Biomimicry considers the natural environment as an element worthy of imitation in the form, function, and process of design. Through the observation and analysis of natural processes, it is possible to learn lessons that generate new forms of integrated design in addition to creating artefacts that show respect for nature. Our definition of bio-inspired design attempts to capture the essence of Janine’s work by focusing on inspiration rather than imitation. In neighboring disciplines, such as engineering and science, approaches like bionics a biomimetics mentioned earlier have been vital in the development of new innovative technologies and solutions (Bar-Cohen, 2011).

As Benyus (1997) and Ternaux et al. (2011) suggest, there are numerous reasons that the biological world serves as a useful analogy for design. Nature is efficient: it relies on one primary source of energy—solar—and uses only as much as it needs and creates the rest. Nature is sufficient, recycling everything. Like the best designers, it matches form to function, bets on diversity, works with local expertise, and uses constraints as a source of creativity. In addition, many optimal structures in nature resemble each other (i.e., water droplets and jellyfish, trees and blood vessels), inspiring us to borrow from them. Finally, the elaborate behavior of many plant and animal species allows the resolution of complex problems and maintains the survival of the species.

Procter & Gamble (P&G) is one company that has transitioned from user-centric design to a deeper design that finds inspiration for new products in nature, as championed by Vice President of Design Innovation and Strategy Claudia Kotcha and CEO A.G. Lafley in the 2000s. When Pete Foley, the associate director of P&G’s cognitive science group, was looking for an inspired solution to the challenges of one of P&G’s business unit, he took his R&D staff to the San Diego Zoo. The San Diego Zoo, in fact, is developing a program in bio-inspiration to help companies innovate by looking at the natural world. Coca-Cola, Colgate-Palmolive, General Electric, Boeing, Herman Miller, and Nike have all experimented with using nature as inspiration for product design. But similarity of form and processes between a natural object and a manmade object is only one aspect of inspiration. The use of natural forms and processes in design can be a stepping stone for a corporation to become more sensitive to bio-inspiration in a broader sense.

The presented research and case examples clearly suggest vital benefits of consolidating design thinking and related approaches aimed at fostering innovation and creativity with bio-inspired design as a fundamental principle. It is in fact inherently rooted in innovation to recombine analogical principles into novel solutions and nature is a paramount source of inspiration for this. However, to fully address the challenges of our century, this would be insufficient if bio-inspiration did not explicitly consider nature as a constraint in the design process.

Nature as a constraint
Bio-inspired design marks a deep transition from user-centered design to system-driven bio-design – a move away from an anthropocentric focus to placing equal value on all organisms. For design to be respectful of nature, nature itself rather than potential
customers must be the driver of the design process. Thus, a broad section of the environment rather than a single element — such as an animal or a plant — should play an active role in the design. This approach enriches the designer’s inspirations while also lessening the environmental impact of the final product, simply because the impact on all these other organisms is explicitly considered in the design process. We foresee design moving toward this type of co-evolutionary process, where multiple environmental factors intervene in the making of a product and its placement in the marketplace.

A proactive observation of natural processes and ecosystems can allow both designers and managers to learn lessons that inspire design solutions and strategies that are not only “constrained” by the natural environment but also better integrated with it. As a result of this new approach, bio-inspired design considers the object being designed in the context of a large ecosystem of resources, objects, and actions, each of which limits and alleviates the environmental stress currently imposed on our planet. Natural systems are interconnected, and natural cycles give each other feedback in a balanced way. But the increased pace and scale of human activities has unknown consequences for the balance of systems that allow all species, including our own, to thrive. In bio-inspired design, designers aim for interconnectedness in design—that is, the integration of nature’s solutions with innovative problem solving for manmade environments.

Nature as both an inspiration and constraint in the design process is indeed a difficult yet attainable goal. Companies such as Patagonia and Ittala, for example, pay attention to the environment, explicitly promoting durability and asking their customers to avoid overconsumption. Since its inception, but especially after filing for bankruptcy in 1991, Patagonia has put environmental values at the forefront of its mission. In founder Yvon Chouinard’s words, “The reasons we hadn’t sold out and retired was that were pessimistic about the fate of the world and felt responsibility to use our resources to do something about it” (Chouinard, 2005). The near-death experience of bankruptcy was followed by a stringent environmental impact assessment of the company’s products as well as efforts to reduce waste. The former led Patagonia to use only organically grown cotton; the latter to changes in packaging and a request to customers to send back old Patagonia products to be recycled into fabrics. More recently, Patagonia has asked its customers to buy only what they truly need. Of course, these practices are reflected in higher prices, which customers have proven willing to pay, as witnessed by the company’s financial recovery and recent profitability.

Ittala’s approach to durability and overconsumption is stated on its mission statement:

We believe that in today’s increasingly disposable world people value things that are well-designed and made to outlive changing times and trends. Our strategy is to build on superior consumer understanding, customer satisfaction, strong brands, an efficient supply chain, and growth in both individual product segments and geographically.”

In using nature as a source for analogy and as constraint, designers may be able generate solutions that alleviate the potential pitfalls associated with excessive focus on user-centricity discussed earlier. This approach explicitly views consumption of products and

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4 See http://www.patagonia.com/us/common-threads/
5 See https://www.iittala.com/about-us-meet-the-company
services as part of a large ecosystem, as purchasing, usage, and disposal decisions explicitly consider the impact on the environment. Given, however, that implementation of novel solutions imperatively requires backing from management typically focused on economic growth, this automatically begs the question how bio-inspired design solutions may feasibly and cohesively be integrated into lucrative businesses.

THE ROLE OF THE DESIGNER: REFLECTION QUESTIONS FOR IMPLEMENTING BIO-INSPIRED DESIGN

Efforts to employ bio-inspired design will fail unless business leaders can be persuaded of its benefits. Brown (2009) conceived design thinking to have the capability to not only lead to novel product or service solutions but provide a pathway to improve society. We strongly concur that focus on individual product or service innovations will lead to a neglect of an overarching strategy. Moreover, while launching novel and commercially successful products and services remains imperative to business venturing, history has taught us repeatedly that product innovations are typically picked up and replicated quickly by competitors (Massa and Tucci, 2013; Casprini, 2015). This poses stark challenges to companies to repeat the innovation cycle quickly after a novel product has been launched leading to shorter cycles between product generations, which is eventually detrimental to sustainability (as discussed earlier). Extant literature informs us that changes of business models are much more likely to lead to a much longer sustainable competitive advantage (Achtenhagen et al., 2013), as they are distinctly harder to replicate. What is more, research has shown the vast opportunity for value creation and monetization that a change towards more sustainable business models carry (Kiron, et al., 2013; Kramer & Porter, 2011). Examples can be found in diverse sectors, such as the high-tech companies Google and IBM, but also Johnson & Johnson, Unilever, Nestle, in private equity and the clothing industry (Bocken, 2015; Short et al., 2014; Bocken et al., 2014). Arguably, such endeavors are still far from the norm, but their potential is undeniable.

To frame their arguments for maximum appeal to business leaders (Teece, 2010), designers need to understand the concept of business models, which describe simultaneously how a company creates, delivers, and captures value (e.g., Teece, 2010; Sinfield, Calder, McConnell and Colson, 2011). On the basis of our research, we have identified three areas that designers and companies need to consider in order to successfully bring bio-inspired products and services to market and anchor it in a concerted business model. Like Teece (2010) and Markides and Oyon (2010), we do not provide a recipe for how to design a business model for bio-inspired products and services, but rather raise questions to be considered. New business models provide provisional solutions to customers’ needs and wants. Through discovery, learning, and adaptation, these models are likely to be replaced by improved models that take advantage of further innovations. As noted by Teece (2010), designing good business models is in part an “art.” In fact, the right business model is rarely apparent early on, but a strong template can help designers and managers learn and adjust.

In this spirit, we address these three key elements of business models that will help designers and companies alike create, deliver, and capture value from bio-inspired products and services: the value proposition offered to customers, the role of the business in the value chain, and how the business makes a profit. To achieve buy-in, designers can
leverage the opportunity to communicate the benefits of bio-inspired products and services in terms of these three elements. Table 1 below summarized our proposed template for the creation, deliver, and capture of value through bio-inspired products and services.

Table 1: Template for the creation, deliver, and capture of value through bio-inspired products and services

<table>
<thead>
<tr>
<th>Value</th>
<th>Bio-inspired products and services: Key questions</th>
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<tr>
<td>Value creation – users’ value</td>
<td>How does your product or service create immediate and delayed value to users?</td>
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<td>How does your product or service create value direct value to the (direct) users and indirect value because of a better environment due to the way material is sourced, the product is produced, used and finally disposed?</td>
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<td>How does your product or service consider direct benefits to the environment?</td>
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<tr>
<td>Value delivery – new distribution of value across actors in the value chain</td>
<td>How do you (or the company you work for) deliver efficient and adaptive value to the users in a bio-inspired value chain?</td>
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<td></td>
<td>How does your product or service take advantage of cheaper and more sophisticated additive manufacturing?</td>
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<td>How will co-location of design and manufacturing facilitate bio-inspired value chains?</td>
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<td>How does your role as a designer expand in bio-inspired value chains?</td>
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<td>Value capturing - Competitive advantage</td>
<td>How does a company use bio-inspired design thinking as a source of competitive advantage?</td>
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<td>How can these sources of competitive advantage be protected over time, as bio-inspired design is more broadly embraced?</td>
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<td>How is bio-inspired products and services’ value captured through innovative price systems?</td>
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<td>How can traditional companies capture value while designers’ role in the value chain expands?</td>
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Redefining value creation: Value created by bio-inspired design products and services

The first element of business models that designers need to think about when using a bio-inspired design approach is the value they create for users. Unlike traditional approaches, which focus on a specific user, a bio-inspired design approach considers how each organism is impacted by the product or service during its entire life cycle. By doing so, and by explicitly considering all stakeholders, designers create value that goes beyond the
As discussed earlier, there are barriers to communicating these benefits. Namely, consumers or direct users may not perceive these goals as important due to a short-term focus. A bias toward the present causes people to place more weight on consumption today rather than tomorrow, next year, or 50 years from now. In addition, there is currently a trend toward buying products that “look” green rather than actually being green.

How can designers communicate the immediate and delayed benefits of bio-inspired products and services to facilitate their adoption and reduce overconsumption? To address these challenges, designers could consider distinguishing between two types of value generated by bio-inspired products: value that directly benefits the user of a good or service (e.g., the car takes me to work) and value that comes indirectly from living in a better environment (e.g., the quality of air in a clean town versus an overpopulated one).

That is, questions arise as to how take into consideration benefits that accrue directly to individuals and benefits that are come indirectly from the fact that bio-inspired design will generate products and services that will improve our environment. This exercise directly considers the value created for the broader environment in which the material is sourced and products are made, used, and disposed.

Redefining value delivering: The role of designers and companies
Companies operate not in isolation but as part of industry value chains that proceed from the extraction of materials to production, delivery of products and services to users, usage and maintenance, and final product disposal (Porter, 1980). Traditionally, the value chain is focused on the industry level and consists of actors ranging from suppliers to customers. By contrast, bio-inspired design extends this notion to encompass a lifecycle value chain that considers any organism that comes into contact with the company or its products during the product or service lifecycle. Given the complexity of bio-inspired product design, companies that follow this model will be embedded in a large, strong network of collaborators that starts with biologists. A value chain inspired by nature is energy efficient, as actors work in the same environment and keep intermediaries to a minimum.

Designers and companies will have to redefine their understanding of the value chain, for two primary reasons. First, with the advent of new technological tools for the manufacture and marketing of products and services, from additive manufacturing processes to 3D printing to the Internet, designers can directly connect with customers. As

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6 In particular, from a practical point of view, we could explicitly distinguish between two types of users. Direct users are those who ultimately use an artifact or benefit from a service. Indirect users are those who do not directly use the artifacts but are impacted by them in some ways. These can be organisms that come in contact with the artifact, the extraction of resources for its production and its disposals. But this group also includes all the future generations that inevitably will be affected by a poorer and more polluted environment. In fact, we ourselves are already the “future” generation that has been affected by a poorer, more polluted, and in many ways damaged environment.
a result, designers have the ability to produce and distribute the final product anywhere in the world, a change that affects how we think about the value chain.

Second, there has been a growing recognition of the importance of physically co-locating design, manufacturing, and management for the sake of innovation. In their work, Pisano and Shih (2009) show that keeping industrial and design capabilities close to company headquarters is the key to long-term competitive advantage and innovation, as the manufacturing process is a source of innovation for most high-tech companies. They also note that keeping industrial capabilities within a country creates a virtuous circle around shared know-how, competences, and infrastructures for specific industries and thus stimulates innovation. Co-location of design and manufacturing also resembles the type of energy-efficient value chains found in nature.

**Re-defining value capturing: Competitive advantage through selling and profiting from bio-inspired design**

Bio-design may lead to products and services that offer new value for customers as well as a new value chain, but what competitive advantage does bio-inspired design offer companies? An examination of the fundamental definition of competitive advantage can bring us to a deeper understanding of how bio-inspired design may provide differentiation from competitors and financial rewards.

A firm is said to have achieved a competitive advantage over its rivals when it has driven a wide wedge between the willingness to pay it generates among buyers and the costs it incurs (Ghemawat, 2009)—specifically, a wider wedge than its competitors have achieved. Products and services inspired by bio-design thinking offer sources of value that, if correctly communicated, will be greater than those of non-bio-inspired products and services. As a result of the greater value generated, the prices of bio-inspired products can be higher than those of other products, at least in the short run. In turn, higher prices translate into relatively higher revenues for bio-inspired products.

As others have claimed before us, we believe that prices need to reflect the environmental impact, such as pollution generated, of man-made products and services (Chouinard et al., 2011). In addition, changes in pricing mechanisms may induce behavioral changes by corporations. For example, as pointed out by Owen (2012), if customers must rent electronic gadgets from manufacturers rather than buying them, manufacturers would have sufficient incentives to make products that last beyond the mandatory warranty period rather than frequently enticing consumers with incremental, paid upgrades.

Innovating through bio-inspired design is not cheap. Innovation requires R&D spending; however, given that bio-inspiration calls for companies to use as many resources as are required and no more, cost savings are likely achievable in novel ways. Ultimately, the cost of designing and producing bio-inspired products is perhaps the greatest challenge to leveraging bio-inspiration. Fortunately, designers thrive on constraints and challenges.

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7 3D printing services companies such as Shapeways, Kraftwurx, i.materialise, and Freedom Of Creation will facilitate this process. Also, Thingiverse of MakerBot Industries allows the sharing of 3D printing files and serves as a community resource. Finally, these services are now moving to smartphones, such as the applications Sculpteo.
Moreover, analytics can assist in monitoring demand and production can be democratized, as it is with 3D printing. Bio-inspired products and services can be developed that save costs to the benefit of the environment at large.

**DISCUSSION AND CONCLUSION**

Design has unequivocally peaked as a source of value creation for individuals, companies, and society at large (e.g., Norman, 2004, Dell’Era and Verganti, 2007). Notably, in 2011, the European Commission launched the European Design Innovation Initiative (EDII) to exploit the full potential of design for innovation and to reinforce the link between design, innovation, and competitiveness. In this somewhat provocative piece, we have used a comprehensive review of literature and examples from practice to gradually construe and underpin our proposition that, by embracing a bio-inspired perspective in design and business venturing, we can try to approach the 21st century with a stronger vision of the environment at large. When focusing on the bigger picture, designers are aspired to be able to satisfy user needs and desires while also sustaining the planet’s resources. To achieve these goals, intervening in the design-to-consumption lifecycle becomes critical. We propose doing so using an eco-system-inspired approach that requires designers to regain contact with nature and humbly observe the living world for sources of information and inspiration.

At its most radical, bio-inspired design will not be limited to the creative actions of designers but includes the entire production process (from idea generation to marketability to production, to use and final disposal) and all players involved, including the environment (which provides resources), designers (who interpret problems and design solutions), and business actors (who champion new ideas and solutions and successfully take them to the market). An ecological, system-like mind-set drives the design process rather than the final customer. Collaboration among multidisciplinary individuals is perhaps the first step in building awareness of interdependencies and cyclicality and better integrating artificial and natural cycles.

In fact, it is crucial that bio-inspiration stay not only with designers but extend to managers and management scholars as well. Luckily, these recently started to embrace design thinking as a way to innovate and form company strategy (Garbuio et al, 2015; Garbuio et al, forthcoming; Mintzberg et al. 1998; Liedtka and Mintzberg, 2006; Brown, 2009; Martin, 2009; Carlopio, 2010; Liedtka and Olgivie, 2011). Designers may become the catalysts advancing this transformation in management and strategy scholarship and practice. The shift needs to deeply modify corporate behaviors and dramatically reduce the use of scarce natural resources.

**REFERENCES**


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About the Authors

**Massimo Garbuio** is a Senior Lecturer in Entrepreneurship at the University of Sydney Business School. He holds a PhD from the University of Western Australia and studied at the University College London and the University of Pennsylvania.

**Boris Eisenbart** is Assistant Professor of Design Theory and Methodology in the Product Innovation Management Department at the Delft University of Technology. He holds a Diploma in mechatronics engineering from Saarland University, and holds a PhD from the University of Luxembourg.

**Ilaria Mazzoleni** is an architect, biomimicist, and the founder of IM Studio Milano/Los Angeles (www.imstudio.us). She holds a Bachelor of Architecture from the Polytechnic of Milan, and a Master of Building Science from USC.
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