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Title: Design for Biodiversity: a new approach for ecologically sustainable product design?

Theme: Embedding Sustainability

Abstract

McDonough and Braungart proposed the “Cradle to Cradle” design framework to provide solutions to the world’s current ecological crisis. This approach, based on examples from nature, ensures that human activities can have a positive ecological footprint, capable of replenishing and regenerating natural systems, as well guaranteeing that we are able to develop a world that is culturally and ecologically diverse. In their framework they describe the notion of biological nutrients, where industrial waste (non toxic & biodegradable) may be used as a beneficial nutrient for ecological systems, eliminating the need for efficiency, as “waste is good”. Consequently, Cradle to Cradle industrial systems will benefit the environment.

A group of New Zealand scientists were asked to evaluate ‘Cradle to Cradle’ in an attempt to determine the potential of this approach for the sustainable design of products. Analysis of interview data indicated that sustainability is a complex and multifaceted concept, especially with regard to practical applications. In particular, understanding the input of biological nutrients into the environment was identified as being critically important. Furthermore, science can play an important in understanding the impacts of products, as well as how biological nutrient’s may be best used in environmental systems. The insights gathered from these interviews were used to explore the potential for an alternative sustainable design approach, which builds upon McDonough and Braungart’s concept of a biological nutrient, and aims to support the design of products that have a strong ecological foundation. Consequently, Design for Biodiversity is outlined as a potential approach for designing environmentally sustainable products. During the development of this approach, the relationship between science and design was explored to support the notion that ecosystems are the basis of human consumption and should be incorporated as an integral part of society to ensure the development of strong sustainability. The intent of this approach is to help to design ecologically beneficial products. It is relatively untested, and should be evaluated and revised during future design projects.

Introduction

Sustainable development is defined as “meeting the needs of the present generation without compromising the ability of future generations to meet their own needs” (WCED1987, p47). Few scientific, social and political areas have not been examined in the context of sustainability. Consequently the activities and definition of sustainable development is in constant evolution (García-Serna et al. 2007). Historically, advancing ecological sustainability required a trade off against economic profitability. However, a triple bottom line approach has become more prevalent. This approach recognises that a long-term solution requires balancing social equity, economic health and the environment (Elkington 1997).

However, the triple bottom line approach has been criticised for being more divisive than unifying. Furthermore, the division between society, environment and economy is artificial (García-Serna et al. 2007).

The loss of biodiversity, arguably the dominant contributor to environmental sustainability, is considered one of the greatest threats to the continued survival of humans on earth (Wood 2000). The destruction of biodiversity and associated failure of ecological systems resulting from human activities is a main factor contributing to the collapse of many societies throughout history (Diamond 2005). In addition, our reliance on ecosystems, and the likely failure of these ecosystems to further adapt to human impacts, will have serious implications on the health and wellbeing of future populations (Walter-Toews 2004).

Sustainable Product Design

Design practitioners, through their roles in shaping the future, are viewed as being able to promote change in society, especially around unsustainable behaviours (Sosa & Gero 2008). In "Design for society", Whiteley (1993) argues that designers have a moral and ethical obligation to be responsible for their designs, and the social and environmental impacts of their work. Whitely (1993) follows the writings of others (i.e. Papanek 1971) to reveal a lack of values and ambition, in the marriage between design and consumerism. Consumer-led design is so prevalent that it appears as a "*natural and inevitable aspect of our society*" (Whiteley 1993:7). For design to change, the role and values of design, as well as the relationship of design with society needs to change. This may come from a reflection as to whether design is merely a servant of industry, or can inform through intelligent thought and action, while contributing to the global ecological balance (Whiteley 1993).

The design community has responded to the growing issues around social and environmental issues by developing concepts and frameworks to guide eco-design and sustainable design activities (Sherwin 2004). These concepts are centred on ideals of acknowledging ecological limits and demonstrating responsibility, and increased contribution to society and the environment (Sherwin 2004). Eco-design approaches aim to minimise environmental impacts (Tischner & Charter 2001). Motivation for these approaches is usually justified by the economic gains associated with financial savings associated with greater "efficiencies". Strategies reflect product development processes that consider the environment at each design and manufacturing stage to reduce or minimise environmental impacts throughout the product's life (Glavič & Lukman 2007). While atempts are often made to lower environmental impact materials during production, a product's environmental impact may not be considered after it has been sold (Ljungberg 2007). Many methods are non-generic and require customisation prior to use to be compatible with current product development processes. Furthermore they are often not based on rigorous design and engineering principles (Knight & Jenkins 2009).

Sustainable (product) design encompasses and goes beyond the principles of eco-design incorporating greater innovation, ethics and the socio-economic dimensions of sustainability. Sustainable design frameworks have been described as utilising ecological principles as methods of design, yet this is in conflict with the aim of designing for 'triple bottom line' solutions, as described by Tischner and Charter (2001) and Sherwin (2004), exponents of sustainable design frameworks. Few actual product examples of exist, and these are often experimental (Zafarmand et al. 2003, Sherwin 2004).

The feasibility of the Cradle to Cradle design framework

Cradle to Cradle (C2C) design is a design framework (and paradigm) for designing products inspired by looking to natural systems (McDonough & Braungart 2002, Braungart et al. 2007). In contrast to using "eco-efficiency" as a driver for producing environmentally benign products, Braungart et al. (2007, p1338) suggest their "eco-effective" approach "*proposes the transformation of products and their associated material flows such that they form a supportive relationship with ecological systems and future economic growth*". They claim this generates a synergy between economic and ecological systems. Eco-effectiveness starts with a vision that industry is 100% good. The concept of waste does not exist, as all outputs from one process become inputs for other processes. Therefore eco-effectiveness supports and regenerates ecological systems and enables long-term prosperity, and is the basis for "triple top line" objectives (Braungart et al. 2007). Simply, eco-effective design results in products that are absorbed into the environment, so that industrial systems wastes may become nutrients for ecological systems (or biological nutrients). Technical nutrients are described as synthetic or mineral materials that safely remain in a closed loop system of manufacture, recovery and reuse to maintain their material value through many cycles. McDonough and Braungart (2002) suggest using their approach may result in the replenishment and regeneration of natural systems, as well guaranteeing that we are able to develop a world that is culturally and ecologically diverse.

The C2C approach for the design of products was recently explored from an ecological perspective in an attempt to determine the potential of this approach for the design of products. This particular framework was specifically selected as it is relatively well known and has received favourable attention from the design community. Furthermore, literature searches indicate that it has received little attention from the scientific community. Finally, the authors suggest their approach can ensure that human activities have a positive ecological footprint (McDonough and Braungart 2002).

Reay (2009) undertook a series of semi-structured key informant interviews of senior New Zealand scientists. The scientists were selected using a non-probability purposive sampling technique, and were employed in a senior science position in either a Crown Research Institute or New Zealand University. The group was selected as having a broad understanding of the biological processes that underpin sustainability, or the development of materials and processes that may be required for the development of sustainable systems, and were from a range of scientific disciplines (e.g. biologist, materials scientists, chemical & process scientist, biotechnologist etc.). Participants were given a copy of Braungart et al (2007)'s C2C article prior to being interviewed. The interviews were analysed using a qualitative thematic analysis method whereby the textual data was read and coded to identify common and divergent viewpoints. The key perspectives or themes were developed into an explanatory model.

A dominant theme that emerged from the interviews was the complexity associated with understanding the interactions of humans, societies and their environments. To address issues of sustainability with rigour requires an ability to explore and work within complex systems and demands (Bradbury 2002, van Roon & Knight 2004). This requires the capacity to ask questions framed in an appropriate context and the aptitude to interpret and discuss complex results. The key informant interviews illustrate that consideration of human impacts on the environment is critical, and was the most discussed factor when referring to sustainability. The participants' considered the environment as the foundation of sustainability. Therefore the protection of biodiversity and the natural systems in which it persists is fundamental to sustainability. In general participants' expressed caution when approaching the concept of biological nutrients as a simple solution to sustainability problems. While participants' generally favoured the C2C rationale, most considered it to be idealistic: a good idea in principle, but not in practice. Overall, C2C was not widely accepted as a framework that would reflect the realities of complex social and environmental ecosystems. Most participants viewed the goals of reducing human impacts to zero as a more realistic than attempting to generate positive environmental impacts. Furthermore, in order to have a positive impact we must know what that positive might be, which might not always be the case. The study concluded the concept of a biological nutrient, as identified by Braungart et al. (2007), represents an exciting opportunity for designers who can play an important role in developing sustainable futures. However, ensuring ecological sustainability requires all decision making being made within an ecological context, and recognising that humans are part of ecological systems (van Roon & Knight 2004). Therefore the functional capabilities of ecosystems need to be central to decision making processes.

Design for Biodiversity

The key findings from Reay (2009) were used to propose a new design approach that places biodiversity central to the design decision-making process. This design approach is intended to be used as a concept ideation tool, and to support subsequent design process. The approached builds on Braungart et al.'s (2007) concept of a biological nutrient, and encourages the designer to view biological organisms with the same importance that they view human centredness in most design activities. Design for Biodiversity is relatively untested approach, and attempts to encourage the designer to consider the ecological implications of their design process in a more rigorous way. In general, this may mean engaging with specialists who have an understanding of a particular organism or ecological system in which the product might be deployed.

The Design for Biodiversity approach implies that the needs of human users are potentially less tangible than with traditional design approaches, recognising higher levels of complexity and the connection and dependence of people and ecosystems. The impacts of products/human activities are complex, dynamic and long-term, and are intimately connected throughout a products life with the environment. With this approach, a primary role of products is to support biodiversity, and to function as biological nutrients at their end of their life, while satisfying human user requirements.

The Design for Biodiversity approach is the result of applying the discipline of design to current ecological issues. The approach represents a qualitative approach to design to guide decision making process to help make conscious, well informed, best-practise decisions in the early stages of the sustainable design process. Using this approach helps recognise the ecosystem as the basic unit of ecology and represents the systemic relatedness of everything to everything else (Park 2000). This approach acknowledges the importance of human impacts on ecosystems, and "*the intimate, and reciprocal, relationship between human activity and the health and integrity of ecosystems*" (Van Root & Knight 2004, p269), and attempts to enhance the positive nature of these relationships. This approach is in direct contrast to many current "eco-design" activities, where design is primarily focused toward human users with the intent of minimising or reducing environmental impacts.

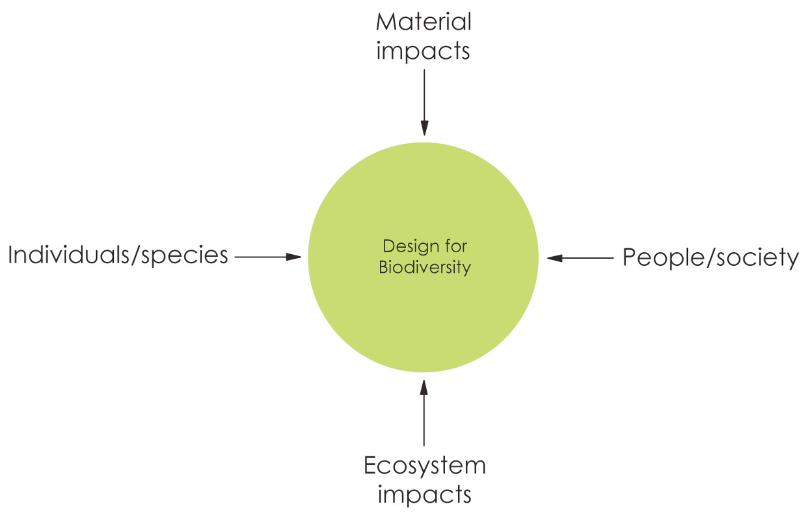

Figure 1: Design for Biodiversity approach

With the Design for Biodiversity approach (Figure 1), human needs are considered alongside environmental needs. Moggridge (2007) describes a hierarchy of complexity with respect incorporating human factors in design. Anthropometrics is positioned at the simplest level of complexity, and represents the role of basic human factors (sizes of people) in designing objects for individuals. Ecology is presented as the highest order, and is described as understanding the interdependence of living things (Moggridge 2007). Design for Biodiversity recognises that the design processes should recognise the importance of a human aesthetic in designing meaningful objects. However, it also addresses the needs of people at higher levels of complexity. Thus, this approach proposes a holistic view toward human factors and recognises opportunities due to the connectedness of ecosystems and society, and supporting the connection and dependence of people on biodiversity, ecosystem processes, and ecosystem function (Lyle 1999, Park 2000, van Roon and Knight 2004). People are highly dependent on the natural systems in which they live, and are an integral part of them. These systems are in turn highly depended on, and vulnerable to people's actions and activities. Design for Biodiversity recognises the significance of nurturing intact, fully functional ecosystems as highly complex, dynamic and unpredictable biological systems crucial to maintaining the human condition. Consequently, design considerations (impacts and benefits) should be addressed in a complimentary manner for both "user groups", and can be considered along a scale of complexity similar to that proposed by Moggridge (2007) (Figure 2).

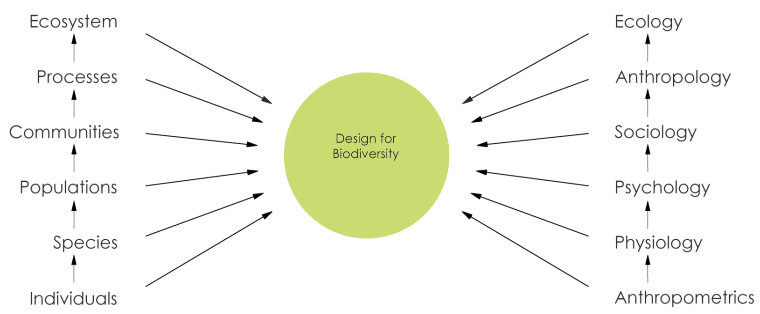

Figure 2: Design for Biodiversity (hierarchy of complexity modified from Moggridge 2007).

At the simplest level of complexity, needs are orientated toward specific individuals. At higher levels opportunities are considered for products to have positive impacts on wider communities. The "materials impact" component of the approach represents the impacts that the materials used in a product may have on both human users/society and individual species/ecosystems, and may reflect the possible tension between different groups. Within this sphere opportunities to enhance the environmental performance of materials should be considered.

The "ecological impacts" component represents the intention to better understand the impacts (positive or negative) of a products lifecycle as part of the natural environment. It is in this sphere that the concept of a 'structural nutrient' may be explored for any given product. A structural nutrient represents the use of the product by an individual organisms or species group/community during the products life. A simple analogy for a structural nutrient is the creation of artificial reefs for the conservation of marine organisms (Bohnsack & Sutherland 1985). Similarly, products may be designed for use as "artificial habitats" for organisms at a point during a products life, with the goal of enhancing biodiversity benefits (particularly if threatened indigenous organisms are targeted) (Michael et al. 2004, Lettink 2007a,b, Bowie et al. 2006). This approach is complementary to and builds on the Braungart et al. (2007) concept of a biological nutrient. For example, a product may be used as a structural nutrient (i.e. habitat) after its 'intended human use' before being discarded to decompose and becoming a biological nutrient.

Product concepts using Design for Biodiversity approach

As previously mentioned, the design approach outlined above is in the initial stages of development, and is therefore relatively untested. Consequently, a small number of product concepts/examples have been developed to evaluate this approach. Three concepts/prototypes are presented below. It is anticipated that this approach will be used to develop additional products/concepts, and that these and the existing will be fully evaluated to determine the success of this approach, and to provide direction for future amendment.

1. Weta Home

This New Zealand inspired toy was designed to help children reconnect with nature in urban ecosystems (Figure 3). A young child may assemble, customise and play with the toy. Following the "play" phase (end of life), the toy was designed to be placed in the garden (e.g. tied to a tree), where it could "frame nature" as habitat for invertebrate communities (including weta) showing children the potential abundance of backyard organisms, before finally decomposing and demonstrating the cycle of natural materials.

Figure 3: Weta Home

2. Lizard Trap

A low-cost, lightweight, biodegradable flat-pack trap was developed to assist lizard monitoring and conservation (Figure 4). This trap was designed to provide an alternative to bulky and difficult to assemble traps currently used. The trap was designed in collaboration with a herpetologist, and knowledge of lizard habitat preferences to enhance attraction and minimise capture stress. While the prototype was manufactured from a biodegradable material, it was not intended that it be disposed of in the natural environment (where it may be used), rather that it be returned to an appropriate system (i.e. compost heap).

Figure 4: Lizard Trap

3. Tree shelter

This concept represents an ecological community response for forest restoration plantings where plastic 'tent' shelters are sometimes used to provide protection against adverse environmental conditions. This tree shelter design (Figure 5) attempts to enhance tree survival and support the re-establishment of ecosystem function. By manipulating ecosystem architecture and targeting the promotion of ecosystem processes and components, the shelter may accelerate the re-colonisation of biodiversity in native forest restoration plantings. In addition the standardised size may help facilitate monitoring colonisation of animals, and help provide a measure of restoration success.

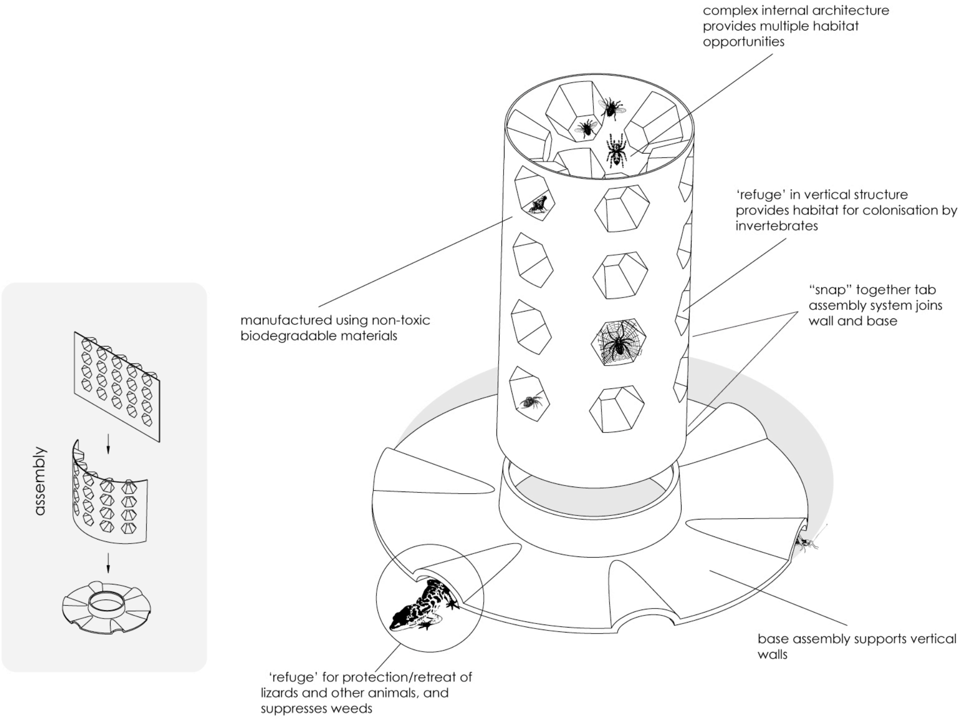

Figure 5: Tree shelter

Discussion

The Design for Biodiversity approach was developed to help designers think beyond eco-design principles and is orientated toward designing for strong sustainability. The abundance of biodiversity reveals the extent of co-operation between people and nature (O'Riordan & Stoll-Kleemann 2002). Biodiversity is an indicator of the health of the planet; "*for humans to be at peace with themselves they need to find peace with biodiversity*" (O'Riordan & Stoll-Kleemann 2002, p19). The approach helps ensure that products have an underlying ecological integrity that will benefit biodiversity and natural systems (and therefore our communities). Consequently monitoring biodiversity is a way to measure sustainable development. Design outcomes for people when using this approach may range from more simple and easily measured anthropogenic attributes right through to more complex and less tangible community benefits (ecology).

Ecosystems are the basis of human consumption and therefore should be incorporated as the foundation of society, ensuring strong environmental, social and economic sustainability. This approach prescribes that sustainable product design should not be undertaken in the absence of ecological understanding. Designers have been charged with envisioning the future. Therefore a working knowledge of ecology is necessary to engage with rigor around issues of sustainability. A specialised designer with new modes of design process thinking is required to help negotiate these challenges, and actively engage with communities and the environment. While this approach has not been thoroughly tested, it is intended that it be applied in real world situations and demands greater collaboration between designers and scientists (biologists, ecologists etc). The consequence of such collaboration should see designers having greater levels of ecological literacy, and a better understanding by scientists of the power of design to look to envisage the future scenarios.

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