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# DESIGN BASED ON NATURE – A LITERATURE INVESTIGATION

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## ABSTRACT

This paper discusses the findings of a doctoral literature investigation considering design practice inspired by Nature into education. Academic and mainstream commercial publications related to Bio-design, Bionics, Biomimetics, Biomimicry and Nature Inspired Design form the basis of this investigation. Several approaches are compared and discussed to determine whether they are suitable for design education and capable of fostering sustainable design thinking. Current sustainable design education in the UK is explored to determine whether the identified current sustainable design methods are consistently embedded across the years of an undergraduate design degree or rather seen as an add-on to traditional design methods. The investigation concludes with 3 core questions that form the basis of further investigations. 1) Are design methods involving inspiration through nature used successfully in sustainable design education? 2) Could the integration of **design based on nature** lead to consistent inherently sustainable design practices. 3) Could this approach foster collaborative cross-discipline design projects at undergraduate level?

*Keywords: Sustainable Design, Design Based on Nature, Design Education, Collaboration.*

## 1 INTRODUCTION

The notion of nature inspired design has grown in popularity and a close relation to sustainable design practice is evident [1,2]. At the same time sustainable design seems to be included in design teaching as an add-on or a module integrated into a much broader design education [3]. Following these findings the following question was asked: *Can design based on nature (DBN) embedded in design education encourage a design culture focussed on creating inherently sustainable design solutions?* The literature review supporting this question forms the basis of this paper. Included in the review were a wide range of publications encompassing design practice, design education and sustainable design. Initial selection criteria were based around the teaching and practice of design, specifically the methods applied as well expert's opinions. Due to increased popularity of nature inspired design solutions the review investigated the fields of Bio-design, Bionics, Biomimetics, Biomimicry and Nature Inspired Design in more detail. It became clear in this investigation that there was a limit to publications with a focus on design education involving methods rooted in design based on nature approaches. Another finding of the review highlighted that outputs of design based on nature approaches are not inherently sustainable and experts therefore clearly separate design approaches based on nature and sustainable design. These findings set the premise for the above mentioned research question, which aims to investigate whether linking design education based on natural principles could result in the creation of design solutions that are sustainable at the core.

## 2 OVERVIEW AND CONCLUSIONS OF CRITICAL SUSTAINABLE DESIGN LITERATURE EVALUATION

To be able to discuss whether inherently sustainable design solutions can be achieved through embedding a design based on nature approach into the education and therefore into the practice of Product and Industrial Design, Sustainable Design practice needs to be briefly summarised and evaluated. To date perceived as a specialised subject [4] Sustainable Design is still not nearly as well integrated as anticipated in design practice [5,6]. The Brundtland definition 'Development that meets the needs of the present without compromising the ability of future generations to meet their own

needs' [7] defines the sustainable development approach of "people, profit, planet". This is often referred to as the model of the three pillars forms what Elkington [8] named the 'triple bottom line'. These models are based on the assumption that economic, environmental and societal issues need to be addressed at equal measures to achieve sustainable solutions [9,10]. It is argued that the triple bottom line approach by now is out-dated and in fact not sustainable. Economic growth always comes first in the consumer driven society [6,12]. Thorpe introduces a progressive version of the Brundtland definition by describing 'development that cultivates environmental and social conditions that will support human well-being indefinitely'[12]. This aligns with the ethos of a design based on nature educational approach but one needs to also be aware that designers and others who turn to nature for inspiration are doing so without their viewpoints 'clouded by a romantic longing' [13]. 'If we can design our way into difficulty, we can design our way out' [14]. Designers have the ability to encourage change; they have an extensive range of influence due to their connection to the creative industries as well as business and manufacture [15]. It is imperative that they take further responsibility. In conclusion sustainability in design is integral to good practice; but it is also confusing not just for students but also for design practitioners. Terminology, approaches, methods and integration are central topics to international debates surrounding the subject of sustainability in design. Research in this area stretches from material selection to adjusting and changing behaviours that have been culturally embedded in western societies for decades if not centuries. Embracing sustainability and changing society permanently is as great an impact as the industrial revolution [16]. Therefore it seems logical to look at design education in order to achieve inherently sustainable design.

### 3 WHAT IS DESIGN BASED ON NATURE (DBN)?

Designers in the 21<sup>st</sup> century are required to be more than just creators of products. They are 'initiators of resource collection, labour application, manufacturing, marketing, distribution, consumption, and disposal.' [17] Design based on nature as a design tool is not a new concept. Mankind has always looked to the natural world for inspiration. Leonardo Da Vinci's flying machines were heavily inspired by nature, so were helicopters and the revolutionary Velcro. Scientific and technological leaps have made collaboration between the life sciences and design easier, more affordable and in fact necessary over the past decades [13]. Initially focusing on Bio-design, Bionics, Biomimetics, Biomimicry and Nature Inspired Design three common denominators can be highlighted. All look to nature for inspiration to solve 21<sup>st</sup> century problems. Their design approach is multi-disciplinary and they represent a link between science, technology and design. What is interesting is that DBN as a field has exponentially grown, particularly since the mid-1990 [18]. By studying extensive amounts of publications in the field of Biomimetics alone a rise from tens of papers published in the 1990s to almost 3000 papers per year today has been determined. The related literature reveals that the various areas are rated in their level of importance and impact on a variety of levels. Biomimetics for example seem to be classed predominantly suitable for technically complex industrial challenges whereas Biomimicry is described as more appropriate in a context that requires much lower levels of technical complexity [19].

Table 1. DBN overview

APPROACH	KEY ELEMENTS	PRINCIPLES/ EXAMPLES
<b>BIO-DESIGN</b>	<i>Experimental as well as functional, collaborative, combining design and biology, using living materials</i>	<i>Motion powered bioluminescent algae, bacteria based textiles</i>
<b>BIOMIMETICS AND BIONICS</b>	<i>Development of new technologies, collaborative, inspired by natural systems</i>	<i>Robotics, Aviation, Nano-technology</i>
<b>NATURE INSPIRED DESIGN</b>	<i>Design, inspired by natural systems, collaborative, focus on sustainable solutions</i>	<i>Waste equals food, use current solar income, be locally attuned and responsive, adapt and evolve, integrate</i>
<b>BIOMIMICRY</b>	<i>Learning from nature, informing design, engineering, business, finance, focus on sustainable solutions</i>	<i>Runs on sunlight, uses only the energy it needs, fits form to function, recycles everything, rewards cooperation, banks on diversity, demands local expertise, curbs excess from within, taps the power of limits</i>

It is anticipated that the analysis of design methods rooted in Bio-design, Bionics, Biomimetics, Biomimicry and Nature Inspired Design will help identify approaches suitable to build the basis for DBN.

### 3.1 Bio-design

Bio-Design is the literal combination of design and biology, in some instances incorporating living materials in structures and objects. It is described as a radical approach that goes further than BM or ‘green design’ by referring to the actual incorporation of living organisms as essential and enhancing factors in the function of the finished work [17]. The explorations of design duo Cohen and Van Balen, as shown in Figure 1 [20] titled ‘Life Support’ propose the use of domestic animals as ‘external organs’ for example a canine lung-machine. Although highly plausible these ideas are still conceptual. Their work challenges the notion that people love their pets, so would they be able to love their respirators? Multi-disciplinary collaborations is central to Bio-Design, requiring designers to work side by side with specialists in the fields of Microbiology and Chemistry [17]. Bio-Couture, pictured in Figure 2 [21] is a feasible design experiment that can be conducted from the comfort of anybody’s home. Designer Suzanne Lee grows clothes from bacteria without ethical conflicts [17] as basic ingredients are green tea, sugar, yeast, grown microbial-cellulose and natural dyes. The cellulose material feels similar to artificial leather. Another interesting example is a light developed by Dutch designer Theresa Van Dongen which utilises bioluminescence to create light without the use of electricity. The light glows when gently pushed inspired by the motion of the ocean waves exposing micro-organisms to oxygen which causes them to emit light. Figure 3 [22] shows the functional Ambio lamp which is the physical output of research on how to use nature as a source of energy.



Figure 1. Experimental Example of bio-design entitled 'Life-Support'



Figure 2. Bio-couture jackets by Suzanne Lee



Figure 3. Bioluminescent Ambio Lamp

### 3.2 Biomimetics and Bionics

The term ‘Biomimetics’ was coined during the 1950’s by polymath Otto Schmitt, through which novel technologies are developed studying principles in biological systems. Biomimetic technologies arise from a flow of ideas from the biological sciences into engineering, benefiting from the millions of years of design effort performed by natural selection in living systems [23, 18]. The gecko robot in figure 4 [24] is only one of many functional designs. The related term Bionics, introduced by Jack Steel of the US Air force, is used in engineering and means copying and taking information from nature [25]. Both practices create highly technical solutions based on or mimicking natural systems. There is a strong association with ‘the future’ and Science Fiction, nano-technology and even artificial

intelligence [26].



Figure 4. Gecko Robot

### 3.3 Nature inspired design

Developed at TU Delft and abbreviated as NID, this approach is based on a thorough evaluation of existing design based on nature approaches with strong focus on Biomimicry and Cradle to Cradle. Since 2012 the NID research team has also worked with practitioners on a number of projects. A combination of literature review and real life application has provided the underpinning for a hand-book aimed at practicing designers as well as design educators. It is intended to help designers integrate the still rather abstract set of green design principles in their practice. Figure 5 [1] illustrates how NID principles can be related to natural systems. Examples of the successful use of the tool are shown in a number of case studies. It is also highlighted that multi-disciplinary collaboration is essential for the successful implementation. Successful design projects require a combination of design, biology, engineering, medicine, ecology and business is essential is suggested [1].



Figure 5. NID principles compared in relation to natural systems

### 3.4 Biomimicry

Looking to nature for answers and inspiration is not new a practice, observing nature has helped humanity develop and cross boundaries for millennia, from simple observation to mimicking complicated processes such as flight and harvesting energy from sunlight [13]. Janine Benyus calls 'Biomimicry the conscious emulation of life's genius [16].' She illustrates the importance of Biomimicry in today's world scope by drawing a parallel to the Industrial Revolution in saying that 'the Biomimicry Revolution introduces an era based not on what we can extract from nature, but on what we can learn from her [16].' Since 1997 BM has been evolved as a method used not only in design but spanning professions ranging from business and financing to engineering, architecture and manufacture [2]. As in nature BM is a multi-level approach that offers practitioners a variety of angles to explore in search for that innovative solution they are seeking. The emulation of life's principles begins at the form level, for example with the shape of a kingfisher's head in search for optimal aerodynamics [27]. Delving deeper into BM then leads to mimicking natural processes such as self-assembly [16, 2]. At the 3<sup>rd</sup> level whole eco-systems are utilised for inspiration. Only when all 3 levels are considered the design will 'behave like a well-adapted organism' and 'create conditions conducive to life [2].' Nature's solutions are incredibly rich and reach far beyond the human eyes ability to see [16]. We have only just begun to comprehend the scope of inspiration that lies hidden to the naked eye in Nature's building blocks as humans are 'deeply and stubbornly selfish' [28]. Our ability to see and comprehend our surroundings has drastically expanded from the intercellular to the interstellar [16].

## 4 DESIGN EDUCATION OVERVIEW

Designers are 'indispensable because they are 'creative', they can create an ecological society or they can improve profit' and very rarely is the combination of both feasible [4]. Morals and actions should form the basis of basic design education where perception and action governed by logic based on aesthetics replace science and technology [29]. Looking at current design education a simple question needs to be raised. Is design a profession or is it an attitude? A quick overview of current practice in the UK indicates that the focus of most design programmes is on business, marketability of products, mass-production, manufacture and material choice. Sustainability is often a very small element that gets thrown into projects but is not delivered as integral part of the course. This can also be supported by the argument that adopting sustainable design practice is still difficult as sustainable design is very much perception based and because design professionals/educators are 'fluent in design for business but they have an inadequate grasp of design for the environment and are rarely engaged with design for society.' Practicing sustainable product design requires the practicing designer to be a life-long learner [5]. In terms of SD the current design education 'fails to prepare students to practice as ethical

entrepreneurs, and sees eco-design as a passing fad or at best a specialist subject.' [4] In the current climate of providing 'on-tap'-knowledge within the university service industry student attitudes seem to have changed and most undergraduate students do not understand that university education prepares for lifelong learning and intellectual independence. This forms a difficult basis for the introduction of new thinking and design patterns.

## 5 CONCLUSION

As a result of the above review a number of additional questions need to be posed alongside the overarching PHD thesis as to whether embedding DBN in design education can encourage a design culture focused on creating inherently sustainable design solutions. Further studies will be conducted based on the following research questions: 1) Are design methods involving inspiration through nature used successfully in sustainable design education? The literature fails to convey any such practice at this point in time. Further investigation into current sustainable design teaching is required to highlight the state of the art in sustainable design teaching. 2) Could the integration of **design based on nature** lead to consistent inherently sustainable design practices? This question will need to be addressed through studies conducted with undergraduate design students as part of their projects units. A suitable method of delivery for a number of **design based on nature** tools needs to be developed to accompany the studies. 3) Could **design based on nature** foster collaborative cross-discipline design projects at UG level? The literature clearly shows that integrating nature into design requires collaboration with the sciences. The feasibility of this level of collaboration will determine whether DBN integration in design education is going to be a workable concept. Collaboration across disciplines is essential in design [30]. Design projects in consultancies such as IDEO are often based on multidisciplinary team work. It is the most effective way to access specialist knowledge and can lead to surprising results as different disciplines will approach a problem from different angles [30]. There are a number of universities in the UK offering UG & PG degrees in Sustainable Design, namely Falmouth, Brighton and Kingston and they will be the focus of further enquiry. The plan is to explore why SD is seen as a separate, specialty element in design and whether embedding an approach to design based on natural principles can create inherently sustainable design in education as well as design practice. As highlighted through this paper, the term sustainability itself often causes confusion. Equally confusing are the separate areas of SD [9,10,11]. Although aware that using nature as inspiration is not a new approach; the amount and scope of information readily and collaboratively available to designers in this day and age actually creates a new level of acceptance for nature inspired strategies in design and beyond. The review of the areas of Bio-Design, Biomimetics & Bionics, Biomimicry and Nature Inspired Design (NID) highlights various points of differentiation. All DBN areas reviewed still requiring a great deal of immersion in the subject before they can be used within design education or practice. It has also been determined that designers think differently [31] to other professions and therefore tend to prefer working with visually intuitive tools much better [15]. It is important that the characteristics of designers are taken in consideration when planning further studies.

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