

Use of Bio-Inspired Design Tools by Industry Professionals

Subjects: **Others**

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Bio-inspired design (BID) has the potential to evolve the way engineers and designers solve problems. Several tools have been developed to assist one or multiple phases of the BID process. These tools, typically studied individually and through the performance of college students, have yielded interesting results for increasing the novelty of solutions. Human-centered design (HCD) and “design thinking” have become standard practice in consumer-product design and development. Now, it is common for industrial designers, engineers, and product managers to be conversant in the process and methodologies of HCD.

bio-inspired design

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design

design study

tools

industry

focus group

1. Introduction

Bio-inspired design (BID) has served as an inspiration and motivation for many engineers and designers to explore the natural world to find novel solutions to problems. Many BID tools and methods have been researched and written about ^{[1][2]}, and many examples have been lauded in popular media ^{[3][4][5][6][7]}.

Throughout history, insights from one field, carried over to another, have driven breakthroughs and discoveries that have led to innovations ^[8]. Flora and fauna such as beaver dams, bird wings, and gecko feet have inspired novel solutions. The process for arriving at these solutions is often framed as a “eureka!” moment or the result of decades of lab work. It is difficult for engineers and designers to systematically apply knowledge from the field of biology to problems in their industries, despite headlines loudly proclaiming that nature has the answers. Tools have been developed to assist in jumping over the hurdle of finding and applying biological inspiration. However, none have emerged as an obvious solution to bridging the gap between engineering and biology.

Human-centered design (HCD) and “design thinking” have become standard practice in consumer-product design and development. Initially, these were areas of primary concern to industrial designers, but as the value of HCD became apparent across industries, it began to be integrated into engineering and business school curriculums. Now, it is common for industrial designers, engineers, and product managers to be conversant in the process and methodologies of HCD. Using similar language and working from a shared base of knowledge leads to clearer and faster communication and better comprehension of the motivation for and importance of design features. Innovation is achieved through products that better fit the needs of end users.

The next evolution in transdisciplinary collaboration for design and engineering may very well come from biology. Nature has a wide variety of solutions to functional problems that can be drawn upon for inspiration. However, this corpus of knowledge is of a different composition than what designers and engineers are familiar with [9]. To utilize knowledge from biology, engineers and designers must first be able to comprehend it, then translate it into a context that is relevant to the problem they are solving. One way to do this would be to have a biologist as part of the team [10][11]. Another way is to introduce tools and processes for practicing BID.

In industry, more experienced engineers and designers tend to set the standard for processes and practices. As new engineers and designers join a company, they are mentored by those with more experience, who pass on their processes and practices, thus solidifying a culture and set of expectations for how new ideas are generated and tested. This creates a significant barrier to introducing a completely new approach to problem solving in industry, such as bio-inspired design. For a new approach to be adopted, it needs to be comprehensible and relevant to the engineers and designers who will practice it. It also needs to be supported at the highest levels of the company to justify the time it will take to learn a new way of doing things. BID presents an additional complexity in that it is unlikely that any company involved in engineering and design will have a biologist on staff, leaving engineers and designers to attempt the process without the benefit of an expert. Thus, engineers and designers that want to apply BID will need to leverage existing tools and processes. Although there are a growing number of publications on tools and processes for practicing BID, challenges to adoption remain, such as (1) the lack of addressing the inherent challenges in organizations; and (2) industry engineers and designers being infrequently engaged in the studies to determine how, or more importantly, if, the tools and processes could be adopted.

The research carried out on the efficacy of tools for systematically applying BID has typically been performed with college students [12][13][14][15][16][17][18][19][20][21][22][23][24][25][26][27][28]. While college students provide large, easily accessible sample sizes, they do not have the same level of work experience, nor do they work within similar constraints as industry engineers and designers. For example, industry engineers and designers are constrained by the specific business needs of their organization as well as the materials and manufacturing processes common to their field. Development timelines and budgets are also primary drivers of which solutions can be applied to problems. Furthermore, the culture and expertise within an organization drive how likely a tool is to be adopted. Thus, to know if a BID tool could be successfully put into practice, more research with industry engineers and designers is required.

2. Use of Bio-Inspired Design Tools by Industry Professionals

Various tools and processes have been well studied for performing bio-inspired design. These tools are generally studied to assess their effectiveness at generating novel solutions rather than for their long-term adoption. Methods such as Bio-TRIZ [29], PeTAL [30], biological functional modeling [31], E2B Thesaurus [32], the Aalborg BID method [33], the biomimicry design method [34], the spiral design method [35], the bio-inspired design method [21], and the bio-solution in search of a problem method [21] have been developed to facilitate the translation of principles from nature to usable solutions for engineering, design, and business problems.

Previous research on BID tools has focused on the value of a tool or method for achieving an explicit end result (i.e., “more sustainable” or “more creative”). Mead et al. evaluated the relative improvement in the sustainability of solutions when using bio-inspired design [36][37]. The study found that companies that use BID as a long-term approach to innovation found greater success with sustainability-oriented innovation. Kennedy et al. compared the use of far-field biological vs. industrial analogies during concept generation with industry participants [38]. This study only examined whether the novelty/creativity of concepts increased. It did not assess the likelihood of this tool being used or whether it generated practical and usable ideas. Kennedy et al. [39] also explored frames of inquiry with industry professionals for the beginning or exploratory part of the BID process. The study focused on investigating whether frames of inquiry could lead to finding a larger number and a wider variety of inspiring biological models. The study did not find significant positive effects. This study is especially relevant as it was carried out with industry professionals and calls attention to the gap between the desire of R&D professionals to use biomimicry and the lack of definitive industry-based studies on which to base best practices.

It seems logical to assume that a demonstrably better tool or process should justify adoption on its own; however, the reality is that companies develop over time to reinforce existing processes by hiring people whose skills fit into the business needs and culture. New tools, and especially new processes, require a company to disrupt what they have built themselves up around. A new process slows an experienced employee down and disrupts team workflows, something few companies are willing to do as they are incentivized to stay on schedule and within cost, no matter how valuable the change could be. Barriers to implementing BID in product development and BID product commercialization have been researched, but do not examine the influence of individual tools in industry applications [40][41].

There is little written on teaching multiple tools for the purpose of understanding what engineers and designers would be most likely to adopt. Faludi et al. studied three design approaches to understand how the components of the approaches were perceived by industry engineers, designers, sustainability professionals, and managers for value in two categories: sustainability and innovation [42]. The study revealed that some components of each design method were favored more than others and that the participants viewed them not as requisite parts of a process but as individual tools that they could use in isolation outside of the prescribed process. This reflects both a desire and a need amongst industry professionals to have a hybrid approach to their design process, custom built to meet their own needs and preferences.

There is evidence that industry has adopted some BID practices, though it is unclear whether this has led to repeated or planned use of BID for subsequent problem solving. There are prominent examples of commercialized bio-inspired solutions, including: Whale Power [43], Geckskin [44], Cora Ball [45], Interface Carpets [46][47], PAX [46][48], Encycle [46][49], Skarklet [46][50], VELCRO [51], and Japanese bullet trains [52][53]. A few shoe companies (Nike (Beaverton, OR, USA), New Balance (Boston, MA, USA), and ASICS (Port Island, Kobe, Japan)) found inspiration from animals for shoes [46][54]; however, it is not clear from new product offerings or available information whether this continues to be put into practice.

There is an important difference between companies that have used bio-inspired design to develop a product (Interface Carpets (Atlanta, GA, USA), PAX (San Rafael, CA, USA), Cora Ball (Middlebury, VT, USA)) and those that took research and spun it out into a company centered around the innovation (Whale Power (Toronto, ON, Canada), Geckskin (Somerville, MA, USA), Sharklet (Aurora, CO, USA)). An established company has more hurdles to trying new approaches to problem-solving than a start-up: legacy knowledge, established processes, cost constraints, material and manufacturing constraints, and assumptions about what innovation should look like. Bio-inspired design requires that engineers and designers engage in a time-intensive, unfamiliar process with subject matter that may be difficult to grasp. There is a desire within companies to utilize time efficiently and towards company priorities. Bio-inspired design researchers do not necessarily take into account the constraints on industry engineers and designers and consider what they need to integrate BID tools into their existing workflow.

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