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Learning from Nature: Biomimetic Design in Architectural Education

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Abstract

Biomimicry is the study of nature to emulate or be inspired by its designs or principles to solve human problems. A noteworthy example includes Velcro derived from bur hooks.
This paper describes a Basic Design Studio assignment that is informed by arthropods, a rich source of inspiration. First-year architecture students were expected to offer a solution to a common human problem through the observation of the forms and behavior of arthropods. The final work required the inclusion of a mobile structure in the design. Educational benefits include the introduction of students to alternative design methods and multidimensional thinking.

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1. Introduction

Designers draw their inspiration from multiple sources to address challenging design problems. One method is to study nature, and attempt to comprehend the ways in which it has evolved to address environmental challenges. This practice has been coined biomimetic, a term introduced in the 1950s by Otto Schmitt (Schmitt, 1969). Biomimetic has increasingly been employed in architecture and engineering. That global patents involving biomimetic or bio-inspired approaches have increased by a factor of 93 from 1985 to 2005 should be sufficient proof of the recent interest in the field (Anonymous, 2012). However, the practice is not new to engineers and designers, Leonardo da Vinci's flying machines come to mind.

Proponents of biomimetic, the study of nature's models to imitate or take inspiration from its designs and processes to solve human problems, argue that 3.85 billion years of evolution has honed designs of our natural environment and its inhabitants by necessity to allow for survival, thus we are surrounded by a world of ingeniously designed natural organisms (Benyus, 2009). Examples of such adaptive transformation observed by biologists,

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zoologists, botanists, geneticists, and biomechanics researchers (GalhaBártolo & Bártolo, 2002). What remains is to extract this information in meaningful ways.

Multiple approaches to the utilization of biomimetic as a design process are discussed in literature. These methods either: (1) identify a design problem and examine ways other organisms or ecosystems have solved it, or (2) identify a specific trait in an organism or ecosystem and translate that into a design that responds to a human problem. The former may be referred to as a top-down, problem based approach, or "design looking to biology", and the latter a solution based, bottom-up approach, or "biology influencing design" approach (El-Zeiny, 2012; Zari, 2007).

For either of the stated approaches to function, a framework for the application of bio mimicry is necessary. Varying perspectives are offered in literature. For instance: form, process, and ecosystem have been identified as different levels of mimicry (Anonymous, 2012). Other classifications with multiple dimensions are also explored: organism, behavior, and ecosystem (Zari, 2007). In essence, a design may imitate the characteristics of an individual organism, it may be inspired by how the organism behaves, or the design may draw from the entire ecosystem of an organism and its surroundings.

2. Biomimetic in Architectural Education

Schön (1985) contends that the design studio environment is a place for students to learn both about designing and about learning to design. To achieve effective learning, Schön (1988) suggests, the architecture studio becomes an environment where the "real world of practice" is replicated without the pressures associated with the professional world. Students learn by doing, as they seek to achieve competency in the field, by mastering its instruments and methods (Schön, 1988).

Biomimetics suggested by multiple authors to hold value as an inspiration to the practice of architecture (Berkebile& McLennan, 2004; El-Zeiny, 2012; Knippers& Speck, 2012; Panchuk, 2006; Stachelberger, Gruber, &Gebeshuber, 2011; Yowell, 2011; Zari, 2007). Building on Schön's contention, biomimetic should become an invaluable tool for teaching architecture.

The authors of this paper have determined that arthropods, with a 5-10 million estimated number of species (Ødegaard, 2000) and 500 million years of evolution, could serve as the ideal tool to aid in a studio project. Arthropods, from Greek "jointed leg," include arachnids, insects, millipedes, centipedes, crustaceans, as well as other invertebrate animals with jointed, external skeletons.

Students are guided through a design exercise utilizing a solution-based, bottom-up, "biology influencing design" approach (El-Zeiny, 2012). The exercise involved (1) identifying an arthropod for a solution-based approach, (2) defining the biological solution, (3) extracting biological principles, (4) reframing the solution, (5) searching for a problem, (6) defining the problem, and (7) applying the biomimetic principles to the design problem.

The Basic Design Studio exercise is outlined below.

2.1. Exercise: Reinterpretation of Arthropods in the Context of Architectural Articulation

Research and utilization of bio mimicry has gained momentum in recent years; however, is not new to engineers and designers. Leonardo da Vinci's flying machines serve as an example.

The "Arthropods-Architectural Articulation" exercise aims to guide first-year architecture students in designing a mobile space for humans through the study of arthropods. To grasp the concept of "articulation" Basic Design Studio participants study arthropods' modes of movement that correspond to their structural peculiarities, how they have evolved to adapt to environmental factors, and the advantages of their segmented bodies.

The exercise is among a number of studio projects that aim to achieve the goals of the Basic Design 2 course; namely, to attain 3-dimensional thinking and problem solving skills, and be able to transfer these skills to the process of solving architectural design problems. Other topics covered through the semester include: transparency/light, sound, smell, adjunction, kinesthetic-space perception, time-space perception, color, biomimetic, design utopia and the city, creativity techniques, and verbal (semantic and typographic) as well as visual (digital and