BIONIC DESIGN IN INDUSTRIAL DESIGN EDUCATION AT UNIVERSITY OF TEHRAN

Jamshid EMAMI, Mahshid TASHAKORI and Zahra TASHAKORINIA
Industrial Design Dept, Fine Arts Faculty, University of Tehran, Tehran, Iran,

ABSTRACT
Nature has demonstrated to be a rich source of inspiration for product design throughout history. Bionics is an interdisciplinary field which deals with structures, methods and processes found in biological systems. Bionic design provides design process with incorporating both form aspects and functional principles.
Bionic design can serve as a bridge between design and other related sciences, and therefore performs a prominent role in development of product design domain.
The aim of this paper is to show how Bionic design can be used as an instrument to increase the quality of educational curricula for industrial design students. The process introduced here, is the procedure currently offered to 4th year BA industrial design student in University of Tehran as the Bionics course.

Keywords: Bionic design, design education, industrial design, product development process.

1 INTRODUCTION

Bionics is an interdisciplinary field which looks for inspiration in nature to provide solutions for design problems in different fields and various branches of industry such as Design, Tissue engineering, Bioengineering, Aeronautics, Space Science and Biomaterials [1] . Its applications range from emotional translation of form to utilization of functional principles [2]. So, Bionic design can be considered as a useful tool for generating concepts and developing products, which are visually pleasing and environmentally sustainable.
Although some historical documentation from 16th century, show a high interest in inspiration from nature in Leonardo da Vinci's works, the main concept of Bionics didn't appear until 60s in the US. Then it was developed especially in German and Italy with great works of Nachtigall, Bartolo and designers like Callatravi, Collani, Starck, Gaudi, etc [3]. Because of the undeniable importance of natural phenomena in the generation of creative concepts, there is a good opportunity to incorporate Bionics in industrial design curricula. Bionic design, the 8th project of industrial design, is a required course offered to 4th year BA students of industrial design in the Industrial Design Department of Faculty of Fine Arts, at University of Tehran, Iran.

2 WHAT IS BIONICS?

In 1983 Bionics was defined as an "Interdisciplinary field within biology and technology which covers systematic studies of functions, relations, structures, and processes in biological systems and the transformation of these to the solutions of primary technical and technological problems" [3].

Colani says: “Whenever I encounter some problem in design work, I make it a rule to look into my microscope for an inspired breakthrough. It is because the earth has existed for millions of years and contains in it all the laws and methods of solving problems. Man is certainly making wonderful things, but couldn’t possibly compete with nature” [4]

Definition given by Neuman implies that Bionics has to do with interactions between bio systems and their environment, and Nachtigall, one of the German pioneers in Bionics, acknowledges the importance of learning and inspiring from nature, instead of directly copying its principals into technical solution [5].

- “Bionics is a tool - not more but not less
- Bionics is not a cure and not a copy of nature
- Bionics is a tool which may not must be used
- Bionics is no universal tool for solving problems, but may in the best way be an excellent assisting tool” [3].

Many examples from aviation technology demonstrate this approach in borrowing inspiration from nature, as well as other fields of Bionics application such as well-known example of lotus-effect which was applied in dirt-repelling and self-cleansing surfaces [6].

Bionics is about what nature can teach us about design. Bionics process can begin with a problem or with a fascinating biological system that seems to be inspiring. In fact there are two main strategic approaches of Bionics: Top-down approach, which starts with the technical problem and finds the solutions through natural systems, and Bottom-up approach which begins with a biological phenomenon and transfers it to a potential technical solution (Figure 1) [5].

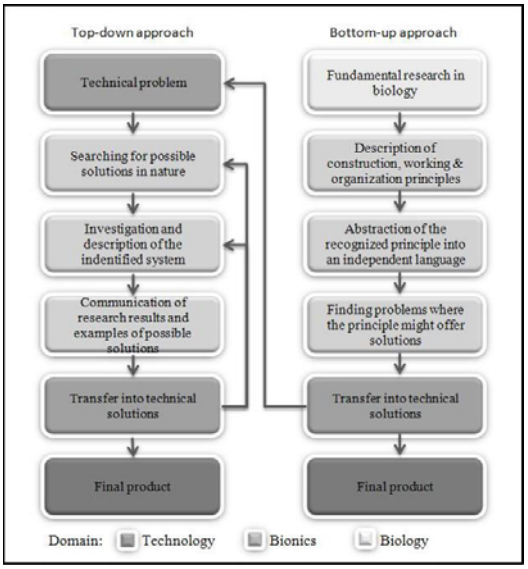

Figure 1 The two strategic approaches to integrate bionics into technological development [5]

Bionic design also pays attention to mechanical and morphological characteristics in addition to new materials, environmentally sustainable solutions and energy saving problems [6]. The natural evolutionary processes which resulted in natural selection, have many lessons that can be used and adopted to design process [7].

3 BIONICS IN UNIVERSITY OF TEHRAN

The University of Tehran, founded in 1928, is the oldest university in Iran [8]. In 1983 the Industrial Design Department was established in the Faculty of Fine Arts in this University. A Bionics course, the 8th project of Industrial Design, has been offered as a 2 credit required course in fall semester to 4th year students, since 1998. The main goals of this course and activities related to it are:

- Introduction to Bionic Design as a creative method in product design.
- Analysis of natural principles found in biological systems.
- Abstraction and Transformation of natural principles to form and functional principles.
- Implementation of adopted principles in concept creation for product design.
- Considering Sustainable Design principles, following the study of biological interactions within environment.

The duration of the Bionics course is 17 weeks, each week a 2-hour session. The first sessions are consisted of lectures for introduction of Bionic design. In other sessions some complimentary information about related scientific fields is given briefly and the remained time is focused on experimental researches and the main project.

Many student works have been accepted by industrial manufacturers, and questionnaires filled by participants at the end of each semester demonstrate a positive feedback from students.

At the end of the semester an exhibition of students' work is held in the Faculty.

4 EDUCATIONAL PROCESS IN BIONIC DESIGN COURSE

As mentioned before, the Bionic design course is one of the 10 main projects in Industrial Design curricula in the University of Tehran. The programme includes lectures as well as project work. Through the lectures, students are provided with general information about Bionics, and the project part follows the structure introduced as the Bionic design process.

Table 1 Sessions and lecture contents

Session	Contents
1	Introduction - Interdisciplinary sciences - Bionics application domain
2	Bionics role in future technologies development - Bionics keywords
3	Cybernetics and Bionics - Synthesis process in idea creation
4	Biomorphology - Phyllomorphs, biological models, modular and life geometry, fractals, etc - Different perspectives related to nature's forms
5	Biodesign - Anticipating future technology - Introduction to biodesign pioneers: Gaudi and Colani
Other sessions	Brief introduction to other related interdisciplinary fields: biotechnology, bioengineering, aerodynamics, biomechanics, etc.

4.1 Lectures

The aim of the lectures is to introduce Bionic design as an interdisciplinary field with a wide range of application. The lecture part will provide students with the basic principles of Bionics, introduction of famous pioneers in this field and other related fields to Bionic design (Table 1).

4.2 Bionic project

The purpose of the project is to develop new innovative designs inspired by a biological phenomenon, and implement natural principles into a creative design concept. The approach commonly followed in this course, is a Bottom-up approach which starts from a natural system and transfers its principles in an abstracted way, into a technical solution.

To conduct a design project with a Bionic design approach, the requirements of the artificial system must be defined initially, and then a natural system which performs a similar function is investigated [9].

In the project structure, after lectures are given about Bionics, Cybernetics and the Synthesis phase combining these two approaches, each student / group of students studies some biological systems like: plants, insects, animals, environment effects, etc and analyses them to find any interesting or inspiring principle which has the potential to be applied into the generation of an innovative concept.

In this analysis step, the natural object is examined in order to find relations between form, structure, and the geometry within as well as the functional principles [3].

With analysing the object and recording its characteristics by sketching and photography some information such as morphological structure, connection mechanisms, functional principle and environment influences is gained [10].

Four main concerns studied in the analysis phase in the University of Tehran are:

- Natural and functional systems.
- Forms related to function.
- Creature behaviour and life style.
- Environment and interactions.

Two first mentioned aspects, will shape a concept of FORMACTION (form + function), which is consisted of a form structure which is able to perform the biological functions. Two latter aspects support the sustainable design principles, consequently implemented in design.

Studies conveyed in the analysis step, then are transformed to technical solution through an abstraction and simplification phase [6].

In the transformation step, a deeper understanding of the form-structure relations and functional principles is gained and these principles are transformed to a geometrical and mechanical model. So, skins, materials and surfaces which are necessary to define the concept structure, are determined in this step.

In the next stage of bionic project, transformed principles from the inspiriting sources are implemented in the innovative concept [3]. This implementation step can be done with sketches and 3D modeling in addition to physical models or prototype. Furthermore, it is necessary to incorporate all effective aspects in an industrial design concept, to have a rational and producible concept. This Product development step is titled as “industrial design process” in our process diagram (Figure 2).

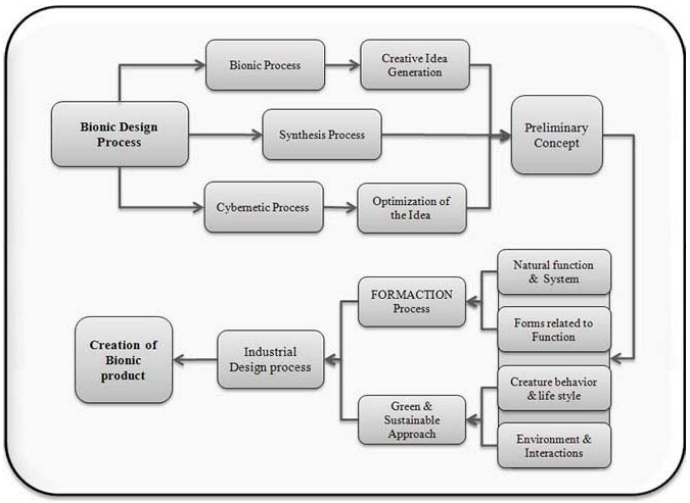

Figure 2 Bionic design process in the University of Tehran

The important aspects must be considered in this step are:

- Respect of the cost and economic production
- Safety factors and ergonomics
- Material with characteristics of resistance and duration
- Social and psychological concerns
- Aesthetic principles, and
- Sustainable design concerns and integration with environment

The process of Bionic design is finally exhibited, showing the procedure from the initial steps of studying biological creatures, to final products which incorporate both aesthetic and functional principles found in the nature.

Figure 3 Students' work

5 CONCLUSION

Bionics is an interesting, wide area which provides us with innovative alternatives from the nature. Nature gives us a various aesthetic range as well as functional and mechanical solutions that can be applied in a product design process.

Bionic design also offers an active learning concept that increases the quality of the educational content taught to the industrial design students, through exercises, experimenting, and application of creative principles found in the nature. Informal questionnaires filled by industrial design students after passing Bionic Design Project in

University of Tehran, shows a high level of increment in students' creation and innovation ability. Regarding these questionnaires, students learn to think more scientific and futuristic, interact their knowledge of design with other scientific fields, experience a more scientific approach than other design projects and benefit from an undeniable development in their thinking way and perspective of problem solving.
Bionic design, as an interdisciplinary knowledge, promotes the current industrial design situation through connecting other related sciences with the available design methods, and it needs to be considered as a main component of the design education system to perform its leading role in the education of design students, the future professionals.

REFERENCES

[1] Colombo, B. Bionics Design as an Innovation Tool in the Product Design. *World Universities Forum*, (Davos.Switzerland, 2008).
[2] Kepler, J.A., Stokholm, M., Bionic Design Methods-A practical approach. *International conference on advanced Engineering design*, (Glasgow, Scotland, 2004).
[3] Stokholm, M., Bionics, Students'guide for mini project on 4th term 2006, Architecture & Design, Aalborg University, 2006.
[4] Colani, L., *Bio-Design of tomorrow*, (Car styling, special edition, 1984).
[5] Neurohr, R., Dragomirescu, C. *Bionics in Engineering-Defining new Goals in Engineering Education at "Polytehnica" University of Bucharest*, [PDF] ICEE 2007. Available: http://icee2007.dei.uc.pt/proceedings/papers/571.pdf [Accessed on 2007, 12 December], (2007).
[6] Colombo, B. Biomimetic design, inspired by Nature for new learning developments. *International conference on design education*, pp. 1-6 (university of New South Wales, Sydney, Australia, 2007).
[7] Junior, W.K. and Guanabara, A.S. Methodology for product design based on the study of bionics.*Materials and Design*, 2005, 26, 149-155.
[8] http://www.ut.ac.ir.
[9] Vakili, V., Shu, L.H. Towards Biomimetic concepts generation. *Design Engineering Technical Conferences*, pp. 1-9 (Design Theory and Methodology, Pittsburgh, Pennsylvania,2001).
[10] Colombo, B. Biomimetic for new technological developments. *Schwäbisch Gmünd*, pp. 29-36 (University of Art and Design Helsinki, 2007).

Mahshid TASHAKORI
Industrial Design Dept., Fine Arts Faculty,
University of Tehran, Tehran, Iran
PO Box 13145-1318, Tehran, Iran
mahshid.tashakori@gmail.com
00989122099613