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Biomimicry in Architectural Design Education

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Abstract

In all sciences, nature is used as a guiding spirit. A domain exists which makes progress through the imitation and observation of nature. This domain, which is called biomimicry, can be expressed as the imitation of the life system in nature. As in many areas, in the field of architectural design behaviour is seen to imitate nature. The aim of this study is to describe the concept of biomimicry, which has confronted us in the field of architecture in recent years, and to consider design and nature in relation to architectural design education. At Karadeniz Technical University, the Department of Architecture Architectural Design Courses are carried out for this purpose. Courses within the scope of the concept of biomimicry, include the architectural design process that examines the relationship of nature and design in a comprehensive manner. At the end of the period during which biomimicry is applied to the design proposal a study was made of the relationship between biomimicry and design.

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Keywords: Architectural Design Education, Analogical Design, Biomimicry.

1. Introduction

Innovative approaches and different education methods have been seen, together with up-to-date developments, in the design education field. Broadening the point of view of a student in design education gives them the opportunity to evaluate the things around them in a way that is different from usual.

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For example, looking at nature and seeing solutions is very valuable, especially for designers. By keeping design flaws to a minumum, choosing the most appropriate material for design, providing recycling and solutions according to the circumstances, nature is an immense factory which is durable and aesthetic. Design should be done with this in mind and this value should be made universal. Finding solutions to design by seeking inspiration from nature is one of the approaches that should be supported in design education.

Historically, the designer observed how life continued in the residential environment and tried to accommodate the design to this environment. Nature offered them all kinds of opportunities in this sense. A great number of mechanisms and designs that evoke admiration have the potential to enrich many fields of life. As a result of the increase of our accumulation of knowledge and the development of technological opportunities, this potential gradually reveals itself every single day. Biomimicry is a method that has been tried in the field of design in every historical period, whether consciously or not, with positive results. A great many researchers have made comprehensive studies of the subject. Even if it has a short history and is seen as something new, as a science rather than a design approach, biomimicry has a place in all design education.

The main aim of this study is to teach students one of the design methods by applying biomimicry and showing the contributions of living animals to architectural design. The goals that are devoted to this main aim are to examine biomimicry design and its relationships; teach the concept of biomimicry, especially in architectural design education; broaden the method of finding solutions by looking at nature; and to introduce a different point of view and evaluate this method's effects on design education. The study used active lesson methods directed towards this aim and goals.

2. Architectural Design Education and Design Approaches

The occupation of Architect is one of the oldest occupations of mankind, because it is related to the production of the designed environment that heralds life (Nalçakan, 2006). For this reason, architectural education has gained an importance. One of the fundamental concepts of architectural education is design. Uluoğlu (1990) states that design education can be considered as the behaviour development process in which ways of thinking and reasoning are explored (Uluoğlu, 1990). In architectural design education; the educator can offer different design process models to his students. Many design approach methods are available that are used widely. Broadbent (1978) says that four different methods have been applied when forming architectural style. These have been described as the following approaches:

- Pragmatical
- Typological
- Canonical
- Analogical (Usta, 1994).

The Analogy method that has been used in this study is an approach that determines the similarities between two things. It produces new styles with a known or recognized phenomenon or style.

2.1. Analogy Method in Education and Architecture

Analogy is one of the effective cognitive mechanisms that people use to draw conclusions and learn new concepts. It plays an important role in the development and instruction of cognitive opinions and concepts. Analogy is a strong teaching and learning tool and it is also a perfect tool for many other purposes, such as problem solving, making definitions and creating discussion environments. In Greek, analogy is the similarity in proportional relations 'according to a proportion'. As this similarity can be between two forms (for example, two triangles) in different scales, it can also be between two different quantities. In education, analogy is defined as a simulation technique. In recent years, analogies are considered to be one of the best components in the process of teaching something related to science (Brown, 1993). The definition of analogy is expressed differently by different researchers. Some of these definitions are shown below:

- Analogy is the resemblance of some parts by concept, principle and formula to each other. More specifically, analogy is a mapping made between the features of these concepts, principles and formulas (Glynn et al., 1989).
- Analogies, metaphors and physical models are useful and effective tools that are used for primary education students to keep information in their minds as meaningful wholes (Asoko & de Boo, 2001).
- Analogies are descriptions used for comprehension of new information. In other words, analogies are used for creating new information that takes place in long term memory (Lawson, 1993).

In architecture the inspiration of the subject by analogy is not just nature, but is also affected by concrete and abstract concepts, such as culture, religion, image, humanity, etc. Biomimicry is the analogy of living in nature. Nature has always been an inspiration in architectural form and architectural theory. Much architectural design has been affected by things in nature (living or not living). Being a guiding spirit for all of the sciences today and making progress as a result of the imitation and observation of nature, biomimicry also affects us in the architectural domain (Tokman, 2012). The effect of biomimicry on the architect of the future will increase gradually. It will help him/her understand the fact that a simple spider he/she comes across is not just a simple spider, but a producer of material and a designer, and that an ant he/she sees is not just an ant, but an ant that builds structures similar to sandcastles. Within this context, biomimicry essentially highlights the importance of regarding and understanding nature from a different perspective.

3. Biomimicry

Both biomimicry and biomimetric are new sciences that observe the materials in nature and then aim to produce solutions for humans by imitating these designs or by taking inspiration from them. The biomimicry concept discussed in this study is a new work area that selects the principles of nature and designs materials and processes in accordance with the principles that have ensured the continuity of life for 3.8 billion years. İn short, biomimicry can be defined as ‘the innovation that gets inspired by nature’.

Biomimicry is a concept that was first put forward by writer and science observer Janine M. Benyus, from Montana. Upon thinking about the wonders that he saw in nature, Benyus believed that the models in nature should be imitated. Some of the examples which directed him to support such an approach are the following:

- The fact that bee-eaters can go through the Mexican Gulf with fuel of less than 10 gr,
- The fact that damsel flies can out manoeuvre the best helicopters,
- The fact that air conditioning and ventilation in thermite towers stands head and shoulders above that of humans in terms of equipment and energy consumption,
- The fact that multifrequency transmitters of bats are much more efficient and sensitive than the radar that humans created,
- The fact that beaming algae draw various chemicals together so as to lighten their body warping ends,
- The fact that polar fish and frogs can revive after they have been frozen for a long time and their organs are not damaged by the ice,
- The fact that chameleons and cuttle fish are perfectly in harmony with their environment,
- The fact that whales and penguins can dive without oxygen tubes,
- The DNA helix’s capacity to collect data,
- The fact that leaves perform the greatest chemical process in the world by generating 300 billion tons of sugar each year photosynthetically.

Such mechanisms and designs in nature that evoke admiration, some of which we have given as examples above, have the potential to enrich or develop many areas of technology. As a result of the increase and accumulation of our knowledge and the development of technology, this potential reveals itself with each passing day. Once the concept of biomimicry was treated as a science by Janine M. Benyus, it was generalised with the help of his co-workers and those people who had a close interest in the topic. The domain that drew the particular attention of scientists and designers began to be put into conscious practice. Thus, biomimicry became a form that generated

positive results and was implemented in many professions (Kuday, 2009).

3.1. Biomimicry in Architecture

While discussing the architectural concepts in his book *Architecture 2000 Predictions and Methods* (1971), Jencks highlighted that for biological engineering, under the effect of the biomorphic concept, the last ten years of the 20th century were very effective years for architecture (Jenks, 1971).

The word 'biomimicry' stems from the roots *bios* life and *mimesis* to imitate. Similarly, this concept, which includes the terminologies like 'Biomimetic', Biomimesis', 'Biognosis' and 'Bionic', is used in different disciplines for studies and research to develop more advanced technology by learning from nature. Biomimicry, which can be translated as 'learning the best opinions of nature by imitating them', started to be considered as a new science by materialising the 'possible solutions and solution potential in nature', and in fact materialising disciplines with an interaction that gathers them together. Beyond considering nature as a model, human beings who previously used to acquire experiences by observing nature now learn lessons from it, as a comparison criterion and mentor. According to Benyus, if this learning process continues by spreading to different disciplines, 'a biomimitric revolution' is going to take place in the forthcoming years. As is the case with the prediction of Benyus, the capacity of modelling, analysis and observation of features such as self-repair, silence, the stylistic and structural features that ensure conservation of energy, resistance to static and dynamic charge and the required durability, lightness of the forms and materials in nature, direct the attention of scientists to animate and inanimate formations (Benyus, 1997).

The buildings that do not use cooling systems in desert heat were designed by using ant nests as examples (Eastgate Binası, Zimbabwe) (Figure 1). In the apparel industry, the fabric that does not contain chemical pigment was developed after analysing the relationship of the wings of the Morpho butterfly with light (Morphotex). The works of Calatrava at the Milkwaukee Art Museum or the Art and Science Centre, Valencia take a form that resembles an eye or bird.

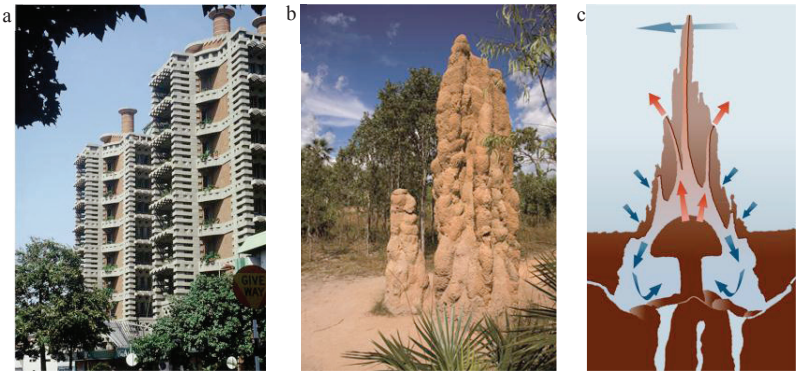

Figure 1. (a)Eastgate Building-Zimbabwe; (b)Ant nest; (c)The system of ventilation (Richard Dahl, 2013)

These points of inspiration by nature show that biomimicry has taken place in the field of architecture, especially as form, structure and texture. Similarly, architects Peter Cook and Colin Fournier's project Kunsthaus has been seen as the imitation of exterior surface with the computer control and form of a monster (Figure 2). Vito Acconci's work Cafe Insel has the same effect (Tokman, 2012), (Figure 2).

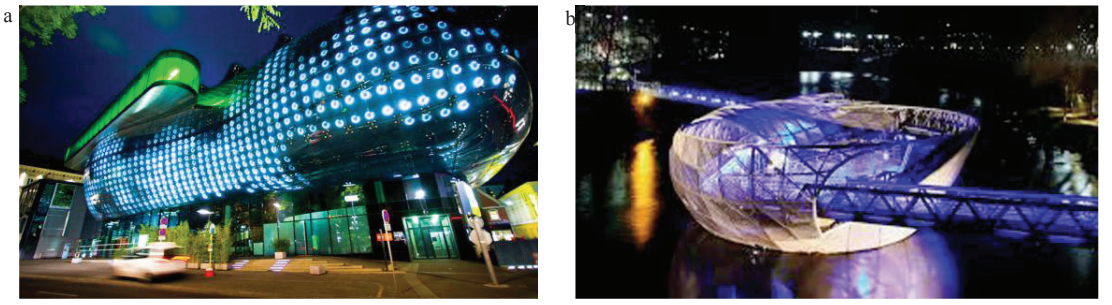

Figure 2. (a)Kunsthaus; (b)Cafe Insel (Wikipedia, 2014)

As a form, the Bahai House of Worship has been designed with inspiration from the lotus flower and a design that derived its name from the animal that inspired it is the Armadillo Concert Hall (Clyde Auditorium) (Figure 3).

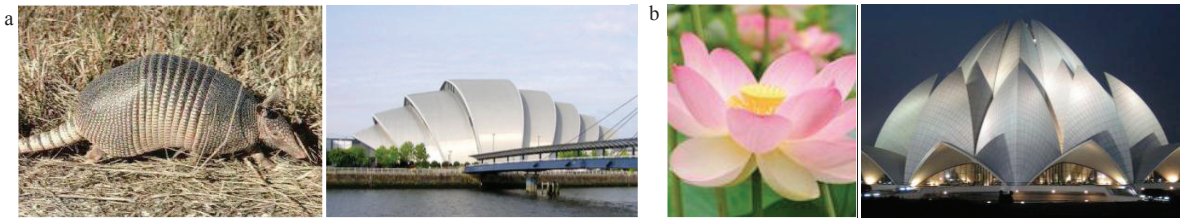

Figure 3. (a)Armadillo Concert Hall; (b) Baha'i House of Worship (Wikipedia, 2014)

The geometrical form of the Lisbon Orient Train Station has a tree branch style that determines the structure. The tree branch style structure can also be seen at Stuttgart Airport (Figure 4).

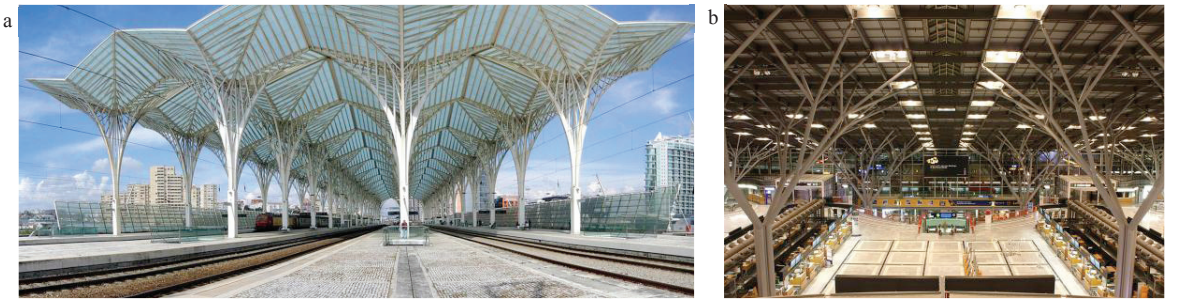

Figure 4. (a)Lisbon Orient Train Station; (b) Stuttgart Airport (Wikipedia, 2014)

The exterior surface of Mar da Palha Auditorium has been designed with a scale texture and the Esplanade Theatre has a skin inspired by durian texture *(*Figure 5).

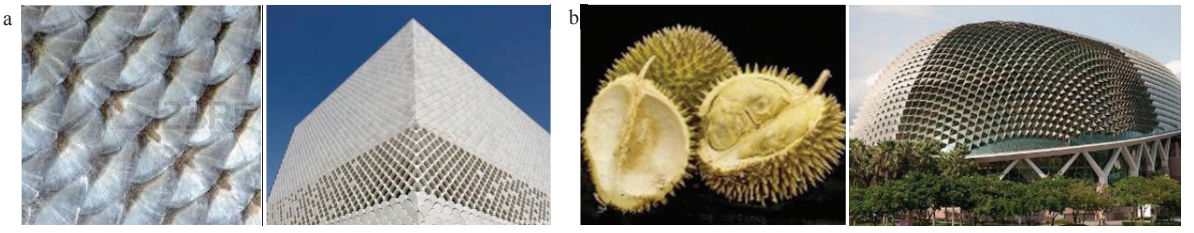

Figure 5. (a)Mar Da Palha Auditorium; (b)Esplanade Theatre (Wikipedia, 2014)

4. Study's Method and Technique

The main aim of this study is to apply part of the biomimicry concept to studies by using the analogical method as one of the design methods in the 'Architectural Design Knowledge' lesson. The study group consists of 100 people. The studies are design studies that have been done in the KTÜ Faculty of Architecture 2. The terms fall within the scope of the 'Architectural Design Knowledge' lesson inspired by "Biomimicry-Living in Nature". Students were given information in presentations about propulsive Biomimicry. The subject of the study was to design a house for "Life Under the Sea". The students were asked to design a living area within the scope of a fiction that forces life under the sea as a result of a natural disaster. The subject was limited to sea creatures. Every student was asked to research from different sources and as a result of this research they analysed the life under the sea within the scope of form, texture, material, function, and structure. They were tasked to design a house by observing every living animal in the sea with a micro and macro scale. At the end of this process, they were asked to design, within the scope of features indicated above, by choosing an animal that lives in sea.

Study comprised six steps: Subject Descriptions, Literature Research, Analysis of Research, Inspection and Argument, Design and Presentation. The steps of the study are given below (Figure 6).

STEP	PROCESS TITLES	STUDY TO BE DONE	ACTIVE EDUCATION METHOD
1.STEP	SUBJECT DESCRIPTION	Description and visual presentations about biomimicry	Description and visual presentation
2.STEP	LITERATURE RESEARCH	Searching biomimicry and biomimicry in architecture	Problem solving
3.STEP	ANALYSIS OF THE RESEARCH	Analysing architectural buildings that have been affected by nature and formed in terms of form, texture, material, function, construction	Analysis Method
4.STEP	INSPECTION AND ARGUMENT	Argument of research and analyses in a lesson with brainstorming method.	Argument Method (Brain Storming)
5.STEP	DESIGN	Inferring from a sea creature that the student chooses after research and design. Taking advantage of certain features of a sea creature, such as form, texture, material, function, and structure, and designing an architectural building.	Analogy Method
6.ADIM	PRESENTATION	Presentation of formed design to other students	Cooperative Method

Figure 6. Study Steps

5. Study Indications

Each of the 100 students that participated in the lesson was asked to research individually and as a result of this create a design inspired by a chosen living creature. Each student prepared their study as a poster (Figure 7-8). After the study, different designs were produced, depending on each student's level and perception. The designs were presented in a classroom and shared with other students.

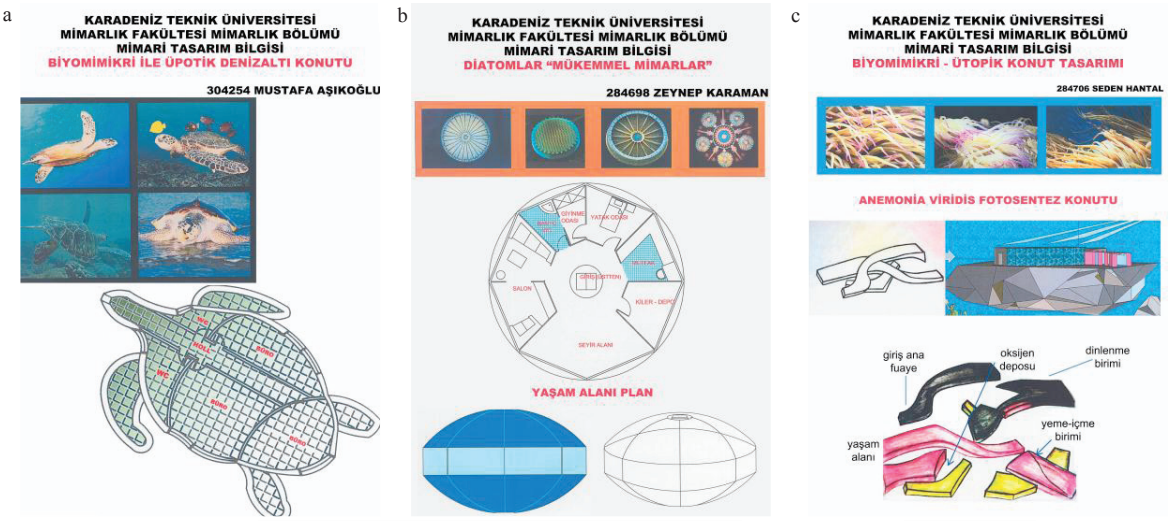

Figure 7. (a) Sea turtle inspired design; (b)Diatom inspired design; (c)Snakelocks anemone inspired design

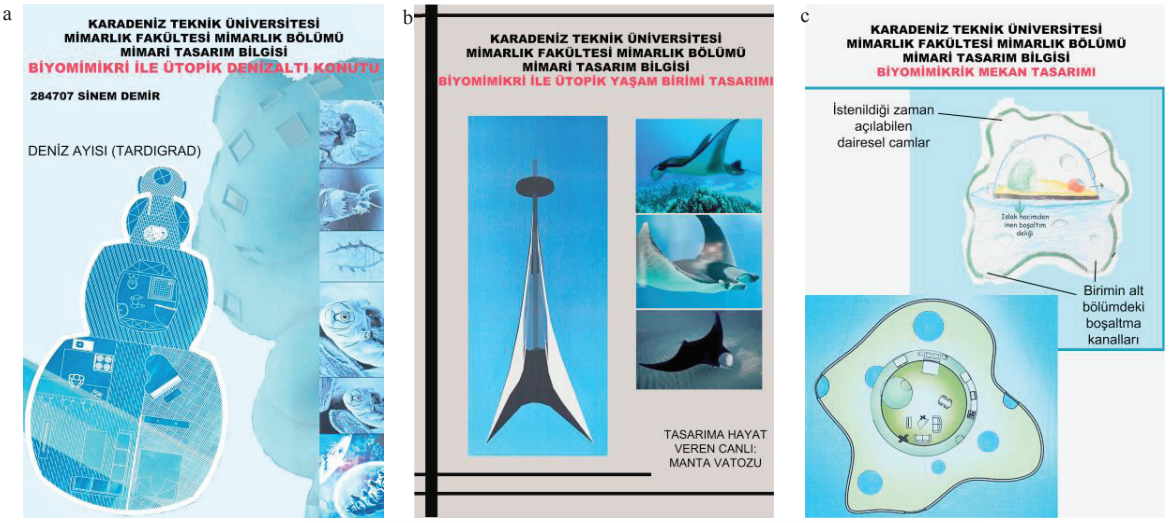

Figure 8. (a)Walrus inspired design; (b)Manta ray inspired design; (c)Amoeba inspired design

In the study, students have been inspired by the creatures, both in macro and micro scales and in design. In the designs that have been created, although the students focused on form, it has been observed that they designed their house by using the creature's life cycle and conceptual similarities. Participation of the students was achieved at a high level.

6. Result

The study has tried to enable faster and more practical learning by applying Biomimicry to one of the subjects in the 'Architectural Design Approaches' lesson. In an Architectural Design Knowledge lesson, students used the active method of student centred learning. It tried to obtain students' different points of view about a design and showed students how the Design and Nature interaction had an effect on each other. As a result of the study, the indications support the case that analogies aroused interest and wonder and increased motivation (Keller, 1983),

supported conceptual change (Dagher, 1994) and supported that this is an effective means to make contact among the concepts (Stepich & Newby, 1988).

The end of term results in the Architectural Design Knowledge lesson produced the following design approaches:

- to learn well by applying one of the design methods in the lesson taught,
- to reinforce taught/learned knowledge in a lesson with application,
- to learn by imitating the creatures in nature,
- to apply the effect of different disciplines to a design in a design process,
- to enable students' active participation in the lesson,
- to think scientifically,
- to develop problem solving and guessing abilities,
- to develop learner's thinking skills and creativity,
- to learn scientific concepts and keep them in mind for a long time,
- to form a student centred, active learning place for students,
- to motivate more and enable motivation,
- to develop their analytical ability,
- to learn that many problems have a solution in nature,
- to learn scientific concepts and correct concept mistakes,
- to make the students enjoy the lesson and arouse their interest in a lesson.

As it was a short term study involving second grade students, we were unable to produce qualified designs. The main aim of this study, apart from developing qualified designs, was to learn by doing/applying design approaches and to teach how to use inspiration by nature in the design field and the features that can be used. Whether or not this study has achieved its aims should be checked. In subsequent years, students' consistent use of this design approach in Architectural Project Lessons should be observed.

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