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PAD

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DESIGN FOR SOCIAL AND ENTEPRENERIAL INNOVATION

Bio-inspired Design System for the Egyptian Market: a Short-term Project Case Study

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Keywords
Biomimicry, Bio- inspiration, Product Design Process, Nature, Egypt

Abstract
Product Design development requires many sources of information and inspiration, one of which is nature. Bio-inspiration and Biomimicry are tools based on extracting information from nature and applying them to reach sustainable, efficient products. Bio-inspiration involves gathering ideas from nature and adjusting them based on project requirements and available resources. It provides flexibility by integrating possibilities without the limitations. These processes deliver realistic, short-term compromises that are applicable, efficient, and functional. Egyptian businesses, including small companies and startups focusing on Corporate Social Responsibility, will benefit because projects will be realizable, leading to innovative products that encourage local manufacturing. The research aims at developing a system that creates innovative, efficient, and sustainable solutions while satisfying the Egyptian market's needs. Research methods used were interviews with local companies and designers in Egypt as well as a case study of a short-term product development project. Research outcomes led to the development of a Bio-inspired design system where products were developed with the consideration of user needs to be locally produced and cost efficient. It is recommended to develop an ecosystem, which incorporates teaching skills to local workers in Egypt while investing in production techniques and materials' development, leading to local, environmentally friendly products.

1. Introduction

The focus on nature-inspired product development is becoming greater due to the current serious environmental issues. According to Hoeller et al. (2016), it is now a designer's priority to develop sustainable products. Applying systems from nature would create "efficient, effective, ecologically appropriate, and less risky" solutions (Hoeller et al., 2016, p.37). Professionals from different fields have frequently turned to nature for inspiration. One of the growing fields focusing on this approach is Biomimicry; imitating nature while following life's principles to reach faultless outcomes. These principles limit project applications, causing them to remain conceptual especially in countries like Egypt. Alternatively, Bio-inspiration focuses on simulating and abstracting inspirations in Biology without precise replication. It provides researchers endless, idea sources. This is more convenient to companies and clients creating sustainable and innovative projects as it saves time and money.

Therefore, the research aims at comparing Biomimicry and Bio-inspiration, and argues that Bio-inspiration is more convenient for design in Egypt due to limitations in available materials, production technique options, and craftsmanship quality. These cause a gap between the market needs, that are influenced by aspects of imported goods such as product finishing, usability, and design aesthetics. A design system was developed based on a freelance short-term design project used as a research case study to provide a process for future Bio-inspired products. The study hypothesizes that following the proposed design approach leads to realizable and sustainable products to the local Egyptian market.

2. Nature-inspired systems & design

Studying Biology creates a mix of methods for emulating nature and applying it into different fields such as Bionics, Biomimicry, Biomimetics, and Bio-inspiration (Whitesides, 2015). Although the terms seem similar they have different meanings and application processes. Reed, Lumb, Koobatian, and Viney (2009) discuss that several researchers use "Bio-buzzwords" assuming that methods such as Biomimicry (focusing on design processes) and Biomimetics (focusing on the field that applies the design process) are simply techniques of imitating nature "without giving thought to the value or limitations or consequences of such copying" (Reed, Lumb, Koobatian & Viney, 2009, p.1572). Therefore, it is important to first define the meaning of the Bio-terms Biomimicry and Bio-inspiration before comparing and analyzing them to each other.

2.1. Defining Biomimicry

Biomimicry stems from the Greek words *Bios* (life) and *mimesis* (imitation). It became famous in 1997 through Janine Benyus' *Biomimicry: Innovation Inspired by Nature* book (Biomimicry: Designing to Model Nature, 2019). It is a tool for innovation that involves searching for solutions by emulating nature's strategies and patterns. By doing so, innovative and sustainable outcomes can be achieved to "create conditions conducive to life" (Benyus, 2007). Biomimicry breaks down a project into three levels: model, measure, and mentor.
The first level, model, mimics an organism's form to create a solution and the second involves replicating chemicals in nature. Finally, using nature as a mentor establishes complete ecosystems similar to those in nature.

2.1.1. Life's Principles

Life's principles are rules present in any living organism according to its natural conditions based on limits and boundaries, water, sunlight, and gravity, and dynamic non-equilibrium (Baumeister, 2011). These principles are:

- Evolve to survive
- Be resource (material and energy) efficient
- Adapt to changing conditions
- Integrate development with growth
- Be locally attuned and responsive
- Use life-friendly chemistry

Each principle is based on analyzing strategies and patterns found in nature; if all are replicated in the design process the outcome would be as sustainable as any organism in nature (Biomimicry Institute 3.8, n.d.).

2.2. Defining Bio-inspiration

Bio-inspiration offers idea sources from Biology to achieve research in non-biological entities such as science and technology. It provides new opportunities to areas with limited resources and creates a bridge between geographical areas' cultural interactions and technical differences. According to Whitesides (2015), inspiration from nature should consider function, simplicity, and dissipation.
Finally, everything in nature requires a flow of energy and can be studied to achieve sustainable Bio-inspired products (Whitesides, 2015).

2.3. Product design processing

Many processes exist depending on challenges to create a solution according to the designer's perception and analysis. Design processes include three core phases present in different design disciplines: Research, Ideation and Implementation. They are sometimes referred to using different nouns or surrounded by other leadings steps and broken down into multiple phases. The Design Thinking model, for instance, is broken down into five phases: empathize, define, ideate, prototype, and testing, as shown in Figure 1. The process is not linear and designers begin or return to any step (Hasso Plattner Institute of Design, n.d.).

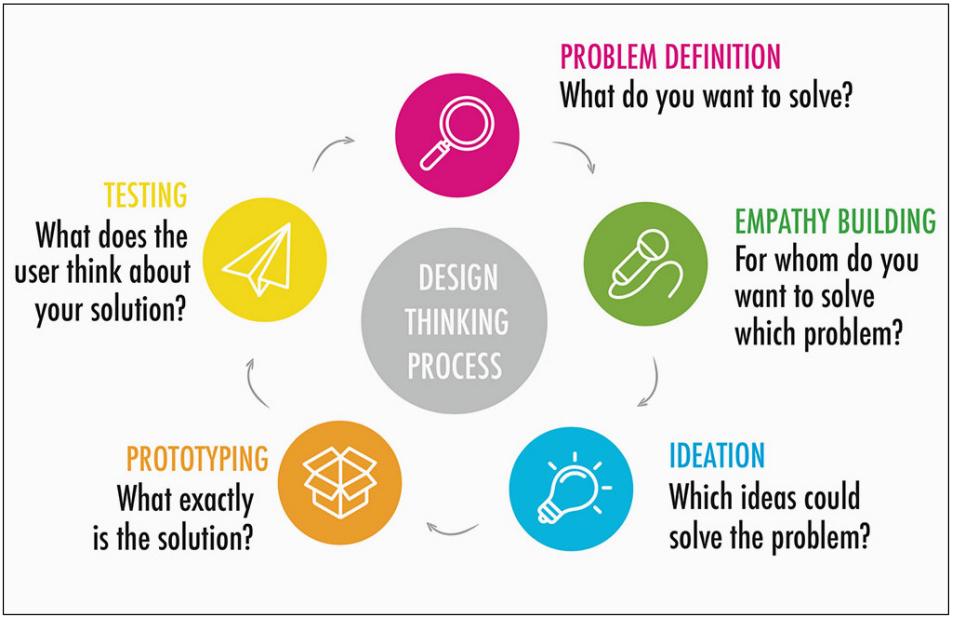

Figure 1. Hasso Plattner Institute of Design at Stanford. Design Thinking model.

2.4. Nature-inspired design systems

Nature-inspired product design systems have different approaches depending on a product's marketing strategy: market pull or technology push. Some systems follow steps to categorize creative processes including Biomimicry using levels of form, process, and ecosystem. Another approach, the Biom Bridging Model, connects systems' components according to its "structure, behavior, and functional role" (Hoeller et al., 2016, p.3). In this case, Bio-inspired systems start with inspirations to create new technologies or find solutions for existing problems using nature's knowledge.

3. Designing in Egypt

Product design, in the Egyptian market, is not well established due to misunderstanding of the designer's role. Innovation in the industry has depleted since the Sadat's "Infitah" (the open door policy). According to Ates, Duman, and Bayraktar (2006), the Sadat government worked towards becoming a financial and commercial centre in the Middle East. Companies found faster, easier profits with Sadat's government "encourage(ing) commercial activities, particularly importing advanced technology and stimulating exportation", rather than investing in local production development (Ates, Duman & Bayraktar, 2006, p. 63).

Companies nowadays prefer to assemble finalized imported products rather than developing their own. Egyptian products are forced out of the international competition because local consumers prefer foreign, high-quality finished goods. Consumerism led to a fast-paced industry where large quantities of goods are produced in low qualities.

After Egypt's revolution in 2011, several economic changes caused an increase in customs on electronic products. This led to a rise in startups and motivated companies to invest in R&D departments and develop high-quality products that suit market demands. Egyptian product design projects can now be divided into two categories; long-term and short-term projects.

3.1. Long-term projects: Industrial developed products in companies' multidisciplinary teams

These projects are developed under established companies owning large-scale factories that produce electronic goods and mass-produced furniture. Processing these projects requires years of development and financial investment to serve the masses. Interviews conducted with representatives from two industrial companies in Egypt showed that both work in similar processes. Dr. Bahgat Saad (Chief Technology Officer at Universal group for household appliances) stated that the product design process consists of Ideation, Market Brief, Design Concept, Feasibility study, Engineering Design, Digital Simulation, Functional Prototype, Functional Testing, Tool and equipment preparation, Pilot production, Reliability and performance Testing, and Launching. A similar process is used at ElAraby group with the addition of cross-functional teams to engage designers in different roles depending on project requirements.

Product design in Egypt is not yet recognized with few vacancies advertised for the position in large industries because companies still rely on assembly.

Dr. Saad states that the country needs to fight against the assembly industry to urge factories to build R&D departments to increase the need and support for product designers. According to Youssef ElAraby, product design senior manager at ElAraby Group R&D center, design priorities depend on project and market requirements. At Universal group, priority goes to new ideas with a unique selling point and new technology. The industry's current goal is getting rid of import and assembly to produce their own products, making sustainability a secondary goal.

3.2. Short-term projects: Independent freelance projects developed by local designers

Short-term projects target niche markets developed under small companies and startups. Production is minimal, relying on importing materials or producing designs in China for low costs. Several companies invest in one machine to produce small amounts of products to sell to a market percentage. Some produce their own handcrafts or outsource local crafts workshops to teach additional skills to reach high-quality products with an authentic Egyptian identity.

According to an interview conducted with Doa'a Refaat, a product designer in Egypt, the designer introduces new tools and methods of design thinking and product development to the Egyptian industry. Although most industries use traditional methods, the best approach is to mix local industries' experiences with modern techniques to develop new business concepts that can compete internationally. The designer manages interdisciplinary research as an intermediate between the technical and management expertise.

However, designers in Egypt are not deeply involved and often mistaken for engineers. Until now, the industry is not fully aware of the importance of research and conceptualization in business concept development. Usually market clients are uninterested in the research stage at the beginning and require immediate concepts.

3.3. Reflection on Design and Biomimicry/ Bio-inspired in reality: The application of producible designs

Rajeshwar discusses that although Biomimetics is important in basic science and exploratory research, it is limiting and needs to go beyond nature. This involves transitioning from the imitation of Biomimicry to the recreation of structures in Biomimetics to, finally, achieving Bio-inspiration by pushing functionalities beyond what is offered by nature (Rajeshwar, 2012). According to Whitesides, using Bio-inspiration in research is simplistic and easy to achieve in a less expensive manner. It is more suitable to short-term projects, especially for the Egyptian market and creates a compromise that allows projects to be developed using inspiration from nature without identical replication. It leaves designers the flexibility to use materials and resources imported from other countries which is not the case in Biomimicry. Bio-inspiration, therefore, is more compatible with existing design processes and nature-inspired development can be achieved realistically and efficiently (Whitesides, 2015).

4. Case study

4.1. Overview

A project was developed by the researchers in collaboration with Dayma Journeys, an Egyptian company that focuses on teaching youth about Biomimicry. It is led by environmental educators who offer guided tours to Egypt's natural areas where participants are engaged through games and activities. A journey's main purpose is the exploration of three aspects: discovering self to become better decision makers, discovering nature to create sustainable designs, and the discovery of local Egyptian communities.

The project involved using inspiration from nature to develop products that can be used during Dayma Journeys and sold commercially in the Egyptian market. The focus was using Egyptian crafts, production techniques and materials relating to Egypt's biome. The researchers studied the market trends and target group; active working adults who were largely influenced by advanced finishing of foreign products, aesthetics, and eco-friendly ethics. The products consisted of a bag, bottle, multi-functional cloth, and information pamphlet/notebook.

4.2. Developed process

Initially, the client requested a Biomimetic process. However, the process that was followed used different steps which included:

1. Client briefing
2. Break down of product elements
3. Analyzing product elements

4. Categorizing core product specifications
5. Defining each core product specification
6. Use taxonomy to highlight organisms
7. Research
8. Clustering and narrowing down
9. Selecting strategies
10. Research
11. Simplify and apply
12. Model
13. Test

After the client brief, product elements were broken down into target group, target environment, and product specifications, which included primary and secondary functions, as shown in Figure 2. Based on the usage environment, functions were categorized into three core product specifications: protect from radiation, protect from elements, and practicality, as shown in Figure 3.

Functional, sellable products were designed by analyzing the purpose, environment, and target group. Combining all four products' main features into three core product specifications ensured that product functions were the main focus.

According to Cohen, Reich, and Greenberg, some strategies were used by several organisms fulfilling the same task (Cohen, Reich & Greenberg, 2014). For example, protection from heat strategies involved layering, hair, surface shapes, etc. Information from nature was found using the Biomimicry Taxonomy on the AskNature Database and broken down into the following common strategies: cells/ pigments, casing, structures, air, and coating.

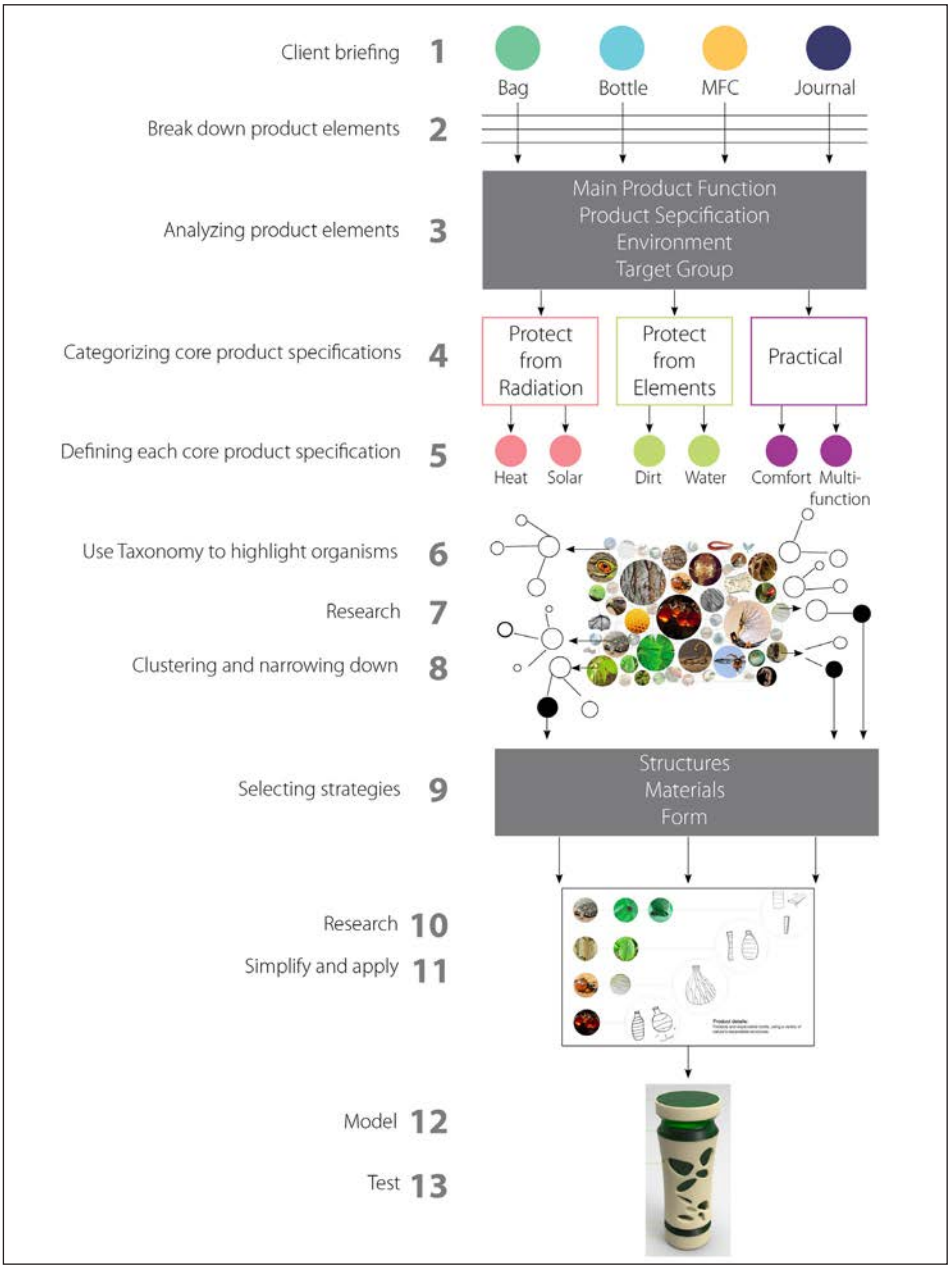

Figure 2. Nariman G. Lotfi and Dina Bahgat. Dayma Journeys Project. 2017. Project process followed in the case study.

	Main Practical Function	Extra Practical Function	Product Material Specification	Decisions	General Material Specification	General Target Environment	Additional Target Environment	General Target Group
								Uni-Sex
Bottle	To carry liquid	- keep temperature - size modularity	- expandable - insulation - structured - light	- referring to previous design attempt - keep aesthetics - Biomimetic functions need to be enhanced			daily use (hot & cold beverages)	**Age: 13 -16** - school teenager - attached to technology - go on Dayma trips
Bag	To carry a number of item around for one day or more	- back supports - organized compartments - safety pockets - insulated part to keep food or beverages - attach items to it	- easy to clean - UV protection - breathable - light - expandable - padded (for ergonomic fit) - structured (for back support) - insulated (parts of it)	none			daily use (school / college / work)	- dependent - not frequent campers **Age: 16 - 30** - a lot of outdoor activities - school \ college \ work
MFC	Protect against external elements	- assisting the user during 1-2 day trip in a number of situations - fashionable direction - allows storage	- breathable - easy to clean (self cleaning) - space efficient - reacts to (dry and wet) - waterproof - insulated - light - shaping flexibility - structured	none	- durable (weather resistant) - hygienic - modular - user friendly - standardized - biodegradable	Outdoor (daily use) Camping extreme activities (limited resources + Unpredicted weather conditions)	day to day (leisure / sport / maternity)	- busy - independant - active - slightly superficial - attracted easily to aesthetics
Journal	To collect thoughts during Dayma trips	- informative section about the trip and biomimicry - interactive	- water proof - rigid	2 directions incorporating nature journal - Dayma trips using existing materials - create new journal for commercial purposes when Dayma material is out, the commercial design will be used in Dayma trips journal will be divided in half and we will design a cover			introducing nature journal to the mass-market	- tech-updated - financially unstable **Age: 30 - up** - financially stable - can afford luxury - afford free time - selective - independant - willing to invest in long time products - busy - active during weekends - health conscious

Figure 3. Nariman G. Lotfi and Dina Bahgat. Dayma Journeys Project. 2017. Product specification analysis.

It was decided that the most realistic strategies were structures, materials, and forms as they were the most applicable in the time constraint. Figure 4 shows the list of organisms used for the research and inspirations of the project.

4.3. Design outcomes

The requirements of the project led to the ideation of two design proposals for each product based on the different structural inspirations. They were developed into preliminary models to communicate initial ideas to the client.

It was planned that the Egyptian craftsmanship would be involved in the production process by making use of their expertise while improving the quality and finishing of the final product. To design the products, structures and organisms addressing the three core product specifications were studied in more detail to analyze, understand, and abstract, as shown in Figure 5. Tessellated and deployable structures were applied to all four products.

List of inspirations	
	Organism
Egyptian Biome	Acacia nilotica
	Acacia raddiana/ tortilis
	Tamarix
	Doum tree
	Date palm
	Barnacle
	Starfish
	Fire coral
	Tiger shark
	Whale shark
	Hermit crab
	Sea urchin
	Sea cucumber
	Fennec fox
	Egyptian jerboa
	Osprey Perch
Foreign Biome	Austalian mice
	Honey ants
	Fireflies
	Barrel cactus
	Bristles and barbs
	Tree bark
	Beetles
	Millipedes
	Scales
	Bromeliads

Figure 4. Dina Bahgat & Nariman G. Lotfi. Dayma Journeys Project. 2017. Inspirations from organisms found in Nature.

Figure 5. Dina Bahgat & Nariman G. Lotfi. Dayma Journeys Project. 2017. Different organisms used as reference and inspiration.

4.3.1. Deployable structures

This product family consists of structures folded compactly when not in use, to provide practicality during backpacking trips. The structural folds provide protection from heat and dust (elements in environment). Figure 6 shows the bag design development process according to the deployable structure inspiration. Insect wings (earwig and ladybird), bat wings and snake jaw joint as well as seahorse bone structures inspired the deployable bag design. Those provided strong structure in addition to flexible and foldable features. The structures also inspired the deployable pamphlet design as shown in Figure 7 and 8.

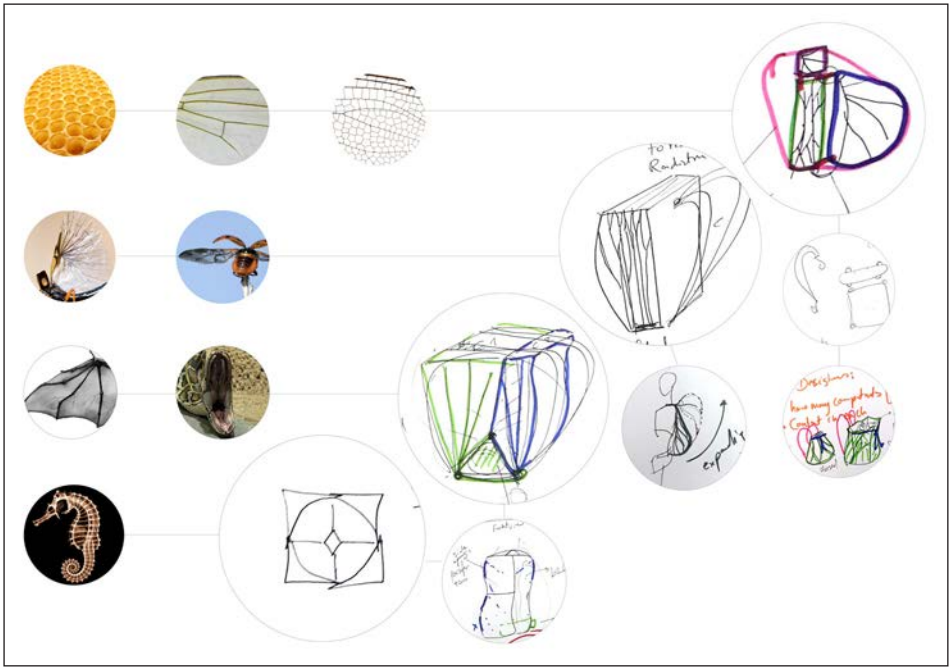

Figure 6. Dina Bahgat & Nariman G. Lotfi. Dayma Journeys Project. 2017. Bag design development process according to the tessellated structure inspiration.

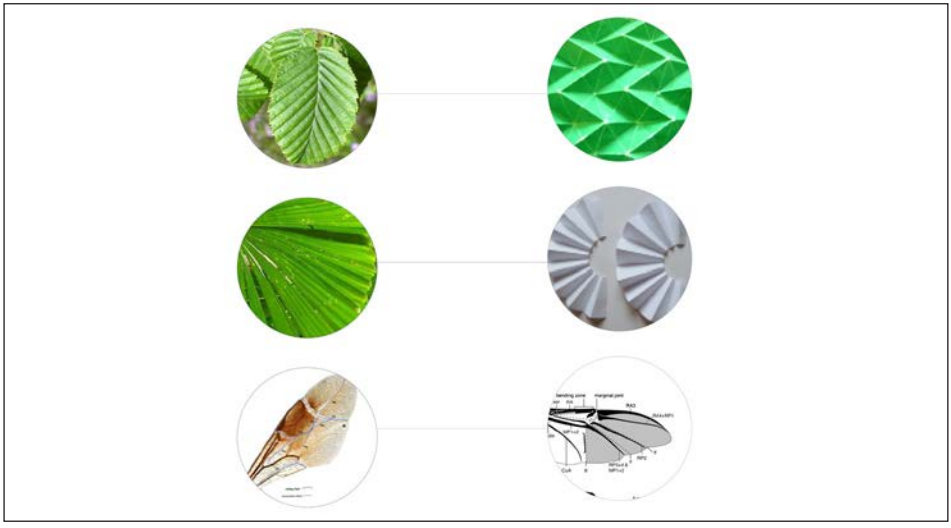

Figure 7. Dina Bahgat & Nariman G. Lotfi. Dayma Journeys Project. 2017. Deployable structures made into the pamphlet design.

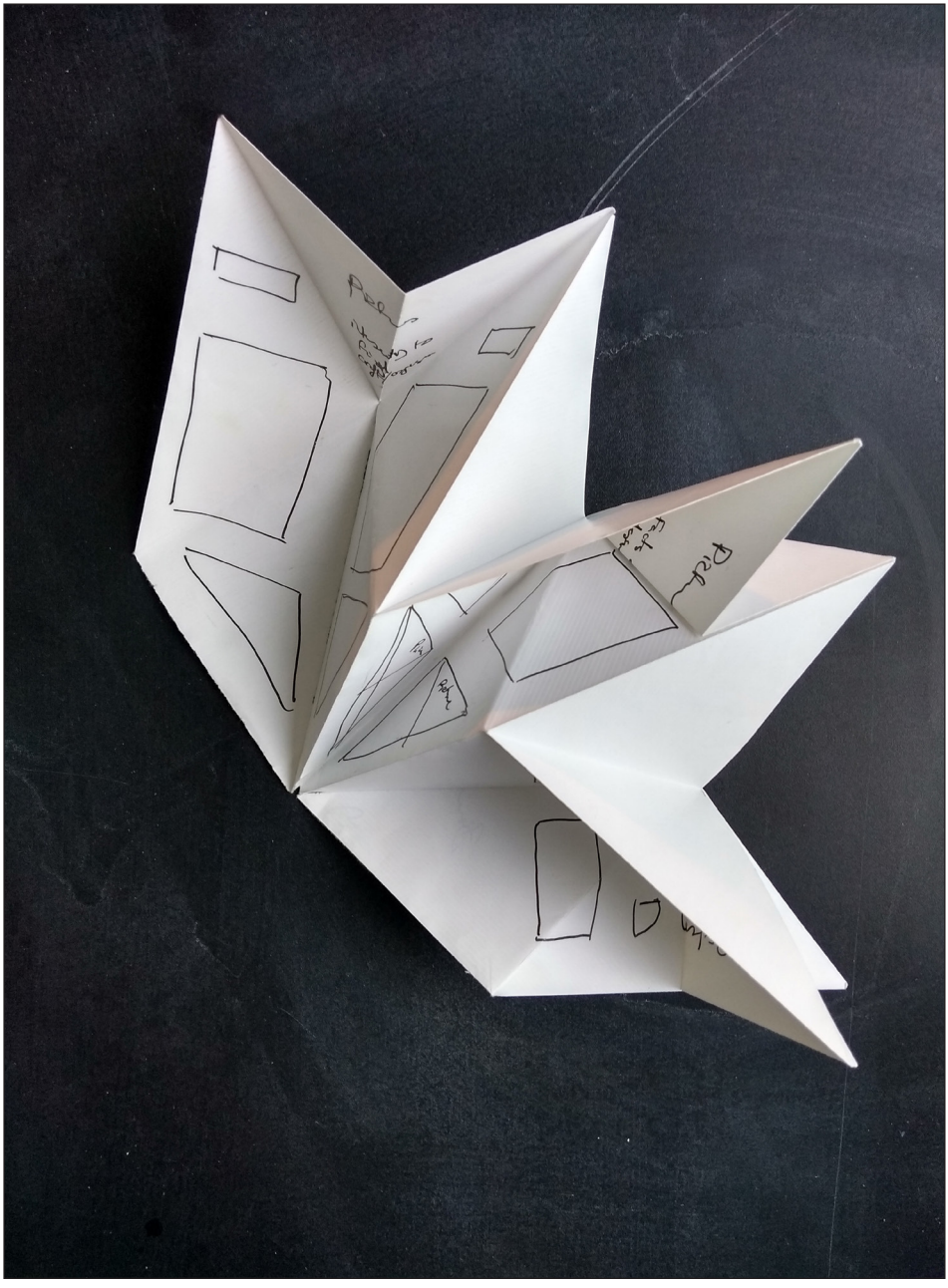

Figure 8. Dina Bahgat & Nariman G. Lotfi. Dayma Journeys Project. 2017. Final pamphlet prototype.

4.3.2. Tessellated structures

The product family followed structures that offer different possibilities depending on how many objects are carried, as shown in Figure 9. Because our customer has an active lifestyle, this structure provided them with diversity in the products. Figure 10 shows the variety of inspiration and the development process of the tessellated bag design. Prism shaped ant hairs, scorpion exoskeleton's water resistant properties, wasp's nest compartments, tree bark layers and date palm leaves inspired several functional elements for the tessellated bag design.

4.4. Case study reflection

According to our previous literature review and interviews, the case study considered the following:

- Fast paced development of designs
- Developing know-how of Egyptian manufacturers/craftsmen
- Mixing between crafts and design
- Fighting against the importing industry and becoming self-dependent
- Developing research and conceptualization to fit the market needs through problem-solving

The project provided several key findings including the misuse of Bio terms by clients as well as a difficulty in finding relevant inspirations from the local biome.
Finally, it was also found that communication between client and designers was essential to reach optimum design outcome.

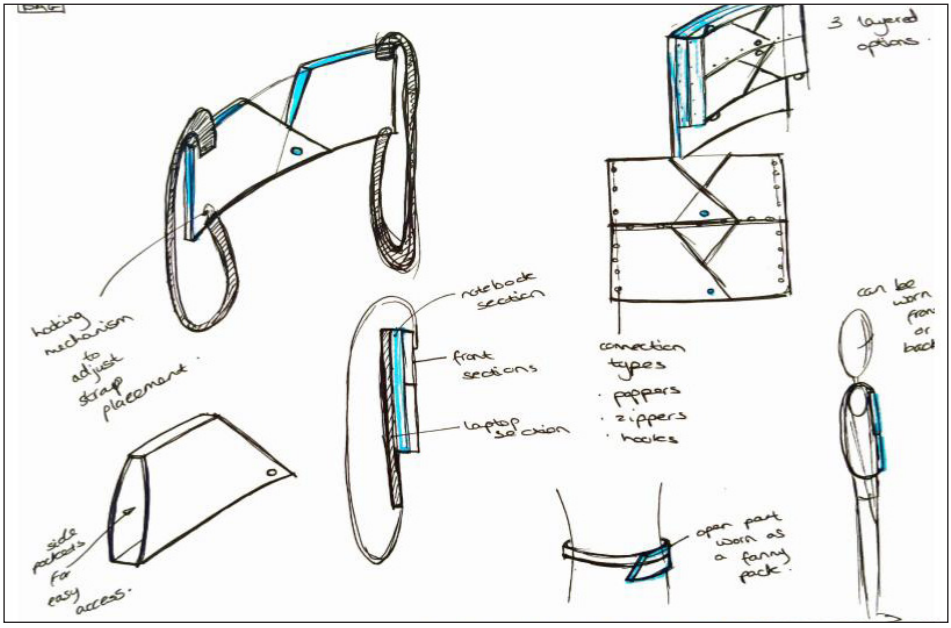

Figure 9. Nariman G. Lotfi and Dina Bahgat. Dayma Journeys Project. 2017. Tessellated bad design sketches and ideation.

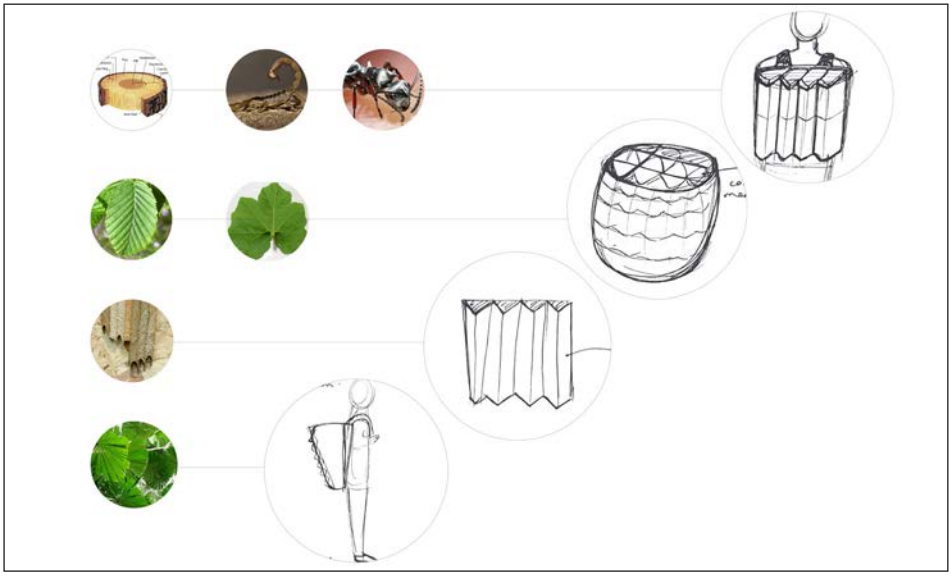

Figure 10. Nariman G. Lotfi and Dina Bahgat. Dayma Journeys Project. 2017. Bag design development process according to the tessellated structure inspiration.

4.5. Case study development and recommendation

For further development, it is suggested that products are manufactured by skilled artisans to teach them how to make the products. Developing an entire system and production plan, starting from acquiring the material, would help increase incomes and introduce a new product to the Egyptian market. Market acceptance needs to be tested and analyzed to find out if consumers would be interested in purchasing Bio-inspired products.

Cost analysis and feasibility studies need to be carried out to examine if a Bio-inspired process is worth investing in. Testing the process on other projects including long-term projects in the Egyptian industry is recommended.

A method of introducing the Bio-inspired process to industries would be needed to communicate how things can be done in a more efficient and optimum way.

5. Conclusion

Biomimicry life's principles create limitations during the realization stage which leaves projects in the concept phase.

A case study proved through practice that a Biomimetic design approach could be restraining at the moment in Egypt. Therefore, a switch to Bio-inspiration was needed to deliver realizable outcomes, regarding client needs, materials, production techniques available, and market perception. By exploring the Egyptian industry and product designers' reflections on design, it was found that designers are still limited to styling tasks and rarely included in the development process due to lack of awareness of their potential and limited amounts of product innovation in Egypt.

Implementing nature-inspired systems in large companies is welcomed with acceptance and appreciation. Companies are interested in applying Bio-inspiration to their line of work but have not yet done so because there is still not an apparent need in the market for it. Applying Biomimicry is seen as too complicated which needs investment in time and money with insecurity about market acceptance. Therefore, it is recommended that Bio-inspiration is applied to small industries of products in Egypt for now, where mass production is not a main demand, for easy realization and introduction to the market.

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Progetto grafico is an international graphic design magazine founded in 2003 and published by Aiap, the Italian association of visual communication design. A point of reference for such design in Italy from its start, it has also been fully translated into English since 2012. • In December 2017, Jonathan Pierini and Gianluca Camillini became the current editors. • The new *Progetto grafico* offers a critical look at graphics and visuals through a narrative broken up into fragments. Its aim is to offer articles connected in different ways so as to foster a series of transdisciplinary, historical and contemporary considerations. This multiple viewpoint, ranging from very distant to very close, seeks to look at the real both in the broadest terms as well as in a more specialist context. Our belief is that observation, whether of artifacts or representations, as well as production of visuals or graphics can add to today's cultural debate. • Contributions can include visual material, essays and interviews. Each issue intends to explore the storytelling opportunities of the journal.

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Aiap CDPG, the *Graphic Design Documentation Centre*. Working to collect, catalogue, archive, enhance and promote any documents related to graphic design and visual communication. These documents (originals as well layouts of projects, books, posters, prints, catalogues, correspondence, photographs) help reconstruct the history of graphic design in Italy and support research and educational activities, as it is the CDGP's intention to make these documents widely available.

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