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URBAN SPACE ALERT

Industrial Waste Management in Egypt: a Sustainable Design System

Nariman G. Lotfi, German University in Cairo

Keywords
Industrial Waste, Design System, Sustainability, Management, Design Thinking

Abstract
Every year, industrial companies in Egypt discard tons of materials during the production process. However, these unused materials can be utilized by small workshops to make new products. The study aims at investigating disposed materials at the industrial stage of a product life-cycle. The research hypothesizes that by applying design-thinking strategies, designers can establish a link between large industrial companies in Egypt and small workshops, thereby creating a sustainable waste management cycle. By implementing this cycle, companies, workshops, and consumers will benefit. The research collected information from all those involved in the production process: engineers, craftsmen, company managers, and users. Findings showed that the materials industrial companies get rid of can be exploited by small workshops. One example of this production chain, glass, was used to offer a practical solution to the industrial waste problem. The research outcome was a waste management system proposal applied using one of the wasted materials. The report shows that design and product quality need not be compromised for the creation of a sustainable product, emphasizing the importance of the designer's role in addressing this issue.

1. Introduction

As prices increase in Egypt, producers are seeking local materials for cost-efficient products. Accordingly, one alternative possibility is solid industrial waste. Due to the growing rates of mass consumption and high production, our societies are facing majors developmental issues, including the amount of waste generated. Therefore, unused waste materials are a crucial factor in keeping Egypt from becoming a sustainable society.

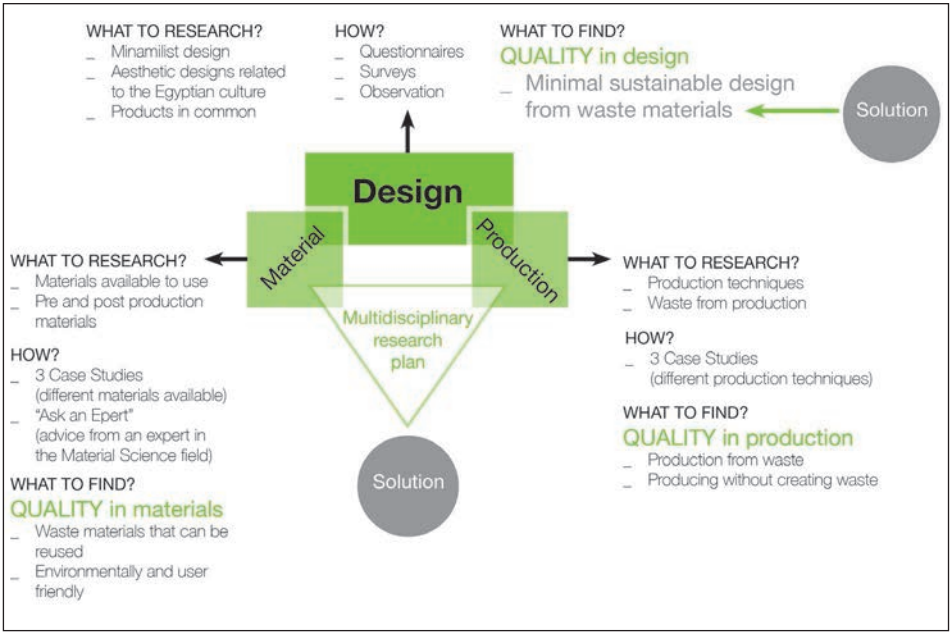

Figure 1. Multidisciplinary research plan combining the study of materials, production, and design.

As shown in Fig. 1, the research followed a multidisciplinary approach covering: material resources, production techniques in Egypt, and design. The research aims to reduce material discarding during industrial production by creating minimal

designs. By doing so, a waste management system is developed to locate designers between industrial companies and small workshops. By integrating this system it is hypothesized that industrial waste will be repurposed and the livelihoods of small workshop owners will improve, thereby creating sustainable development.

2. Sustainable Development

Sustainable development can only be established if economic, social and environmental sustainability are all considered in one way or another. Several researchers have suggested that without environmental sustainability and natural capital there would be no social sustainability. Goodland (1995) describes environmental sustainability as protecting source materials while making sure that sink materials are not surpassed (Goodland, 1995). To create social and economic sustainability, natural resources must first be sustained.

2.1. Source and Sink Capacities

Environmental sustainability focuses on maintaining the natural capacity as a provider of input (sources) and as waste outputs (sinks). Raw materials such as food, water, air, energy are categorized as sources whereas any wastes or outputs are defined as sinks (Goodland, 1995). Source capacities are used in staggering amounts with sink capacities created during production, following a linear process; materials > production > waste > products > use > waste again. Sustainability proposes the use of circular cycles to reduce material consumption, reuse waste materials, and recycle final discarded materials. To effectively sustain, both source and sink capac-

ities must be considered to find a use for the sinks in a way which will not affect the global life-support systems.

2.2. Product Life-cycle

There are four main stages in the Product Life Cycle (PLC) which are suggested to represent the biological life stages: "a seed is planted (introduction), it begins to sprout (growth), it shoots out leaves and puts down roots as it becomes an adult (maturity), after a long period as an adult the plant begins to shrink and dies out (decline)" (Product Life Cycle, 2010). Unlike natural objects that disintegrate into the environment, our products are thrown away after decline with no value or disintegration.

Life cycle thinking is a fundamental part in creating sustainable designs which focuses on obtaining raw materials, production, and "the distribution, use, recycling, and, finally, disposal of products" (Prosler, Rubik, Schmincke & Tischner, 2000).

2.3. System development using checklists

The relationship between materials and the environment is clear: one cannot logically be considered without the other. It is difficult to include both in the same project or design because designers are often limited by clients or companies. However, some clients will brief designers about a project aiming towards environmental friendliness and, accordingly, designers need to develop tools to include this in the design process. One technique, checklists, allows a designer to refer to a set of reminders such as "Can a recycled polymer be used? What material is more recyclable? Which produces less waste?" (Benjamin, Edirisinghe & Zwetsloot, 1994).

This enables designers to find new information and techniques for designs and allows designers inclusion in the industrial process to make environmental aspects of the design intuitive.

2.4. Integrating designers to create sustainable development

By reducing product sizes and material quantities during manufacturing, designers have the potential to change product concepts significantly. As indicated by Ashby and Johnson (2002), reducing materials can be achieved by using renewable materials, recycling, creating services instead of goods, and miniaturization (Ashby & Johnson, 2002).
To create successful sustainable products designers need to identify:

- Reusable energy sources
- Waste product recycling
- Wasteful consumption pattern alteration
- Excessive product packaging reduction
- New product aesthetics from recycled materials
- Technologies to reduce industrial waste production
- Better environmental impact statements for products
- Methods of recycling waste materials into new products (Margolin, 1998).

3. Materials and Resources

Technological mediums have increased the materials available to be used and although this allows designers more choice it also has drawbacks. Doordan explained that “materials are not just a ‘given’ to be incorporated into the designer’s calculation but are part of the design problem” (Doordan, 2003).

3.1. Industrial waste generated in Egypt and its relevance to other countries

Due to the rapid development of Egypt, the amount of waste produced is higher than a lot of other countries in the world. When compared to other countries such as the United States of America, where protocols were established in 1994 by the Resource Conservation and Recovery Act (RCRA) which created a recovery rate of 27% in 1995 and increased to 34.7% in 2011. In Austria, 69% of municipal waste was recycled through the Industrial Ecology Close Loop system (Ibrahim & Mohamed, 2016). According to the Country Report on Solid Waste Management in Egypt (2013), 89.03 tons of solid waste were produced in 2012, 6 million of which is an industrial waste (Ministry of State for Environmental Affairs, 2013). The number of industrial enterprises in Egypt is approximately 64,997 with industrial sectors in 2011 representing 37.6% of Egypt's GDP (Gross Domestic Product). This sector "impacts environmental degradation in Egypt to a substantial extent" with a steady increase in the amount of industrial waste produced in Egypt over the years (Ministry of State for Environmental Affairs, 2013). Initiatives to tackle the issue such as "Green Growth" focus on developing green jobs and entrepreneurship to reduce environmental effects from unnecessary discarding of wastes (Sweep Net, 2014). Because of the high amount of industrial waste produced in Egypt annually as well as the growth rate of production and development it is a relevant country to consider as a case study.

3.2. Material and production resources in Egypt

Each society holds its own unique collection of materials, production techniques and resources as well as waste pro-

duced. A designer should focus first on a society's waste problems and material availability before solving world problems. Egypt, in particular, has both traditional and modern resources and techniques unique to the country.

3.2.1. Industrial companies

Interviews and observation with four industrial companies in Egypt were conducted to find out materials and processes used for production. Questions were divided into four categories: the transformation of raw materials, application of the materials, production technique(s), and recycling process (if any). The findings were categorized in the method shown in Fig. 2.

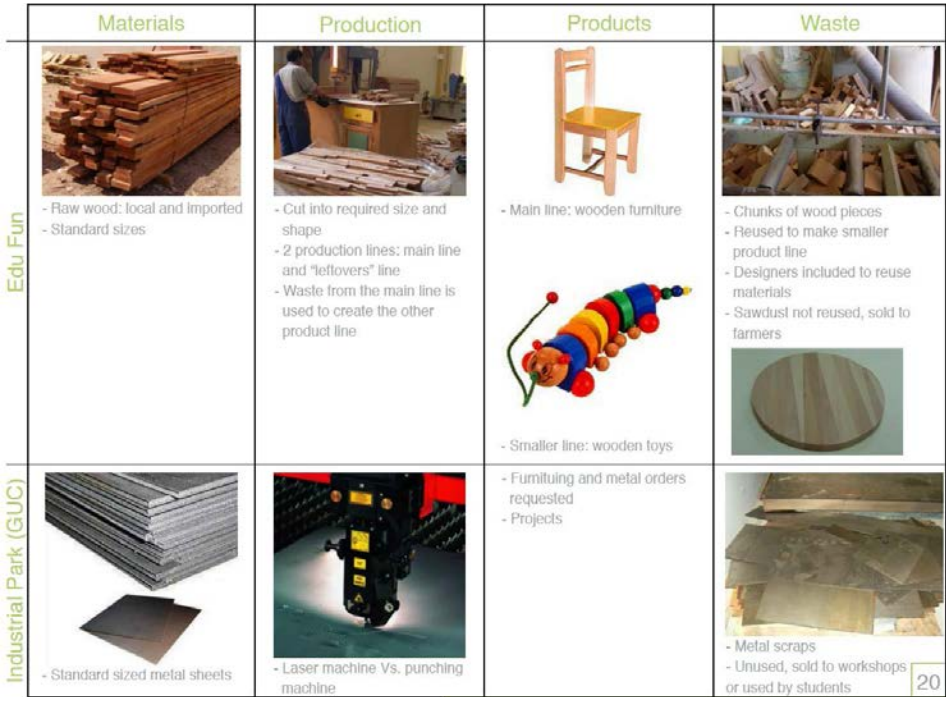

Figure 2. Table showing some of the wasted materials studied in the research collected from the company, Edu Fun, and the Industrial Park at the German University in Cairo.

3.2.2. Small workshops

Materials used, production techniques followed, end products, and recycling involvements were identified in eight small workshops through the use of interviews and observations, as shown in Fig. 3 and 4.

3.3. Research findings and summary

Based on the research findings, it was established that some companies are unable to reuse wasted materials because it would produce different products than the ones they sell. Workshops use waste materials to make new products to profit and are involved in selling unneeded wasted materials. However, there were three main limitations to be addressed.

Figure 3. Table showing the wasted materials studied in the research observed at small workshops across Cairo.

Figure 4. More wasted materials observed during the research.

The workshops were:

1. Unable to retrieve materials from companies easily
2. Unable to visualize design possibilities using sink capacities
3. Producing traditionally designed products not marketed well, creating a loss of profit

Fig. 5 shows that the research found an absence of designer inclusion in the waste management process affecting the way materials are used and products are designed. Consumers indicated that there is a lack of awareness towards the value of the waste materials.

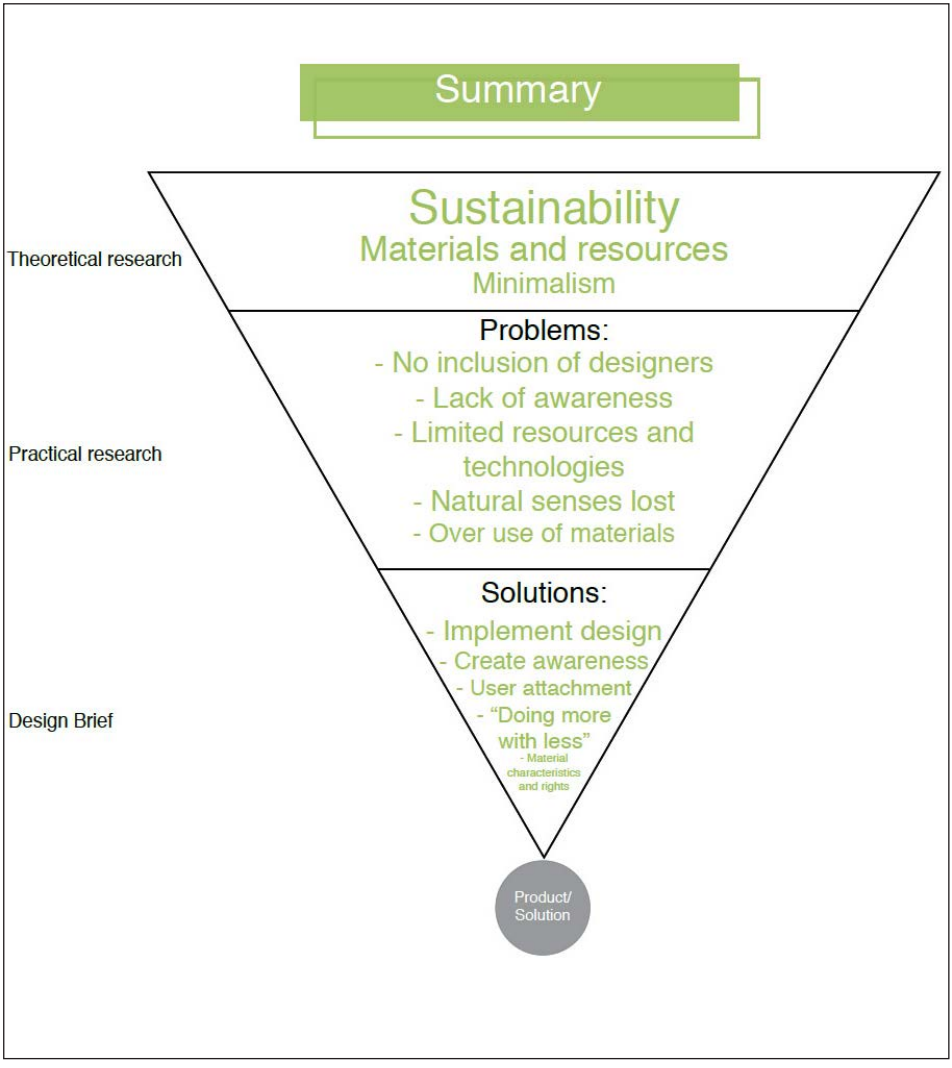

Figure 5. Research summary demonstrating the different levels to be considered to achieve a sustainable design solution.

4. Case study testing

A case study with one of the wasted materials was selected to test the waste management system. The system involved the following steps and incorporates the checklist method described previously:

1. Identifying wasted material from industrial companies
2. Identifying the needs of small workshops
3. Retrieving the industrial waste from the companies
4. Designing products using the retrieved materials
5. Providing the workshops with the materials and the designs
6. Producing new products using the retrieved materials

4.1. Case study process

The sink capacity used in the case study was glass, a material wasted in abundance with plenty of opportunities and needs from workshops. The main companies that waste glass in Egypt are car window companies; if a window has a glitch the complete windshield is broken into pieces and thrown away. Workshops required retrieval of the material in any quantity or shape to be melted and reused for other products sold to consumers. Once products are made, waste is still created that is thrown away and not used again. One of the broken windshields was retrieved and a new design was created for that material. The entire life-cycle of the glass material in Egypt is explained further in Fig. 6.

It was vital that the material be the hero of the design to market the idea to consumers. According to consumer research using a survey, it was found that an everyday product is best to create user awareness for the products they buy.

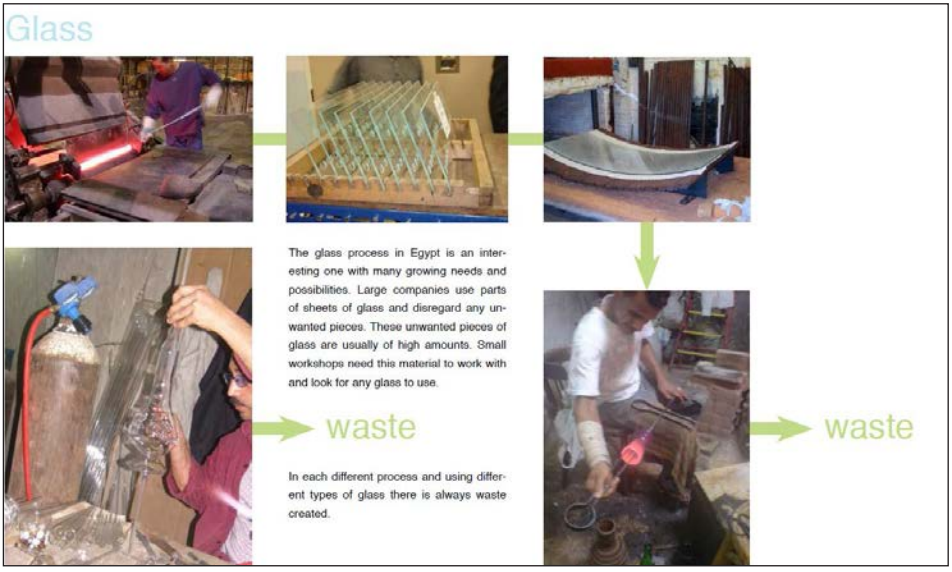

Figure 6. The life-cycle of the glass material in Egypt.

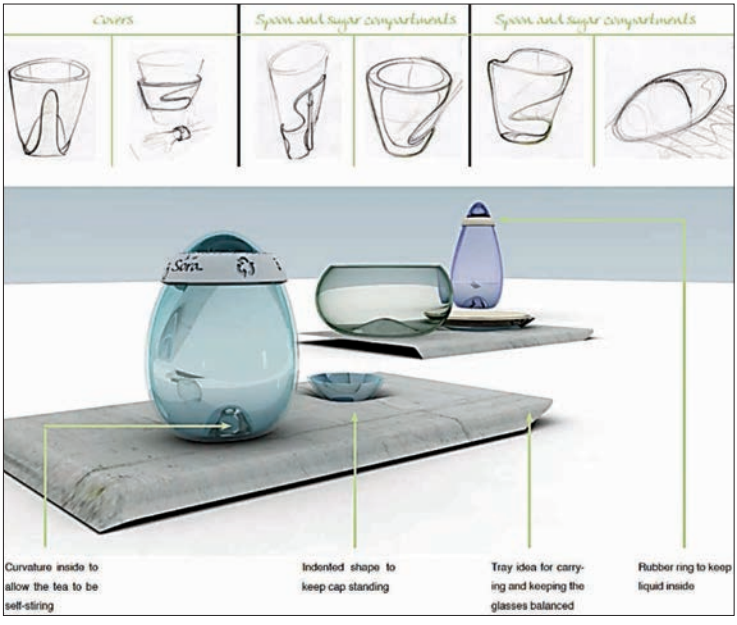

Figure 7. The design process followed by the researcher to develop a new tea set design for the Egyptian market.

The choice of product was a tea drinking set because different target groups buy it, yet it has no unique Egyptian design. Minimalism and doing more with less were considered when developing the simplistic shape, form, and function of the design. Fig. 7 shows part of the design process and a detailed explanation of the design where it considered functionality by providing a cap compartment used instead of a spoon to scoop sugar and cover the cups from external elements. The small bump at the bottom of the glass can be used to swirl the tea to mix the sugar, eliminating any need for a spoon. Emotionally, the new design incorporated a droplet shape to create a natural and unique feeling for the product, tying together with the natural material used to market the sustainable product.

After the design was created the retrieved material was taken to the workshops to communicate the required design outcome. Design thinking and communication were crucial to fulfilling the project requirements at this point in the case study. Two types of glass workshops were visited for this case study to test the reusing of the material and the quality of the final outcome, as shown in Fig. 8.

Fig. 9 shows the final design manufactured by the second workshop with the development of a packaging and branding to further market the products to customers.

Figure 8. Prototype testing of two different workshop techniques in Egypt.

Figure 9. Final product outcome developed using the wasted materials and taken to a small workshop demonstrated in the case study.

4.2. Case study findings and results

The case study showed that using the checklist to create a waste management system worked successfully.
By integrating a designer in the middle of the production process the following was achieved:

1. Reapplication of sink capacities that were previously disposed
2. Implementation of design thinking to create a new design lacking in the market
3. Increase in profit for workshop owners by attracting more consumers
4. Increase in awareness towards sustainable and recycled products

5. The industrial waste management system

The findings of the case study provided information needed to finalize the industrial waste management system in Egypt. Fig. 10 shows a visual plan to better communicate the process to interested designers. It shows the process starting from industrial companies using raw materials (source capacities).

The sink capacities are retrieved and contained by the designer who creates a design for the material given to workshops along with sinks. It strategically locates the designer in the middle between the industrial companies and the workshops to aid communication between them.

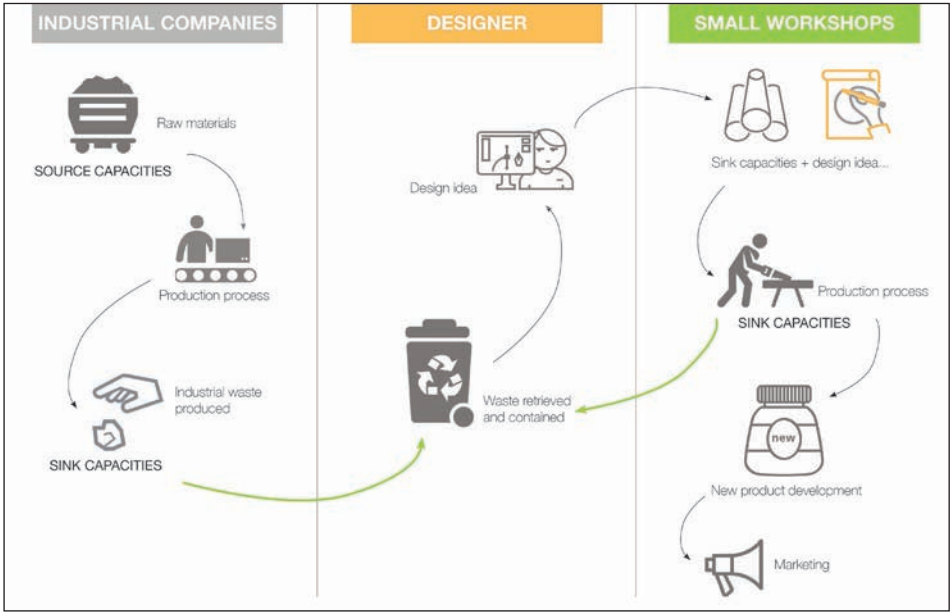

Figure 10. Waste management system showing the different steps to follow to achieve a sustainable design outcome using sink capacities.

6. Discussion

The waste management system collaborates and interacts with several different parties involved creating benefits for each of them. These benefits include:

1. **Industrial companies.** Unwanted materials are easily disposed of and acknowledgement is addressed during marketing.
2. **Workshops.** Provided with materials and designs required to produce products and will profit from selling new designs.
3. **Consumers.** Provided with unique designs catered to their specific needs that are locally produced and less expensive than imported products.

4. **General well-being of the country.** Sink capacities valued and used as source capacities. Waste will be reduced and reused to create valuable products.

Retrieval of the material was difficult at first as industrial companies required the building of trust with the designer to provide materials. Initially, workshops were reluctant to produce products using wasted materials as they were unaware of its necessity or value.

It is recommended to continue to test the system using different materials to produce different products. A wider variety of research on industrial companies is required to get a deeper understanding of other available materials. Formation of a multidisciplinary team dedicated to fulfilling the system is needed to include more people from different fields. Building on the proposed system to develop into a business or a non-profit organization that can sustain and build clusters throughout the country working on this initiative is recommended to integrate a waste management approach for managing sink capacities produced by small workshops, making them self-reliant.

7. Conclusion

Today, designers who intend to create environmental solutions not only need to find orientation among numerous options but must adapt their intuitive capacity, creativity, and work methods towards abstraction, immateriality, and multiplicity of parameters with which they must deal to work with matter.

Therefore, a sustainable designer's process changes the design's planning and processing to optimize product forms and sizes to achieve positive impacts on environmental protection.

This research investigated the challenges and opportunities for sustainable design in Egypt, integrating principles of minimalism and goes further to observe the local manufacturing processes. The research identified a crucial issue in Egypt and proposed a system that can achieve sustainable development. It considers environmental sustainability by reducing sink capacities that are disposed of and reusing them to make products that are missing in the Egyptian market. The system provides economic development for the country by providing less expensive, locally-made products for customers and increases the incomes of small workshops lacking in new design approaches in their product lines.

Finally, through marketing, awareness of sustainable products will increase the value placed on the materials we use for our everyday products.

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BIOGRAPHIES

Jomana G. Attia
Awarded a M.Sc. degree in Design from the German University of Cairo-Egypt. Attia has experience in Marketing, Marketing Consulting and Market research. She has worked with several NGOs and SMEs in the areas of participatory design, branding and communication. She is currently teaching in the Design Theory department at the GUC, while working on her Ph.D.
jomana.gamaleldin@guc.edu.eg

Alaa El Anssary
Awarded a PhD degree in Design from the university of Duisburg-Essen, Art and Design faculty - Folkwang Hochschule der Künste – Germany. El Anssary has been teaching at the department of Product Design since 2007 at the German University in Cairo GUC. With extensive professional and research experience in the field of product design he focuses on the process of designing as an interdisciplinary research including culture, human behavior and technology. Alaa El Anssary is the author of many papers, articles and he has published a book on the design process and innovation.
alaa.elanssary@guc.edu.eg

Sherin Helmy
Holder of a bachelor degree in Product Design from the Faculty of Applied Sciences and Arts, German University in Cairo. As well as currently working as a teaching assistant in the Design Theory department in the same Faculty. Interested in all fields of design and always trying to learn and evolve.
sherin.ali@guc.edu.eg

Peppe Frisino
MA Design for Visual Arts, Design and Arts Faculty (IUAV University, Venice) with a broad interest in artistic practices and do it yourself cultures with a glimpse to social design. His research focus on collaborative practices applied to crafts and social innovation, as well as creating spaces for collective experiences and art residencies.
gfrisino@gmail.com

Alaa Baligh
Holder of a bachelor degree in Product Design from the Faculty of Applied Sciences and Arts, German University in Cairo. As well as currently working as a teaching assistant in the Product design department in the same Faculty.
alaa.gamaleldin@guc.edu.eg

Nora Kahil
Was born and raised in Downtown Cairo, Egypt. She has a Masters degree in the field of Media Design and currently instructs Applied Arts and Sciences students at the German University in Cairo. Her passion for conserving her cultural heritage and her hometown, as well as her specialized field of work, continuously highlights the importance of preservation. Nora's Levantine origins appear to support her desire to revive the grandeur of the past. This topic finds precedence in her publications and the projects she undertakes. Nora is a passionate photographer who, more recently also took the stage as a TEDx speaker.
nora.jean@guc.edu.eg

Carla Langella
Architect, PhD, Assistant Professor of Industrial Design at Università degli Studi of Campania "Luigi Vanvitelli", Department of Architecture and Industrial Design (DADI), where she lectures "Product Design", "Bio-Innovation Design" and "Design for visualization of the Science". Since 2006 she has founded and coordinates the Hybrid Design Lab (**www.hybriddesignlab.unicampania.it**), a design laboratory dedicated to the mutual collaboration between design and science with particular attention to the human centred innovation. Her publications and research projects are related to the themes of biomimetic design, design of new materials and application of digital technologies in cultural heritage.
carla.langella@unicampania.it

Nariman Lotfi
Lotfi is an instructor at the German University in Cairo where she was awarded a Master's degree in Product Design in 2014 focusing on Design and Bionics. She has focused on research in the fields of Product design, Biomimicry, and Sustainability which she presented in workshops and talks including a TEDx talk at Zeweil City University in 2017. She was awarded the Grand Prize by the Biomimicry Institute for an irrigation solution for Fayoum's agriculture in 2013. She is currently working on her PhD degree focused on 4D printing and the future of the industrial design scene in Egypt.
nariman.gamal@guc.edu.eg

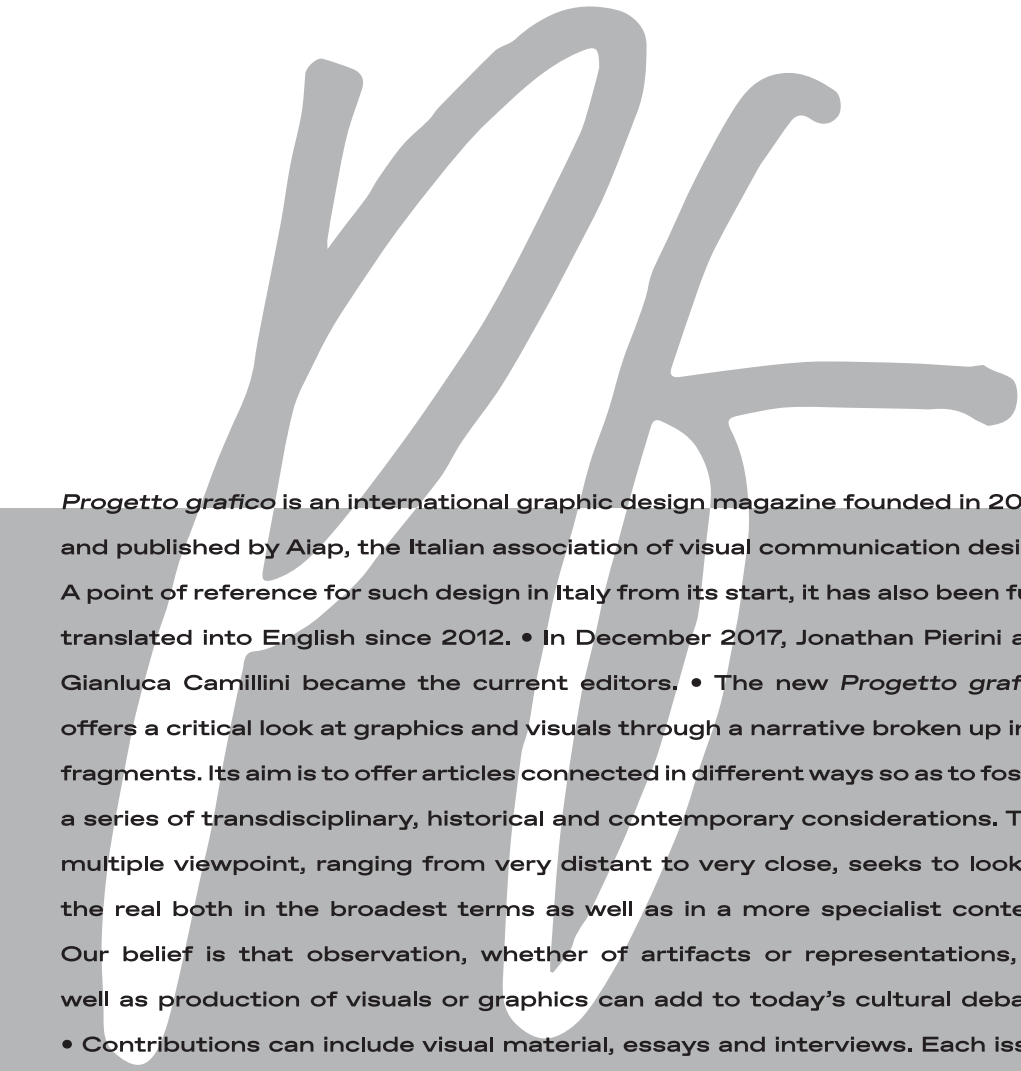
Gabriella Mastrangelo
MA in Interior Design (Politecnico di Milano), she studied illustration at Central Saint Martins and worked at Cinimod Studio (interior and interaction design) in London. Her work is focused on creating spaces for relations, experiences and participation through urban installations and hands-on workshops. In 2011 she started "Make People Do Lab" a research project on crafts and participatory design practices, based in the Apulian region. In 2014 she joined Entropika, a multidisciplinary design lab based in Athens, operating at the intersection of art, architecture and technology. In 2016 she co-founded Bordo, an interior and visual design practice based in Taranto. Since January 2018 she is part of the Open Design School in Matera, Italy, designing urban infrastructures for public spaces for Matera European Capital of Culture 2019.
mastrangelogabriella@gmail.com

Plasticity Studio
Art and research project established in 2017 by Grazia Mappa e Gabriele Leo in an attempt to investigate the natural and political implications of western design culture. Our multimedia work finds itself at the intersection of contemporary art, and design sociological investigation.
Currently we live and work between Taranto and Milan.
plasticity-studio.tumblr.com

Andreas Sicklinger
Professor at the Faculty of Applied Sciences and Arts, German University in Cairo, Egypt.
andreas.sicklinger@guc.edu.eg

Camila Soares de Barros
Dance and movement artist and researcher interested in biopolitics, education, creative processes, and in art as power of life. Brazilian, Bachelor of Dance (UNICAMP- Brazil), Specialist in Técnica Klauss Vianna (PUC-SP, Brazil) and Master in Education (UNIFESP- Brazil). In 2017-2018 she integrated the international collective of artists "O Risco da Dança" at c.e.m - centro em movimento and presented her latest dance work BICHO in Festival Pedras'18, in Lisbon-PT. Back to Brazil since August 2018, she keeps investigating BICHO and its developments and potencies in different territories.
camilasoaresdebarros@gmail.com

Ahmed Wahby
Graduated in 1992 with a degree in Architecture from Ain Shams University, Cairo Egypt. In 2000 he obtained an MA degree in Islamic Art and Architecture from the American University in Cairo, AUC where he had worked as a research assistant for almost 4 years. In 2008 he was awarded his Ph. D degree in Islamic Art, Architecture and Archaeology from the Oriental Department of the Otto-Friedrich University, School of Human Sciences, Art and Culture, in Bamberg, Germany. Dr. Wahby has been teaching since 2008 at the German University in Cairo GUC, the Faculty of Applied Sciences and Arts in the Design Theory Department. He has also served as the Faculty's Vice Dean for 8 years. He has numerous publications in local and international journals.
ahmed.wahby@guc.edu.eg



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aiap.it — aiap.it/cdpg
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