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Nature and technology as interdisciplinary elements in teaching design: Project *"We won't waste you"*

Jorge Lino Alves [(1)], Bárbara Rangel [(2)] and Claudia Alquezar Facca [(3)]

Abstract: This paper presents the interdisciplinary project *"We Won't Waste You"* developed in the Master's Program of Product and Industrial Design, University of Porto, Portugal, in partnership with the Municipality of Matosinhos. Based on the principles of interdisciplinarity, on Project-Based Learning and on *Material Driven Design methodology*, students developed products using discarded materials (crustacean shells, charcoal ash, scales, egg shells, etc.) in two different contexts: nature that is capable of supplying incredibly interesting raw materials and often ready and suitable for use and application in new products, and the catering industry that generates a large amount of discarded waste that can be reused for new purposes.

Keywords: Design - Project - Technology - Nature - Interdisciplinarity - Teaching Design - Materials - Manufacturing Processes - Recycling - Reuse

[Abstracts in spanish and portuguese at pages 73-74]

[(1)] **Jorge Lino Alves** Mechanical Engineer, PhD in Materials Science (University of Lehigh/USA - 1997), Associated Professor at FEUP (University of Porto/Portugal). Director of the Master Program in Product and Industrial Design (MDIP) at FEUP. Director of DESIGNSTUDIOFEUP. Director of the Product and Services Development Laboratory, Member of the Department Council of DEMec, Member of the Scientific Committee of MIETE and Member of the Coordinating Council of CEMUP (2003-). President of the Portuguese Society of Materials (SPM) (2019-21). Coordinator of the Technical Division of Structural Materials at SPM and Director of SPM Materials Science and Technology Magazine (2019-). He was Vice-President of INEGI (2002-2010), Member of the College of Mechanical Engineering (North Region) of the "Ordem dos Engenheiros" (2007-2010), Coordinator of the INEGI Bulletin (2002-09). He is a member of the Technical-Scientific Council of Tecnometal Magazine. Develops research in the area of product development, additive manufacturing, conversion processes and rapid tool manufacturing, ceramics, mechanical behavior and relationship with the microstructure. Supervised more than 100 dissertations, co-authored 1 book on Additive Manufacturing (2001), two on Mechanical Construction Materials (2013, 2017) and one on Advanced Materials (2007). He is author of more than 200 articles in magazines and book chapters, and has 22 prizes in contests. Associate Professor at the Department of Mechanical Engineering, Faculty of

Engineering, University of Porto. R&D areas: Additive manufacturing (3D printing) and prototype conversion technologies and rapid tool manufacturing, ceramics applied in the casting area, mechanical behavior and relationship with the microstructure, and product development. He was Vice President of INEGI in the period 2002-2008. Member of the Coordinating Council of CEMUP in the period 2003-2014 and 2016-2019. Member of the College of Mechanical Engineering of the Northern Region of the Order of Engineers in the 2007-2010 triennium. Vice-Coordinator of the Research and Development Unit "New Technologies and Advanced Production Processes", FCT, INEGI, 1999-2012 and coordinator since 2012. He is director of the Product and Services Development Laboratory from DEMec / FEUP, 3D printing area, since 2015. Director of Design Studio FEUP, since 2015. Member of the Coordinating Council of DEMec, since 2014, member of the Scientific Council of MIET of FEUP, since 2014. Deputy Director of the Master's Course in Industrial and Product Design, since 2013. Belongs to the Technical-Scientific Council of Tecnometal Magazine since November 6, 2018. He was Vice President of SPM in the 2017-2019 biennium. falves@fe.up.pt

(2) **Bárbara Rangel** Architect, Assistant Professor in the Department of Civil Engineering at FEUP (University of Porto/Portugal). Master in Construction and PhD in Civil Engineering both at FEUP. She is an integrated researcher at CEAU/FAUP and a contributor to CONSTRUCT/DEC/FEUP and DESIGNstudio / FEUP. She worked with Arq. Rafael Moneo and Arq. Álvaro Siza. She teaches Architecture in the Integrated Master in Civil and Project Engineering at MDIP and Integrated Project in the Master in Integrated Design in Building Construction. She participates in research projects in the various areas. Under construction as leader BIGmachine educational lab for Civil Engineering, or as a collaborator in iNBRAIL - Innovative Noise Barriers for Railways. She is the editor of "Cadernos d'Obra", an international scientific magazine in the area of Integrated Design, of the "Livros d'Obra" collection and the "Sebentas d'Obra" for the dissemination of nationals works. Guest editor and author of "Editora Internacional Springer". Co-author of several books, chapters and scientific articles in indexed magazines, international and national congresses. In the scientific field, the Applied Ergonomic Society award stands out with the project for an evolutionary chair developed at MDIP for Natulis in 2015 and the 2016 Scientific Recognition Award from FEUP. Since 2015 she has been a member of the DEC Executive Committee and a member of the Social Commissioner since 2014. brangel@gcloud.fe.up.pt

(3) **Claudia Alquezar Facca** Designer, educator and researcher in Design. PhD in Design (Anhembi Morumbi University, SP/Brazil - 2020), "Sandwich" PhD (Faculty of Engineering, University of Porto, Porto/Portugal - 2019), Master in Design (Anhembi Morumbi University, SP/Brazil - 2008), Specialization in Communication and Arts and Didactics of Higher Education (Mackenzie Presbyterian University, SP/Brazil - 1992/1993), Bachelor in Industrial Design with qualification in Product Design (Mackenzie Presbyterian University, SP/Brazil - 1991). She is the coordinator of the Undergraduate and Postgraduate courses in Design at the Mauá Institute of Technology (SP/Brazil). She has more than 30 years of teaching and professional experience in the area of Design, having worked mainly

in the areas of product development: appliances, automobiles, electronics, packaging, furniture, toys and graphics. Research interests: Design Methodology, Design Research, Design and Engineering Teaching and Learning, Multi, inter and transdisciplinarity, Active Learning Strategies, Design Thinking, Maker Education and Culture, Digital Fabrication, Fab Labs etc. claudiafacca@maua.br

Introduction

> In the last 50 years our world has been transformed by an explosion in global trade, consumption and human population growth, as well as an enormous move towards urbanisation. These underlying trends are driving the unrelenting destruction of nature, with humanity now overusing our natural capital at an unprecedented rate. […] As a result of our 21st century lifestyles, our natural world is transforming more rapidly than ever before, and climate change is further accelerating the change (WWF, 2020).

This current economic, social and environmental scenario has required changes in the paradigm of new product development and, consequently, in the academic approach in the training of new designers (OECD, 2018). Education has been the object of study, concern, focus, strategy and discussion in all nations of the globe and reflects the intense changes that the world has witnessed (Facca, Alves, & Barbosa, 2019a) and design education must face these challenges and the opportunities they represent (Friedman, 2019). Design is a complex field that involves both practice and academic disciplines and the designers are entrusted with increasingly complex and impactful challenges and skills for developing creative solutions to those problems, what is increasingly essential (Meyer & Norman, 2020). To face such kind of problems, Friedman (2019) suggested "The Eleven Challenges for Design", based on the United Nations Sustainable Development Goals (2020), that are divided into four groups: Performance, Systemic, Contextual, and Global, as shown in the *Figure 1*. These four groups and eleven challenges define the future of design and our challenge as educators is to train people to become capable of working within and across these 4 groups (Meyer & Norman, 2020).

Figure 1. The Eleven Challenges for Design. Adapted by the authors from Friedman (2019).

All the proposed challenges are very important, but we must draw attention mainly to the global challenge; after all, "we face a world in which we must help to design solutions for the problems of complex sociotechnical systems in a threatened planetary environment" (Friedman, 2019).

Considering the challenges to be faced by designers and based on the principles of Project-Based Learning (PjBL), on the methodology of design based on materials (Material Driven Design - MDD) besides considering the interdisciplinary approach, some projects will be presented here as case studies illustrating and exemplifying how it is possible to recognize opportunities at the present time to open new frontiers, representing a step towards the conscious evolution of humanity, preserving the nature (Guevara & Fazenda, 2013).

This paper presents the experience of interdisciplinary development of a research project under the Master's Program in Industrial and Product Design (MDIP), offered in an integrated manner by Faculty of Engineering (FEUP) and Faculty of Fine Arts (FBAUP), both from the University of Porto (Porto, Portugal) entitled "*We Won't Waste You*" (WWWyou).

Theoretical References

Project-Based Learning (PjBL)

Project-Based Learning (PjBL) is an active learning strategy that seeks a shared goal, emphasizes the independence of students, encourages research and collaboration, applies content in an authentic way, focuses on open questions, develop the skills necessary for the 21st century and seems adequate to improve its interdisciplinary competences (Brassler & Dettmers, 2017; Facca, 2020). PjBL is a student-centered educational model (Grant, 2002),

which organizes learning around projects and allows students to learn by doing, applying ideas and engaging in real-world activities (Krajcik & Blumenfeld, 2006).

> PjBL is defined as a pedagogy that involves two components that are a question or problem that serves to organize and direct (project) activities that result in a series of artifacts or products culminating in a final product that addresses the main question (Brassler & Dettmers, 2017, p. 3).

The MDIP Program is based on the methodology of Project-Based Learning (PjBL) since it contemplates the development of integrated curricular units where students develop several projects simultaneously, always having as real clients some companies that join the university in partnerships in the creation and presentation of project briefings. This methodology encourages the student to be an active asset instead of a passive listener and conducts students through a workshop frame –consisting of high periods spent in school– that allows them to design multiple objects with the assistance of multiple teachers (Leal, Alves, Fernandes, & Rangel, 2020; Fernandes, *et al.*, 2018). Students, organized in groups and guided by teachers, have the opportunity to face real problems and issues what creates good conditions for learning, as it involves individual and cooperative activities, interactive discussions, theory and practice, in addition to professional skills, personal skills, such as cooperation and management (Fernandes A. P., 2019).
Bringing this reality to the academic context has been a priority at MDIP, at FEUP, through the development of projects in a real context, where students, teachers and "clients" together discover new ways to reach innovative solutions. Students have the opportunity to communicate directly with companies and learn more about their routines and manufacturing processes. Companies, in turn, can develop ideas from their needs, which is often not possible in everyday life. This direct relationship with real problems results in extra motivation and dedication, since in this approach there is the possibility of job offers or to have the projects implemented in the market (Fernandes, *et al.*, 2018).

Material Driven Design (MDD) Method

Another important approach carried out in this project is related to the materials and the experiences that people have with them and with the materialization of a product. To facilitate designing when a particular material is the point of departure in the design process the Material Driven Design (MDD) Method was used. According to Karana, Barati, Rognoli & Laan (2015), the MDD Method is grounded on four main premises: (1) Whilst product experience may originate from –or be moderated by– a wide variety of sources like the physical reality of a design; (2) Designing with a material entails a thorough understanding of the material in order to discover its unique qualities and constraints in comparison to other materials; (3) Designing with a particular material in mind requires action steps to be followed that are comparable to a conventional product design process: understanding the domain, creating design requirements and objectives, creating concepts, and selecting and detailing one of the concepts towards product embodiment; and

(4) A journey of a designer is established from material properties and experiential qualities to materials experience vision within a wider context (purpose of existence), from materials experience vision to experiential qualities and material properties, and to products. The MDD Method is based on four main action steps presented in a sequential manner, as shown in the *Figure 2*:

(**1**) Understanding the Material: Technical and Experiential Characterization,
(**2**) Creating Materials Experience Vision,
(**3**) Manifesting Materials Experience Patterns,
(**4**) Designing Material/Product Concepts.

The MDD process starts with a material proposal in a specific scenario and ends with a product and/or further developed material. The method emphasizes the journey of a designer from tangible to abstract –from a material to a materials experience vision– and then from abstract back to tangible –from a materials experience vision to physically manifested, further developed materials/products (Karana, Barati, Rognoli, & Laan, 2015).

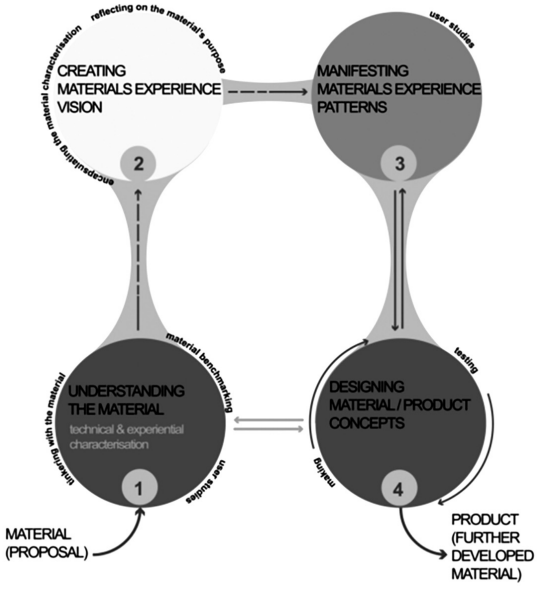

Figure 2. Material Driven Design (MDD) method (Karana, Barati, Rognoli, & Laan, 2015).

MDD is a methodology based on the premise that the technical characteristics and functional aptitudes of the materials are not sufficient characteristics for their commercial acceptance. It is important that it is socially and culturally accepted. It should provoke significant experiences in the users, going beyond its utilitarian evaluation. This requires qualification not only for what it is, but for what it does, what it expresses, the reactions it elicits and what it makes people feel (Fernandes A. P., 2019; Karana, Barati, Rognoli, & Laan, 2015).

Interdisciplinary Approach

The great challenge facing thoughts and education context at the beginning of this century and millennium is the contradiction between the increasingly global, interdependent and planetary problems and the persistence of a mode of knowledge still privileging fragmented, parceled and compartmentalized knowledge (Facca, 2020).
In the current globalized and hyperconnected world, to work with the dynamic complexity of ecosystems, it is necessary to first resort to a new vision and methodology, which promote interconnections and complementarities between the various ways of seeing, interpreting and acting, taking advantage of still possible epistemological and methodological convergences through research and interdisciplinary practice (Guevara & Fazenda, 2013).

> Interdisciplinarity is a concept that we invoke whenever we are confronted with the limits of our territory of knowledge, whenever we are faced with a new discipline whose place is not yet outlined in the great map of knowledge, whenever we are faced with one of those immense problems whose principle of solution we know to demand the competition from multiple and different perspectives (Pombo, 2004).

Interdisciplinarity is a way of thinking. In an epistemological context, interdisciplinarity refers to the practices of knowledge transfer between disciplines and their peers; and in a pedagogical context, it is linked to teaching issues, school practices, knowledge transfers between teachers and students that take place within school curricula, working methods, new organizational structures of which, both secondary school and the University will have to get closer and closer (Pombo, 2004; Alves, Facca, Fernandes, Rangel, & Barbosa, 2020). The need for changes in higher education and the promotion of interdisciplinarity stimulates entrepreneurship, emphasize the cultural, social and technological involvement of universities in the construction of a superior educational system (Fernandes, *et al.*, 2020). The design is, by nature, interdisciplinary (Fernandes, *et al.*, 2020), because it is a propitious area for working together with other areas of knowledge. It is now up to the insertion of the design as an agent in the process of relations between disciplines that, according to the World Design Organization (WDO) industrial design is a strategic problem-solving process that drives innovation, builds the business success and leads to better quality of life through innovative products, systems, services and experiences (WDO, 2020). The

design can contribute in this context, demonstrating new ways to see, think, and act, putting people and their needs at the center of the process, providing techniques and tools of project development and solution of complex problems based on the design thinking principles like empathy, co-creation and experimentation as ways to integrate with other areas of knowledge (Facca, 2020; Fernandes, *et al.*, 2020).

"We Won't Waste You" Project (WWWyou)

The "*We Won't Waste You*" (WWWyou) project is the result of a partnership between FEUP and the Municipality of Matosinhos (a city by the sea, north of the Porto region), whose motto is the principles of circularity. The students are challenged to develop products using discarded materials in different contexts, using wastes from Matosinhos as the main material source what pushed the boundaries of the project and students to come up with an innovative material solution to endorse this problem (Leal, Alves, Fernandes, & Rangel, 2020). In the cases presented here, two main contexts will be considered: nature that is capable of supplying incredibly interesting raw materials and often ready and suitable for use and application in new products and the catering industry that generates a large amount of discarded waste that can be reused for new purposes.
The MDIP students, under the guidance of the teachers, develop the projects at FEUP. Briefings are presented in the Industrial Project curricular unit, and students organized in teams develop proposals that meet the needs presented, through sustainable solutions and with a simplified manufacturing process that they are able to make. The project development method, that starts in the briefing and ends with the delivery of the solution to the client, was based on four main phases:

(**1**) Contextualization,
(**2**) Material Development
(**3**) Product Development, and
(**4**) Registration and Communication
as shown in the *Figure 3* (Fernandes A. P., 2019).

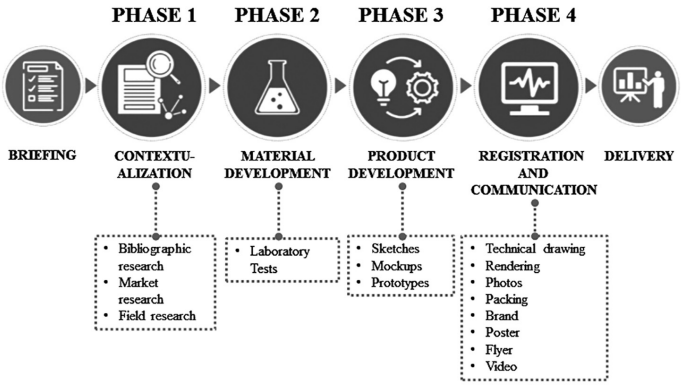

Figure 3. Phases of the development process applied to the project. Adapted by the authors from Fernandes (2019).

The projects start from a contextualization phase with a huge research including bibliographic, market and field analysis and synthesis, observing its main characteristics and needs; then it goes through the development of the material –through laboratory tests– and the product development phases, that uses the techniques of sketches, mockups and prototypes to represent the generated ideas, until reaching the final registration and communication stage where the technical drawings, illustrations, digital modeling, photos, brand creation, packaging, videos, flyer and final poster are executed (Fernandes A. P., 2019). All the process works with the perspective of developing a product that emphasizes the wasted base material and the manufacturing process itself.

Each group of students made a research on what kinds of wastes were available to use, preferably in large quantities, directly in the city, talking, for example, with local merchants, fishermen and restaurant workers. Some innovative materials were developed, mostly composites with natural elements, and the development of these materials was mostly carried at FEUP laboratories. WWWyou's objects have a particular interest in the aesthetics of materials that have unique aesthetic characteristics that distinguishes each one of them. Because the materials developed before were quite diverse, a database with the available information about these materials and a physical catalogue was developed, the Materioteca. Besides material and waste research, cultural research was also demanded for the objects to fit in the city's cultural panorama, once Matosinhos is culturally mostly known for the beaches, seafood restaurants and the fishermen's heritage. The beach and the sea are also the sources of some of the most economically impactful raw materials in the city (Leal, Alves, Fernandes, & Rangel, 2020).

The following will present some projects such as case studies developed that use in their composition natural raw materials such as crustacean shells, charcoal ash, fish bones and

scales, egg shells, coffee grounds, among others, discarded by restaurants in the city of Matosinhos.

This project aims to showcase various contexts in the city, focusing, specifically on restoration, fishing and architecture. The project starts from a global analysis/synthesis of the market situation, considering its main characteristics and needs, with the perspective of developing a product that emphasizes the base / waste material, the city of Matosinhos and the manufacturing process itself. In an attempt to contextualize, as possible, the historical, cultural and social context of the city, a direct contact with those who live the region and its activities was sought. For this reason, the points that move the city –the local commerce, the fish and canning factories, the market and the restaurant– were the main focus of the research, whose main interest was to understand something of its history looking at the things that surround it in the time and place and that give it meaning. The objective was, from a data collection, to complement the information of the literary research, so that, throughout the process, concepts could be defined, narrowing themes and sketching possibilities of products that could serve the community (Gomes, Figueiredo, & Assunção, 2020/2021).

Searching for answers, different sites were visited such as: the restaurant area, the auction, the Northern Fisheries Research Center, the Matosinhos Market, the 'Mar na Lata' Canning Factory, the beaches, the marginal area of Matosinhos and some streets in the city center. Students tried to talk to local workers, raising questions about that best way to reduce waste, creating a product with a new dimension, capable of assuming a utilitarian function while guaranteeing to know and preserve the memory of the city's cultural and social roots.

Through local testimonies, it was identified as greater waste in the remaining environments that surround the city (market, restaurants and factories): charcoal ash (from restaurants); many kinds of packaging; fish skin, scales and bones; shells and metal from the production of preserves as a product. The selected and developed product should convey the culture and history of the city, absorbing its architectural and social characteristics, assuming the natural posture of the place and translating functionality and dynamism. Therefore, the product to be developed should allow a journey through places where tradition and change are reconciled with the charm of demand, motivating discovery through sensory experience, expressing the artistic component of an eminently popular nature and continuing local traditions.

After the initial phase of exploring the possibilities in relation to the selected material, we moved on to the next phase where the product would be developed. Various techniques were applied, such as mind map, brainstorming, empathy map, definition of the persona and the target audience. The analysis of the MET matrix (materials x energy x toxic emissions) was then carried out. The MET matrix is a qualitative or semi-qualitative method used to obtain an overview of the inputs and outputs at each stage of the product's life cycle, as well as areas for which it is necessary to collect additional information (Fernandes A. P., 2019).

Project "Gris"

After analyzing the information on the available materials, coal ash was selected as the raw material to be used in the Project "Gris" that would be collected and deposited in a landfill, without any recyclable or reusable destination, which would lead to extreme consequences for the environment, since the emancipation of the ashes implies the contamination of the soil and water, through the toxic waste generated by the ashes. According to the analysis of the material in its context of use, coal ash is a waste of good quality raw material, which potentialities are mainly exploited in the cement and ceramic industries, and in agriculture where it has a promising utility, besides, of a great capacity as an odor neutralizer. Several studies on ash from the combustion of mineral coal have demonstrated the possibility of being used in the development of vitreous materials, incorporation of ceramic masses, grinding and burning of samples with the addition of clays, deodorizing and purifying properties of the coal in addition to mixing different materials and creating molds.
Applying the MDD method it was possible to visualize the product's life cycle, from its condition as raw material to the idealization of the product *(Figure 4)*.

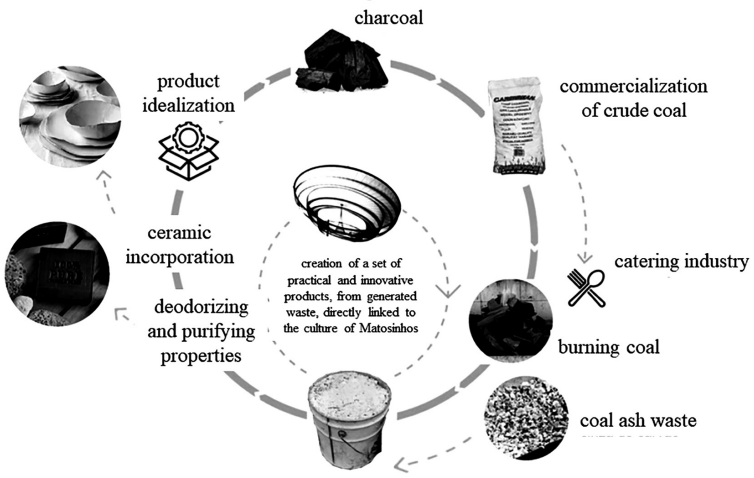

Figure 4. Material Driven Design - Project "Gris" (Gomes, Figueiredo, & Assunção, 2020/2021).

As a result of the creative development process of the project, several products were created with the objective of re-integrating the activity that gave rise to it –the restoration– and contribute to the resolution of fish odors in the restaurant space *(Figure 5 and Figure 6)*.

- *Base and soap:* Made from a mixture of porcelain with charcoal gray, this ceramic piece is an original soap base alluding to the beaches of the coastal city that is Matosinhos. Made of natural herbal aromas, this soap, takes advantage of the odor inhibiting potential of ash to provide an olfactory experience during and after hand washing.
- *Base and perfumed plaster:* A perfect air freshener for any space, created with the potential to inhibit odors from ashes and a mixture of intense natural essences that spread through the simple application of a drop of water. This perfumed plaster is accompanied by a gray-cement mix plate and makes it possible to fit the two pieces together.
- *Candle with holder:* An aromatic candle with holder, made from the waste of coal ash, it becomes the perfect air freshener for any space and occasion.
- *Accessory box:* Accessory box alluding to the theme of beaches and marine forms, created from the waste of coal ash. The sustainable piece with great durability, that will keep your accessories.
- *Ceramic base:* Ceramic piece made of porcelain reinforced with charcoal ash, the inside of which was covered with "napkin" paper and protected with ceramic varnish all around. Once made of ceramics and due to its good properties as thermal insulator, this piece is intended to support wooden spoons and kitchen utensils, and is decorated allusively to the facades and tiles, characteristics of the Matosinhos' identity.
- *Plate / base:* Dish that accompanies the soap consists of a mixture 30% coal ash and 70% plaster. Once again, this compound was used due to the phases compatible with the ceramic formulation that the coal has, allowing the group to conceive the desired configuration.
- *Mop:* The mop is 100% based on fishing nets. Since it is made of a thermosetting polymer, this material cannot be recycled. When used as a mop, a new purpose is given to this material, which was found damaged and unusable on the Matosinhos quay.

Figure 7 presents the diagram that shows the manufacturing process of some developed parts: soap and scented plaster.
Thus, the collections created take advantage of the culture of the city of Matosinhos to be inspired, showing the association with cuisine, gastronomy and restoration, through pieces for this purpose. Taken together, all the materials reflect the history that the city tells - fishing nets, coal ash and derived materials, and decoration of the products inspired by the facades and typical tiles of the same streets (Gomes, Figueiredo, & Assunção, 2020/2021).
In the last phase of development, the visual identity of the brand and the packaging of the products were created as a means of registration and communication *(Figure 8)*.

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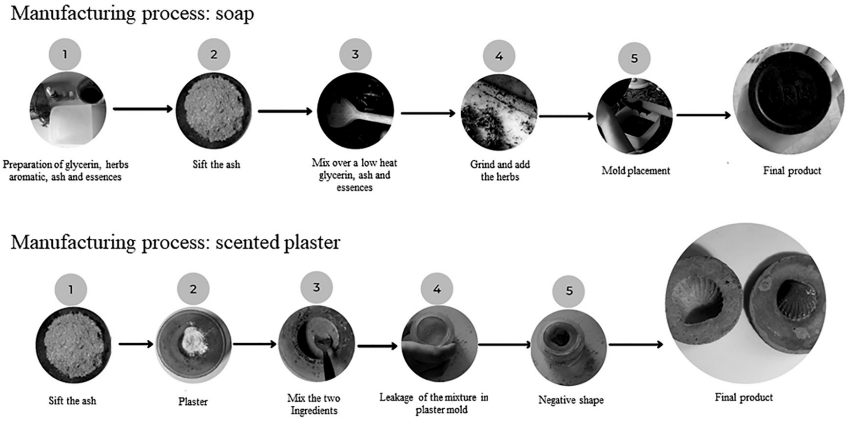

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Figure 5. Final Products - Project "Gris" (Gomes, Figueiredo, & Assunção, 2020/2021).
Figure 6. Final Products - Project "Gris" (Gomes, Figueiredo, & Assunção, 2020/2021).
Figure 7. Manufacturing process - Project "Gris" (Gomes, Figueiredo, & Assunção, 2020/2021).
Figure 8. Visual Identity and Packaging - Project "Gris" (Gomes, Figueiredo, & Assunção, 2020/2021).

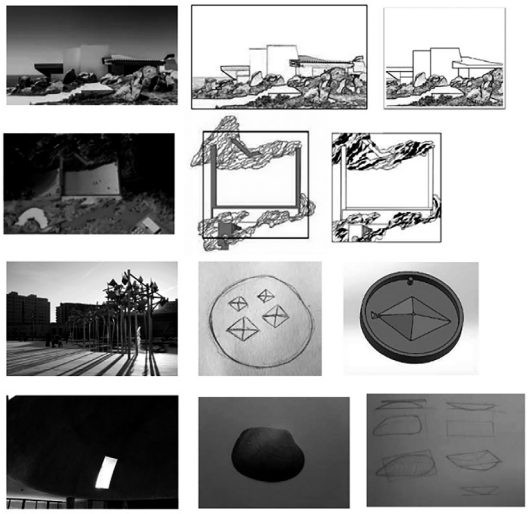
Project "Conchatura"

The Project "Conchatura" team chose as raw material the residues from the shells of shellfish (clams, mussels and oysters) that are discarded by restaurants and whose final destination is garbage.
After an initial study on what would be the best way to process the discarded shells, the team developed an experimental process for the preparation of the material. This experimental process was based on the following steps: washing, burning, pre-crushing and shredding of the shells; development of a natural binder; mixing of components and molding of parts (Sá, Batista, Catarina, Barbosa, & Pinto, 2020/2021).
The development of each of the four products is inspired by the architecture of the city of Matosinhos, more precisely in each object there is the representation of a city building, of which the tea house, the tidal pools, the Municipal Chamber of Matosinhos, more precisely its dome and Praça Guilherme Pinto to represent in the objects of the project. The project is called "Conchatura" due to the connection of the shells and architecture to the project, the logo being the silhouette of a simple shell (Sá, Batista, Catarina, Barbosa, & Pinto, 2020/2021) as shown in the *Figure 9* and *Figure 10*.

- *Cup base:* The Tea House in the city of Matosinhos is depicted in low relief. A work built on the rocks, just two meters from the water, with the sea in the background, is one of the places most sought after by lovers of architecture, by lovers of a good meal. The building was conceived in 1956 and was designed by architect Fernando Távora. After choosing the location for its implantation, on the rocks of Boa Nova, Távora handed the project over to one of his collaborators, Álvaro Siza Vieira, one of the most important Portuguese architects.
- *Tile:* The choice to develop a tile is due to the association that exists subliminally to architecture, and this is found as a complementary object –decorative or protective of the surface– in the homes until the great architectural works scattered throughout the world outside. Here, the tile takes on a new meaning, instead of being an object that is repeatedly camouflaged on a facade, it becomes a piece to be exposed in a unique way and that has the ability to remind the Swimming Pools of the Tides to anyone who has loved the place. The tile has represented the "Piscinas das Marés", a place that can be considered iconic in the city of Matosinhos and especially for lovers of the sea but also of architecture. "Piscinas das Marés" have the ability to unite the "architecture" of the sea itself - rocks –with man-made architecture– on the one hand, cement and stylized forms, and when we speak of man, we refer too to Álvaro Siza Vieira.
- *Costume jewelry:* The initial decision to create a necklace came from the interest in trying a simple and different process. In addition, it would be an object that a tourist from Matosinhos would easily like to acquire. Inspired by Praça Guilherme Pinto by Architect Luísa Valente, built in 2019, it is a large space that represents several companies that existed in Matosinhos and the strength of the Port of Leixões, which became the largest sardiner port in the

world. The square is made up of the illustrious sculptures by Ruy Anahory, geometric and simple shapes that fit the general concept of the product.

• *Plate:* The main inspirations for the construction of the object were the dome of the Municipality of Matosinhos and the delicacy of the architectural works inserted in the context of the city. The dome with its internal texture, can refer to the textures present in the city, like the rocks on the beach, like the concrete resting on the sand in the work of Siza, with the ocean and the closing of its waves. The shape, objective and choice of what this object would be made, started from the basic concept of the materials used for its construction, the shell being an element that will create the wrapping for the same food to be appreciated.



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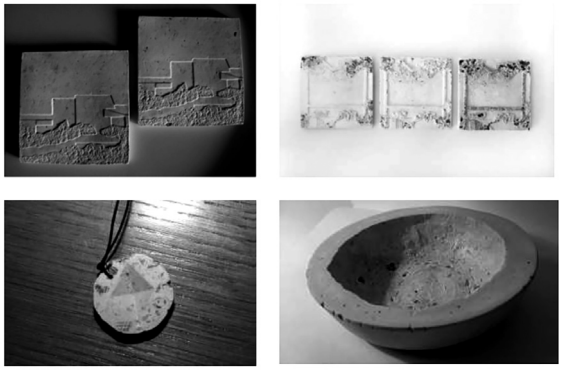

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Figure 9. Inspiration and Studies - Project "Conchatura" (Sá, Batista, Catarina, Barbosa, & Pinto, 2020/2021)

Figure 10. Final products - Project "Conchatura" (Sá, Batista, Catarina, Barbosa, & Pinto, 2020/2021).

All objects meet each other due to the particularity of the representation of architecture present in the city of Matosinhos in them as already explained, but there are a variety of objects with different functions and therefore the manufacturing process, selection of materials and equipment, times and runs are different between each of them.

Project "Re-Birth"

Bearing in mind the proposed challenge to be applied to the products to be developed, it was decided to use the shells of crustaceans wasted in restaurants as the main material. Thus, it was thought to use as a concept the reuse of this waste to create a set of restaurant table pieces, with the aim of giving a second life to the sea shells wasted in meals with shapes alluding to tourist spots or features characteristic of the city of Matosinhos and / or crabs or lobsters. For this same reason, it is a product that is mainly aimed at tourists or people who appreciate the gastronomy of the city (Oliveira, Oliveira, Torres, & Pêgo, 2020/2021).

The product's target audience is focused on residents, tourists, food lovers and those who frequent local restaurants in Matosinhos. The aim of the Re-Birth Collection is through ways alluding to scrub and / or shoe shells trying to approach the older public, namely adults or the elderly, through the relationship of shapes with the environment *(Figure 11)*.

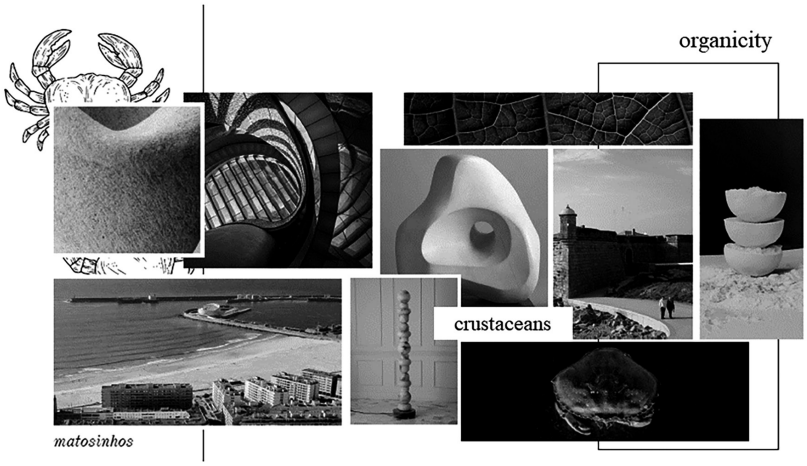
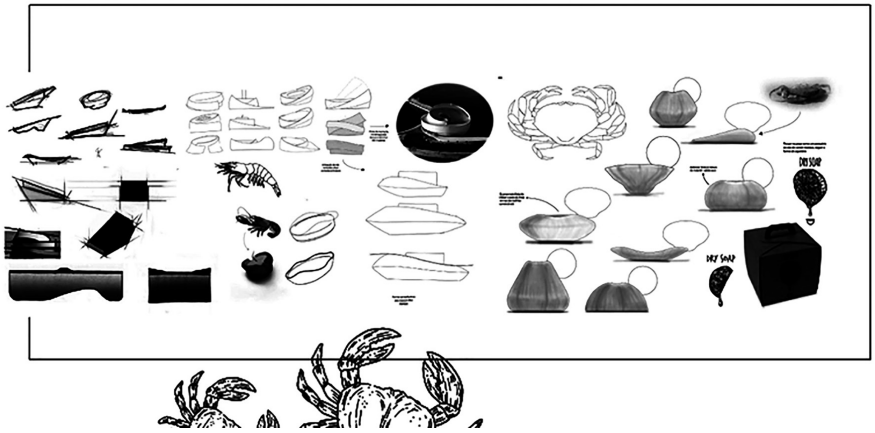


Figure 11. Mood board - Project "Re-Birth" (Oliveira, Oliveira, Torres, & Pêgo, 2020/2021).

Re-birth is a set of restaurant table objects that have shoe crust shells as a waste. It consists of four objects, a candle holder, a bead holder, a napkin holder, and a dry soap *(Figure 12 and Figure 13)*. This product has a decorative character and alludes to the city of Matosinhos and the circular economy by reusing wasted material (Oliveira, Oliveira, Torres, & Pêgo, 2020/2021).



12

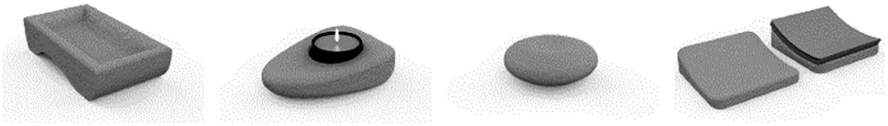


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Figure 12. Development Sketches - Project "Re-Birth" (Oliveira, Oliveira, Torres, & Pêgo, 2020/2021).
Figure 13. Final products - Project "Re-Birth" (Oliveira, Oliveira, Torres, & Pêgo, 2020/2021).

The product line of the Re-Birth Collection consists of the following components (Oliveira, Oliveira, Torres, & Pêgo, 2020/2021):

- *Account Support*: The target audience for the product is focused on residents, tourists, food lovers and those who frequent local restaurants in Matosinhos. The aim of the Re-Birth Collection is through ways alluding to scrub and / or shoe shells trying to approach the older public, namely adults or the elderly, through the relationship of shapes with the environment.
- *Candle Holder:* The candle holder was thought as a decorative object with the aim of providing a more welcoming environment and improving the aroma while eating lobster or crab, provided by the intense smell left by the food when it is served or in contact with the hands. Alluding to the city of Matosinhos, it was inspired by one of the views of the cruise terminal and the outer part of the shoe shells. Bearing in mind that this city is also marked by fishing, a shape inspired by the hull of a boat was modeled and the edges rounded according to the general concept of the group.
- *Napkin Support:* The napkin holder, as its name implies, aims to support the napkins on a base. Not only does it have the function for which it was developed, but its shape and lines remind us of Matosinhos and its culture, both marine and gastronomic, providing the user with good feelings and connections to the city. This product is totally inspired by the shoe rack and the Port of Leixões and features a depression to improve the user's comfort when removing a napkin, as the napkins glide across the surface, making it easier to identify each one.
- *Dry Soap:* The dry soap was thought as an object that could replace the traditional refreshing lemon wipes that have the function of removing the characteristic seafood smell that is felt in the hands after a seafood meal. The crumbling soap leaves a lemon scent in the user's hands, thus combating the smell of seafood. The shape was mostly inspired by the crab shell structure and the cruise terminal, thus creating a circular shape with smooth curves to meet the rest of the collection.

The parts manufacturing process was developed as shown below (Oliveira, Oliveira, Torres, & Pêgo, 2020/2021):

Peel treatment process: Collect the shoe rack housings; sanitize the shells by boiling them in water and lemon; dry the shells with a cloth; break them with a hammer to break them into small pieces; place the pieces in a shredder until you get a powder; process for obtaining material; mix the powder obtained in the previous process with corn starch, water, glycerin and plaster. Then wrap everything until it becomes a homogeneous mixture (in the case of dry soap also inserted in the mixture, lemon juice and crushed lemon peel to give the aroma).
Mold making process for the leak: Liquid plaster is placed inside a hand-made box to form the female of the mold, then a model made in 3D printing of the object dipped until

its middle in the plaster is placed (the use of a release agent in the 3D piece is necessary). After drying, grooves are made to ensure that when the mold is to be opened and closed again, the female and male are always in the same position. Subsequently, liquid plaster is poured back into the box where the mold is being made, completely covering the 3D model (before the plaster is placed, a plasticine tube is glued to the 3D model to make it possible to later leak the material). After the plaster is dry and in a solid state, the mold is removed from the wood bark and the opening is made. The 3D model is removed from the mold that is greased with a release agent to make sure that the material will not stick to the plaster mold. The mold is closed again, and the new material is inserted through the hole left by the plasticine until the mold is filled. After drying, the mold is opened again, and the piece is removed with the desired shape with the new shoe-based material (average drying time of 12h).
The Re-Birth collection is entirely sustainable, with shoe shells mixed with other natural material. They are entirely natural products and have their own characteristics, being similar to a ceramic. The packaging is made of cardboard which makes it recyclable or reusable. They are very unique products that carry the responsibility of bringing Matosinhos and its gastronomic culture with them (Oliveira, Oliveira, Torres, & Pêgo, 2020/2021).

Final Considerations

This publication aims to disseminate the importance of project-based learning, and its contribution to the training of designers with the ability not only to design, but also to manufacture the products they idealize, and simultaneously reflecting the importance of issues related to environmental sustainability and circular economy.
The "*We Won't Waste You*" Project is an innovation space open to social and environmental changes that develops and produces original products, capable of telling a story and transporting the Portuguese soul. Unlike industrial production, WWWyou products have a socio-environmental responsibility, are created and produced locally, contributing to the social inclusion of people in a situation of economic vulnerability, using discarded materials, reducing environmental impact and promoting awareness.
When evaluating the activities developed in the case studies presented, it is possible to realize that the use of the Project-Based Learning and Materials Driven Design methodologies, plus the interdisciplinary character of the different areas involved in the projects, were fundamental to provide great involvement and extra motivation, as it allows the students themselves to establish project objectives and ways to achieve them.

References

Alves, J. L.; Facca, C. A.; Fernandes, A. P.; Rangel, B., & Barbosa, A. M. (may de 2020). Interdisciplinaridade entre Design e Engenharia: Novas Competências no Ensino de Projetos

para a Inovação Circular. *Cuaderno 114 - Centro de Estudios en Diseño y Comunicación*, pp. 179-203.

Brassler, M., & Dettmers, J. (2017, 07 31). How to Enhance Interdisciplinary Competence—Interdisciplinary Problem-Based Learning versus Interdisciplinary Project-Based Learning. *Interdisciplinary Journal of Problem-Based Learning, 11*(Article 12), p. 15. Retrieved dezembro 07, 2019, from https://doi.org/10.7771/1541-5015.1686

Facca, C. A. (2020). *A contribuição do pensamento do design na formação do engenheiro: o espaço do Fab Lab como experiência transversal.* Tese de Doutorado, Universidade Anhembi Morumbi, PPG Design, São Paulo.

Facca, C. A.; Alves, J. L., & Barbosa, A. M. (2019a). Overview of Design Teaching on Engineering Courses: A Comparative Study between Brazil and Portugal. In W. -W. Science (Ed.), *International Conference on Education and New Developments*, (pp. 129-133). Porto.

Fernandes, A. P. (2019). *Formando designers para a inovação sustentável: Aprendizagem baseada em projetos para conectar estudantes à sociedade e ao meio ambiente através do design.* Dissertação, Universidade do Porto, Mestrado em Design Industrial e de Produto, Porto.

Fernandes, A.; Cardoso, A.; Sousa, A.; Buttunoi, C.; Silva, G.; Cardoso, J.; . . . Alves, J. L. (2018). *We Won't Waste You*, Design for Social Inclusion Project Based Learning methodology to connect the students to the society and the environment through innovation. *3rd International Conference of the Portuguese Society for Engineering Education (CISPEE)*, (pp. 1-10). Aveiro (Portugal). doi:10.1109/CISPEE.2018.8593425

Fernandes, A.; Facca, C. A.; Alves, J. L.; Rangel, B.; Leite, R.; Neto, B., & Barbosa, A. M. (2020). Sustainability as a theme of interdisciplinarity between design and engineering courses. *IEE EDUCON - Global Engineering Education 2020.* Porto.

Friedman, K. (2019). Design Education Today: Challenges, Opportunities, Failures. *Chatterjee Global Lecture - Ullman School of Design - College of Design, Architecture, Art and Planning - University of Cincinnati*, (p. 104). Cincinnati, Ohio (USA). Retrieved Apr. 17, 2021, from https://www.academia.edu/40519668/Friedman_2019_Design_Education_Today_Challenges_Opportunities_Failures

Gomes, D.; Figueiredo, G., & Assunção, J. (2020/2021). *Projeto Gris.* Faculdade de Engenharia da Universidade do Porto (FEUP), Mestrado de Design Industrial e de Produto.

Grant, M. M. (2002). Getting a Grip on Project-Based Learning: Theory, Cases and Recommendations. *Meridian: A Middle School Computer Technologies Journal, 5*(Issue 1), p. 17. Obtido em 07 de dezembro de 2019, de http://www.ncsu.edu/meridian/win2002/514/3.html

Guevara, A. J., & Fazenda, I. C. (2013, March 23). A sustentabilidade é a causa; a interdisciplinaridade, o caminho. *Revista Pátio-EM16*, 5. Retrieved April 17, 2021, from https://ken.pucsp.br/interdisciplinaridade/article/download/16789/12550

Karana, E.; Barati, B.; Rognoli, V., & Laan, A. Z. (2015, August 31). Material Driven Design (MDD): A Method to Design for Material Experiences. *International Journal of Design, 9*(2), pp. 35-54. Retrieved April 18, 2021, from http://www.ijdesign.org/index.php/IJDesign/article/view/1965

Krajcik, J. S., & Blumenfeld, P. C. (2006). Project-Based Learning. Em R. K. Sawyer (Ed.), *The Cambridge Handbook of the Learning Sciences* (pp. 317-333). New York, NY: Cambridge University Press. Obtido em 07 de dezembro de 2019, de http://interchange.education/

sites/default/files/The%20Cambridge%20Handbook%20of%20the%20Learning%20Sciences_0.pdf

Leal, D.; Alves, J. L.; Fernandes, A., & Rangel, B. (2020). *We Won't Waste You:* A research project to introduce waste and social sustainability in design thinking. *IEEE Global Engineering Education Conference (EDUCON)*, (pp. 1959-1963). Porto (Portugal). doi:10.1109/EDUCON45650.2020.9125180.

Meyer, M. W., & Norman, D. (2020, Spring). Changing Design Education for the 21st Century. *she ji - The Journal of Design, Economics, and Innovation, 6*, p. 37. doi:https://doi.org/10.1016/j.sheji.2019.12.002

OECD. (2018). *Oslo Manual 2018: Guidelines for Collecting, Reporting and Using Data on Innovation 4th Edition.* Organisation for Economic Co-operation and Development - OECD/Eurostat. Luxembourg: OECD Publishing, Paris/Eurostat. Retrieved oct. 05, 2019, from https://doi.org/10.1787/9789264304604-en

Oliveira, B.; Oliveira, G.; Torres, L., & Pêgo, P. (2020/2021). *Re-Birth Collection.* Faculdade de Engenharia da Universidade do Porto (FEUP), Mestrado de Design Industrial e de Produto.

Pombo, O. (2004). Epistemologia da Interdisciplinaridade. Em P. C. Pimenta, *Interdisciplinaridade, Humanismo, Universidade* (p. 235). Porto: Campo das Letras.

Sá, A.; Batista, B.; Catarina, Barbosa, & Pinto, C. (2020/2021). *Projeto Conchatura.* Faculdade de Engenharia da Universidade do Porto (FEUP), Mestrado de Design Industrial e de Produto.

United Nations. (2020). *The Sustainable Development Goals Report.* New York, NY (USA): United Nations Publications. Retrieved Apr. 17, 2021, from https://unstats.un.org/sdgs/report/2020/

WDO. (2020). *Definition of Industrial Design*. Retrieved outubro 12, 2019, from WDO - World Design Organisation: https://wdo.org/about/definition/

WWF. (2020). *Living Planet Report 2020 - Bending the curve of biodiversity loss.* Almond, R.E.A.; Grooten, M.; Petersen, T. Gland, Switzerland: WWF ; - World Wildlife Fund. Retrieved apr. 17, 2021, from https://livingplanet.panda.org/pt-br/about-the-living-planet-report

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Resumen: Este artículo presenta el proyecto interdisciplinario "*We Won't Waste You*" desarrollado en el Programa de Maestría en Producto y Diseño Industrial de la Universidad de Porto, Portugal, en asociación con el Municipio de Matosinhos. Basados en los principios de la interdisciplinariedad, en el Aprendizaje Basado en Proyectos y en la metodología del Diseño Dirigido por Materiales, los estudiantes desarrollaron productos utilizando materiales desechados (cáscaras de crustáceos, cenizas de carbón, escamas, cáscaras de huevo, etc.) en dos contextos diferentes: la naturaleza que es capaz de suministrando materias primas increíblemente interesantes y, a menudo, listas y aptas para su uso y aplicación en nuevos productos, y la industria de la restauración que genera una gran cantidad de residuos desechados que pueden reutilizarse para nuevos propósitos.

Palabras clave: Diseño - Proyecto - Tecnología - Naturaleza - Interdisciplinariedad - Enseñanza del diseño - Materiales - Procesos de fabricación - Reciclaje - Reutilización

Resumo: Este artigo apresenta o projeto interdisciplinar "*We Won't Waste You*" desenvolvido no Programa de Mestrado em Design de Produto e Industrial da Universidade do Porto, Portugal, em parceria com a Câmara Municipal de Matosinhos. Com base nos princípios da interdisciplinaridade, na aprendizagem baseada em projetos e na metodologia de Design Driven Design, os alunos desenvolveram produtos utilizando materiais descartados (cascas de crustáceos, cinzas de carvão, escamas, cascas de ovos, etc.) em dois contextos distintos: natureza capaz de fornecendo matérias-primas incrivelmente interessantes e muitas vezes prontas e adequadas para uso e aplicação em novos produtos, além da indústria de catering que gera uma grande quantidade de resíduos descartados que podem ser reaproveitados para novos fins.

Palavras chave: Design - Projeto - Tecnologia - Natureza - Interdisciplinaridade - Ensino de Design - Materiais - Processos de Fabricação - Reciclagem - Reutilização