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Biomateriality Bridging Design and the Community

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ABSTRACT

The current environmental crisis is turning designers to the development of new biodegradable materials, that are produced through clean processes: the biomaterials. They present not only alternatives to existing materials, but actually an opportunity to reflect upon new materialities that indicate different ways of consuming and living to their users. In order to be massively adopted and lead change, biomaterials need to be validated and possibly co-created with real communities. Complemented by a literature review and by two surveys, one directed to rapid prototyping facilities' coordinators/founders, and another with a focus on citizens from Portugal, this research explores how biomaterials can connect Design and their surrounding communities. A deeper understanding of related dynamics and how the democratization of Design processes unfolds and is perceived is key to effective communication and implementation of holism-focused methodologies. Additionally, this study highlights aspects such as the role or the empowerment of the community through the search for solutions and activism.

Keywords: Bio-based materials, Product design, Community, Materiality

INTRODUCTION

Since the industrial revolution, material consumption has increased exponentially, creating great concern over subjects such as social, climate and economic crisis, loss of biodiversity, resource scarcity and waste (UN, 2019). In the past decades, various approaches have been explored and adopted to tackle these issues (OECD, 2018; Ellen MacArthur Foundation, 2019; EEA, 2019); and to follow the guidelines of the United Nations sustainable development goals (UN, 2020)

Among many other strategies, Design is attempting to fight the need to resource from fossil reserves and to control the emission of carbon by embracing circularity and the use of bio-based materials (MacArthur Foundation, 2017). These are mostly, produced from renewable resources, including waste and surplus from various industries; they can be resourced and produced locally, with minimum transportation costs and with low environmental impact due to their renewable capacity and cascade use; they are, additionally, able to be compostable or biodegradable, in most cases (Biofabricate, 2020).

They also go by the term *Biomaterials* (shared by the medicine field to label materials that are compatible with the human body) and may be produced and assembled, partially or totally, by living systems such as microorganisms (fungi, bacteria, algae) (Biofabricate, 2020). These materials are grounded in a highly collaborative practice, fusing Craft and Design with Digital technologies, Engineering and even Synthetic Biology, allowing for a diversity of applications, simultaneously pressing the re-evaluation of the materiality concept (Meyers, 2012). The interest and adoption of biomaterials present not only alternatives to existing materials, but actually new materialities that indicate different ways of creating, consuming and living to their users (Collet , 2019). In order to be massively adopted and lead change, these need to be validated and possibly co-created with real communities.

To this end, despite their peculiar nature and although usually (traditionally) limited to the confinements of scientific laboratories, related experiments are being extended to the general public, disseminated in rapid-prototyping facilities such as *Greenlabs, Fablabs, Hackerspaces* or *Biolabs*. These fabrication laboratories are worldwide connected, well-equipped with a wide-range of free, shared tools, methods and data, enabling for prompt manufacture and highly interdisciplinary projects (Bandoni, 2016), harboring a great community of *makers* democratizing and swiftly evolving the Design processes (Niaros, Kostakis & Drechsler 2017; Halbinger, 2018; Browder et al., 2019). *Makers* are a global movement comprised of creatives, professionals, students, hobbyists, among others; common citizens with tinkering, experimental and revolutionary profiles connected to the *Third Wave Do-it-yourself (DIY),* (Fox, 2014). They are exploring alternative ways to respond to the various negative impacts, using open-Design as an instrument for radical change (Anderson, 2014; Hatch, 2014, Halbinger, 2018) advancing mind-set shifting, economics, entrepreneurship, research (Browder, Aldrich & Bradley, 2019).

Portugal, a country with natural conditions for the development of bio-based solutions, is the focus of this study. As rapid-prototyping spaces have risen in Portugal in the last years, this study questions their interaction with the local communities and how ordinary citizens are engaging with Design, particularly on the subject of its intersection with biological narratives, for the creation of materials and products.

Can (Bio)Design effectively dialogue with the local community? Are the general public prepared to experiment with laboratory-oriented methodologies? Are they open to alternative narratives? How can this be further facilitated? These are some of the guiding questions this research attempted to explore to understand the relationship between Design and the Portuguese community, to whom the access to Design (and mechanisms) may be empowering, like never before.

To fully acknowledge the dynamics of Community/Design and how the democratization of processes unfolds, this paper analyses and discusses related literature and the perspectives of founders/coordinators of Open-Design facilities to infer possible barriers or opportunities for biomaterials to be explored, evolve and disseminate. These are key aspects,

able to inform Design education and how it might further assist the community.

Learning further on this subject is relevant to recognize how the community embraces interdisciplinary endeavors and collaborative innovation; are there barriers that should be acknowledged? This is important to identify what approaches have so far been put in place and if there are (still) methods that can facilitate and elevate the shared work.

METHODOLOGY

This research started with a revision of literature, important for background and to contextualize the concept of biomaterials, an approach embracing challenges as opportunities to innovate and push the Design field forward. Subjects related are the rapid-prototyping facilities and the *makers* community, both with key roles in the sustainability, economy and social equation.

The study was followed through the use of quantitative and qualitative analysis. Two online surveys by questionnaires were applied (in the form of open-ended questions as well as close-ended questions using various scale methods). A more comprehensive one addressed to coordinators/founders of fabrication labs (survey 1) and another one to the Portuguese community (survey 2). Due to pragmatic reasons, the surveys were published online using the Google forms platform and disseminated through email and social websites.

RESULTS AND DISCUSSION

Biomaterials and Design/Science Synergy

Under the biological related economic activities, biomaterials are aligned with the circular perspective (Ellen MacArthur Foundation, 2017). Expected to be a viable alternative to fossil reserves, they can be applied in the creation of objects and may use, as raw material, the waste and surplus generated within the Portuguese region (residues from various industries e.g., olive pomace, textile deadstock, winery and beer production, carob, rice). Furthermore, the use of synthetic biology with its sophisticated technologies greatly widens the horizon and possibilities for Design (Collet, 2019), leaving us to ponder on the appropriation of living organisms as co-creators or material components of a given project and their (im)materiality values.

To this end, biomaterials value is not only connected to economic factors but is also linked with its characteristics, origins, aesthetics, narrative and possibilities. Besides their idiosyncrasies, bio-related objects may carry with them multiple assigned meanings. Their relevance goes beyond profit or ecosystems' restoration purposes and may as well imply an underlying desire or, rather, a necessity to deeply (re)connect with Nature, recognizing that humans are part of her and therefore nothing can be fully evaluated or designed if not through a holistic perspective. To integrate wasted organic ingredients and living structures (and their processes) to generate materials

and products is, ultimately, to celebrate the symbiosis and the communion with all living things.

Understandably valuable for the Design field, biomaterials' exploration has certainly found in *makers*' rapid-prototyping and open-knowledge clusters fertile places to push its expansion. Nevertheless, looking to Biology through the eyes of a designer or a *maker* changes the original practice discourse, adding multiple layers to the creative process, nuances not always discerning at first glance. On one side, this Design/Science synergy assists and enhances the design process, allowing for highly inventive, disruptive and thought-provoking projects (Meyers, 2012; Collet, 2021). On the other, Design has to embrace collaborative work with scientists in an effort to resolve particular difficulties and arrive to answers that are determined as much by aesthetics as by practical factors. The latter is not without specifics in need of careful assessment.

The Facilitators' Perspective

To inform the study on the dynamics of open-(bio)Design and the community, survey 1 was addressed to specific community members, coordinators/founders of rapid-prototyping facilities (e.g., *Fablabs, biolabs*). A better understanding of how these laboratories operate within their surrounding society, their dynamics, and whether or not they empower their users with new technology was the focal point of this questionnaire.

Nine valid answers were received and analyzed. Half of our respondents has worked for 10 or more years and the other half has worked in between 3 to 6 years in these Labs. The majority (50%) of the sample work in facilities located in the Lisbon metropolitan area, 12.5% in the north (Porto) or in the interior centre (Fundão) and 25% in facilities outside Portugal. All these labs have been implemented in the last 10 years, and most of them mention the objective of sharing knowledge and democratizing access to digital fabrication tools, making it a citizen's accessible science lab is mentioned as well as to foster ecosystem innovation. Few labs mentioned the focus on creating a space that allows active experimentation of new (bio)materials with a strong socio-ecological connection with local territories.

Labs were founded and are maintained at 37.5% by public and private investment, 37.5% exclusively by private investment and 25% exclusively by public investment. The 3 main fields that represent these labs are Design (87.5%), Engineering (75%) and Biology (50%). Architecture, Artificial Intelligence, Information Technologies, Education and Art are also mentioned.

When questioned about community empowerment, whether this is felt by the community through the dynamics of these spaces, 50% say that they sense is growing, 25% mention difficulties and mostly internal community oriented whilst 25% state that they certainly are. As positive examples, one respondent referred: "*Our particular examples revolves around a community of artists, makers, independent researchers and tinkerers. Thus, the dynamics of our lab is directly related to how people feel they can make use of the space. We have had great feedback after inviting people for workshops and talks and*

letting them know the space is open for projects and ideas." Another answer was: "*We have 2 weekly open days with free access to the tools and this is a game-changer. We are going to implement this formula in the BioLab too*."

The most important factors mentioned in their relationship with the local community were: turning ideas into problem-solving (62.5%), exploration, information and test application (37.5% each). 87.5% of the labs have space and will to cooperate with the Academia, and they consider this collaboration extremely important (50%) or important (37.5%). A large number of the inquiries (62.5%) have a close relationship with the surrounded Industry and believe this collaboration is of extreme importance or important (75%). Partnerships such as these are indeed key for innovation effectiveness, as confirmed by the literature (Halbinger, 2018; Zhou, Rognoli & Ayala-Garcia, 2018; Tabarés & Kuitttinen 2020). When working within a makerspace/community, obstacles acknowledged vary: from lack of money, schedules, availability, project management, among others. All respondents mentioned that open-source facilities and shared knowledge is a strong advantage, for being access-free, for promoting democratized knowledge and collaboration. Some of the hurdles for collaboration mentioned in the survey were poor communication, bureaucracy, intellectual property, non-transdisciplinary approaches and lack of funding.

75% of this sample rated the multidisciplinary work between the intersection of Biology and Design as extremely important. Regarding the possibility of having adequate conditions to produce biobased products, half responded positively and half negatively. Those who are enabled to produce these products mention they are usually facilitated through workshops, space, equipment, protocols, etc.

Literature asserts that biomaterials' interest is increasingly growing (Ellen MacArthur Foundation, 2017) and in regards to this type of spaces, they seem to be vital, as agents for overall positive change (Niarios, Kostakis & Drechsler, 2017; Halbinger, 2018). Asked if they have sensed the rising interest in the intersection of the fields of Biology and Design, 62.5% have mentioned that they are feeling it; one testimony said "*I have been contacted by more and more people who are willing to merge and cross the border between the two universes. Each time more designers have contacted me to learn how to access and make use of a wet lab, for example, in order to explore and create biomaterials*."

The Community Perspective

Survey 2 was developed to reach a large community of people in Portugal that may use the mentioned above facilities in order to assess: i) their understanding on the dynamic of these spaces; ii) their knowledge about biomaterials; iii) the possibilities of consuming bioproducts (in relation to the new materiality). From this survey, 75 responses were collected. Most of the respondents live in the north and center regions of Portugal. The age groups vary mainly between the 30-60 years (72%), the 20–30 years (24%) and the <60 years(4%). When asked how do they rate their knowledge about biomaterials, 86,7% have heard, read and seen information

Table 1. Biomaterials knowledge rate.

Percentage	Biomaterials knowledge
6,7%	No knowledge
46,7%	Yes – I have heard about it
40%	Yes – I have seen or read about it
6,7%	Yes – I work with biomaterials

Table 2. Requirements for the diffusion of the consumption of biomaterials.

Percentage	Requirements
18,7%	Acceptance
18,7%	Ethical benefits
21,3%	Perception
24%	Experience
25,3%	Social benefits
29,3%	Economic benefits
30,7%	Knowledge
61,3%	Price
81,3%	Environmental benefits

about biomaterials, 6.7% work in the area and 6,7% never heard about it (Table 1).

The survey highlighted the need to bring communities closer to science, by, for instance, endowing citizens with *DIY* facilities and narrowing the gap between daily life and scientific biomaterials knowledge. Regarding how people view this approach, most of them saw themselves interested as: citizens (77%), consumers (68%), activists (12%), professionals (45%) and investigators (8%.) A significant percentage, 45%, also relate to this approach as professionals. Given some examples of products incorporating biomaterials available in the market, the audience was asked about how they would react to them. The majority would do a rapid research (51%) or an in-depth research (40%) on the materials prior to purchase. Only 3% would not purchase these options due to lack of information or lack of time to research about biomaterials. The respondents also pointed the most important requirements they would consider for their choice/consumption of biomaterials: Environmental benefits was the most important factor (81,3%), followed by price (61,3%) – as shown in Table 2 below.

Most of the people who answered the survey (58%) are not aware whether their community has spaces dedicated to the development of innovative projects that bring citizens closer to science. This suggests that more promoting is required, in order to attract and integrate the population. Nevertheless, the importance that the community has for these places and vice versa, was rated as important (33,3%) or extremely important (30,7%) by the majority of the respondents on 5 points Likert scale, which emphasizes the need for their existence. People have heard about these spaces and they can have different names, mainly recognized by *FabLabs* (34,7%), *BioLabs* (34,7%), and

Table 3. Preferred activities.

Percentage	Requirements
75%	Presentation of materials/products
68%	Workshops
45%	Training
36%	Open day
36%	Online activities
29%	Conferences
16%	Informative online forums

Research & Development Centers (46,7%). Only 37,3% have had the opportunity to be involved in these centers. When questioned about their interest in these facilities, people were vague on their answers, 18,7% declared interest and 9,3% were uninterested. This might indicate that there is, still, some skepticism about these labs and their real utility to the general public.

When asked about the type of activities they would be interested in doing inside a related Design+Biology space, respondents selected "materials or product demonstration", followed by workshops and training (Table 3 below). These choices reveal a desire/aspiration to learn more and deepen understanding about bio-products and about the field.

CONCLUSION

The main purpose of this study was to explore and further understand the relationship between the local communities and open-Design, in particularly the symbiosis Design/Biology, important to recognize how these communities embrace interdisciplinary endeavors and collaborative innovation as well as barriers to this process and opportunities to improve, facilitate and elevate the shared work.

Outcomes reveal that Portuguese cities are implementing *makers*' clusters committed to bring Science and Design to its citizens, via training and through the development of collaborative work, to develop innovative and interdisciplinary projects. This narrows the gap between the city and its inhabitants, making them part of the discussion whilst fostering networking and skills. There is evidence of a growing interest in the intersection of Design/Biology, specially by students. Furthermore, results indicate that this concept is not totally foreign, as previously believed, and that the community seems open to learn and engage with biomaterials (both in terms of practice and through consumption).

Overall, social engagement, open-knowledge and technological scopes are innovation enablers, and the role of rapid-prototyping laboratories in disseminating and evolving the biomaterials' field is of extreme relevance as a reliable place to iterate and explore. Indeed, the experimental, cutting-edge and peer-led approaches of the *makers* community sparkle debate and stimulate further questions which leads, simultaneously, to the constant advancement of ideas, from aesthetics and imageries to their prompt exploration, alongside the rapid prototype and validation (*proof-of-concept*). However,

challenges are varied and need to be reflected upon. Mentioned hurdles include managing, engaging the community (long-term) and communicational issues. Design and Biology are, indeed, very different fields of knowledge, with distinctive ways to express and communicate their concepts, which maybe an obstacle when developing projects (Myers, 2012). A common language must be developed and many terms and methods need demystification, as noted by one participant: "*We call it kitchen lab, because a kitchen provides a safe space to experiment. This has helped us to reach to people outside the academia or formal studies and open it to artisans, entrepreneurs, teachers, etc*."

As for future improvements, interdisciplinary research could improve other areas, as this is particularly relevant when the subject is about democratizing not only Design and its processes but also Science with its own specifics. Furthermore, it is important to extend this study to other countries so that a more comprehensive analysis and strategies can be designed to facilitate the dissemination of the biomaterials' narrative.

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REFERENCES

Anderson, C. (2014). *Makers: the New Industrial Revolution*. 1st Edn., Crown Business, New York, USA ISBN 0307720969

Bandoni, A. (2016). The Digital Age Reaches the Fringers - A Public Fab Lab in Brazil and its (Possible) Implications for Design. In Helvert, M. (Ed.) *The Responsible Object: A History of Design Ideology for the Future*. pp. 209–214, Valiz.

Biofabricate and Fashion for Good. (2020) *Understanding 'Bio' Material Innovation: a primer for the fashion industry*. Available from: https://fashionforgood.com/wp-content/uploads/2020/12/Understanding-Bio-Material-Innovations-Report.pdf

Browder, E.R., Aldrich, H.E. and Bradley S.W. (2019). The emergence of the maker movement: Implications for entrepreneurship research. *Journal of Business Venturing* 34(3), pp. 459–476

Collet, C. (2021). Designing our future bio-materiality. *AI & Soc* 36, 1331–1342 https://doi.org/10.1007/s00146-020-01013-y

Ellen MacArthur Foundation. (2017) *Urban Biocycles*. Available from: https://www.ellenmacarthurfoundation.org/assets/downloads/publications/Urban-Biocycles_EllenMacArthurFoundation_21-06-2017.pdf

Ellen MacArthur Foundation. (2019) *Completing the picture - How the Circular Economy tackles climate change*. Available from: https://ellenmacarthurfoundation.org/completing-the-picture

Fox, S. (2014). Third Wave Do-It-Yourself (DIY): potential for prosumption, innovation, and entrepreneurship by local populations in regions without industrial manufacturing infrastructure, *Technol. Soc.* 39, 18–30.

Halbinger, M. (2018). The role of makerspaces in supporting consumer innovation and diffusion: An empirical analysis. *Research Policy* 47(10), 2028–2036. https://doi.org/10.1016/j.respol.2018.07.008.

Hatch, M. (2014). *The maker movement manifesto: Rules for innovation in the new world of crafters, hackers, and tinkerers*. 1st Edn. New York: McGraw Hill

Myers (2012). *Bio Design: nature, science, creativity*. 1st Edn. London: Thames & Hudson

Niaros, V. Kostakis, W. and Drechsler, (2017). Making (in) the smart city: the emergence of makerspaces. *Telematics Inf*. https://doi.org/10.1016/j.tele.2017.05.004.

OECD (2018), *Meeting Policy Challenges for a Sustainable Bioeconomy*, OECD Publishing, Paris, Available from: https://doi.org/10.1787/9789264292345-en.

Tabarés R. and Kuittinen H. (2020). A tale of two innovation cultures: Bridging the gap between makers and manufacturers. Technology in Society 63, 101352 10.1016/j.techsoc.2020.101352

The European Environment Agency. (2019). *State and Outlook 2020. Knowledge for transition to a sustainable Europe*. Available from: https://www.eea.europa.eu/publications/soer-2020

OECD (2020) *How's Life? Measuring Well-being*. Available from: https://read.oecd-ilibrary.org/economics/how-s-life/volume-/issue-_9870c393-en#page1

UN Environment Programme. (2019) *Global Resources Outlook 2019. Natural Resources for the future we want*. Available from: https://www.resourcepanel.org/reports/global-resources-outlook

United Nations (2020). *The Sustainable Development Goals Report*. Department of Economic and Social Affairs, United Nations Publications, NY, USA, ISBN: 978-92-1-101425-9

Zhou, Z., Rognoli, V. and Ayala-Garcia, C. (2018). Educating designers through Materials Club. Proceedings of *4th International Conference on Higher Education Advances (HEAd'18)*, http://dx.doi.org/10.4995/HEAd18.2018.8206