

O ensino formal da colaboração em design interespecies (biodesign)

Formal education in interspecies design collaboration (biodesign)

Elisa Strobel do Nascimento

elisastrobel@ufpr.br

Adriano Heemann

adriano.heemann@ufpr.br

Resumo

A comunidade de biodesign (colaborações interespecies em design) parece estar caminhando para uma sólida auto-organização e formalização. Alguns autores especulam que a aproximação com a biologia poderia marcar a prática do design do século 21. Parece relevante entender como o ensino e a aprendizagem acontecem no biodesign para desenvolver como poderiam ser melhor introduzidos nos currículos de design. Parece que ainda não foi feita uma análise da educação formal em biodesign. Para atender a esta lacuna de pesquisa, este trabalho visa compreender o cenário da educação formal em biodesign através de uma análise de alguns dos principais cursos e programas. A estratégia metodológica é uma revisão sistemática e narrativa por meio de um buscador popular. Foram analisados 16 resultados: 1 masterclass para profissionais, 8 disciplinas, 1 curso de graduação (Major), 4 programas de mestrado e 2 de doutorado.

Palavras-chave: Biodesign; Design Interespecies; Educação Formal

Abstract

The community of biodesign (interspecies design collaborations) seems to be heading toward solid self-organization and formalization. Some authors speculate that the approximation to biology could mark the design practice of the 21st century. It seems relevant to understand how teaching and learning are happening in biodesign to develop how it could be further introduced in design curricula. It doesn't seem that an analysis of formal education was made yet. To address this research gap, this paper aims to understand the formal education scene in biodesign through an analysis of some of the main biodesign courses and programs. The methodological strategy is a systematic and a narrative review through a popular search engine. 16 results were analyzed: 1 Masterclass for Professionals, 8 courses, 1 undergraduate course (Major), 4 master's, and 2 Ph.D. programs.

Keywords: *Biodesign; Interspecies Design; Formal Education*

1. Introduction

The community of biodesign seems to be heading toward solid self-organization and formalization. The consistency of specific competitions suggests that biodesign is not an ephemeral trend: like the “Bio Art & Design Award” (BAD, 2021), since 2011, and the “Biodesign Challenge” itself, since 2016. The subject also features events, like the annual Biofabricate summits (BIOFABRICATE, 2021), the “Design with the Living” annual Symposium (DESIGN MUSEUM, 2020), and “Still Alive” (STILL ALIVE, 2020). These events bring together researchers from around the world.

The term biodesign has many interpretations, in this paper, Dade-Robertson's definition is the reference: “[...] design and design research which use living systems as part of their production and operation” (2021, series introduction note) – in other words, biodesign implies in interspecies design collaborations. Examples of the biodesign practice include works with different species, from bacteria to animals. For instance, the company Fullgrown shapes living trees into furniture through horticultural techniques (FULLGROWN, 2021); Modern Synthesis weaves bacteria into shoes (MODERN SYNTHESIS, 2020); the Blast Studio develops 3D printed mycelium modules to compose objects such as lamps and columns (BLAST STUDIO, 2020); The Reef Design Lab develops 3D printed calcium carbonate structures to be collaboratively fulfilled with corals (REEF DESIGN LAB, 2021). Some of these examples are illustrated in Figure 1.



Figure 1 - Biodesign examples.

Source: From left to right: Fullgrown's chair production (MATERIAL DISTRICT, 2018). Modern Synthesis' microbial woven shoe (MODERN SYNTHESIS, 2020) and Blast Studio's 3D printed mycelium lamp shade (BLAST STUDIO, 2020)

Some authors speculate that the approximation to biology could mark the design practice of the 21st century: “Building with bacteria and other organisms is simultaneously becoming

a technological possibility and a necessity” (MYERS, 2018, p.16). Collet writes that “the beginning of the twenty-first century marks a strong shift towards the amalgamation of the binary code (1s and 0s) with biological systems” (2020, p.1). She sees a shift in the role of design “from working with inanimate matter such as plastic and metals to making with animate living entities such as mycelium, yeast, and bacteria” (COLLET, 2020, p.1).

Designing with the living is reportedly different from what designers are used to. Antonelli writes that “It goes without saying that when the materials are not plastics, wood, ceramics, or glass, but rather living beings or living tissues, the implications of every project reach far beyond the form/function equation and any idea of comfort, modernity or progress” (2018, p.7). Dade-Robertson says that “You can’t master life in the way a painter masters oils or a joiner masters wood” (2021a, p. 95). To Collet (2020), growing would now be part of the design process, which impacts form, structure, aesthetics, and material specification. The creating and controlling, she argues, brings to light new competencies to the designer besides the traditional methods they would be used to. Camere and Karana (2018) refer to these new skills and competencies as the “new designerly sensibilities”.

It seems relevant to understand how teaching and learning are happening in biodesign to develop how it could be further introduced in design curricula. It doesn’t seem that an analysis of formal education was made yet. To address this research gap, this paper aims to understand the traditional education scene in biodesign through an analysis of some of the main biodesign courses and programs. In the following sections, the methodological strategy for finding and analyzing the courses and programs is presented; following the results and discussion; finally, conclusions are drawn with recommendations for future studies.

One last consideration to be acknowledged before beginning is that this research intention still lies in an anthropocentric perspective of science because it still thinks in means to operationalize collaboration with living organisms in terms of a useful resource. But the hope is that it leads to a respectful conscience and way of treating living organisms, and towards a more ecocentric attitude of design (MELKOZERNOV; SORENSEN, 2020). This is also why the term collaboration is used to describe the relationship of the designer with other living organisms.

1. Methodological Strategy

The systematic review is adapted from Conforto, Amaral, and Silva’s (2011) roadmap. The selected search engine is Google, using the search strings: “biodesign” AND “course”; “biodesign” AND “master’s” OR “Ph.D.” OR “graduation”; “biodesign” AND “program” OR “programme”.

The filter application follows an open reading strategy, exclusion criteria are:

- (1) courses that are not provided by universities
- (2) courses in which the scope are not designers

(3) term disambiguation – when the term biodesign is not related to design and only related to medical and health sciences. When it refers only to biomimicry, not to biodesign as described by Dade-Robertson (2021);

To prevent some biases, such as search strings, a narrative review was also necessary (FERRARI, 2015) and references found in the literature were added.

In the analysis process, available data were organized into three categories when the information was available: (1) Title, University, Course Load; (2) Infrastructure; (3) Course overview. The process involved reading each course material and summarizing it.

2. Results and Discussion

After the filter application, the systematic review retrieved 14 results. The Biostudio project summarized some of the opportunities to study biodesign (BIOSTUDIO, 2021) – through this reference, one more result was added. Finally, a paper was found about a biodesign course at the Faculty of Fine Arts and Design of the University of Economics of Izmir. The analysis comprised 1 Masterclass for Professionals, 8 courses, 1 undergraduate course (Major), 4 master’s, and 2 Ph.D. programs. Table 1 presents information for each of these initiatives:

Table 1: Masterclasses, courses, undergraduate courses, masters and Ph.D. programs

1	<p>Title: Biological Design (course) - University of Pennsylvania</p> <p>Course load: not informed</p> <p>Infrastructure: not informed</p> <p>Course overview: The course assumes the dynamics of a studio. According to Upenn (2023), it is a research-based course that “introduces new materials, fabrication, and prototyping techniques to develop a series of design proposals in response to the theme: Biological Design”. Life sciences and biotechnologies are introduced to designers, artists, and non-specialists. (UPENN, 2023)</p>
2	<p>Title: Biomaterials: Designing with Living Systems (course) - Faculty of Fine Arts and Design of the University of Economics of Izmir</p> <p>Course load: not informed</p> <p>Infrastructure: not informed</p> <p>Course overview: [...] Pedagogical objectives are: “to reinforce basic design principles through a new media and to broaden the students’ understanding of design as a cross-disciplinary problem-solving process” (PINTO; PUGLIESE, 2017, p.1). Activities of the course comprise: “observation, tinkering, playing, gathering, sketching, experimenting and predicting” (PINTO; PUGLIESE, 2017, p.2). Students work together on projects around a specified organism, like silkworms. The course is organized into two main modules: one theoretical and one “application unit”. The theoretical module presents a case study analysis and introduces to the basics of “morphological, physiological, anatomical, behavioral, origin, and distributional, aspects of many biological actuators and in particular silkworms” (PINTO; PUGLIESE, 2017, p.4-5). In the applied module students developed their own projects around a design hypothesis and scenario simulation. Students were asked to make records of their progress and the development of the other organism in the project (PINTO; PUGLIESE, 2017).</p>
3	<p>Title: BioDesign Fundamentals course – The University of Sidney</p> <p>Course load: 6 credit points</p> <p>Infrastructure: not informed</p>

	<p>Course overview: According to the course description, it presents basic concepts of designing with science and reinforces the participant's own domain expertise, augmenting the participant's existing skills with new approaches to problem-solving. The unit introduces "prototyping for science and biology, evaluating ethical implications of designing with life, communicating scientific processes to justify biodesign choices" (THE UNIVERSITY OF SIDNEY, 2023), and shows the participant to support peers with their own expertise. Learning objectives are related to: ethical concerns; prototyping in a biodesign context; interdisciplinary thinking; developing the ability to explain scientific concepts "using abstracted models to a broad audience"; supporting peers in the development of new skills; and "understand the theory, methods, and technology that underpin key approaches to biodesign" (THE UNIVERSITY OF SIDNEY, 2023).</p>
4	<p>Title: IDE Design Master Class for Professionals – Biodesign - TUDelft Course load: 2 days, paid course Infrastructure: not informed Course overview: The course introduces the participants to the "world of living organisms, to fundamental biodesign theories, tools, and methods to understand and design with living organisms" (TUDELFT, 2023) – it is oriented to a "cleaner production and unique experiences in everyday products" (TUDELFT, 2023). Learning objectives concern: theory and principles of biodesign; "get a feeling for bio lab tools and machines, basic bio lab technical and research skills to grow, maintain, and observe living organisms"; hands-on experiences; and "gain competence in envisioning future applications for living materials" (TUDELFT, 2023).</p>
5	<p>Title: (1) Biodesign theory and practice: biodesign challenge part I (course) and (2) biodesign experimentation and prototyping: biodesign challenge part II (course) - University of California, Davis Course load: 3 hours (part I) +3 hours (part II) Infrastructure: not informed Course overview: These courses prepare the participants to take part in the Biodesign Challenge (BIODESIGN CHALLENGE, 2023). Students must enroll separately in each part. Part I gives the participants an overview of biodesign foundational principles, presenting biodesign examples in many segments. Later on, it develops participants' "team-based experience in biodesign intervention; first steps in a mini-entrepreneurial start-up experience" (UNIVERSITY OF CALIFORNIA, DAVIS, 2023). Part II is the continuation of the team's work, focusing on prototyping.</p>
6	<p>Title: The Biodesign Challenge (course) – University of Cincinnati Course load: not informed Infrastructure: not informed Course overview: The course aims to prepare students to participate in the Biodesign Challenge. Participants work in interdisciplinary teams, with advice from experts to solve a specific problem. Focus lies on ideation and prototyping (UNIVERSITY OF CINCINNATI, 2023).</p>
7	<p>Title: Aesthetic Crossovers of Art and Science and Art and Life Manipulation (courses) – The University of Western Australia Course load: not informed Infrastructure: not informed Course overview: There are two elective courses, the first one, called Aesthetic Crossovers of Art and Science, focuses on "A practical and theoretical investigation, through critical engagement of the nexus and differences of the art and science cultures through the use of the technologies of life science/biotechnology as an art-form" (UWA, 2022). The second course, called Art and Life Manipulation, aims at introducing biological lab "practices and techniques dealing with the manipulation of living biological systems within the context of contemporary arts practices" (UWA, 2022).</p>
8	<p>Title: Biological Design Major – The University of Sydney Course load: not informed Infrastructure: not informed</p>

	<p>Course overview: This program brings together design principles, along with biomedical science and engineering to create innovative solutions for human and planet health (THE UNIVERSITY OF SIDNEY, 2022). Students learn about ethical implications, prototyping for Science and biology, communicating scientific processes, and supporting peers with their own expertise. There are also interdisciplinary projects with industry partners including one aiming at the Biodesign Challenge (THE UNIVERSITY OF SIDNEY, 2022). The courses in the program are (some of them have an advanced version):</p> <p>- Animal behavior; BioDesign Fundamentals; BioDesign Studio; Biology of Insects; Biomedical Design and Technology; Biomedical Engineering 1B; Botany; Cell Biology; Co-Design and Participatory Approaches; Design Thinking; Design for Wellbeing; From Molecules to Ecosystems; Fundamentals of Human Anatomy; Fundamentals of Visual Design; Global Challenges: Food, Water; Human Biology; Industry and Community; Introduction to Interface Design; Key Concepts in Physiology; Life and Evolution; Principles of Design; Reproduction, Development, and Disease; Responsible Design for Innovation; Science Interdisciplinary Project; Systems Physiology; Terrestrial Plant Ecosystem Management; Zoology (THE UNIVERSITY OF SIDNEY, 2022).</p>
9	<p>Title: Master of Biological Arts – The University of Western Australia Course load: not informed Course overview: The program emphasizes on developing "critical thought, discussing ethical and cultural issues, and encouraging cross-disciplinary experimentation in art and science" (UWA, 2022). The target audience of the master's is art practitioners, scientists, and humanities scholars who wish to engage with creative bioresearch. Students must take art and science credits – with a balance of disciplines (UWA, 2022).</p>
10	<p>Title: Master of Arts Biodesign - University of the Arts London Course load: 2 years, 30 hours per week (180 credits) Infrastructure: Grow-Lab (Containment Level 1 biology laboratory); Biologist in the teaching team; International network of the Design & Living Systems Lab; Knowledge exchange with industry partners. (UAL, 2022). Course overview: The curriculum is research-driven, with an emphasis on ethical concerns and learning by making – students develop a personal research agenda. Learning objectives concern: understanding critical context challenges for design in the 21st century "social, political, economic, ethical and sustainable issues" (UAL, 2022); bio-informed design strategies and whole system thinking; biomimicry principles in design; biological sciences and biofabrication tools and methods; sophisticated lab-based biodesign practice; "to explore and integrate biocomputation tools into design practice" (UAL, 2022, p.5); to develop biodesign portfolio of work. The program is divided into three units: (1) Seed; (2) Grow; (3) Harvest. The first unit forms the theoretical basis and students develop a series of small projects, it concludes with the submission of a biodesign portfolio [... and an] oral and visual presentation" (UAL, 2022, p. 8). The second unit focuses on a personal project to apply the different biodesign competencies. The third unit is dedicated to "creative production and communication of the final MA project" (UAL, 2022).</p>
11	<p>Title: Master of Architecture Bio-Integrated Design (Bio-ID) – University College London Course load: 2 years (300 credits) Infrastructure: BiotA Lab (Biotechnology and Architecture Lab). Taught jointly by UCL's "The Bartlett School of Architecture" and "Biochemical Engineering Department". Course overview: The course aims to "[...] integrate biotechnology, advanced computation, and fabrication to create a radically new and sustainable built environment" (UCL, 2022). Students work simultaneously in a scientific laboratory, in a design studio, and at a fabrication workshop. Participants engage in short projects in teams and also in a speculative design project (thesis). The final module aims at research career preparation. Course modules consist of:</p>

	- Introduction to Scientific Methods, Laboratory and Environmental Practices; Computational Skills; Literature Review; Preliminary Design; Year 1 Design Project and Fabrication; Year 1 Thesis Report; Design Specialisation and Interdisciplinary Context; Comprehensive Project Thesis.
12	<p>Title: Biological Design, MS – Arizona State University Course load: 30 credit hours and a thesis, or 30 credit hours including the required applied project course Infrastructure: not informed Course overview: The program emphasizes a continuum between technology and biology. Students have to “take one program core course (Principles of Biological Design), one course from a suite of biotechnology courses, and one from a suite of statistics courses” (ASU, 2022). In this program “students read literature; identify critical problems related to energy, environment, human health, sustainability, and security; and develop solutions to these problems using a synergy of technological and biological solutions, either in teams (course projects) or individually (thesis or applied project)” (ASU, 2022). Courses are:</p> <p>- Research Methods in Biological Design (mandatory); Topic: Six Sigma Methodology/Engineering Experimentation (statistics); Design Engineering Experiments (statistics); Regression Analysis (statistics); Mathematical Statistics (statistics); Topic: Bioenergy and Microbial Biotechnology (biotechnology); Topic: Cellular and System Modeling (biotechnology); Topic: Chimeras and Recombinant Organisms in Medicine (biotechnology); Advanced Environmental Biotechnology (biotechnology); Environmental Microbiology (biotechnology); Topic: Bio-inspired Design (biotechnology); Microbial Bioprocess Engineering (biotechnology); Topic: Nanobiotechnology (biotechnology); Topic: Synthetic Biology and Metabolic Engineering (biotechnology); Seminar; Applied Project; Thesis.</p>
13	<p>Title: Biological Design Ph.D. – Arizona State University Course load: 84 credit hours Infrastructure: not informed Course overview: “The program is a joint effort by the College of Liberal Arts and Sciences, The Biodesign Institute, and the Ira A. Fulton Schools of Engineering” (ASU, 2022). Besides the credits, a qualifying exam, a comprehensive exam/proposal prospectus, and a dissertation are required. There is a system of research rotations, where students rotate between laboratories in order to define a potential advisor and research topic. After the first year, students decide on one of the three labs for their Ph.D. studies. Besides the credits of specialized coursework, “there is a recommendation to include courses with components in bioethics and grant writing” (ASU, 2022). Some of the courses offered:</p> <p>-Biological Design II (required); Biological Design Proseminar; Biological Design Seminar; Research; Lab Rotations; Dissertation; Patterns in Nature; Materials Synthesis; Structure and Properties of Materials; Materials and Civilization; Sensing the World (ASU, 2022).</p>
14	<p>Title: Biological Arts and Ph.D. – The University of Western Australia Course load: not informed Infrastructure: not informed Course overview: Not informed, a general statement is given: “Emphasis is placed on developing critical thought, discussing ethical and cultural issues, and encouraging cross-disciplinary experimentation in art and science” (UWA, 2022).</p>

Source: Authors.

It is important to note that biodesign education happens in other educational constellations, such as the “Cluster of Excellence Matters of Activity” (MoA, 2023) and the “Hub for Biotechnology in the Built Environment” (HBBE, 2023). The cluster and the hub

gather funding around common projects – where Ph.D. students and other researchers develop their projects associated with these initiatives. The cluster even has a Ph.D. program, but it is not exclusive to biodesign projects.

Course load varies between institutions. For example, the Master’s in Biological Design, from Arizona State University requires 30 credit hours and a thesis, while the Master of Architecture in Bio-Integrated Design (Bio-ID), from the University College London, requires the completion of 300 credits.

Infrastructure is not always informed, a highlight is the University of the Arts London, which offers a containment level 1 biology laboratory, a biologist in the teaching team, an international network, and knowledge exchange with industry partners. (UAL, 2022).

Regarding the course overview, five results emphasize laboratory work or introductions (TUDELFT, 2023; UWA, 2022; UAL, 2022; UCL, 2022; ASU, 2022). A highlight of this approach is given by Arizona State University (ASU, 2022), where students rotate between laboratories to define a research interest and an advisor. Ethical implications are a main topic in five of the results (THE UNIVERSITY OF SIDNEY, 2023; THE UNIVERSITY OF SIDNEY, 2022; UWA, 2022; ASU, 2022; UWA, 2022). Project/studio structures are adopted by 7 of the initiatives (UPENN, 2023, PINTO; PUGLIESE, 2017; ASU, 2022; THE UNIVERSITY OF SIDNEY, 2022; UNIVERSITY OF CINCINNATI, 2023; UNIVERSITY OF CALIFORNIA, DAVIS, 2023; ASU, 2022). Interdisciplinary experience is promised by 6 of the results (THE UNIVERSITY OF SIDNEY, 2023; THE UNIVERSITY OF SIDNEY, 2022; UWA, 2022; UCL, 2022; ASU, 2022; UAL, 2022). Prototyping is the focus of five of the courses/programs (UPENN, 2023; THE UNIVERSITY OF SIDNEY, 2023; UNIVERSITY OF CALIFORNIA, DAVIS, 2023; UNIVERSITY OF CINCINNATI, 2023; THE UNIVERSITY OF SIDNEY, 2022). Market-driven/application-driven solutions are the goal of TUDelft (2023) and the University of California, Davis (2023). The University of Sidney (2023) and the University of the Arts London (UAL, 2022) emphasize on the ability of the students to communicate their projects. Four of the initiatives were oriented or had activities oriented to the participation in the Biodesign Challenge (2023) (UNIVERSITY OF CALIFORNIA, DAVIS, 2023; UNIVERSITY OF CINCINNATI, 2023; THE UNIVERSITY OF SIDNEY, 2022). The Biodesign Challenge is an international competition sponsored by companies like Google, Science Sand Box, Ginkgo Bioworks, and others. It introduces students to the intersections of biotechnology, art, and design. Universities and high schools may register, gaining access to pedagogical resources and a mentor network.

In the next section, the final considerations are outlined, along with the recommendations for future research.

3. Final considerations

The biodesign community, which collaborates in interspecies designs, seems to be reaching a solid development. It seems relevant to understand how teaching and learning are happening in biodesign to develop how it could be further introduced in design curricula. It didn’t seem that an analysis of formal biodesign education had been made yet. To address this research

gap, this paper aimed to understand the formal education scene in biodesign through an analysis of some of the main biodesign courses and programs. The methodological strategy was a systematic and a narrative review through a popular search engine, Google. 16 results were analyzed: 1 Masterclass for Professionals, 8 courses, 1 undergraduate course (Major), 4 master's, and 2 Ph.D. programs.

It was found that biodesign education doesn't happen only in biodesign formal programs – but also happens in other constellations, like the “Cluster of Excellence Matters of Activity” and the “Hub for Biotechnology in the Built Environment”. The course load varies greatly between institutions. Infrastructure and resources are not widely informed, but some initiatives state that they offer laboratories. Course overview highlights are: laboratory work or introductions; ethical implications; project/studio structures; interdisciplinary experience; prototyping; focus on market-driven/application-driven solutions; the development of the ability of the students to communicate their projects; and activities oriented to the participation in the Biodesign Challenge.

For future studies, it seems interesting to interview the teachers and professors in these institutions and to look into other educational constellations, such as Matters of Activity, the Hub for Biotechnology in the Built Environment, and others.

This study was financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Brasil (CAPES) - Finance Code 001. The authors also acknowledges the support of the Cluster of Excellence »Matters of Activity. Image Space Material« funded by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) under Germany's Excellence Strategy – EXC 2025 – 390648296.

References

- ANTONELLI, P. Vital Design. In: MYERS, W. **Biodesign. Nature, science, creativity**. High Holborn: Thames & Hudson, 2018, pp.6-7
- ARIZONA STATE UNIVERSITY (ASU). **Biological Design**, Ph.D. 2022. Available at: <<https://degrees.apps.asu.edu/masters-phd/major/ASU00/GCBDSPHD/biological-design-phd;jsessionid=3B8A30E8C20A21C0036E87D348018B0B>>. Accessed on July 12, 2022.
- BIODESIGN CHALLENGE. **Grow the Future**. 2023. Available at: <<https://www.biodesignchallenge.org/>>. Accessed on: March 15, 2023.
- BAD - BIO ART & DESIGN AWARD. **About the award**. 2021. Available at: <<https://www.badaward.nl/>> Accessed on: May 4, 2021.
- BIOFABRICATE. **Events**. Available at: <<https://www.biofabricate.events/summit>>. Accessed on May 04, 2021.
- BIOSTUDIO. **Universidades que oferecem cursos de Biodesign**. 2021. Available at: <<https://biostudiodesign.com.br/universidades-que-oferecem-cursos-de-biodesign/>> Accessed on March 14, 2023.
- BLAST STUDIO. **Projects & Exhibitions**. Available at: <<https://www.blast-studio.com/projects-exhibitions>>. Accessed on January 21, 2021.

CAMERE, S.; KARANA, E. Fabricating materials from living organisms: An emerging design practice. **Journal of Cleaner Production**, v. 186, p. 570–584, 2018.

COLLET, C. Designing our future bio-materiality. **AI and Society**, n. 0123456789. Springer London, 2020.

CONFORTO, E. C.; AMARAL, D. C.; SILVA, S. L. da. Roteiro para revisão bibliográfica sistemática: aplicação no desenvolvimento de produtos e gerenciamento de projetos. In: 8º Congresso Brasileiro de Gestão e Desenvolvimento de Produto – CBGDP, 2011, Porto Alegre. **Anais...** Porto Alegre, 2011. 12p.

DADE-ROBERTSON, M. *Living Construction*. New York: Routledge. 2021.

DESIGN MUSEUM. **Design with the Living 2020**. Available at: <https://designmuseum.org/whats-on/talks-courses-and-workshops/design-with-the-living-2020>. Accessed on May 04, 2021.

FERRARI, R. Writing narrative style literature reviews. **Medical Writing**, v. 24, n. 4, p. 230–235, 2015.

FULLGROWN. **About us**. Available at: <<https://fullgrown.co.uk/about-us-full-grown/>>, Accessed on May 17, 2021.

HBBE - HUB FOR BIOTECHNOLOGY IN THE BUILT ENVIRONMENT. 2021. Available at: <<http://bbe.ac.uk/about-3/>>. Accessed on March 15, 2023.

MoA – MATTERS OF ACTIVITY. **About us**. Available at: <<https://www.matters-of-activity.de/en/about/>>. Accessed on March 15, 2023.

MELKOZERNOV, A. N.; SORENSEN, V. What drives bio-art in the twenty-first century? Sources of innovations and cultural implications in bio-art/biodesign and biotechnology. **AI and Society**, Springer London, 2020.

MODERN SYNTHESIS. **Microbial Weaving**. 2020. Available at: <<https://modern-synthesis.com/microbial-weaving/>> Accessed on: January 02, 2021.

MYERS, W. *Biodesign. Nature, science, creativity*. High Holborn: Thames & Hudson, 2018.

PUGLIESE, S., & PINTO, R.P. **Designing with Living Systems: a pedagogical tool for basic design education**. Cumulus: Together, 2017.

REEF DESIGN LAB. **About**. Available at: <<https://www.reefdesignlab.com/about-2/>>. Accessed on May 19, 2021.

STILL ALIVE. **Welcome**. 2020. Available at: <<https://www.stillalive2020.com/welcome>>. Accessed on May 04, 2021.

THE UNIVERSITY OF SIDNEY. **Biological Design**. 2022. Available at: <<https://www.sydney.edu.au/courses/subject-areas/major/biological-design.html>>. Accessed on July 12, 2022.

THE UNIVERSITY OF SIDNEY. **BioDesign Fundamentals**. 2023. Available at: <<https://www.sydney.edu.au/units/BDSN2001>>. Accessed on March 14, 2023.



THE UNIVERSITY OF WESTERN AUSTRALIA (UWA). **Symbiotica**. 2022. Available at: < <https://www.symbiotica.uwa.edu.au/courses>>. Accessed on July 12, 2022.

TUDELFT. IDE **Design Master Class for Professionals: Biodesign**. 2023. Available at: < <https://www.tudelft.nl/io/studeren/ide-design-master-classes/biodesign>>. Accessed on March 14, 2023.

UNIVERSITY OF ARTS LONDON (UAL). **Master of Arts in Biodesign**. Available at: <https://www.arts.ac.uk/subjects/textiles-and-materials/postgraduate/ma-biodesign-csm#course-summary>. Accessed on 12, July 2022.

UNIVERSITY OF CALIFORNIA, DAVIS. **Biodesign theory and practice: biodesign challenge part I**. Available at: < <https://arts.ucdavis.edu/course-description/des-128a-biodesign-theory-and-practice-biodesign-challenge-part-i-4>>. Accessed on March 14, 2023.

UNIVERSITY OF CINCINNATI. **The Biodesign Challenge**. Available at: < <https://www.uc.edu/campus-life/honors/students/experiences/seminars/seminar-spotlights/ene-d3050daap3050.html>>. Accessed on March 14, 2023.

UNIVERSITY COLLEGE LONDON (UCL). **Bio-Integrated Design (Bio-ID) MArch/MSc**. 2022. Available at: < <https://www.ucl.ac.uk/bartlett/architecture/programmes/postgraduate/bio-integrated-design-bio-id-marchmsc>>. Accessed on June 12, 2022.

UNIVERSITY OF PENNSYLVANIA (UPENN). **Biological Design**. Available at: < <https://www.design.upenn.edu/courses/dsgn-2510>>. Accessed on March 14, 2023.

Transição de Parques a Ecoparques Industriais: insights acerca dessa necessária e complexa transformação

Transition from Parks to Eco-industrial Parks: insights into this necessary and complex transformation

Henrique Lisbôa da Cruz, Engenheiro Químico, Mestre em Engenharia Mecânica, Universidade do Vale do Rio dos Sinos - UNISINOS

cruzhnrq@yahoo.com.br

Carlos Alberto Mendes Moraes, Engenheiro Metalúrgico, Doutor em Ciência dos Materiais, Programas de Pós-Graduação em Engenharia Mecânica e, de Engenharia Civil - Universidade do Vale do Rio dos Sinos - UNISINOS

cmoraes@unisinós.br

Resumo

Esta pesquisa se centraliza na problemática que envolve a transição de parques a ecoparques industriais, com foco em parques de uso misto e logístico. Por meio de metodologia exploratória, um estudo de caso foi conduzido em um parque empresarial e logístico situado no Brasil, visando explorar oportunidades de aplicação dos conceitos de Simbiose Industrial. A avaliação permitiu observar que as possibilidades de aplicação da Simbiose Industrial nesse tipo de parque estão mais atreladas aos compartilhamentos de infraestrutura, utilidades e serviços do que propriamente de intercâmbios físicos. Um plano de ação foi proposto, contemplando estratégias de Simbiose Industrial e atividades complementares visando ao aumento do potencial simbiótico. As principais sugestões foram o gerenciamento coletivo de resíduos sólidos e oferta de suporte técnico ambiental. Quanto ao compartilhamento de utilidades, existe um potencial para aproveitamento da água da chuva para fins não potáveis e para a geração ou aquisição compartilhada de energias renováveis.

Palavras-chave: Ecoparque Industrial; Simbiose Industrial; Gestão Ambiental.