Biological Systems

Outcomes in Architectural Design Studios

Devon Ward, Robert Cameron, Loren Kronemeyer and Kirill de Lancastre Jedenov
University of Western Australia, Perth, Australia
devon.ward@uwa.edu.au, robert.cameron@research.uwa.edu.au, loren.kronemeyer@gmail.com,
kirill.delancastrejedenov@uwa.edu.au

Abstract: This conference paper is the second of two papers that discuss the outcomes of a long-term pedagogical research project into the integration of interdisciplinary design-research, and making practices into the content of second-year architecture studios. This paper focuses on one studio involved in the design of biological systems. The studio introduced students to the socio-cultural and bioethical dilemmas that arise when using living organisms as a design material. Students were required to create a biological system using traditional design materials and Physarum Polycephalum, a harmless, yellow single-celled organism capable of solving complex mazes and which grows up to 30cm in length. Through the design, prototyping, and testing of these systems students are encouraged to learn through practice, developing their projects iteratively while being critical of the implications of their actions. Through a discussion of the studio aims, structure, project examples, and outcomes, this paper outlines an initial approach to teaching biological design within a studio context. Along with the paper on Responsive Systems these works highlight the importance of critical engagement with materials and processes and of opening up future architectural pedagogy to new fields of exploration.

Keywords: Architectural education; critical design; biological systems; making.

1. Introduction

The architecture that I have studied, that I have practiced with other architects, with my professors... It is over.

Eduardo Souto de Moura (2016)

Architecture consumes earth’s limited resources, it is long lasting and expensive, and it can significantly alter the quality of living of its users. We live in a fully explored, finite, over populated world and so it is imperative that we do not think of and produce architecture in the same ways that we have in the past. It is essential that we understand humans, non-humans, objects, buildings, cities and regions not as isolated entities, but as parts of systems of increasing complexity and uncertainty. As humans, it is
important that we understand our place in these systems, not an overwhelmingly important position but only as part of it. Climate related natural disasters, over population, uncontrolled consumption, disregard for non-humans and non-humans environments, food and water supply constraints, artificial intelligence, massive migrations, cultural tensions, raising inequalities, extremist groups and unannounced acts of random violence are unprecedented challenges that are all connected. It is important to recognize that actions have consequences and that there is no such thing as designing an isolated entity. As a part of this system, architects need to understand the world that they live in, in order to raise awareness about the consequences of their designs.

Starting from these foundations, a long-term pedagogical and research project was implemented at the University of Western Australia under the Integrated Design ethos. During their second year, architecture students are given the opportunity to take a studio called Making. As a part of the school’s design stream, students are invited to develop solutions to design problems that may or may not include architecture. During the semester, students are required to submit both prototypes and finished products at their real scale as opposed to drawings and models. This encourages design development through experimentation, and the production of multiple prototypes that are critically examined and iteratively improved. Through this process, students are expected to develop a better understanding of the difficulties faced in producing built objects, and to consider the relations between projects that only exist in print, on screen, as models and those that exist in the built environment, leading to careful and thoughtful future designs.

The majority of studio coordinators of Making are not architects, and those that are have specific skills that are unusual within architectural practice. Some of the most recent specialized skills ranged from: ceramics, eco-activism, responsive electronic interfaces, biological systems, ecological systems, traditional carpentry, graphic design and conceptual art. By opening the design studios to coordinators with diverse backgrounds, students can focus on different underlying design systems. A different specialist will read and understand a different system. By offering the opportunity for students to work with diverse specialists, we are expanding their fields of action. By opening up the discipline to new fields of action – biological, electronic, multispecies, conceptual arts, we enable students to collaborate in trans-disciplinary approaches and complex environments where outputs are unpredictable, through design. We empower students to become independent thinkers, to have the desire to run their own practices. We accept unexpected ambitious, unfinished projects that can be more interesting than expected finished predictable outcomes. To do that, we ask students to redefine what success means, as its archaic interpretations might not fit anymore. We ask students to pose their own questions instead of reacting to defined problems. It is important to assume that by doing it we are no longer in an expert/apprentice position; we are together with our students in an experimental research journey with unpredictable outcomes. We do not know exactly what students will produce and we do not know how it will be applied in future architecture. It is precisely this, the acceptance of uncertainty, the program’s greatest strength. Together we lay the foundations for a future that we cannot foresee. Our world is quickly changing. Architecture education and practice have to adapt, to open up new fields of exploration and to prepare students for uncertainty.

This conference paper is second in a series of conference papers from our long term pedagogical and research project. The first paper, “Responsive systems and electronic spatial interfaces: outcomes in architectural design studios”, discusses the outcomes from a studio within the same Making unit that specifically focused on the development of responsive systems using electronic media. While the primary design materials differed in each studio, the approach to critical making was the same. Together, these papers contribute to pedagogical research concerned with developing diverse, dynamic studios that
provide architectural students with an environment to engage with emerging media and their future socio-cultural and ethical implications.

**2. Biological Systems using *Physarum Polycephalum***

Designers are increasingly using living organisms as both material and subject matter in order to critically engage in contemporary socio-cultural and bioethical issues (Catts and Zurr, 2002; Catts and Cass, 2008). This practice has loosely coalesced under the title of biodesign, which by necessity is experimental and interdisciplinary, drawing from information from fields such as biological art, critical design, synthetic biology and other life sciences (Antonelli, 2011a; Myers, 2012). Biodesign involves the intervention in an organism’s genetic material, cellular processes or exterior environment. The disruption that may be caused by this intervention is often used to raise questions about the future relations between humans, nonhumans and the environment (Catts and Zurr, 2014).

Inherent within the practice of biodesign is the notion that some living systems are artefacts of human culture. As Eugene Thacker notes, the intervention into living systems necessitates the dynamic exchange between two concepts that often have been considered categorically distinct, that of *bios* (life) and *technê* (art or craft) (Thacker, 2010 pp.117-18). In other words, activities such as biodesign break down the hard-and-fast notion that living organisms are somehow separate from the processes of human cultural production, for better or worse. The lines between nature and culture are blurred, if not altogether obliterated, when designing with/for living systems.

Consequently, biodesign can raise vital questions about what activities are morally acceptable when using living organisms as cultural mediums. Who has the right to design life? How will an altered organism or biological material impact other systems? Will there be any unintended consequences? Is it possible to know these consequences in advance? The host of questions that this field of design opens up necessitates pre-emptive thinking about the potential hazards of meddling with other organisms. As Paola Antonelli explains:

> When the materials of design 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. Design transcends its traditional boundaries and its implications aim straight at the heart of the moral sphere, toying with our deepest-seated beliefs (2011b).

At the heart of these ethical questions is a concern about the impact a new design may have on other systems, a question that is common to architectural discourses. Thus, this studio was conceived as a means of asking familiar design questions with a new medium in order to prepare students to deal with uncertainty.

To design with a living organism in an architectural studio provides many ethical complications. In order to mitigate some of the potential issues, *Physarum polycephalum* was selected as the primary design material. *P. polycephalum* is a harmless, yellow, single-celled amoeba capable solving complex three-dimensional mazes and grows up to 30cm in length. This organism was chosen as an introductory biodesign organism due to the fact that:

- There exists an adequate depth of popular do-it-yourself literature that is readily accessible and allows students to grow *P. polycephalum* outside of a laboratory (Barnett, 2009).
• *P. polycephalum* can be cultured using relatively cheap materials that can be purchased from a local grocery store. The required materials are namely Tupperware, rolled-oats, water, spray bottles and tweezers (*Culturing slime mould*, 2012).

• *P. Polycephalum* grows fast enough to allow for students to develop multiple prototypes during each assignment.

• *P. polycephalum* is neither animal, nor plant and, therefore, does not have ethical restrictions at the University of Western Australia (Australia, 2013).

By developing designs using *P. polycephalum*, students became familiar with the organism’s agency, time-cycles and growth requirements, which often conflicted with their own daily schedules. Over the course of the semester, students learned to adapt to an organism’s needs and behaviors when using it as a design medium.

### 3. Method: the studio format

This studio acted as an introduction to biodesign. The initial aim of the studio was to familiarise students with important themes from the field and provide techniques necessary to successfully culture *P. Polycephalum*. The initial prompt for students was “how can living organisms be ethically used to design systems that either grow or decay?” The studio format combined discussions and workshops to balance information acquisition with hands-on making. Students were presented with readings on: biodesign and biosystems (Antonelli, 2011a; Antonelli, 2001b; Eck and Lamers, 2013); bioethics (Devall and Sessions, 2001; Singer 2011); and *P. polycephalum* and its living conditions (Barnett, 2009).

These readings provided students with established pedagogies to develop their own ethical positions throughout the design process. During studio discussions, students voiced various concerns about the use of living organisms for design. Some were focused on the use of *P. polycephalum*, while others related to broader bioethical issues (e.g. the use of animals for food, the impact of new development on local habitats, industrial farming, ecological rights and industrial global warming). These discussions offered fertile ground for students to translate ethical questions, in which they were personally invested, into concepts and ultimately designs.

In tandem with discussion-based learning, students got their hands wet, so-to-speak, by growing numerous cultures of *P. Polycephalum*. The amoeba grows in warm, dark, humid environments, which contrasted with the dry, brightly light studios. Through multiple tests, students refined studio methods for culturing *P. polycephalum* in preparation for creating their biological systems (Figure 1).
After students became comfortable with the growth cycles of *P. polycephalum* and were successfully able to culture the amoeba over multiple surfaces, they were tasked with designing a final prototype for their biological system. The system needed to ethically incorporate *P. polycephalum* as the primary material and to respond to the theme of either growth or decay.

![Figure 1: Growth rate of *P. Polycephalum*, Matthias Widjaja](image)

**Figure 2:** *Physarum Polyoculus*, Simon Bow. Designed as a paradoxical system, this project examines the tension between the desire to observe another organism’s growth and the contrasting conditions required for its growth. By integrating *P. polycephalum* with Arduino-based electronics the systems responded to visitors. The project was devised to be installed in a dark room and when viewers walk in front of the sensor (on the right) a light turns on to reveal *P. polycephalum*; however, since the amoeba does not grow in light, this action inhibits the growth of the amoeba.

### 4. Results

Due to the studio’s open-ended and interdisciplinary focus, the students’ responses were experimental and varied. Many projects acted as conceptual vignettes that examined the impact design may have on other organisms. The common theme across the studio was that each project was critically engaged with
the use of *P. polycephalum* as a design material. Projects have been separated into the following typologies:

4.1. Biological systems to promote ethical considerations

These projects functioned as vehicles for thought to provoke questions about ethical dilemmas.

- *Physarum Eatery*, a food system using *P. Polycephalum* as the main ingredient
- *Physarum Polyoculus Hybrid*, a sensor based system that halts amoeba growth in the presence of visitors (Figure 2).
- *Cultured Communication*, translates electrical activity of amoeba into sound.
- *Physical Pressure on Nature*, installation that halts growth when visitors stepped on system.
- *Physarum Sound*, amplifies the presence of the amoeba through sound (Figure 3).
- *Physarum Racing*, ironically questions the use of other organisms for entertainment by developing a system that allows participants to bet on races between multiple amoeba cultures.

![Figure 3: Physarum Sound detail, Lucinda Trevaskis.](image)

Figure 3: *Physarum Sound* - detail, Lucinda Trevaskis. The system aimed to amplify the presence of the amoeba through sound. Through the use of an Arduino, a Macbook Pro and computer speakers, this project translated the electrical activity from the slime mould into sound.

4.2. Biological systems as building materials

*P. polycephalum* was grown on various substrates to act as a binding agent or alter qualities of light.

- *Canopy*, system that uses amoeba growth on Perspex to create shade canopy.
- *Physugi Cup*, taking precedents from wabi-sabi and kintsugi, the amoeba is used to mend broken ceramics (Figure 4).
- *Self-healing*, amoeba is used to repair cracks in wooden structures.
- *Degeneration*, amoeba is grown on fabric to acts as shade cloth.
- *Light Maze*, amoeba is grown over fabric to create a patterned lamp shade.
- *Physarum Homeware*, amoeba grown on Perspex to act as domestic pet.
Figure 4: Physugi Cup, Inspired by kintsugi, the art of mending broken pottery, this project used *P. polycephalum* as system for symbolically mending and venerating imperfections in broken tea ceramics.

4.3. Biological mapping systems

The growth of *P. polycephalum* was used as a mapping system.

- *City Walk*, Jhan Fung Siah, amoeba growth on map is used to plot paths in city.
- *Globalization Networking*, amoeba growth on global map to represent resource distribution.

4.4. Systems that care for *P. Polycephalum*

Systems were designed to protect and/or cares for *P. Polycephalum* in changing environments

- *Transitional Habitat*, system that maintains correct lighting conditions for amoeba growth. It opens at night and closes during the day (Figure 5).
- *Slime Mould Habitat*, participatory system that allows visitors to interact with slime mould by delivering it various types of food, which may limit or enhance its growth.
- *A story of life and death*, hard-shelled spherical habitat that allows amoeba to grow in multiple environments.
Figure 5: *Transitional Habitat*, Siema Safaefar. This system was designed to maintain the proper lighting conditions for the growth of *P. polycephalum*. During the day the outer shell is closed to limit light exposure and allow for growth. At night the system can be opened for viewing.

After students developed their final prototypes, they voted on a single project to pursue as a group for their final assignment. They chose to develop *Physarum Eatery* by Hae Yun Jung due to the potential for designing a rich multisensory experience, since a food system would provide a way to experience *P. polycephalum* through taste, touch, sight and smell. Consequently, the second half of the studio semester was dedicated to creating a performative installation in the form of a restaurant, the *Physarum Eatery*. To supplement their research and provide context for developing a food-based performance, students were presented with precedents from relational art (Bourriaud, 1998) that utilise food as a vehicle for thought. This included Rirkrit Tiravanija’s *Untitled (Free)* (1992) and The Tissue Culture and Art Project’s *Disembodied Cuisine* (2003). After a robust research and design process, the final project entailed the creation of: three separate dishes using *P. polycephalum* as the main ingredient; a menu that could be printed and displayed on an iPad; a serving table; a system to display cultures of *P. polycephalum*; a short video showing the amoeba’s growth; and a basic ‘script’ for the servers to explain the concept of the project to visitors. In order to complete these tasks, students were separated into five teams: design + visuals; construction; growth; budget + materials; and research + text.

The final system focused on biophilia, a term made popular by E. O. Wilson which describes an affinity between humans and other organisms. Students described their project as a performance that used food to promote a ‘biophilic consciousness’ and an appreciation of the symbiotic relationship between humans and other microorganisms including *P. polycephalum*. The *Physarum Eatery* debuted during a school-wide exhibition and two student-performers served dishes containing *P. polycephalum* to over fifty individuals.

Figure 6: *Physarum Eatery*, studio collaboration. This dish is composed of *P. Polycephalum*, oyster mushrooms and edible dirt made from rye toast, roasted almonds, walnuts and olive paste.
5. Discussion

While biodesign is a nascent field, studios that teach this field have a rich potential to engage students in contemporary ethics, particularly regarding their current and future relationships with other organisms. Through studio-based learning (and growing), students can see, first-hand, the importance of pre-emptively considering the ethical implications of their designs and how they will impact other systems. This approach exposes architecture students to fields they may otherwise not come into contact with and allows them to become more comfortable with experimentation and interdisciplinary research.

This open-ended studio introduced architecture students to design as a field with concerns beyond utilitarian objects, form and function. Instead, it focused on the creation of thought-provoking, ethically-minded systems that look beyond a human-centred focus. Studios such as this have the potential teach students to actively think through the implications of different types of design to create desirable futures. In this way, this studio is similar to other design studios that foster critical and pre-emptive thinking. However, the use of living materials may elicit a more immediate concern for other living organisms since students see the impact of their design in a matter of hours.

This paper provides an introductory framework for teaching biodesign to architecture students. By providing the reading lists and methodologies, it lays the groundwork for future research into the further pedagogical methods for presenting biodesign in a studio. While this studio focused on growing *P. polycephalum* using DIY methods, this environment also presented significantly limitations to culturing the organism with precise techniques. Providing a laboratory or hybrid environment for this type of studio may allow for more precise culturing and more nuanced design investigations.

Considering the recent growth in techniques for do-it-yourself biology, the intervention into living systems is likely to become more common. This increasing interest in designing life calls for further discussions about how to teach biodesign at a tertiary education level. Currently, there are a limited number of institutions that offer courses that touch on biodesign. These institutions include Central Saint Martin’s Material Futures Masters course, Design Academy Eindhoven’s Food Non Food undergraduate program, the Royal College of Art’s former masters program Interaction Design, The University of Pennsylvania’s Biodesign class and SymbioticA’s Master of Biological Arts at The University of Western

---

Figure 7: *Physarum Eatery*, studio collaboration. The food, menus (digital and paper), displays and tablewere designed and created by the entire studio.
Australia. An increase in biodesign discourse concerning teaching materials, methods and ethical frameworks can only make this field more robust and biodiverse, literally and figuratively.

References