ABSTRACT

Students in a fourth-year studio in the University of Arizona designed architectural responses to environmental crises. They generated their designs from the properties of “smart materials,” or materials that transform in response to outside forces. The interactive nature of the materials offered ways for the students to merge sites and functions into hypothetical scenarios. Media functioned in the design process and the proposal to manage and communicate variables, uncertainty and time. As they suggest ways to design for interactive and changing conditions, these methods are also a way to account for environmental fluctuation in designing for sustainable systems.

1. SUSTAINABILITY

“A thing is right,” Aldo Leopold writes in his Sand County Almanac, “when it tends to preserve the beauty, integrity, and stability” of the biotic community. The biocultural stability that he is describing is dynamic and sustained. He is describing conditions of homeostasis—maintained equilibrium in environments of perpetual change.

Ecological sustainability is dependant on perpetual change. For architectural design to also be truly sustainable, designs must account for their place in existing dynamic systems. Designs should anticipate their own change over time and the interdependent change in their environmental context. While any construction is susceptible to Aldo Rossi’s tempo, as he uses the word to stand in both for weather and for time, temporal change in architectural design should be anticipated and purposeful.

A way of designing for this kind of sustainability has to account for information that is not always included in the media of architectural...
design—systemic, reciprocal relationships and transformations. What if architectural design was better at anticipating this material change from the passage of time? What ways of working methods would be needed to replace the current media and processes of architectural design?

2. RESPONSIVE MATERIALS

Students in the course had the chance to address questions like these in a fourth-year design studio investigation of smart materials. In this case, smart materials are defined as materials that change form or mechanical property in response to environmental stimuli. Students became familiar with shape memory alloys, gels, nano-solar material, photo and thermal chromatic dyes, bio-based plastics, foils and films, and conductive and breathable textiles. These materials all change their chemical properties, microstructure, and/or physical attributes in direct response to stimuli such as variations in light intensity, heat energy or humidity levels.

The studio was instructed by Dale Clifford and Peter Testa and was directed towards fulfilling the requirements for the Lyceum Foundation Fellowship competition in 2005. Guided by the competition program, students applied smart materials to design a "wearable architecture that is self-sufficient, inhabitable by a single individual or used to create larger environments when colonized."

The instructors organized the studio process with three “memos” that directed students’ work at each of three stages of the design process.

2.1 MEMO 1: SMART MATTER

To begin, students researched the particular materials that the competition program suggested. The instructors’ first memo directed the students to learn properties and parameters—the materials’ abilities to transform and combine with other materials, as well as joining and manufacturing techniques for making assemblies and reactive systems. Material research occurred as speculation, analogy and physical manipulation.

Rather than forms, the students were designing dynamic relationships between material properties and outside forces—small relationships of the kind that might make up larger, interdependent systems. The instructors used analogies from natural history to suggest ideas for reactive mechanisms and to help students design for changing conditions or with a changeable form. The students looked to ecosystem models to understand how layers of simple mechanisms make up complex systems (figure 1).

Because these materials were unfamiliar, it was necessary for the students to begin by developing an intuitive, physical knowledge of the material. Most importantly, this direct experimentation and invention was a
shortcut to discovery for the students; in using their hands to explore the tendencies of the materials they came easily to forms beyond what they might have conceived of with their imaginations alone (figure 2).

The most significant discoveries came when students were able to work directly with the material and combine the real materials in systems, or in analogous systems that were dynamic. In these cases, students were able to move in scalar steps—from the material to a working assembly (figure 3). Like the single materials, the assemblies had parameters of their own—in mechanisms of connection, range of movement, and in their reactions to outside stimuli.

Figure 1  Matan Mayer constructed an assembly of pores from acrylic, silicone and latex that simulated phase change and thermo-chromatic material properties intended to mimic the water harvesting mechanisms of desert plants.

Figure 2  Brandusca Bullarca discovered new forms by replicating a single connecting mechanism to make a series of jointed assemblies.

Figure 3  Wayne Jenski laser cut polystyrene arms to fabricate an articulated framework powered with thermally activated Nitinol tendons are meant to simulate activation by fluctuations in water temperature during tidal change.
2.2 MEMO 2: SCENARIOS

The instructors’ second memo directed students to discover an application for one of the systems that they were developing. In particular, the memo directed the students to think of possible biotopes with high levels of contamination or hostile conditions and then to imagine how the functional properties of their assemblies might mitigate those conditions.

In a way, this directive merged the convention of architectural site and architectural program into a single idea—the idea of the architectural scenario. In this case, the scenario is a hypothetical event or a category of typical event that is likely to reoccur. As the students were directed to address ecological and humanitarian crises, the scenarios were things like an ocean oil spill, a desert border crossing and construction site activity. The students described these scenarios in film-still or storyboard-type photo collages and renderings.

Perhaps because of the physical way that the students developed the assemblies, because the Lyceum Fellowship prospectus asked students to “blur the boundaries between architecture and clothing,” or because human actors in the students’ scenarios brought catastrophes to the scale of the human body, the students’ projects all bridged easily from abstract material assemblies to architectural space scaled for both the body and the landscape. In several cases, such “Earth Wear” and “Water Harvester,” the designs were meant to be active filters, mediating the movement of materials and energy between people and their environment (figure 4 and 6).

Figure 4  Brandusca Bullarcas’ proposal, “Earth Wear”, mitigates airborne particulate generated when the protective layer of desert crust is broken during construction. The proposition is a new type of construction trailer composed of layers of geotextiles that collect and filter dust from the disturbed site. Once the filters are clogged, the layers are shed and returned to the site.
2.3 MEMO 3: HYPOTHESIS

The title of the last memo, hypothesis, was apt. The memo directed the students to present their final designs in use, in context. Their final presentations included photo-collage and 3-d renderings, diagrams, photos of their models, and a text description. The presentations suggested a high level of resolution; the students diagrammed and rendered the designs as if they were fully developed, already proven and in manufacture. They did not hesitate to guess at the structure and feasibility of the final proposals. Their designs were meant to be hypotheses—assumptions to be tested later (figures 5 and 6).

The fundamental premises of the studio, of working with material properties and accounting for those properties in context and time, are not limited to reactive materials. Even if the measure is on a geologic scale, all materials will be affected in time by the forces around them; this is speaking of both the materials of architectural design and the inseparable materials of their environments. In order to help perpetuate stability in dynamic ecosystems, it is necessary to be able to design the way these systems operates—as an infinitely complex network of reactions.

Figure 5 Wayne Jenski designed colonies of spill mats to address the environmental effects of an oil spill. The mats’ strata, in contact with the oil, form a vascular network of absorbent lignite sponge that transmits oil to a holding reservoir. At high tide, the network is exposed to water temperature change that activates an embedded Nitinol mesh that generates a floating shelter for environmental workers. The spill mats unfold at low tide and absorbs the newly deposited oil.
Matan Mayers’ “Water Harvester” is a woven network of artificial roots that mimic the water location and retention ability of native desert plants. Capillarity and micro-encapsulated phase change materials are used to generate a humid bio-climatic ‘island’ to sustain desert crossers in border zones. The harvester is intended to be deployed by local humanitarian groups and to be used for very short periods, mostly as a life saving device.

3. REFERENCES

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