Machine[s] in the Garden: instruments, simulations and new ecologies

Author Simon Bussiere and Lance Walters
University of Hawai'i at Mānoa

Introduction: The Machine in the Garden

The Machine in the Garden: Technology and the Pastoral Ideal in America, published first in a 1964, is a seminal work of literary criticism by Leo Marx. The book's title refers to a common trope in mid-century American literature which examines the technological disruption of the pastoral ideal landscape, brought about by industrialization of America during the 19th and 20th century. Marx identifies a major theme in literature of the nineteenth century—the dialectical tension between the "pastoral ideal in America" and the rapid and sweeping transformations wrought by machine technology. Extended into the design academy, this theme – of an artificial interruption of humans into nature - persists to a large extent in design curricula despite efforts in recent years to fuse or integrate a more holistic understanding of natural and built systems. Exploring this problem in two parallel courses with similar structure & methods, the authors and their students looked for ways that increasingly complex simulations could offer a way of better understanding both ecological and technological patterns and processes; reinforcing precision and controls where possible, while embracing indeterminacy and failure/unpredictability, and thereby coming to a greater understanding of Marx's implied and arguably false binary.

At the University of Hawai'i at Mānoa School of Architecture there is a very small bit of space in the curriculum for open electives. Those courses – intended to offer complimentary but often divergent content for either a BenvD or D.Arch programs – range considerably in variety, scope and focus area, but recently two squared together around a central topic and produced a concerted exhibition on a selection of early results. One course, *Make Your Method* dealt with the design and construction of 1:1 machines to develop logic-based principles and skills in seeing and making, and the other *Drawing Ecologies* explored methods of recognizing and anticipating natural patterns and focuses on the representation of natural materials as the change over time to attempt just this. By taking complex systems into more manageable scales, these courses are attempting to bridge young design student's interests in making and playing, with their innate sense of the fusion between nature and technology.

Rather than an explicit engagement with operation or output, these courses explored the composition and construction of tools and methods in order to put the designer, not the machine, in a higher degree of direct control. Learning outcomes included a deeper appreciation for indeterminacy, and a stronger grasp of design intention vs. reality. The authors discuss a series of key projects that challenged students to read and recreate patterns in nature while fostering design experimentation through mechanical instrumentation. Results varied widely, and the work will continue in subsequent iterations in future semesters. In the following pages, this paper will unpack key discoveries from these two courses, situating them in conversation with one another across disciplines, vocabularies and spanning extremes of the human-nature spectrum in the context of design education.

Background & Significance: coordinated courses/projects, oscillating between ecology & technology foci

The surrealist German artist Max Ernst made drawings and paintings with overlays and overlaps, repetitive lines, systematic arcs, but with something slightly errant. Something in the system shifts, and there's a degree of play, of unpredictability. Inspired by the physical properties of earth's axis, spinning at a relatively constant rate, but with a slightly unpredictable wobble. That wobble can swing the planet into a millennia-long ice age or situate us nicely in the comparatively stable climate we've known for generations. Supporting Ernst's artful geometric proposition, in the seminal book "Creative Evolution", Henri Bergson states that "the role of life is to inject some indetermination into matter. Matter is nothing more than the deposits of life." As if to say that *life* is a continuously unraveling agent or energy-force that leaves behind traces of matter. His argument shapes the idea that life (or nature) itself can be thought of as "the static residues of actions done, choices made in the past, unfolded actions already on the way to becoming something else." This sophisticated yet intuitive notion should be more fully explored in design education as a means of preparing critical thinkers, or what Richard Forman calls better "landscape detectives" in order to help them better understand what it is they're seeing. The development of formal static design and representation skills is important, but these practices of honing intuitive physical recognition skills must also be encouraged to more quickly evolve to meet the shifting needs of our programs and our students.

Figure 1. The Bewildered Planet, Max Ernst. 1942. This painting shows Ernst's fascination with geometry and his awareness of a simultaneous control, creative consciousness of a broader indeterminacy in nature.

New visual and mechanical forms and processes are therefore needed for the next generation of environmental design to advance. The same time-tested representation conventions persist to some degree of effectiveness, despite existing in a rapidly changing technological and environmental context. Those same conventions, *the Plan, Section, Elevation, etc.,* struggle to capture nuance or ambiguity, indeterminacy or the rich phenomenology of the natural world. Due to strict dimensional constraints, they also often fail to communicate dynamic or time-based qualities of the environment, and can lead to limitations in creative and technical design thinking.

As architects and landscape architects, we're asked to solve environmental "problems", often in the form of designs and the subsequent construction of what regularly amounts to static elements inserted into the land. Yet we face an ever growing and increasingly challenging set of dynamic environmental conditions beyond our control, from sea-level rise to atmospheric carbon-based pollution at a global scale. By enabling the detection of key spatial and circulatory arrangements across a variety of surfaces and conditions, the applied methods explored in the courses described in this paper help to demonstrate that those multi-layered systems in the land relentlessly change over time, accruing and self-modifying in often indeterminate ways. In practical terms, this form of anticipatory learning is arguably largely deficient in some design curricula, despite being so well-suited to contemporary landscape architecture education - a pedagogy mutually linked so directly and simultaneously to both the arts and sciences.

In contrast to some conventional environmental design classes which tend to focus more or entirely on representation and less on working with tactile media, the authors push their students to engage physical materials in pure analog to enable the sensing of physical forces in nature; learning to distinguish between intention and reality, with concrete, measurable and objective veracities to gain a greater understanding for the landscape and its inherent instability. We deliberately integrate creative and technical processes with a focus on simulations as early-integrative learning tools, rather than as post-design rationalizations.

In teaching his students about core principles of landscape ecology at Harvard's Graduate School of Design, Forman defines a model as "the simplification of a complex system to gain understanding." (Forman, 2001) His simple yet elegant definition situates two important and distinct issues addressed in this essay: tactile simplification toward tacit understanding, and the rational or logic-based diagnosis of design opportunities within complex large-scale systems. Generations of landscape architecture faculty and students have followed Forman in modifying visual and analytical processes in the design studio - breaking down and categorizing the land and its constituent materials into legible and discernable patterns for the sake of recognizing their broader relationships.

Reinforcing the necessity for early-introduction of such foundational concepts, James Corner states that "the process by which ecology and creativity speak are fundamental to the work of landscape architecture. Whether biological or imaginative, evolutionary or metaphorical, such processes are active, dynamic, and complex, each tending toward the increased differentiation, freedom and richness of a diversely interacting whole" arguing convincingly that ecological comprehension is a fundamental challenge in the training of landscape architects (Corner, 1997). His assertion crosses from the theoretical to the pragmatic. In his 1997 essay Ecology and Landscape as Agents of Creativity he illustrates that "landscape (architecture) is not only a phenomenon of analysis, but is more significantly something to be made, or designed. The landscape architect is very much interested in physically manipulating the land to reflect and express human ideas about nature and dwelling therein. After all, landscape architecture is not simply an ameliorative or restorative practice, but is more precisely a figurative and representational art." This challenge to recenter focus on the visual and sensorial qualities of landscape – with borrowed methods of simulation and synthesis from both science and art – offers a persuasive framework and underpinning for the integration of this mode of critical thinking in the design studio.

Methods: reading & simplifying complex patterns to gain understanding

The problem: design students tend to struggle with understanding complex systems. *The fix:* Breaking down and simplifying patterns through Formal mechanical instrumentation, through scalable and intuitive simulations with natural materials and measurable step-wise processes.

Understanding and invention do not always go hand in hand. To grasp ideas from a given set of existing principles is very different than building something completely new. In his essay "Toys" Roland Barthes describes (french) toys as objects which "...literally prefigure the world of adult functions…", continuing "...faced with this world of faithful and complicated objects, the child can only identify himself as owner, as user, never as creator; he does not invent the world, he uses it…". To Barthe, freedom of thought permits invention and true creativity, and is hindered by literal representation and the presence of too much complexity.

The notion of prefiguration applies to other objects and tools as well. Being objects of play and discovery, toys have an important utility that overlaps with the systems and instruments that designers work with. Like many toys, these also come with presuppositions or biases which impact their utility and ability to help us discover new concepts. Often the more complex these tools are (and are becoming) the more intense these new-found notions become. These presuppositions are tied to how these tools are seen: as specific means of production or output. Instead, by looking at them as a means of understanding, as explored through these two courses - stripping preconfigured ideas about what they do - we can invite invention and discovery back into 'play'.

Two methods were employed to help students see these instruments in a new light. In the first half of the semester students worked with simplified and deconstructed versions- mechanisms and component parts taken from the whole machine. In the second half, students were given the makings of a whole machine, but tasked developing it in such a way that they would understand how it would work but not what it would produce. In this later project phase, rather than simplifying our instruments in order to foster open-ended creativity approaching a complex instrument (or part of one) in a new way can be just as effective at reinforcing deeper understanding and even rudimentary invention. In other words, if we are able to unsee the *doll as a doll*, we permit greater awareness and thus creativity, perhaps even with more complex objects and eventually of systems.

Like toys, or tools, beginning design students often perceive machines as *things* rather than as parts of larger systems, or as systems unto themselves. The projects for these parallel courses aimed at this cognitive dissonance. Of the limitations of *thing-seeing*, and of promoting *systems-seeing*. Both were organized as a means of simplifying and gaining a greater understanding of complex systems, and in both courses, students were asked to investigate familiar instruments of design and in nature. Simple movements and relationships between parts such as gear reductions and motion control were used to interrogate interactions between corresponding or conflicting forces. Simple machines are relatively easy to understand and to describe generally, however their complexity is revealed as students began drawing and building them. Early unfounded assumptions about what they could do quickly with basic materials disappeared as they dug deeper into making the machines or natural experiments work in replicable and controlled ways. Similarly, when tracing the movements of an incoming tide, students assumed the water would rise and fall consistently. However, depending on the scale of optics applied, they quickly observed just how indeterminate, unpredictable and endlessly scalable that motion can be.

In class, the students were asked to consider *"how does this (it) work?",* rather than *'what can you do with it*?". Placing less emphasis on future application, than on a basic and tacit understanding of the inherent logics of the given patterns and processes under study. Students first recorded visual notes in the field or in studio, observing their experiments unfold, and documenting discoveries. Constructing simple mechanical movements prior to developing more complex "machines" students were exposed to the challenges of integrating previously studied movements at larger measurements. Due to the physical/analogue qualities of the projects, a tactile and richer understanding of inner workings for each test was made possible. As failures developed, students were able to trace problems back to their origins, and judge the impacts and implications of the specific issues. New knowledge of optimum geometries, forces and physical attributes for the experiments was rolled into subsequent iterations.

Despite the universality and ubiquity of mechanical design technology embedded in architecture over the last 50 years, knowledge of these systems often remains in the hands of consultants and other designers. To a large extent, the documentation and study of complex dynamic natural systems also often falls outside the purview of building-architects, and are instead addressed by supplemental consultants who function through a more methodical approach to non-static structures and environmental processes. From constructing simple/complex machines, to lofting/tracing water or yeast/dough patterns, these two courses deliberately focused on these classical limitations of the field. Integrating built and natural systems/motions together, students learned that it became increasingly more difficult to predict results. (Figure 2, 3.) It can be taken for granted that additive interactions and variables present a greater challenge. Students know a little bit about how the test or the machine is *supposed* to work, they've seen the tide come in and go out, they've watched an engine start up, but they generally struggle to predict outcomes the more complicated the system. (Figure 4.)

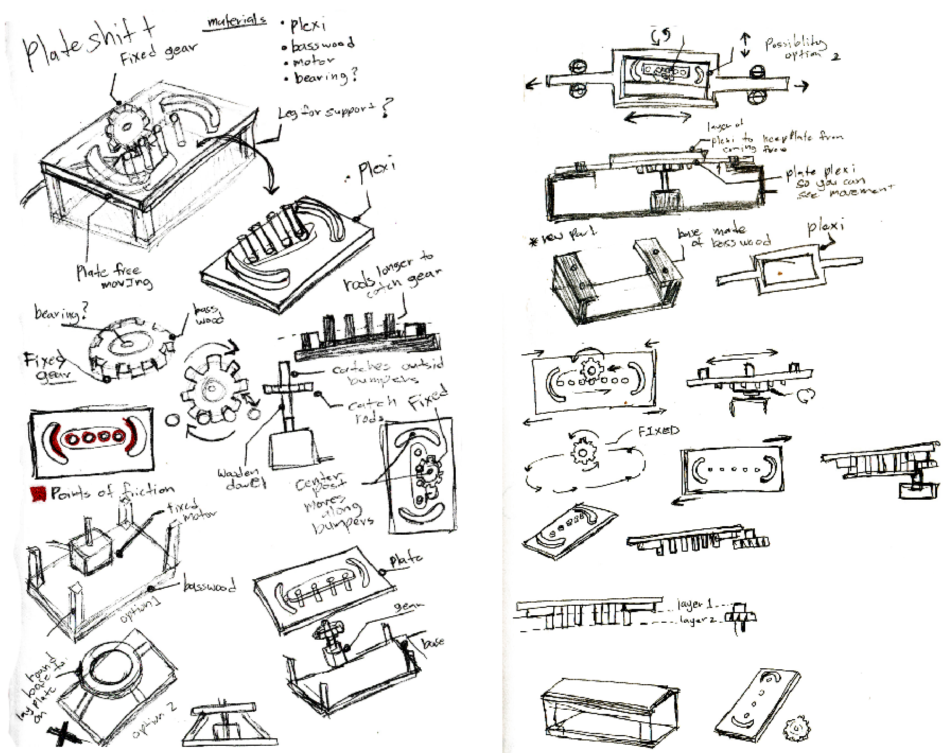

Figure 2. Studies of simple and recognizable mechanisms with a single motion. These early conceptual sketches show an understanding of key features including physical controls and constructions.

Figure 3. Photograph of a selection of increasingly complex machines on a student's desk.

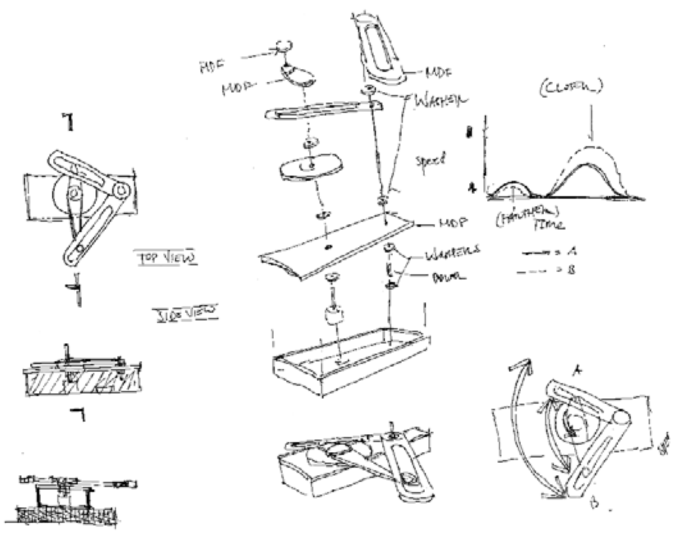

Figure 4. An early conceptual sketch study for a more complex machine. As the semester progressed, students demonstrated an increased awareness of potential combinations of complementary actions and operations.

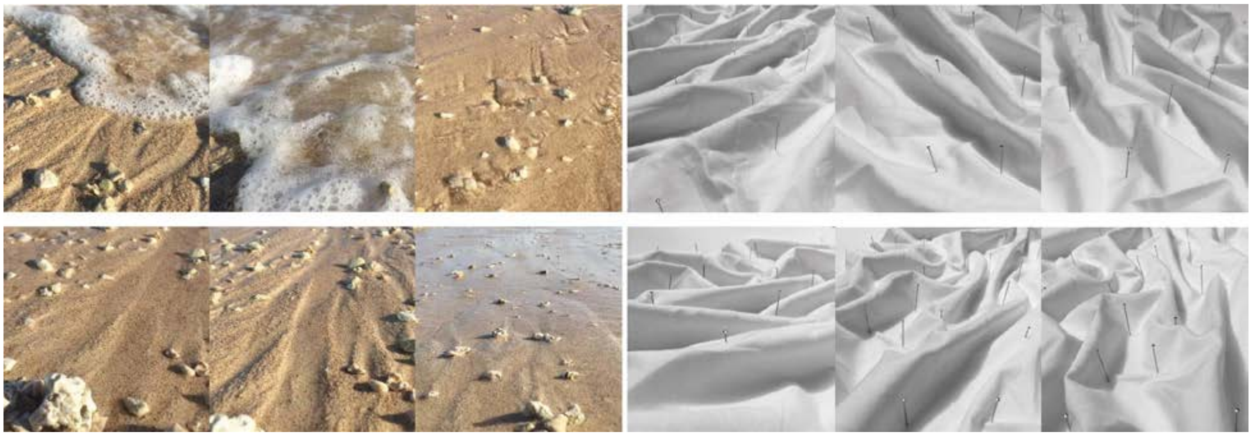

Figure 5. Tidal studies, with multiple abstracted iterations using cloth and pins at control points. The studies demonstrate an inherent complexity to the forms that result from water scouring a sand surface as the tide pushes material in and out in a liminal/measurable zone.

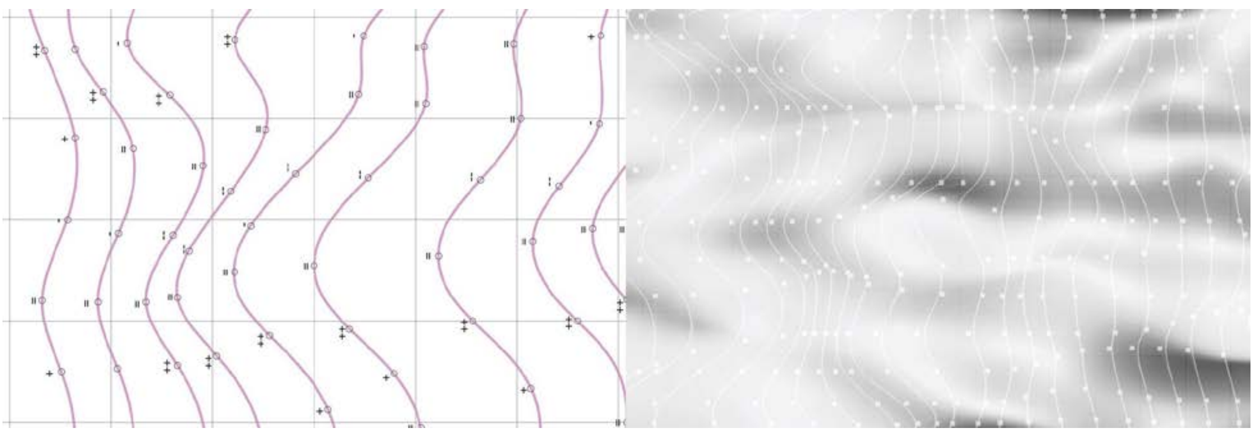

Figure 6. Tidal studies, following photographs at the beach and abstraction with cloth, using basic lofting calculus. Similar to curve-making common to classic boat-building, these lofted forms are transferred from a 2-dimensional measurable surface to a more complex 3-dimensional terrain/network.

Figure 7. Yeast and dough assemblages, essentially an unbaked bread recipe. Students three controlled experiments. Left. Lateral expansion within a fixed container. Middle. Vertical volumetric expansion through a fixed container. Right: Compression and tension between two surfaces, with the resulting forms becoming highly unpredictable but optimal.

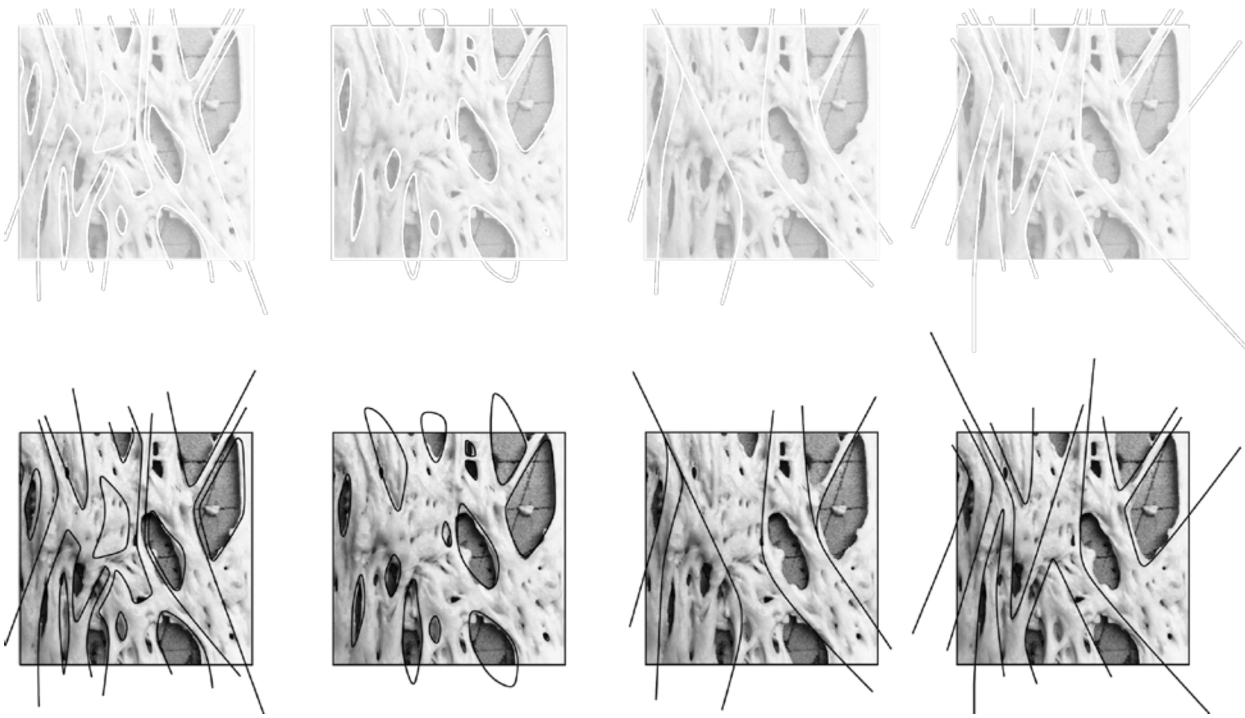

Figure 8. Sets of line-drawings/diagrams, tracing key contours of the experiments to gain an understanding of how the material is shaped and self-modified over time.

Conclusions: scalability/larger implications, attitudes/assumptions and future outlook

"Their ears are serenaded with the perpetual murmur of brooks, and the thorow-base which the wind plays, when it wantons through the trees; the merry birds too, join their pleasing notes to this ritual consort, especially the mock-birds, who love society so well, that whenever they see mankind, they will perch upon a twigg very near them, and sing the sweetest airs in the world." - Robert Beverley.

This elegant quote from Beverley's History and Present State of Virginia 1705, excerpted from Machine in the Garden sums up the potential depth of beauty in these two seemingly convergent factors, ecology and technology, or humanity and the natural, coming into view through human exchange and interaction. As this paper has described, by testing and probing first-hand with physical, non-representational material including water, soil, plants, bacteria and yeast in Drawing Ecologies, and with the design and construction of simple-to-complex machines in Make Your Method, students can learn to more quickly recognize the fundamental dynamic patterns, processes and mechanics of a range of natural and built systems and potentially gain a greater appreciation for their inherent dynamics and indeterminacy.

These methods enable a replicable form of open-ended exploration, and due to the infinitely-scalable nature of the mediums used, provides corollaries with and reflective discoveries of material arrangements in much larger systems. Slowing down and taking the necessary time to learn a few of nature's hard-earned secrets proves worth the investment. That longer duration, combined with a sharpened narrow focus on the mechanics and the nuanced patterns in nature certainly reward scrutiny. Not surprisingly, the greater mysteries of nature remain. Beyond a few days forecast, in the year 2018 it's still basically impossible to predict the weather.

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