CHANGE / NO CHANGE: EMPIRICISM IN THE MAKING

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INTRODUCTION

Change in environmental pressures upon the building industry and on the architecture profession raise questions about how we teach environmental responsibility in the discipline of architecture. Given all that is offered with the digital tools available to the architecture and engineering professions, we explore where and how *empirical learning* might be effective in enriching the acquisition of digital analyses and modeling skills.

Additionally, the embodiment of the architect's increasing responsibility to the built world as it relates to environmental impact inspires change in the form of working toward integrative, or holistic, approaches to design and building. Consequently, how we teach environmental technologies and studio proposes that we employ a like-minded, collaborative model.

This paper focuses on three interrelated pedagogical approaches to environmental concerns and the designer's response to it: first, how *experience can form the basis for technical knowledge* and in turn how *technical knowledge is enriched by the poetic qualities of experience*; second, the *act of making* and the *phenomena of the made object*; and third, *design as empirical inquiry*.

The method for teaching based in experience, making, and empirical inquiry that we propose is most salient to beginning undergraduate studies in architecture. By virtue of physicality and scale, students are better able to *experience* the construction and *perceive* the space, light, and tectonic processes therein. We believe this method can provide an internalized understanding of passive design principles, responsive strategies, and site-specific design concepts. In turn, that understanding forms a foundation for comprehending active technologies and builds towards more advanced quantitative methods and abstract models.[1]

The student work we present here is the product of an integrated methodology of teaching, one of deliberate coordination and horizontal connections between the technology survey course and the design studio.[2] In generating collaborative projects that bridge technology lecture and studio, students are more fully engaged in learning and are able to test environmental principles using their minds and hands. We find that this pedagogical structure as it relates to sustainability[3], and the production of environmentally responsive performative work, requires a level of thinking that our students are most able to attain when engaged in the act of making.

Through a discussion of three projects, the Sanctuary of Light, Big Models (detailed façade precedent models writ large and *very* physical), and Weather Follies (sculptural climate data instruments installed on campus), we explore the relationship between thought, making and things made.

CHANGE

Environmental change is increasingly processed through new digital technologies: from energy modeling and daylighting tools, design modeling, to Building Information Modeling (BIM) and drafting tools. One can if desired, rely solely on these methods of inquiry and representation. However, we observe a disconnect in student comprehension when they are exposed to these tools before having directly experienced and measured climate phenomena for themselves. Some students struggle to internalize the implications of the output from these tools. So we ask if students, by working in a direct medium where eye, body and mind are all directly engaged, gain a fuller learning experience? Rather than being held as a contradiction or as a dated mode of pedagogy, does empirical learning actually support the mastery of more abstract modeling tools?

Concurrently, an increasingly global view of climate and diminishing natural resources informs students' understanding of the environment. Additional considerations of climate and culture on a global scale challenge them to understand sustainability's role in a universal context. While a global perspective is important, asking students to understand distant climatalogical issues before they have mastered basic principles of environment and energy seems premature. Instead, we ask whether students, before they tackle abstract (or overwhelming) global concerns, should inform their understanding of global issues by beginning with the immediate context. The observation of their surroundings and the sensory experience of (local weather) phenomena come into analytical focus and build to deep comprehension. This in turn, can expand to address the larger global context.

"NO CHANGE": EMPIRICISM IN THE MAKING

Inspired by Richard Sennett and Tim Ingold's writings on the craftsman and the act of making, we begin with the premise that providing a tactile understanding of phenomena, and experimentation through making, together form an avenue for comprehending the built world. Richard Sennett writes in his book *The Craftsman*, "The craftsman represents the special human condition of being *engaged*".[4] As Sennett claims, humans have an "impulse to make," to use the intimate connection between mind and hand, which can relate directly to learning and the practice of architecture. Anthropologist Tim Ingold describes the act of making as "improvisational mastery," [5] where each stroke of the craftsperson contributes to mastery and is a foundation for the next. If that thinking is extended to student work, and we consider the craftsperson as a member of the same community as the modern designer, we can see that there is a clear connection between making and understanding.

The sub-title "No Change" is deliberately overstated. The implication is that even while technology continues to produce new methods for processing environmental change, the sensory experience of light, heat and air remain much the same as they have always been. However, as discussed above, we do not propose empirical learning in contrast to, or at the exclusion of, digital tools, but rather that the two can *mutually support* one another. More precisely, for beginning design students, direct engagement with sun, wind and light through their senses early in their academic career forms a firm foundation on which to build mastery of more sophisticated tools and analyses.

The student work that we discuss in the following section demonstrates a threefold pedagogical approach. While presented separately, these three principles are in fact intertwined and interrelated.

Experience as the basis for technical knowledge; Technical knowledge enriched by the experiential qualities of the poetic

Many of the exercises described below are designed to build upon that which students already know from experience, where their innate understanding forms the basis for technical knowledge. With concepts pertaining to daylight, solar orientation, wind and rain, students draw on a lifetime of experience that can be brought forward from a sub-conscious level of understanding and ordered systematically. Thereafter the effort comes full circle: having worked to translate sensory experiments with natural phenomena into something more systematic, the students become increasingly aware that technical knowledge need not be isolated. To the contrary, it is enriched by the poetic qualities of experience, and can be further explored in larger conceptual ideas.

The act of making and the phenomena of made objects

We begin with making as a process that takes students on a trajectory of exploration: from testing, to calibration, to comprehension. Students derive direct feedback from making; making demands close inspection, and is unforgiving of superficial efforts. The completed objects reveal the level of care taken by the craftsperson. Finally, the finished artifact holds lessons as well. We have a visceral reaction to them as objects in and of themselves on a number of levels, from their size, to their material, to the number of parts, to how the parts are connected.

Design as empirical inquiry

Finally, students proceed through a more deliberate and systematic experimentation where empirical inquiry forms the basis of design. Empirical comprehension is the sinuous tissue that binds seemingly disparate pieces of knowledge. The exercises provide students with opportunities to experiment and test their results against abstract principles.

THREE PEDAGOGICAL EXPERIMENTS

The three pedagogical experiments presented here are assigned during the early part of the undergraduate architectural sequence. The "Sanctuary of Light" and the 'Big Models" are projects completed by the students during the second semester of second year; they undertake "The Weather Follies" in first semester of third year. For the sake of clarity we have assigned each of the three principles above to one of the experiments described below. However, in actuality, all three pedagogical experiments draw on all three principles, and the three projects build upon each other, with increasing complexity and scope.[6]

Sanctuary of Light: Experience as the basis for technical knowledge; Technical knowledge enriched by the experiential qualities of the poetic

The Sanctuary of Light has a two-part learning objective: to expand and enrich students' grasp in manipulating natural light for effective passive design by challenging them to consider light as a *conceptual building material* that forms, and is formed by poetic and varying spaces.[7] At this point in the curriculum, students are first introduced to the meaning of environmental stewardship and how it impacts the field of architecture in their second year. In the lecture sequence, students are introduced to *qualitative* climate responsive design concepts, focusing specifically on site and orientation, and techniques of passive design, such as controlling daylight, solar heat gain and natural ventilation. In the studio sequence, the Sanctuary of Light is the students' first project on a real site. The three-sided site requires students to contend with issues of orientation, building massing and envelope for the first time. The program, a "space for the contemplation of light and passage of time,"[8] further calls for students to work with light as a *conceptual* and *ephemeral* building material, and to think beyond the technical requirements for well-lit

Figures 1a, b and c: Light Instruments, second year studio, spring 2012. (From top: Alex Russo, Rachel Mulcahy, Leslie DeLeon.)

spaces to a more poetic experience (and even metaphysical meaning) of how light in space varies with time.

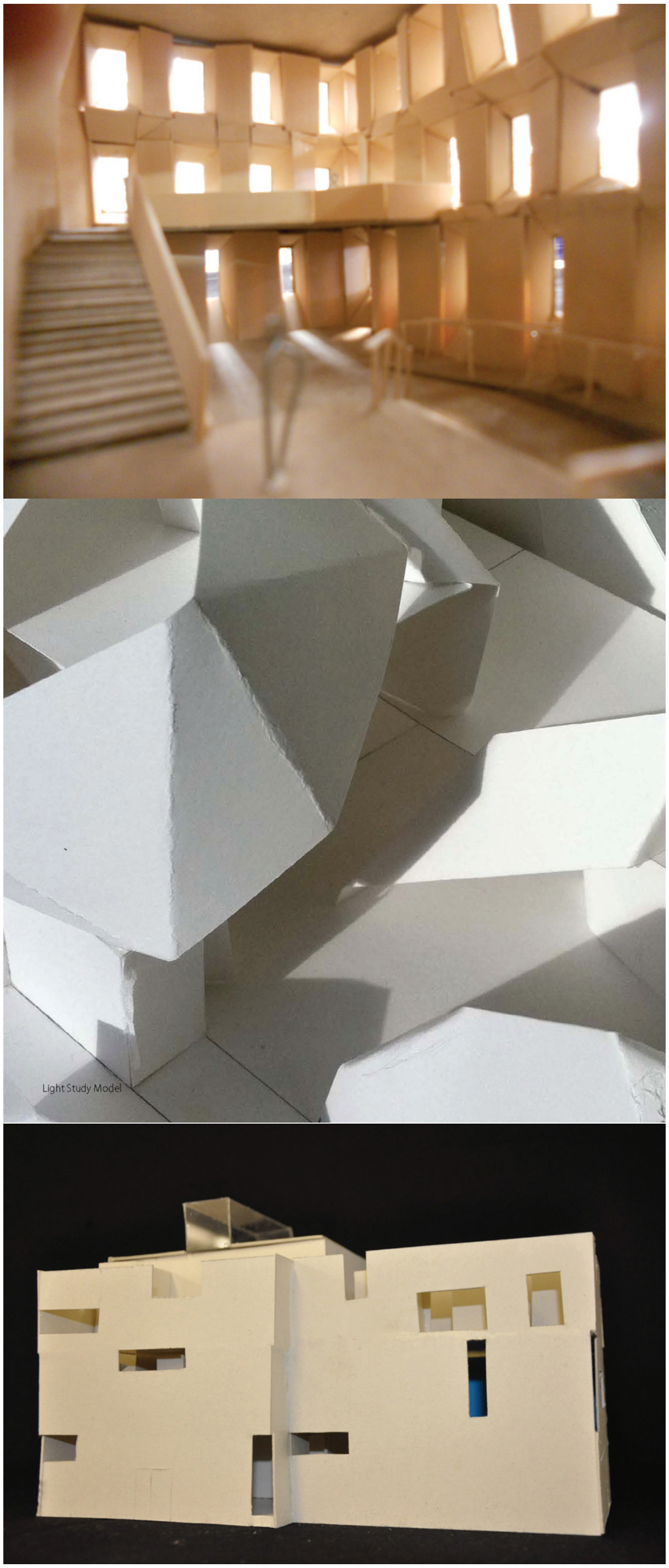
We begin with an exercise written with the assumption that experiential understanding can form the basis of technical knowledge, by asking students to experiment with "instruments for light".[9] The students cast three "light instruments" out of plaster. Each light instrument has to enclose a space and contain an opening or openings that let light into that space and manipulate the light differently. Types of light we ask them to capture include direct, indirect, filtered and diffuse light. The students build shields for their light instruments, to block the light that seeps around the model, so that they can really see how the openings are illuminated. They then photograph their models in studio under artificial lights or bring them to the site to test them under natural light and under different orientations. In this way, students build on what they already know from experience -- that the angle and intensity of the sun varies with the time of day and with orientation. They enrich their innate understanding through empirical testing of phenomena, and correlate intent and outcome through making.

Students build up their technical knowledge of how light behaves when they see the light instruments lit from within, and rotate these objects in their hands while standing on the actual site. Through the unself-conscious creation of these plaster casts, the students produce often unintended but compellingly lit spaces of varying kinds. These early exercises form the springboard for their design projects. Equipped now with a technical understanding of how spaces are lit, the students are able to further meditate on the often poetic results of their experimental light instruments, and develop larger concepts of light, illumination and enlightenment upon which their designs for a sanctuary space develop.

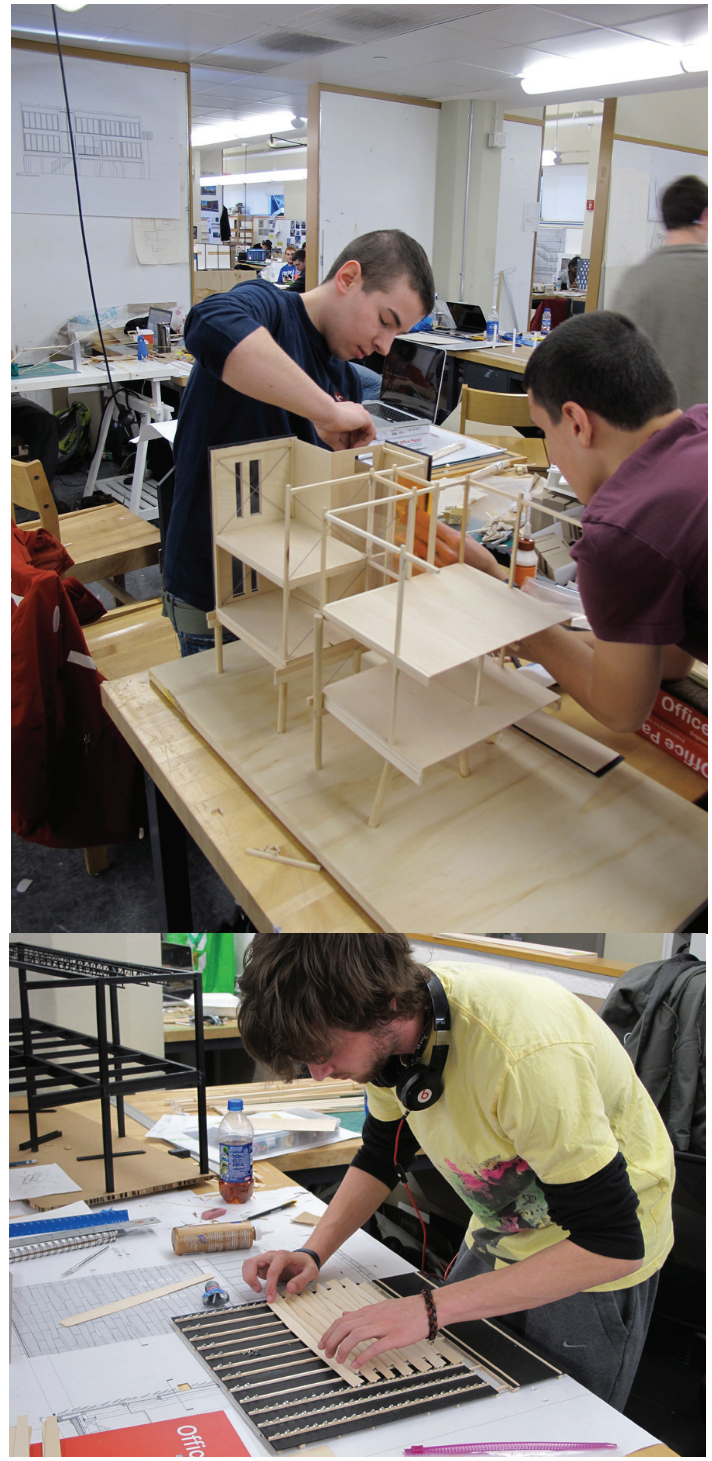
Big Models: The act of making and the phenomena of made objects

Working from a selection of built works, students break into groups of three, to research, analyze and reconstruct a building envelope first in drawing, then as large-scale models of their chosen building. The façade model or "Big Model" is the culmination of this experiment. The act of making allows for a deeper examination of the transformation of an abstract idea to the construction of a surface: idea to form, form to material, material to structure. Specifically, model making acts as a powerful tool for a deeper understanding of tectonic language as it informs decision-making in design processes.

The focus of the Big Models assignment centers on the building enclosure and follows directly after the Sanctuary of Light. The assignment has two parallel learning outcomes with regard to building enclosure. First for students to identify, model and then (eventually) to compose the components of enclosure assemblies in their own designs. Second, for students, through research and analysis, to verbally and visually explain the performance of the building envelope as a carefully composed light, thermal, and moisture boundary.



Figures 2a, b and c: final sanctuary of light, second year studio, spring 2012. (From top: Alex Russo, Rachel Mulcahy, Leslie DeLeon.)



Figures 3a, b: Big Models in progress, spring 2012.

Precedents are drawn from built projects that employ innovative enclosure assemblies and performance. Where possible, the precedents are local examples that students can visit, such as the Isabella Stewart Gardner Museum Extension in Boston by the Renzo Piano Building Workshop, the MIT Media Lab by Maki and Associates, the Genzyme Center by Benisch Arkitecten both in Cambridge, and the Harry Parker Boathouse in Brighton by local architects Anmahian Winton. Precedents with sophisticated environmentally responsive strategies drawn from further afield include the New York Times Building in Manhattan also by the Renzo Piano Building Workshop, the Swiss Embassy Residences by Stephen Holl Architects in Washington D.C. and the Kunsthaus Bregenz by Peter Zumthor, among others.

Figure 3c. Completed Big Models, spring 2011.

The exercise takes the students through a series of steps. Beginning with observation, the façade is broken down conceptually into its attendant parts. Through a process of translation it is then reconstituted as a series of (re)interpretative drawings and fragment models, before being built, literally, as a physical model. Students begin by studying some of the formal qualities of the façade in elevation. They then shift to the section to research and diagram the assembly and performance of the enclosure. From there they draw the wall section at the final required scale, taking care to look carefully at the layers of the building enclosure, how the building meets the ground, and how the wall and roof connect. Finally the students begin the large detail-scale models, where the reality that how façade and structure are assembled is of paramount importance to both the function and aesthetics of a building. In making the models, students have to make careful decisions regarding component sizes, material, sequence of construction, craft and how to support the model. The benefits of building at a large scale are that the realities of scale, material depth and weight, of connections and of how to support all of the above require rigor in their own right.

When the students' work is complete, the phenomena of the made objects continue to engage the observer. Like silent sentinels, the completed Big Models are strangely compelling precisely because of their *thing-ness*. They seduce through their outsized presence and the contrast between their size and the intricate level of detail they possess. There is a visceral reaction that only a large model can create in an observer, and there is a minimum threshold above which one begins to imagine inhabiting a model. The models are specific to the human body by a series of measures: they can be no larger than can be completed (and carried) by three individuals in a set number of days, no smaller than can be worked on by those three individuals at the same time, and the smallest pieces are those that can still be precisely worked by the human hand. The painstaking efforts of the model makers are manifest in the finished product. The relationship between the model and the maker is apparent to the observer. We conclude that there must be a mode of learning that is achieved through a phenomenology of scale, the intimacy of the miniature and the enduring fascination craft holds for us.[10]

The Weather Follies: Design as Empirical Inquiry

Our evolving perspective on how foundation students are able to experience and record environmental phenomena provides a springboard into deeper applied learning methods. Empirical inquiry is the hallmark of the technology sequence in their Junior year. The primary intent of this project is to find the basis of design within the realm of sustainability, i.e., the role of climate responsive, performative making in our environment. Phenomena of weather and climate become a point of departure for quantitative analysis. The students start with what is immediate: they directly interface with the microclimate of the Wentworth campus as a way of understanding larger climatic conditions. The students 'invent' ways of observing, recording, then representing their findings graphically and as accurately as possible.

As with the preceding projects, students are enrolled concurrently in studio and a technology lecture course. Specifically, we assign a design-build project to the third year students in the lecture class. We research modes of environmentally responsible thinking through making. Students identify and capture, in a scientific way, phenomena that are ineffable but ever-present and ever-changing in our climate. The students experiment with the impact of the environment on built structures and vice versa. The final product, the "Weather Follies," marries the collection of subjective data (through the senses) to the design of objective measuring tools and instruments.

The Weather Follies are temporary interventions sited around campus to record wind, sun angles, precipitation, humidity, surface and diurnal temperature over one semester. Students are required to:

- use recycled and/or found materials;
- calculate embodied energy of materials used;
- reduce embodied energy and material waste;
- work within 24"x24" to disassemble or collapse for storage, and consider aspects of disassembly and storage as part of the project.

When exposed to their specific site conditions, the Weather Follies have to function fully as data collection devices. Inherent in the project is the idea that design and performance are inextricably linked. In essence, students are asked to act as designers, engineers and fabricators.

Some of the follies measure local conditions, while others record more universal concerns, such as solar geometry as tied to our larger climate and latitude. (In the spirit of experimentation, students experience mixed results, contrary to their expectations, in both the performance of their follies, and in their anticipated climate mapping data.[11])

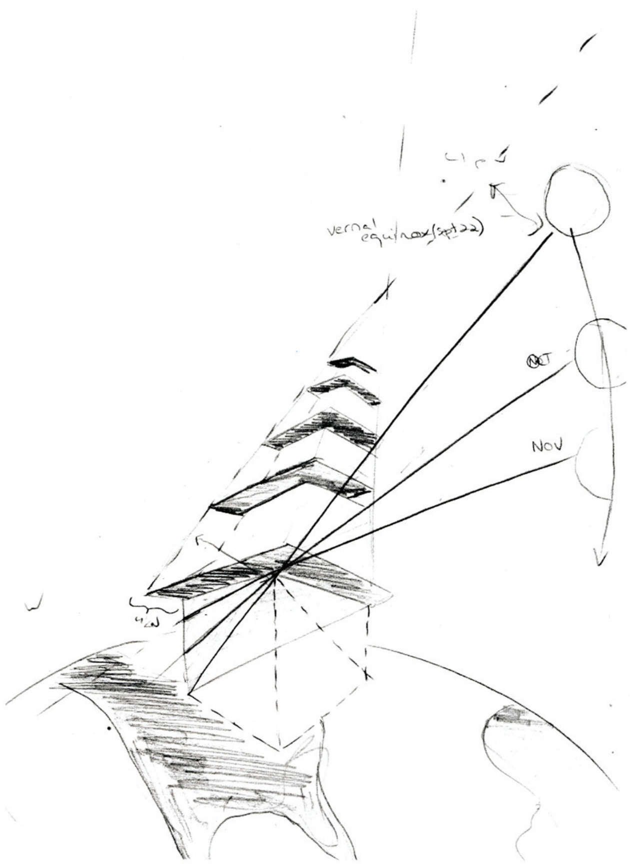


Figure 4. Weather Follies sun angle study, fall 2008.

Once the project is officially launched, the follies become a part of the larger campus experience. They testify to particular student accomplishment, but, in their 'finished' state, as tools, are still works in progress. The scale of each varies widely, and the level of engagement from observers seems linked to the follies as figures; regardless, their physicality invites interaction and reaction. The follies pose as largely still, but animated, figures as they measure outdoor phenomena regardless of weather or time of day. By *design,* they respond to the weather and are ever-changing, and therefore engaging.

Figure 5. Folly's inscribed sun angles, fall 2008.

Empirical investigation begins at the outset of the project, when students analyze and choose their sites before beginning design, and continues throughout. Working through problems of folly construction requires many modifications to their designs. Many of the students conclude that the richest part of their experience in this process is finally seeing and touching what they had imagined their designs to be.

CONCLUSION:

Even with technological advances we believe that when responding to environmental challenges, architectural education continues to need both *intellectual* and *tactile* processes. We propose **experience**, **making**, and **empirical inquiry** as effective modes of learning, and useful precursors to abstract (digital) modeling. In particular architecture students in foundation benefit from this type of introduction to principles of climatically responsive design. Bjarke Ingels has paraphrased the following regarding learning: "What I'm told, I'll forget; what I'm shown, I might remember; what I make, I'll know well."[12] Investigations such as the projects described above bear witness to the empirical learning process. The Light Instruments (with the Sanctuary of Light), the Big Models and the Weather Follies are each premised on these three pedagogical principles.

First, as we experiment with how experience can become a basis for technical knowledge, and the potential for the enrichment of technical knowledge with experiential qualities of the poetic; the problem lies in students' abilities to understand their perceptions of space, light, and environmental factors in a systematic manner in order to then use them intelligently. We hope for students to fully feel the potential of poetic acts, and to aspire to connect both the comfort of a building and the beauty of it simultaneously in a singular architectural gesture. How this is most clearly accomplished relies on leaps of faith grounded in a progression of cause and effect investigations.

Second, we test the scope for the act of making, and learning from the made object as a path to deeper comprehension. Tim Ingold, whom we refer to earlier argues that, with the carpenter sawing repeatedly, "No two strokes of the saw are quite alike, and each – far from following its predecessors like beads on a string – grows out of the one before and prepares for the next."[13] This returns to Sennett's ideas about craftsmanship: continuous adaptation in mastering a skill is rewarded by a feeling of accomplishment. Mastery of craft is one reward of the process; the power of the actual constructed piece (or, the phenomena of the made object) is another. The persistence of the completed objects as embodied process, and their built presence hold visceral lessons for the observer. To consider their *thing-ness,* the made figures are undeniably visual and tactile evidence of deep student engagement. The finished pieces are the product of team efforts in calibrating details and connecting with the physicality of their work.

This ties in with our third and final precept. Design as empirical inquiry becomes applied investigation that speaks to the much broader philosophy that architecture, in its myriad incarnations -- practice, teaching, learning – depends on empiricism. Otherwise, *pedagogical change* in response to *environmental change* would be limited: how can we adapt without a deeper understanding of the basics through making? Art and science both rely on experimentation and spontaneous adaptation based on what is observed, as does architecture. Ingold argues that, "The draughtswoman with her pencil, just like the carpenter with his saw, must feel where she is going...the drawn line does not connect predetermined points in sequence but 'launches forth' from its tip, leaving a trail behind it…it has no end point, for one can never tell when a drawing is finished."[14] This speaks to the spontaneity of creating as supported by empirical feedback that furthers the next gesture of the pencil.

We propose that there is a similar interrelationship, between planning (anticipating) and improvising ('launching forth') that takes hold in architectural learning. Iteration and repetition are key; and so is crafting, as it provides feedback that informs the next move. Generating, building and constantly calibrating ideas *physically,* ties to curiosity. Curiosity leads to investment in making, and making leads to engagement in the made. Perhaps couched as 'learning how to learn', acquiring the skills of empiricists broaden our perception of what is actually possible. It speaks to the embodiment of knowledge and the mastery of needed skill. The student is the empirical scientist, honing tools in order to both understand, and master, ideas in the making.

Figure 6. McKenna Kendall and her new "Big Model" dollhouse.

ENDNOTES

1 Students are introduced to digital analysis tools in the first semester of their Junior year. Ecotect, SketchUp with V-Ray, with other energy analysis and daylighting tools are used in workshop format, and incorporated into studio projects.

2 In their second and third years (in addition to other courses), all students are typically enrolled in both a technology survey lecture course and a design studio. The lecture course is typically team taught, with one of the team members acting as the course coordinator. The students are divided into 9-10 studio groups, each with their own instructors. Again there is a single coordinator for studio, who is also responsible for generating the syllabus and project descriptions. Our lecture co-instructors include Manuel Delgado, Patricia Kendall, Tim Nistler, Mark Pasnik and Aaron Weinert. Patricia Kendall also served as studio coordinator in the spring of 2010 when precursors to the light instrument and façade analysis exercises shown here were given. Finally, Elizabeth Gibb conducted an earlier exercise in façade analysis in a fourth year course before it was shifted to second year. The authors would like to recognize the contributions of our colleagues in the conception and development of many of the ideas and exercises presented here.

3 The use of the terms "sustainability" and "green" as descriptions of possible solutions to global warming are somewhat insufficient. We try to broaden the scope of that term with the alternatives, 'environmental stewardship' or 'environmental responsibility'. This terminology will be used throughout. At Wentworth, we do not

teach "sustainability" as a separate course, but address it as a fundamental part of design throughout the curriculum.

4 Richard Sennett, *The Craftsman* (New Haven and London: Yale University Press, 2008), 20.

5 Tim Ingold, *Being Alive: Essays on Movement, Knowledge and Description* (London and New York: Routledge) 216-217.

6 The Sanctuary of Light and the Big Models were largely developed while Ingrid Strong and Jennifer Lee Michaliszyn served as the coordinators of the lecture and studio courses respectively, in the spring semesters of 2011 and 2012. We also served as co-instructors for the courses the other was coordinating. A third project, the Weather Follies, was written and conducted by Ingrid Strong in the Fall of 2008, in the workshop as a part of the third year technology sequence. While last in the student educational sequence, the Weather Follies project was the earliest experiment.

7 With thanks to Mark Pasnik and Patricia Kendall who wrote assignments that preceded the Sanctuary of Light. The use of light as a "conceptual building material" has been a consistent thread inherited from their project descriptions.

8 Conceptually, the program was a contemplative space that allows users to reflect or meditate on the ephemeral qualities of light and the passage of time. In more prosaic terms, the program was a place for memorial services and an associated mausoleum for the interment of cremated remains.

9 The Light Instrument exercise was adapted from an exercise originally written by Patricia Kendall. The main change was from additive planar models to the introduction of volumetric plaster casts to encourage students to work in subtractive manner, and to consider the composition of negative space.

10 The appearance of these "big models" in the department generated an excitement and enthusiasm that we had not anticipated. The students have begun to compete informally where each class tries to outdo the efforts of the year prior, and the best models that are selected for display are always a popular stop on tours of the department. In an effort to support some material reuse, the big models have gone on to some varied second lives. Many remain on display in the department, while others have been exhibited at their real world counterparts, and some live on as educational tools to benefit the next generation:

11 One team of students initially observed an urban wind tunnel (between two buildings). At its most powerful, the students registered a breeze. They discovered that the proportion of surrounding buildings to the space in between them was not extreme enough to support consistently strong winds. Graphing data allowed students to measure climate trends and deviations. Perhaps the most creative form of graphing was invented by a team recording sun angles. Through the course of the fall, they inscribed shadow lines directly onto the folly itself. This folly ultimately became three tools: the made instrument, the measuring instrument, and the recording instrument. The lines drawn each day on the folly became a living artifact of sorts, recording not just the changing angles of the sun through the fall season, but also capturing the hand at work.

12 Bjarke Ingels, keynote address, American Collegiate Schools of Architecture International Conference, Barcelona, Spain, 2012.

13 Ingold, *Being Alive,* 216-217.

14 Ingold, *Being Alive*, 217.