Form, but Not Style
Seeking a Climate-Responsive Design Pedagogy

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"Sustainable" architecture is on its way out. Five years ago, "sustainability" was a buzzword that by now has been so overused, it seems inevitable that it would go the way of the many "-isms" of the post-modern age.

What are we left with? Has the collective consciousness of the architecture profession changed in any measurable way with all this emphasis on ecology and design?

While the usage of the word may be on the wane, the ideas still hold considerable currency in design schools and architecture firms across the country. Ten years ago, ecological issues were seldom addressed in design studios of architecture schools, and were mostly relegated to building technology classes – if discussed at all. Yet a recent survey of design schools by *Metropolis* magazine reveals that 66% of them teach studios that "engage students in the investigation of environmental or ecological issues," and 93% agree that "sustainability is relevant" to their design curriculum.[1]

An informal survey of student work on the websites of our nation's top design schools reveals the issue of ecology in some form or other is very much on the minds of our students.[2] In the professional world, we now have a growing body of work – fully realized buildings – that at some level are attempting to reconcile the impact of construction with the earth and its resources. While the majority of the truly innovative and rigorous work is happening in Asia (mostly Japan), Australia and Europe, there are more and more worthy examples in the U.S.

Star architects (such as Thom Mayne, Richard Meier and Rafael Vinoly) and corporate firms (including SOM, KPF, Perkins & Will, Gensler and RTKL, to name a few) are promoting their concern for the environment, and investing in training for their staff. To date more than 5,000 individuals (architects and others) have been certified by the U.S. Green Building Council as L.E.E.D. certified professionals.[3] The result is we are a better-informed profession. More and more designers are becoming aware of the real impact that architecture has on the environment. As our collective sophistication increases, the profession is recognizing that to "green" a building, it takes more than specifying certified sustainable harvested wood products. Architects are figuring out that it requires a complex and fully integrated design process to make real progress.

The facts and figures continue to be daunting. The building industry is largely responsible for 48% of energy consumption in this country,[4] and generates more than 136 million tons of landfill waste per year – which translates into 2.8 pounds per person, per day.[5]

Clients are more aware of this information, and are looking for "green" or "sustainable" buildings – even if they don't exactly know what that means. Besides architecture and engineering firms, dozens of major corporations have joined the U.S. Green Building Council, including the Ford Motor Company, Bank of America, Starbucks, Turner Construction and Johnson Controls.[6] Clients are asking for better buildings, professionals are asking for better-informed graduates, and students are asking for better ecologically based coursework.

"Sustainability" as a catch phrase may be on its way out, but I believe these indicators give us reason to be optimistic that the architecture of the future will be more energy efficient, ecologically aware, and climate responsive.

Fortunately, the issues have not become too closely identified with a specific formal strategy – other than the general overuse of wood slatted louver walls, (thanks to the important work of Glenn Murcutt and Renzo Piano). The passive design movement of the 1970's and early 1980's may have been killed by the elimination of renewable energy tax incentives, but the boxy sheds and pitched roofs with solar panels became passé because the formulaic implications for building form had a limited life span.

Today, concern for the environment can be expressed in blobs,[7] boxes,[8] or pediments.[9] Ecology not longer equals style.

We know buildings will look different ten years from now, so how should we teach ecology in design studio without imposing formal dogma?

The answer is in acknowledging that while ecology doesn't imply a specific "style," there are some enduring principles that can be used to shape a building's form. Design should not be too closely aligned with any method of form making. Rather, it should be informed by passive and climate responsive design principles, which can influence a building's form, without dictating it.

The building can look like anything, but we can teach students about how a building responds to natural forces in a way that can enrich their education. It is the designer's choice to fully express or suppress the reading of a building as climate responsive, but it is increasingly important for our students to know how to achieve the baseline of minimal environmental impact, thermal efficiency and effective daylighting.

The literature of the 70's passive design movement, with its emphasis on solar orientation and ventilation, is a good place to start. Ed Mazria's writings[10] of that era are still relevant, even if the resulting architecture looks different than the buildings in those publications. In addition, there is a lot of newer literature and websites that serve as great teaching tools. The second edition of G.Z. Brown's and Mark DeKay's "Sun, Wind and Light" is particular favorite of mine.

Yet books and websites are not enough. Students need help intelligently integrating these ideas into their design work. Initial attempts by young designers tend to demonstrate a very loose understanding of how light, heat, air and water actually work with buildings. They also tend to be too literal or overly referential.

I have been grappling with these issues in design studios for a few years, with varying degrees of success. While I am cautious of being exclusively identified as the "environmental" professor, I have generally emphasized ecology and climate in my studio project assignments – sometimes implicitly and often quite explicitly.

The remainder of this paper briefly outlines three projects that seem to have been successful in helping my students understand the interaction between natural forces and architecture.

DWELLING

For the first five weeks of a housing design studio, I assigned my students a dwelling that could not utilize electricity or fossil fuels of any kind. By pushing the exercise to it's logical extreme, the students were forced to legitimately address and understand how nature and buildings interact. I didn't tell them that the dwelling had to be comfortable – or even livable. I wanted them to decide what was important to them, and formulate their own agenda. I strictly constrained the overall volume of the design to a 12'-0" x 24'-0" x 24'-0" box, in an attempt to simplify the struggle to find an "appropriate" form. I also required that they work mostly in 3-D computer model and physical models made from reclaimed materials.

We started the exercise with a series of brief student presentations about solar orientation, ventilation, heat gain, heat loss, insulation, thermal mass, water, shading, and other strategies for maximizing or minimizing the effects of natural forces. This led into a more thorough analysis of natural light, hydrology and microclimatic conditions at two nearby locations – Thomas Jefferson's Lawn at the University of Virginia, and the pedestrianized area along Main Street in Charlottesville. The students diagrammed the interaction of natural forces and buildings at both sites, and proposed architectural changes that would improve them. The two exercises helped them begin the research and design process.

Despite the fact that this was only their third studio, the students responded well to the project. It probably helped that the university and surrounding community experienced extended power outages in the middle of assignment, due to extensive electrical system damage from a hurricane. Designing a dwelling without artificial light, heat or air conditioning seemed less abstract when the students were actually living in those conditions. It also made them better critics of the buildings where they live and learn.

The solutions ranged from an overnight lodge for a highway emergency response team partially imbedded into a six-lane tunnel (utilizing air displacement from passing cars for ventilation) to a dwelling intended to support the rituals of a deer hunter (shooting, butchering, smoking, and eating the venison). One student used glazing and mirrors to simultaneously explore the line between public and private, and the qualities of reflected and refracted light. Another focused on seasonal and sectional variation possibilities in sleeping quarters. Yet another conceived of her dwelling as a dam in a stream to explore the thermal advantages and disadvantages of moving water.

The students responded to the climatic analysis, their own conceptual ideas and the constraints of the project. Most of them manipulated the form of their buildings to capture light, encourage breezes, retain heat, or adjust to various climate conditions. The research and analysis directly impacted the form of their designs, but did not strictly define it.

SHELTER

The other two projects overlap, but are not directly related. As advisor/coordinator for my school's team participating in the first-ever Solar Decathlon (sponsored by the U.S. Department of Energy), I taught a variety of graduate and undergraduate students in design studios, classes and independent studies. As a four-week warm-up exercise for a 4th year undergraduate studio joining the team mid-way through the process, I assigned a short design/build project.

Working in teams of three, the students collaborated on a shelter to house themselves for one night in the middle of winter. They were restricted to reclaimed or natural materials that could be easily assembled on site in three hours, and later returned to whatever waste stream from whence they came. Although not explicitly stated, ergonomic and thermal comfort of some sort were implied – if only because I wanted them to survive a cold, winter's night.

The review occurred the day after spending the night in their shelters, and was organized as a mini-competition. Their solutions included a highly insulated boxy igloo made from stuffed printer paper boxes; a structure with a south-facing gabion wall of two liter soda bottles filled with colored water; a stacked set of five gallon water bottles covered in plastic sheathing and then at night by a custom building quilt; and a shed made from used telephone books, the structure of a broken swing set, carpeting, gravel and a slightly broken double glazed window. This last design, named "eclectic headstrom," won the event, due to it's thoughtful design, careful construction, and the fact that it measured over 60 degrees inside as the students went to bed that night in below freezing weather. The judging was conceived as a mini Solar Decathlon – a triathlon actually, with categories in firmness, commodity and delight.

In a short time, the students got a very direct understanding of the value of insulation, thermal mass, and minimizing infiltration. Yet the teams were also concerned with broader theoretical or conceptual issues – from the phenomenon of natural light filtered through water, to the ideal body position for sleeping and/or stargazing. Design was not considered separately from natural forces, but was simultaneously challenged and inspired by them.

UVA SOLAR DECATHLON TEAM — THE TROJAN GOAT

From October 2000 to October 2002, more than 100 graduate and undergraduate University of Virginia students participated in the design and construction of a 750 square foot house, powered entirely by renewable energy. The team participated in the afore-mentioned Solar Decathlon, a university competition sponsored by the U.S. Department of Energy (DOE), and largely organized by one of its agencies – the National Renewable Energy Laboratory (NREL). As the architecture advisor and coordinator, I organized the architecture, landscape architecture and environmental planning students participating in the event – more than 75 of the student participants on the UVA team. Most of the remaining students were from the School of Engineering and Applied Science.

In addition to the previously mentioned studio, there was an earlier 4th year studio that collaborated with a small group of engineering students on the schematic design, and a large group of graduate students, who enrolled in the design development/construction detailing class, and later became project leaders while receiving independent study credit.

The team's design can adapt to a variety of weather conditions, by adjusting the many sliding and hinging panels. Passive solar design, environmentally responsible materials and highly efficient appliances, are essential components of the house. A stone-clad sun space distributes heat to the surrounding rooms in winter. The house is powered entirely by photovoltaic cells. Water is heated with solar thermal panels on the roof and along the bottom of the south wall. There is an integrated energy storage system for use at night or on rainy days, and a control system to optimize the distribution of power efficiently. The current and cumulative energy performance of the house is displayed on an interactive system control website, to enhance public awareness of energy use.

A graduate architecture student researched solar luminaire technology, and then assembled the world's first residential scale version. These systems collect sunlight with a solar tracking dish, and deliver it to the interior via glass fibers connected to an etched glass tube. Oak Ridge National Laboratory originally developed the technology, and they provided the team with advice and assistance to source, fabricate and assemble the parts. The surrounding landscape, including a grey water collection/filtration system, green roof, decks, and garden, is also an integral part of the home.

It was a complex process to design a small house with such a large team of people with varied backgrounds. Initially, we had to bridge the language barriers between the architects and the engineers. Design students like to speak of narrative, theory, concept and form. For them, answers are elusive and temporary – the questions are really more important. In contrast, engineers are looking for objective answers to specific problems. Several of the early designs were abstract and formally complex – bearing little resemblance to anything remotely residential. The engineers could not understand why we weren't simply starting with a double-wide trailer, and modifying it with efficient insulation and photo-voltaics on the roof.

Yet the complex dialogue challenged the participants' preconceived ideas, and forced them to be rigorous and clear about their intentions, even when the idea was something like the phenomenology of natural light. Vagueness became the enemy as architecture and engineering students alike were forced to justify their ideas or concerns. As a result, the design got better at each stage of the evolution.

The first studio initially worked in teams to prepare multiple design concepts, and I constantly rearranged the teams as the ideas began to come together. By the end of that first semester, the group was working on a single design – informed by many of the designs that preceded it. The schematic design was truly the effort of each student in that first studio.

The students in the design development/construction detailing class worked both in small groups and individually. They researched specific topics related to aspects of the design – from the photo-voltaics and battery back-up system, to the exterior cladding; from the landscape design to the plumbing. I firmly believe in a simultaneous process of design and research, with architecture students participating in some of the engineering and number crunching. The distinctions between the architecture and engineering students started to blur during the middle stage of the project.

The final academic stage of the project was the previously described 4th year design studio, collaborating with continuing graduate architecture students, and a slightly expanded team of engineering students. Many of the final unresolved aspects of the design began to come together as the student project managers (with council from the advisors) worked through a number of difficult decisions. It was particularly clear during this phase that there are no objectively correct decisions when you are attempting to reach the highest standards for architectural design, engineering, and the environment. The process was really more of a balancing of tradeoffs while confronting aesthetic, technical, ethical and financial issues.

The identities of the architecture and engineering students became noticeably blurred during the final phases of the process. During a long discussion about a proposal for locating the solar thermal panels for the building, an architecture student brought up a legitimate concern about the distance between the panels and the associated pumps, at the same time an engineering student questioned the impact the installation would have on the proportions of the exterior façade. It was at this moment that I knew interdisciplinary collaboration, with active participation by all sides, is a uniquely powerful educational tool.

Construction occurred in the summer and early fall of 2002. As the final deadline approached, previously defined roles broke down further as several architecture students learned how to install electric wiring and connect plumbing. Engineering students helped install cabinetry and apply finishes. A few of the most difficult design decisions had to be adapted or changed when the team confronted the realities of budget and schedule. In most cases, ideas were simplified, which is often a good thing for both architects and engineers. Inevitably, the aspects of the design that survived the entire process unscathed were the strongest ideas with the most energetic advocates.

As a microcosm of the real world, the project was an extraordinary educational process, for both my students and myself. The vast majority of the students from both Schools and from all stages of the project have said it was the single most important part of their education. For many, it completely transformed their understanding of design, natural forces, ecology and construction.

For me, it is a clear example of the importance of design/build projects in higher education. Schematic design is inherently abstract. When designers are forced to figure out how to build their ideas, the design has to become more rigorous and clear.

Instead of hiding behind seductive 3-D graphics, the students confronted the realities of constructed proportions. Rather than making vague references to sustainability, the students researched actual building materials, and how they would respond when confronted with natural forces. Instead of designing something in the abstract – assuming an engineer will eventually figure out how to make the space "comfortable," the architecture students had a two year dialogue with the engineering students to collectively define comfort.

CONCLUSIONS

Based on my experience with these three projects, and all of my studio and building technology teaching, the following five items are suggestions for effective teaching in this realm.

Use examples: case studies and lectures with plenty of clear examples are the best ways to teach about ecological and climate responsive design. However, it best to not let the students be passive observers. Get them directly engaged in the material by having them research the examples themselves, and present them to their classmates.

Emphasize principles, not calculations – at first: architecture students often lose interest in technical classes when they have to get out their calculator. In studio, it is particularly important to make sure the students understand and are enthusiastic about the basic principles before jumping into calculations. Later, it will be easier to convince a student to be rigorous about their analysis when the alternative is losing their 'cool' idea. In the context of a complex design/build project, rigorous analysis is essential. But for a conventional design studio, it is often an unattainable goal.

Allow for experimentation and error: it is okay to let students make mistakes. They will learn far more from that than if you have carefully structured the activities for success.

Stay open-minded: studio teaching is a process of discovery – while I get to set the tone, and establish an overall agenda, I enjoy learning what will grab the attention of my students, and helping them explore their unique fascinations. If the designer owns their project, and is encouraged by their studio instructor to be rigorous within their own set of ideas, s/he will gain much more from the process.

Form matters – but is it mutable. Buildings can be sculpted to encourage ventilation, heat gain and integration of daylight. There are many ways to address these principles, but the solutions are not as formulaic as some of the literature suggestions. The architects of the future will need to understand the enduring principles, as they are developing new methods of form-making.

Our job is not to teach them what to do, but how to do it.

NOTES

[1] "School Survey: 2003." *Metropolis* magazine, August/September 2003, pages 104-107

[2] informal survey of top ranked architecture schools, such as: www.gsd.harvard.edu/cgi-bin/studios/: www.arch.columbia.edu/: www.architecture.cornell.edu/index.htm; arch.ced.berkeley.edu/people/index.htm; www.virginia.edu/arch: www.architecture.yale.edu/yworks.html; www.sciarc.edu/v5/gallery/: wnt.utexas.edu/architecture/academic/main.html; and many others

[3] email from U.S. Green Building Council, titled "USGBC Update – October 14, 2003;" statistics about the council are not readily available on the public portions of the website

[4] This figure is from a quote by Ed Mazria in "Architects Pollute: Turning Down the Global Thermostat," *Metropolis* magazine, October 2003, pages 102-107 and 149-152. Prior to the publication of this statistic in *Metropolis*, the author had looked into this information, and found a similar but slightly lower number by interpreting statistics from the Energy Information Administration. The author now accepts the Mazria interpretation, based on the discussion in the *Metropolis* article, and a follow-up clarification communication directly with Mr. Mazria. Like the author's, Mazria's interpretation is based on information found through the Energy Information Administration of the U.S. Department of Energy, at www.eia.doe.gov.

[5] This is based on 1996 figures, the most recent available from the U.S. Environmental Protection Agency. "Characterization of Building-Related Construction and Demolition Debris in the United States," Municipal Information and Analysis Branch (5306W), U.S. Environmental Protection Agency, (EPA530-R-98-010), 1998

[6] www.usgbc.org/AboutUs/whoweare.asp

[7] addition to Fashion Institute of Technology, by ShoP Architects

[8] Gotz headquarters by Webler & Geissler

[9] town of Poundbury, United Kingdom, by Leon Krier

[10] "The Passive Solar Energy Book," Edward Mazria, Rodale Press, 1979