The Art of Integration:
Interdisciplinary Collaboration

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INTRODUCTION

Collaboration is often understood as an organizational issue. A group is gathered and set to work on a particular problem. Though this method brings together individuals' knowledge, a static beginning often limits a breaking through to new questions or formulations outside the normative modes of operation. It is left to chance whether the group crystallizes as an integrated team. The occasions in which the dynamic interaction of individuals – sometimes referred to as chemistry—result in creativity and innovation is often due to the fortuitous leadership of an individual, or an environment that encourages the meshing of individual abilities in a holistic process. The projects presented in the following pages unfold from the latter. An environment of communities of practice overshadowed dominant personalities. (Brown, 1999) in order to exploit *territories of opportunity* that lie between disciplines.

The designer's work environment is increasingly a diverse set of people coming together through shared tasks. This is where much of our knowledge is discovered and refined, living in the social mind, in the artifacts around us, emerging through iterative discussion and practice. Though the design studio traditionally offers formal modes of engagement in the development of explicit knowledge—reviews, juries, lectures, seminars, one-on-one discussions—tacit knowledge as developed by the group has been largely left untapped. The informal mode of the studio environment involving more than one person, where we spend a considerable amount of our time, has largely been left to its own design.

Learning is socially constructed—most of what we know we have learned from each other through conversation, often informal and spontaneous. Though much of our knowledge is anchored in our own experiences or readings, it is engaging in a telling-and-listening activity that shapes, expands, and differentiates our understanding. A symbiotic relationship between individuals and disciplines must be structured in order to break down misperceptions that arise as barriers. It is about situating the place to capture the occasion of education. Thus, the spaces and objects we station around ourselves, sometimes as simple as a table or blackboard, play a strategic role in making the most of chance interactions to support spontaneous discourse as well as programmed interchange. The images below show a gathering of interior designers discussing their work with architects and industrial design students (Figure 1) and a typical studio day (Figure 2). The first depicts a discussion over work presented by visitors to the School. The second image shows the same space in a mode of smaller scale groups working on specific tasks. That these events occur is not significant except for the fact that the table as an element of each studio embeds in the environment a scale of interaction that implicitly supports the development of work in spontaneous groups.

Figure 1. Studio table at impromptu review of work.

Figure 2. Same table during regular studio activity.

Figure 3 shows an informal review of a first year assignment in front of a temporarily erected 40-foot-long blackboard. Students from architecture, industrial design, interior design and landscape architecture drew a diagram of their work somewhere on that surface. They then were asked to find a strategy to link groups of projects into a greater unity. In this case, the work as product defers to a process that inculcates a spirit of learning and working with related disciplines early in their educational environment. In this atmosphere the complexity of the following projects were developed and nurtured by the richness of the process.

Figure 3. First-year assignment: individual and group work.

Figure 4. House on the Mall during the Solar Decathlon Competition.

The first work originated from a competition sponsored by the U.S. Department of Energy. The charge was to design, build and operate the most effective and efficient house powered solely by the sun. In addition to design and construction, the house had to be transported to Washington, DC, for testing and exhibition. The complexity of the task could not be met by a single discipline acting in isolation. Nor could success be achieved by each group contributing expertise in a linear sequential fashion. The process required integration from the start within a free flowing network of information. The team included graduate and undergraduate students from seven disciplines—architecture, industrial design, interior design, landscape architecture, electrical, mechanical, and structural engineering. Faculty and practitioners served as advisors. While it is rare for such groups to work together in the university setting, upon entering practice, collaborative skills will be an essential part of their day-to-day activities. “What made this thing real was the group of students, the team.” (Yousef Nawas, architecture student)

DESIGN CONCEPT AND PHILOSOPHY

The design process was driven by a multidisciplinary approach that challenges research through application. It harnesses the tension created by the dualities of calculation and intuition; technological innovation and cultural expression; optimized performance and sensible materials; and between physical fact and psychic effect. Simultaneous consideration of technology and design content guided the identity of the house. Every decision involving quantitative criteria was measured in terms of its contribution to spatial quality. New forms have been derived from technical considerations, and enriched patterns of daily life find expression in a celebration of energy awareness and resource conservation. This project pushes existing paradigms by proposing an alternative environment that celebrates solar energy while obtaining a high level of systems integration.

Figure 5. Interior from dining room to living room and entry.

DESIGN PROCESS

An internal school competition promoted interest and awareness across a wide range of students. Of the 50 interdisciplinary teams, seven were selected to advance their proposals. With the selection of the first projects, a special research class involving 80 students examined all aspects of the project collaborating on issues such as material selection, energy collection systems, conservation strategies, and transportation. Design development, prototyping, and construction documents proceeded through a network of digital and face-to-face meetings of teams and subgroups. “One of the things I got out of this project was seeing how the views of the designers and engineers collided, but then seeing how we can bring them together to have a successful design.” (Jesse Christophel, mechanical engineering student)

The 24-month process involved individuals with varying degrees of skill, expertise, and background. Teamwork in conjunction with strong student leadership was required. Problem solving, information flow and integration, ideation, alternative generation, innovative troubleshooting and testing are all part of an experience where the consequences of decisions are real and verifiable. This design/build, hands-on learning experience not only requires innovative design strategies; it necessitates a program of funding through corporate and industry contacts. As part of this effort, students in collaboration with designers and engineers, surveyed manufacturers and suppliers to procure materials that were sustainable, energy conscious and a qualitative improvement for the residential environment.

ENGAGEMENT WITH THE PROFESSION

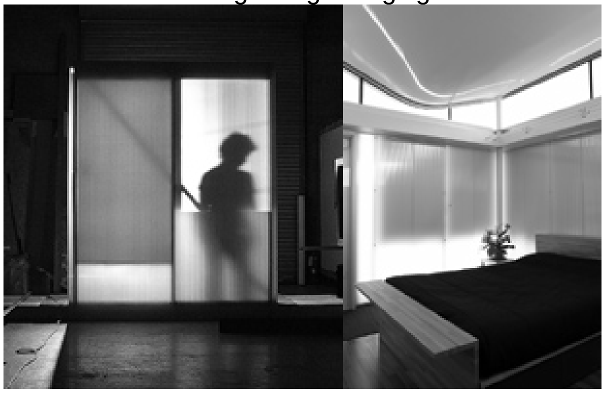
Two years prior to the 2005 Solar Decathlon, office visits were initiated to establish an open forum between practitioners and the solar team. At each office, project presentations were made seeking critical review and suggestions for improvement. Practitioners were also invited to visit the house while under construction at the college’s Research and Demonstration Facility. In these discussions overall design, material selection, and detailing were addressed. Several of the participating firms were selected based on their involvement with the USGBC LEED standard. Our students’ exposure to this cadre of professional leaders proved to be invaluable.

The same pool of firms that advised and supported the project during the 2005 Solar Decathlon are also being asked to advise on continuing education modules under development. Teaming to further research, the Solar Decathlon project is a developing model to integrate the academy with the profession.

RESEARCH

Design research does not often fit the scientific model and thus has not been given due credit in most universities. To the outsider, the iterative nature of design tends to make the process appear redundant or sometimes without focus. The academy is often criticized for generating knowledge that does not always have a direct correspondence to application, while the conventional method of practice is often viewed as too insular and predictable. To break through these stereotypes, our interdisciplinary team sought to develop alternatives to the normative methods of design through the application of new materials and manufacturing techniques. Early interaction between the student, designer, engineer, supplier and manufacturer encouraged the development of more efficient and elegant components. Materials were examined through various qualitative and quantitative criteria. Characteristics of low embodied energy, durability, minimal off-gassing, and recycling potential were contrasted with their contribution to spatial quality. A synopsis of innovative components includes:

- Translucent wall assembly: Polycarbonate panels filled with Nanogel, a translucent aerogel, provide R-24 insulation value while delivering soft glowing light that animates the entire space.



Figures 6 and 7. Prototyping polycarbonate wall system; bedroom showing translucent wall.

- Tunable walls: Motorized shades between the polycarbonate panels allow for darkening of walls; linear actuators ventilate the cavity and provide additional thermal and moisture control; LED (light emitting diode) lights adjust to any desired wall color, no paint required.
- Expanded polystyrene structural insulated panels that are lightweight, easily assembled, and yield a high insulation value comprise the north wall.
- Cabinet enclosures are made of an annually renewable wheat straw. This material exhibits reduced volatile organic compound emissions, including a reduction of formaldehyde emissions by 97%. (Green Seal, 1997)
- The landscape is constructed to demonstrate water conservation techniques with a system that integrates the exterior and interior environments inclusive of a rainwater harvesting system, constructed wetlands, and planting schemes. The water system is developed as a three-part system of rainwater harvesting for recycling as potable water, wastewater treatment system that filters gray water for reuse, and a potential heat sink for the HVAC system.
- Appliance selection was based on three criteria: maximum energy efficiency (energy star rated); practicality and accessibility; and visual elegance that creates a coherent wall module. The kitchen was designed to occupy a minimal volume yet offer full service.
- Paint products use sustainable raw materials such as soy and sunflower oil and emit no VOCs (volatile organic compounds).
- Eucalyptus flooring used throughout the house is highly durable requiring little maintenance and is harvested from renewable, managed forests. A radiant floor lies underneath. Little air movement and no system noise contribute to a high quality heat, in addition to the comfort that is maintained with lower ambient temperature, thus saving energy.
- The roof is a lightweight folded-plate structure filled with foam insulation. Its form sets the solar panels at an optimum angle for energy collection and modulates the interior space. The roof responds to the demands of harvesting sunlight while the corresponding ceiling creates rooms that provide intimacy yet appear much larger than the modest square footage
- Transportation: To maintain clearance for highway overpasses, a lowboy chassis serving as the floor and foundation structure receives a detachable gooseneck and rear axles for transport. Trusses on each side of the long span resist deflection while in transit. Upon site arrival, the trusses rotate down 90 degrees to create a deck surround for the house on site. This transforming technique facilitates the moving of the house as an educational exhibition piece after the competition and also serves as a model for the potential shipment of such units with the roof in place.

Figures 8 and 9. Initial testing of transport structure; final stages of assembly.

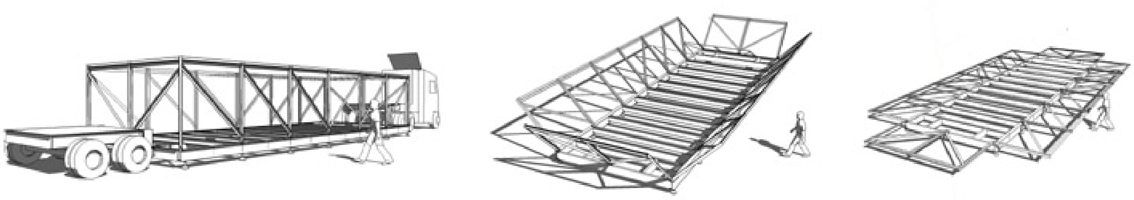


Figure 10. Transport arrives on site and the rear bogey and gooseneck are removed.
Truss structure is rotated to provide structure for wraparound cedar deck.

An innovative wall assembly contains light literally and phenomenally. The east, south, and west facades are constructed of two layers of polycarbonate panels filled with Nanogel, a translucent aerogel. This highly insulated wall acts as a dematerialized surface, holding light similar to that of a Japanese house. Mornings, the walls of the east bedroom come alive with a radiance shifted toward yellow; evenings in the western oriented living spaces are immersed in a reddish cast atmosphere. Increasing natural daylight in building has long been a goal in design. Studies have shown (Heschong Mahone Group, 1999; Andersen, 2006) that people thrive in natural lighting: they are healthier, happier and more productive. In this house, there is no need for electric light from sunrise to sunset and the energy collected during the day is symbolically radiated back out at night through the lantern glow of the house.

A 6-inch airspace between the inner and outer polycarbonate panels contains three systems that enhance energy performance and spatial quality (see preceding Tunable Wall). The most important of these are banks of LED fixtures. This light display is controlled by the user to produce an unlimited set of colors and lighting effects. The walls can be tuned any color desired, thus changing the atmosphere of the space. More needs to be understood regarding how color affects our reaction to space, and studies are mixed regarding its efficacy on biorhythms of the body (Gruson, 1982). The degree to which color forms a determinant of our psychological composition is subject to study (Walker, 1991), but its transformative role in this house is manifest in user enjoyment and a distinctive nighttime identity.

Figures 11 and 12. Interior with colored light in wall. Furniture was designed and made by students; exterior showing initial testing of LED lighting system.

INDUSTRY TIES

Material and system selection evolved hand-in-hand with industry. As much as possible, regional businesses were chosen supplying materials and systems with the desired characteristics identified in the design phase. The students worked closely with industry representatives to understand the requirements of installation and function. In several instances students suggested new and innovative approaches to the use of the products. More than 75 participating companies supplied materials and services. Contacts made with several corporations are evolving into long-term research relationships. As a result of this work three major manufacturers, Cabot Chemical, Colorkinetics, and Duogard are developing a joint project based on the translucent/tunable wall assembly that can be adjusted to any color. An international supplier, Hafele, requested development of a continuing education course based on this research. Additionally, a national manufacturer of cabinets (using the renewable wheat board for the first time in this project) is considering wider use of sustainable materials.

COLLATERAL PROJECTS

Contacts with industry are now an integral component of design education. Though not normally considered part of the design process, students need to be aware of the landscape of resources changing throughout their career. They must develop the ability to adjust quickly to shifting criteria while maintaining focus on their objectives and the greater good of design. They must identify opportunities that can be made operational with proper framing and formulation. One must be able to *think in alternatives*—to envision the innovative. The most effective environment to foster these thinking and working skills is the open studio.

The design studio provides unique interaction between faculty and student, and most importantly between students. A studio that nurtures integrated thinking relies on peer-to-peer learning as much as faculty/student interaction. It relies on the chance encounter—the spontaneous coming together of ways of interpreting—that cracks open the status quo and lead to new visions. This structured environment made possible two related projects that comprised collaborative teams of industrial design and architecture students. Each took material developed for the Solar Decathlon competition and transformed the subject to exhibits presented at the International Contemporary Furniture Fair (ICFF) at the Javits Center in New York City.

The two exhibitions for ICFF (2003, 2005) sought to expand and differentiate the work of the solar house projects. As design efforts subjected to all the consequences of real world projects—funding, material acquisition, production, testing, performance, etc.—both the Solar Decathlon and ICFF are educational watersheds challenging the relation between academia and practice and between research and the corresponding contribution to society. Though participating students for each project have graduated, the knowledge derived from the initial endeavor has been transferred to and transformed by succeeding teams.

Figures 13 and 14. ICFF 03: Packing crate/exhibit structure in assembly process; exhibit presenting components of solar house.

The program for the 2003 ICFF exhibit included innovative materials, building components, and furniture that were developed for the first Solar Decathlon Competition in 2002. The concept centered on the design of a shipping crate that unfolds to become the exhibit structure and establishes the spatial composition of the solar house in the exhibit hall. Students combined graphic boards, digital videos, simulated systems, full scale prototypes, lighting elements and furniture to deliver information about a new model of residential housing focusing on sustainability and energy conservation. Transport, assembly and disassembly were criteria that led to an unfolding exhibit-ready structure. However, the added limit of construction without tools (any work in the Javits Center requiring tools has to be performed by a union member at $150/hr+) challenged the material selection and component assembly process. Much of this experience influenced the design of the 2005 solar house, particularly in the solution of the folding trusses that double as the structure for transport and the exterior deck promenade.

The 2005 ICFF exhibit expanded on previously generated knowledge by inverting the criteria from the earlier project. Instead of a massive, complex set of transforming components, a lightweight, ephemeral exhibit system with greater ease of transport and assembly was designed. Polycarbonate panels (the wall material of the solar house) were used to make a foldable/collapsible structure to present the exhibition, *Material Presence*. The concept divided the assigned exhibit space into five 2-foot x 20-foot bands. These bands were folded at various angles and projected on intertwining paths (some as high as 12 feet) to establish a spatial presence in the Javits Center and to provide platforms to exhibit objects. Thus, both the means to exhibit and the works exhibited form a whole in the investigation of the expressive capacity of materials and processes.

Figures 15, 16, and 17. ICFF 05: Assembly of polycarbonate strips; exhibit; detail of objects.

AFTERMATH

The ICFF exhibits were the result of a competitive RFP process. The initial exhibit was recognized with the Editors' Award for Best Design School. More importantly, the exposure helped establish many industry contacts for the ensuing Solar Decathlon. This research also helped instill confidence that such a technical and innovative environment could be designed and built in a spirit of no compromise with respect to richness and quality of life. Efforts were validated in winning critical awards judged by panels of experts. The Virginia Tech house was ranked first in the architecture, dwelling, daylight and electric light portions of the competition. It was also recognized with the President's Award for Best House. For the first four days of the competition the project led overall, finishing eventually 4th in a field of 19. Rain and clouds dominated the weather on the Mall (if there were sun during any of the five days of competitive measurements, the house would have finished first, but this is a story about energy strategy within the story of the house). Presently, the house is located as an entrance piece to the Science Museum of Virginia in the state capital, serving as an exhibit to excite and entice visitors to consider energy use in their everyday lives. It also challenges prospective students of design to seize the opportunities embedded in the difficult questions of energy use and value while pursuing a simultaneous sense of the sustainable and the beautiful.

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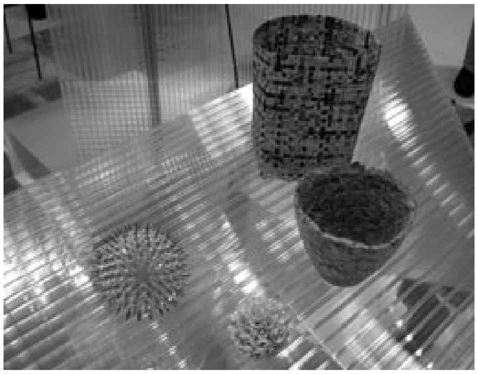

Figure 18. ICFF 05: Objects of Material Presence on polycarbonate exhibit structure.