Sustainable Skins Studio: Design Exploration at the Interface Between Inside and Outside

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Sustainability is central to a topical studio course offered to graduate students at the University of Maryland in Spring 2009. The Sustainable Skins Studio focuses on the building skin as a key interface in the relationship between building and environment. The course is predicated on the beliefs that the studio method is a powerful tool for teaching through research, application, and evaluation; that an explicit focus on sustainability is necessary to help students prioritize when faced with the many competing issues embedded in every design project; that sustainable architecture requires a conceptual shift towards performance-based design; that practicing sustainable design in school is good preparation for designing sustainable buildings in practice; and that partnering with a multidisciplinary firm and its client teaches students about the critical role of the architect in the design of sustainable environments.

The studio is designed to bring students into a broad professional conversation about sustainable architecture. The course connects to the American Institute of Architects (AIA) Committee on the Environment (COTE) work identifying and studying exemplary sustainable buildings[1] and teaches students how to make use of these resources in their design processes. The course anticipates the new emphasis on sustainability, applied research, performance assessment of environmental systems, client role in architecture, and leadership in the National Architectural Accrediting Board (NAAB) 2009 Conditions for Accreditation[2]. The course ties into the United States Green Building Council (USGBC) initiatives, by adopting the regional competition as a project to inspire student thinking about the design of sustainable building skins and joining into the national dialogue among students in the Emerging Green Builders organization.

This case study describes the Sustainable Skins Studio course, evaluates its strengths and weaknesses, identifies pedagogical shifts, and situates this example within the broader context of educational preparation for the architect's transforming and transformative role in society.

STUDIO CONCEPTS

The explicit focus on sustainability in this topical studio stemmed from the observation that, in a typical studio, sustainability is presented as one of a myriad of design parameters, competing for students' attention along with a host of equally urgent and compelling concerns. Indeed, this is great preparation for practice, where design involves the reconciliation of multiple, often conflicting priorities. However, this situation limits the time available for students to learn much about sustainable design and may enable students to ignore the topic in favor of other interests. Putting the word "Sustainable" first in the studio title was a constant reminder to the studio team that sustainability was our primary concern. We were careful to stress that sustainability is the goal; we were engaged in learning to practice green design strategies to move us forward on the path to sustainability.

The word "Skins" came next, establishing the building's skin as our locus of operations. The Sustainable Skins Studio took on sustainable design and building skin as two linked areas of explora-

tion. Building skin is a major building element that mediates between inside and outside. It is the layer or layers that connect indoors and outdoors, linking people to their environments. Skin may seal a building or may provide a controlled interchange between interior and exterior. Skin may play a passive or active role in building systems. As the building element exposed to the weather, skin offers a great potential for harvesting solar and wind energy, water, and, as one student proposed in her competition entry, crops. The relationship between human and nature is enacted in the design of the building skin. An in-depth exploration of building skin offers tremendous potential for students interested in learning about sustainable design.

Building skin is also a compelling topic for a design studio because of its high visibility. To a great extent, building skin defines the public image of the building and forms the lens through which building inhabitants view the external world. When building skin is designed in concert with climate, orientation, local materials and building traditions, it holds a great potential for expression of place and time. Intensive design of the building enclosure is an important aspect of practice, but not generally highlighted in studio, where design often proceeds from the inside out, leaving little time for studying this key element of the building. In my personal experience as a studio instructor, I have found that students often struggle with the design of building enclosure, undertaking the design of facades as an afterthought, with little understanding of the applicable design criteria, and meager exploration. In the Sustainable Skins Studio, we talked about writing a program for the skin as one aspect of the overall building program.

Readings in the Green Studio Handbook[3] aided students in developing an analytical process by defining intents, criteria, and methods in design. We challenged students to declare their intentions, to explicitly state the criteria that would define their success in fulfilling those intentions, and to explore alternative methods to attain their design goals. We added one additional category to the Handbook's list: performance metrics. We challenged students to seek ways to prove their success. Sustainable design seeks architectural and technological solutions to quantifiable problems such as climate change, carbon production, and depletion of non-renewable energy sources. Sustainable practice requires architects to understand and apply scientific knowledge and to reliably predict quantitative results of design proposals. This new demand signals a shift in the balance of art and science in the discipline of architecture and a potential evolution of the architect's role in society.

In the twentieth century, architects lost their leadership role in large areas of the construction industry, most notably mass-market housing, to developers and construction managers, due to a perception that architects were not quantitative thinkers who could assist clients in producing economically viable buildings. At the beginning of the twenty-first century, the growing mandate for sustainable design offers architects a new opportunity to reclaim leadership in the construction industry by rising to the new scientific challenges of knowledge-based, performance-based practice. This studio takes on the challenge of preparing students for an expanding role in practice in several ways: teaching research skills for knowledge-seeking, teaching analytical methods for performance measurement, and promoting the value of knowledge and performance-based design within the studio culture.

STUDIO TEAM

I initiated the studio, based upon my interest and professional expertise in the design of building skin. I invited two colleagues to co-teach the studio, bringing important knowledge to the course. One colleague contributed his expertise in environmental systems and sustainability; the other brought expertise in parametric design and digital modeling of building skin. The three of us served as a collaborative course faculty.

I also invited an architect who serves as Design Director of AECOM Design in Washington, D.C., to join the team, along with assistance from architects and engineers from his firm. AECOM also brought their client, Project Manager for new projects at NASA's Langley Research Center, to join our studio team. My inspiration to work with this particular architect-client team flowed from an opportunity to review one of AECOM'S schematic design presentations to NASA. The project was for an Administration Building, one of three buildings AECOM is commissioned to design following a federal Design Excellence selection process. The presentation featured a set of design alternatives with rich information about the various sustainable design

strategies deployed and performance metrics assessing their relative strengths and weaknesses. I remarked that I wished my students could learn to present design alternatives so clearly and comprehensively, leading to decision-making based upon a broad set of information.

NASA, with its research mission in earth science, is keenly interested in sustainable design. NASA scientists want to see quantitative analysis to predict building performance. They have little tolerance for fuzzy thinking and unfounded assertions about green architecture. I knew from past experience working on a studio project with NASA that the organization has a fascinating material culture akin to the culture of architecture. NASA scientists and engineers manifest a creative joy in making and testing innovative things. At the same time, their work environment consists mainly of drab and aging buildings. As a client, NASA would both inspire our studio and keep us honest.

AECOM would serve as our mentor firm, modeling for us how architects work with clients. In our visits to their office, we would have the opportunity to observe the collaborative design process within the firm. We hoped that the firm's engineers would be able to teach us to use their software for performance analysis. And, we welcomed the Design Director's expertise as a design critic throughout the semester.

The student members of the team were well qualified for the challenges of this highly technical studio because they had just completed the Comprehensive Studio/Advanced Technology Course in the preceding semester. A diverse group of six students signed up for the experience, giving the team an international perspective, with student members bringing personal experience of inhabiting buildings in diverse cultures in varied climates on three different continents.

Three faculty, one architect, one client, and six graduate students came together to form the studio team.

STUDIO PROCESS AND PROJECTS

The studio experience began with case study research investigating the state-of-the art of sustainable building skin design. Students went on to design two projects of different complexity. The first project, re-skinning an existing building, gave students the opportunity to focus all of their design energies on the central theme of the course, the building skin itself. The second project, the design of an entire building on its site, required students to consider the building skin as one element of a complex system connecting humans to their environment by means of a building.

The case study project introduced a collaborative research process in which students collaborated to create a book of six case studies of buildings featuring sustainable skins. After a brief period of broad exploration, students found that they could organize the innovative skins they were investigating by their featured strategies: power-generation, natural ventilation, day lighting, orientation, and double skin. Students agreed to select case study buildings that highlighted a broad diversity of sustainable technologies. The COTE case studies were invaluable sources of information and served as models as the students began to construct their own case studies. We introduced the rubric of intentions, methods, criteria, and performance measures at this point. Students were challenged to speculate about the architects' intentions in each case study. Then, they were asked to identify the method(s) the architects used to fulfill each intention. Next, they were asked to set forth the criteria that would signal success. Finally, they were asked to seek evidence of the extent to which the green strategies succeeded.

An example of this process may be seen in Sarah Bowley's case study of Thomas Herzog + Partner's Soka-Bau Complex in Wiesbaden, Germany[4]. Sarah identified the architects' intentions with respect to sustainability as follows: "high quality, healthy work environment" and "minimize energy consumption". She perceived that the architect aspired to fulfilling those intentions through "intense focus on the building skin." Sarah identified the following as one of the architect's methods for minimizing energy consumption: "In order to ensure low energy consumption, the building skins are treated differently depending on their relationship to the sun…the south skin has an adaptable two wing louver structure designed to respond to changing cloud cover." Sarah modeled the building skin to illustrate the way in which it reconfigured in response to changing solar conditions. Sarah then utilized the model

Figure 1: South Wall Section, Soka-Bau, Thomas Herzog + Partner, analytical drawing by Sarah Bowley

to test the ways in which the louver/light shelf assembly would provide day lighting while minimizing solar gain in summer.

The case study research served several purposes for the studio. It initiated a collaborative spirit in the studio, produced a set of precedents to inform future design projects, introduced a vocabulary for discussing sustainable design, set forth an analytic process, illustrated the level of design detail that would be required in the design projects, and established high standards for digital and physical modeling of building skins.

The second project we undertook was the National Capital Region Emerging Green Builders' 2009 USGBC Natural Talent Design Competition, [Re]facing the Capital. In it's competition brief, the Emerging Green Builders set forth the competition challenge as follows:

> *There is a large inventory of office buildings in the Washington, DC Metropolitan Area…that are reaching the end of their lives. Some of these office properties are being re-skinned and renovated, while others are being torn down and redeveloped. In acknowledgement of this development, the 2009 competition focuses on the re-skinning of an existing building.*
>
> *The design challenge is to modify the building so that it (1) performs better for the environment, (2) is healthier for occupants, (3) is more attractive, and (4) saves money. The scope and scale of the modification is undefined.* [5]

The premise of the competition follows the first of the Pocantico Principles on Sustainability and Historic Preservation:

> *Foster a Culture of Reuse: Maximizing the life cycle of all resources through conservation is a fundamental condition of sustainability. The most sustainable building, community or landscape is often the one that already exists. Lessons learned from historic preservation are transferable to the entire existing built and landscaped environment.*□

Figure 2: National Capital Region 2009 USGBC Competition 2nd Place Winner, Sustainabillboard, board 1, Mercedes Afshar with Michael Fischer

Although the competition did not call for historic preservation, but rather for adaptive reuse, the brief follows the concept of transferring lessons from historic preservation to other disciplines dealing with the built environment. Every competition entry, therefore, shared one green design strategy, reuse of an existing building structure. Students were responsible for re-envisioning the building's use and designing a new skin. This project offered a perfect vehicle for the Sustainable Skins Studio, as it sharply limited the design parameters, eliminat-

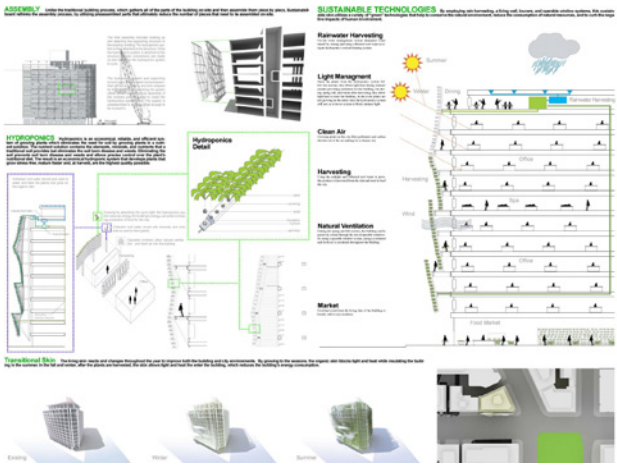

Figure 3: National Capital Region 2009 USGBC Competition 2nd Place Winner, Sustainabillboard, board 2, Mercedes Afshar with Michael Fischer

ing a myriad of decisions, and giving students no option but to immerse themselves in the expressive, technical, material, passive, active, interactive, intelligent, performative, communicative, constructive, living, growing, transforming, harvesting, generating possibilities of building skin design.

Students were encouraged to propose one additional bold, innovative, clearly articulated sustainable design strategy to capture the attention of the jury. Mercedes Afshar proposed a new multilayered living skin for the existing building. She articulates her intentions and methods in the following polemic:

> *As much as we might lament the growth of cities, they are an essential part of contemporary life. The* ***challenge*** *for current and future generations of architects and urban designers is* ***not to abandon unsuccessful development****, but rather* ***improve*** *and* ***regenerate*** *the* ***existing*** *urban* ***infrastructure*** *as a way of helping the environment. We must start with* ***small gestures*** *that confront larger issues within our built environment.* ***Sustainabillboard*** *brings attention to issues that include a need for* ***clean air, locally grown food, green space****, and* ***energy conservation*** *through the implementation of a* ***multi-layered*** *enclosure system that attaches to an existing building. The skin folds, stretches, and peels back to reveal a series of spaces for the building occupants to enjoy. The* ***hydroponics*** *system creates a* ***locally grown food source****, while providing* ***insulation*** *to the building in the summer. After harvesting, the sun's light heats the building when it's needed in the winter. The skin is a* ***reciprocal organism with the building that reacts and changes throughout the year to improve both the building and city environments.***

The third studio project was the design of an Optics and Sensors Lab for NASA's Langley Research Center. This ambitious project challenged students to exercise their new wealth of knowledge and expertise in sustainability and the design of building skins in the comprehensive design of an 80,000 square foot building on a research campus. While students were still focused on the potential for thinking about skin to generate overarching design concepts, students were able to engage a broader range of systems and technologies in sustainable design, as they were concerned with an entire building and its site.

The section perspective below illustrates how Claudia Santos' conceived of all of the building surfaces, whether horizontal, vertical, or diagonal, as layers of skin. The fact that Claudia diagrammed flows through the building as an integral aspect of her rendering illustrates the extent to which sustainability is fore grounded in her design thinking.

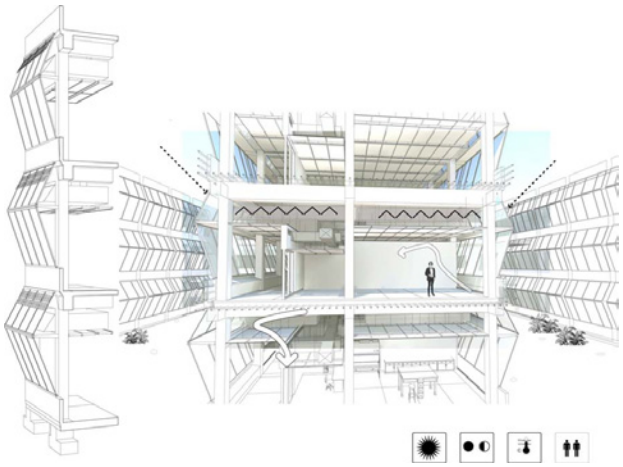

Figure 4: Optics and Sensor Lab for NASA Langley Research Center, Claudia Santos

In this project, we fully engaged both architect and client in our process from site exploration and program definition through final reviews. This was the point at which the studio realized the full benefit from the breadth and diversity of our team. Students had the opportunity to observe the interaction of architect and client, using this as a model for their own interactions with the project client. We were further privileged to have the opportunity to meet and discuss programmatic needs with some of the potential users of the new facility.

These sometimes surprising interactions brought to life for students some of the dilemmas architects face in implementing sustainable design strategies when user needs conflict with what architects may consider their ethical obligation to society.

STRENGTHS AND WEAKNESSES

Looking back upon the studio, it seems clear that all six students gained knowledge and skills in the design of sustainable architecture in general and gained particular understanding of the role of green building strategies in the design of building skins. As a design critic on reviews of the students' work in the preceding studio, I was aware of their entering level of achievement in the areas of sustainability and the design building skins. The projects in the Sustainable Skins studio demonstrated clearly articulated intentions regarding sustainability and a grasp of the green design strategies that would move their projects towards achieving their goals. Students were able to draw and model, both digitally and physically, the materials and assemblies of building enclosure in considerable, credible detail. The overall strength of the studio was that it seemed to provide an effective pedagogical environment for student learning of the intended subject matter. Looking back from the perspective of a faculty member who probably learned as much during the course of the studio as the students, I wish that I had applied the scientific method to measuring student-learning outcomes in the course so that I could offer some proof of that assertion of success. If I teach this studio again, I will plan to survey students to establish their baseline knowledge, expertise, and attitudes at the beginning of the course, then assess their status at the end and analyze the data to measure the effectiveness of the course. I continually stressed to students the importance of performance testing to measure success in the arena of sustainable design. It seems appropriate to apply the same principle to the arena of pedagogy.

The weaknesses of the course likely stemmed from one critical fault, trying to do too much in too little time. In attempting to produce three projects, we gave short shrift to all three. The students produced case studies that were thoroughly researched, well documented, thoughtfully analyzed and articulately written. Students collaborated at the front end of the project on the design of the case studies, so that they could be assembled and published in book form. Due to the rush to start the competition, we did not find the time to publish the case study book. We lost a valuable opportunity to disseminate the results of the students' research.
The competition project benefitted to some extent from a rushed charrette atmosphere. Students felt the pressure to quickly derive compelling concepts. Some students were able to quickly develop and present their concepts. Others, however, required more time for various reasons. One student discovered a passion for investigating the science of vertical wind turbines, studied the physics of fluid dynamics, and utilized specialized software to analyze airflow around the building skin. He never completed the competition boards, but he learned a great deal about cutting edge energy technology and performance analysis. Another student took the summer to digest the critique of her competition project, revise the boards, and win second place in the regional competition.

The final project really suffered from the lack of adequate time for exploration of the wonderful array of issues it presented. Each of the six students defined their personal approach to sustainable design in the project, progressed in developing their scheme, and investigated some aspects of the building skin in significant detail. None of the students, however, was able to document the project thoroughly in the time available. The lack of comprehensive final presentations meant that students were unable to demonstrate to the jury in their final review their success in meeting the objectives of the final project.

In summary, the course yielded little in the way of portfolio-ready material, but resulted in substantial student learning about sustainable design. By the end of the semester, students were demonstrating, on a day-to-day basis in desk crits, increased technical knowledge, greater ability to apply that knowledge, and a sense of commitment to sustainability that manifested itself throughout the design process.

EDUCATING STUDENTS FOR LEADERSHIP OF CHANGE

The architecture profession is in the midst of a significant transition. General societal awareness of the impact of buildings on climate change and non-

renewable energy resources offers potential for architects to take new leadership in the design of the human environment. While the current recession restricts architects' arena of action, educational institutions have an opportunity to prepare students for an expanded role. A major challenge for the schools is striking a new balance between science and art in the discipline of architecture. While architects have a unique potential to bring art and science together in the service of society, the profession is not presently prepared with the scientific knowledge and skills required to meet current and future challenges.

The new NAAB Criterion, Applied Research[7], adds a mandate for the Schools to respond to this unmet need in the profession. The architecture profession has long suffered from the perception that architects are not quantitative thinkers, driving clients focused on the bottom line to seek expertise from other disciplines such as engineers, construction managers, project managers, and program managers. The challenge of sustainability demands even more quantitative thinking to analyze environmental conditions and building performance. Architecture schools can teach skills and emphasize the importance of performance analysis. While analysis is taught in technology courses, it is rarely practiced in the studio environment. Asking students to close the loop in studio by analyzing their designs would reinforce technology lessons and drive home the value of accountability for design decisions. Moving performance analysis into the studios also offers the opportunity to build upon students' expertise in digital modeling. The highly detailed digital models that students produce in the design studios are rich with information for analysis. In order to realize this potential, schools need resources to invest in energy-modeling software and training for students and faculty.

Many architects are motivated by a sense of mission to improve the world. Community design, housing, new urbanism, Architects Designers Planners for Social Responsibility, Structures for Inclusion, Habitat for Humanity, Freedom by Design are some of the issues and organizations around which architects and architecture students have rallied. The new NAAB Criterion, Community and Social Responsibility, institutionalizes "the architect's responsibility to work in the public interest, to respect historic resources, and to improve the quality of life for local and global neighbors."[8] Sustainability is a powerful mission for architecture students in the twenty-first century. Working towards a more sustainable future is one way for architects to fulfill an ethical duty to improve the quality of life for "local and global neighbors", as well as future inhabitants of our planet.

The importance of this mission may have the power to change the culture of architecture school in favor of greater interest in scientific knowledge and expertise. It has already changed the NAAB Conditions for Accreditation. The level of student engagement in learning about sustainability has been elevated from "understanding" to "ability" and the Sustainability criterion has been rewritten in language that places a higher responsibility on students to apply technological solutions to environmental problems[9].

While improving students' abilities to apply science to design, it is crucial to maintain the creative potential of the design process. A process that alternates between periods of lateral thinking and periods of analysis gives students the opportunity free their minds to generate multiple alternatives, then focus their thinking to examine those alternatives against clearly defined criteria. This nimble-minded approach to problems is a great strength of the design process. It is the key to the dynamic balance of art and science in the discipline of architecture.

INTEGRATING SUSTAINABILITY INTO ARCHITECTURAL EDUCATION

The case study examines one course whose objective is to prepare students for an expanded role in architectural practice, a role that brings a dynamic balance of art and science to sustainable design for the human environment. This studio course reflects the present transitional state of the profession; it is explicitly designed to inculcate in students the ethical awareness, technical knowledge, and leadership skills that they need to effect measurable change through architectural practice. The Sustainable Skins Studio exists precisely because of the current difficulties of integrating sustainability into the broader architectural design studio curriculum. It is a worthy ideal to expect students to address sustainability in every project in every studio, but the myriad of design parameters in studio projects vie for students' attention, leaving little time

for students without significant technical knowledge and expertise to investigate green strategies in depth. The new revisions to the NAAB Student Performance Criteria suggest that we will soon see architecture students becoming better prepared for action in the area of sustainability. Once the architecture student population has gained greater technical knowledge and expertise, they will have a better chance at meaningfully engaging issues of sustainability in every design studio. I envision a point at which there will no longer be a need for courses that explicitly focus on sustainability, because students will approach all aspects of architecture with an ethical orientation to act sustainably and the knowledge and skill set to do so. We are not there yet, but we are on the way.

ENDNOTES

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