APPLYING PERFORMATIVE TOOLS IN THE ACADEMIC DESIGN STUDIO: A SYSTEMIC PEDAGOGICAL APPROACH

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ABSTRACT: This paper describes a third- and fourth-year pilot design studio at the University of Texas at San Antonio (UTSA). Two instructors—one with expertise in building performance and the other in architectural design—implemented a systems-based approach to teaching undergraduate design studio that allowed students to explore the oft-misunderstood relationship between architectural performance and form. The instructors integrated advanced performance modeling into the design curriculum, restructuring the studio around 10 parallel and interactive lab sequences: 5 covering topics specifically related to building performance and 5 covering general design topics. The reconfigured studio required participants to pursue issues of sustainability and design in parallel, allowing students to leverage building performance as a form generator, not a technical overlay. Both iterations of the studio produced a winning entry in the American Institute of Architects (AIA) Committee on Technology and the Environment (COTE) Top Ten for Students Competition, which recognizes ten winners annually from a national pool of entries.

KEYWORDS: building performance, sustainability, COTE, studio pedagogy, Architecture 2030

INTRODUCTION

The negative impacts of climate change present an existential concern for architects, as the built environment is a major contributor to the global environmental crisis. The severity of this crisis means that architects have a disciplinary obligation to accelerate the design and construction of carbon-neutral and carbon-positive buildings. Within the professional realm, architects are meeting this challenge, channeling their efforts through programs like the United States Green Building Council's (USGBC)
Leadership in Energy and Environmental Design (LEED), begun in 1994, and the Architecture 2030 Challenge, begun in 2006. Both are widely accepted standards within the industry.

The response from the academy to date has been less clear. While the National Architectural Accrediting Board (NAAB) maintains significant curricular requirements related to environmentally sustainability and building performance, most schools have yet to integrate this critical material into traditional design studios. This paper describes a pilot studio curriculum at the University of Texas at San Antonio (UTSA) that recasts the architectural design studio as a multi-disciplinary, systemic undertaking, one that considers the potentially dynamic interaction between issues of building performance and architectural form in the design studio. The two studio instructors—one with a background in environmental systems and the other in architectural design—initiated a curricular feedback loop, prompting students to engage a continuous dialogue between issues of building analysis and design. In this regard, the pilot course addressed a perceived curricular shortcoming, embedding issues of ecological literacy and performance metrics into a third- and fourth-year undergraduate design studio.

The studios fulfilled multiple learning objectives, seeking to

- advance the design of a carbon-neutral built environment in accordance with the Architecture 2030 Challenge.
- embed issues of ecological literacy into a traditional studio setting.
- create a critical feedback loop between issues of building performance and design.
- embed advanced performance modeling and metrics into a traditional studio setting.
- provide students with the opportunity to enter an international design competition.
- explore contemporary and competing theories of suburban design.
- develop new housing typologies that correspond to the suburban condition in South Texas.

To date the instructors have implemented this curriculum twice, first during the fall semester of 2015 and again in the fall of 2016. Both iterations of the studio focused on programs related to the geographic and demographic expansion of San Antonio, Texas, one of the fastest growing cities in the United States. 1.1 million people will move to San Antonio in the next 25 years, a demographic influx that will bring the population of the city from 1.4 million to 2.5 by 2040. This rapid expansion will require the city to add 500,000 new jobs and 500,00 new units of housing, a significant challenge in a city that already added 430,00 people in the last decade (Rivard, 2014).

The first iteration of the studio called for the adaptive reuse of a commercial big box, the most common and mundane of suburban building typologies. Students recast a prototypical Walmart Neighborhood Market in San Antonio as a neighborhood branch library, taking advantage of the typology's most compelling traits: ubiquity, obsolescence, low-cost and flexibility. The second studio generated new typologies for suburban infill housing, considering the optimal location, design, and construction of these units.

In both cases, the instructors adopted the structure of the AIA Committee on Technology and the Environment (COTE) Top Ten for Students Competition. The AIA COTE Top Ten Competition required students to simultaneously generate formal and environmental responses to issues of innovation, regional design, land use and site ecology, bioclimatic design, light and air, water cycle, energy, materials, adaptability, and feedback loops.

1.0 CURRENT CURRICULAR MODELS

For decades, leading professional and academic organizations including the American Institute of Architects (AIA), the National Council of Architectural Registration Boards (NCARB), NAAB, and Architecture 2030 have advocated for a more thorough integration of building performance topics into core architecture curriculums across the United States. While many architectural educators enthusiastically embrace this principle, actual implementation has proven difficult. Today, most schools continue to deliver material related to environmental sustainability in discrete courses that do not relate directly to design studios. Attempts to address building performance topics within the design studio framework are met with multiple challenges, including a lack of credit hours, limited budget for instruction, and a lack of collaboration among faculty. In the absence of agreed-upon pedagogical methods and curricular structures, most architecture schools rely on trial-and-error when seeking ways to incorporate building performance and design issues. The authors believe that the greatest potential to achieve this integration lies in the design studio, which occupies the intellectual center of architectural education, and typically captures the greatest percentage of credit hours within the curriculum.

Currently, most schools appear to utilize one of three models to teach building performance issues (Figure 1). In the Integrated Model, which remains rare, building technology faculty work side-by-side with design instructors to deliver content associated with environmental control systems and structures in a studio setting. Texas A&M University has implemented a version of this model at the undergraduate level, which requires students take a preliminary systems and structures class, followed by a collaborative studio that integrates building technology and design. This fully integrated arrangement offers a critical advantage: emphasizing the reciprocal relationship between technical topics (structures and environmental systems) and design topics (aesthetics, form, program). Of course, the approach does present challenges, increasing the required resources for administration and faculty. Another version of this model occurs when a building technology faculty with a strong design background leads the studio. While this arrangement offers the advantages of the integrated model, likely at a lower cost, it is limited by the number of faculty who are able to fulfill both the technical and design components of the studio simultaneously.

In the Linked Model, studio and building technology instructors coordinate the terms and sequence of assignments and projects, sharing content and outcomes wherever possible. Like the Integrated Model, the Linked Model reinforces the simultaneous application of technical and design skills in studio, albeit with less direct contact between collaborating faculty. The main challenge here involves guaranteeing that a sufficient scope and depth of building technology topics will be covered in the design studio. Again, a high level of coordination is required among faculty.

In the Unlinked Model, the building technology and studio courses run in parallel, with no direct integration. Students are left to their own devices to integrate the material that they learn in Environmental Systems and Structure courses into their studio designs. This model, by far the most common in U.S. schools, shares most of the limitations of the previous models and, in addition, does not offer a mechanism to help students apply newly acquired technical knowledge to design projects. It also does not provide the opportunity for collaboration among technical and design faculty, which exacerbates the lack of integration within the curriculum. A number of educators have made efforts to address limitations of the Unlinked Model, integrating limited building technology exercises into design studio (Gurel, 2010; Nigra, Grosso, Chiesa, 2016). An example of such efforts is reported by Nigra et al, where graduate studio instructors at the Polytechnic of Turin in Italy used six assignments within an Unlinked Model to integrate sustainability in the studio. These assignments addressed spatial organization, microclimate analysis, technological research and architectural design, envelope system design, ventilation system design, and construction of technological and architectural solutions (Nigra, Grosso, Chiesa, 2016). Their objective was to create environmentally-conscious design alternatives, introduce performance-driven design early in the design process, and create a method for students to handle the complexity of a sustainable design studio.

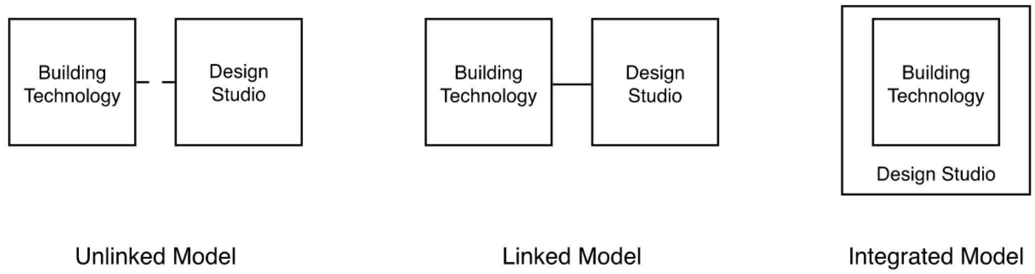

Figure 1. Models for the integration of building performance and design pedagogy. Source: (Authors 2016)

2.0 THE PILOT STUDIO AT UTSA

2.1 Overcoming the limitations of the Unlinked Model

At UTSA, undergraduate students complete a traditional four-year Bachelor of Science in Architecture degree, which requires them to take seven design studios and four total courses in building technology. The latter includes two environmental systems course that cover heating, cooling, lighting, and acoustics. Students also complete two courses in structures. UTSA's curriculum is highly traditional in that there is no direct connection between environmental system topics and design studios. In effect, UTSA is operating using the Unlinked Model, as described above. As we have seen, this model presents a number of disadvantages, most related to the lack of integration between curricula and faculty. This pilot studio began as a way to address the perceived disconnect between environmental systems and design topics within the Unlinked Model of the B.S. program at UTSA. The instructors' short-term objective was not to move towards a Linked or Integrated Model, as this change would require a fundamental transformation of the B.S. curriculum. Instead, their objective was to integrate course materials within the Unlinked curricular model, thereby providing students with the skills necessary to design climate-responsive, high-performance buildings.

The instructors began by restructuring an advanced elective studio around 10 parallel and interactive lab sequences: 5 performance labs covered critical topics including bioclimatic design, energy flows and futures, light and air, water cycle, and materials and construction; and 5 parallel design labs focused on related topics including regional and community design, land use and site ecology, programmatic adaptability, collective wisdom and feedback loops and design & innovation. These 10 labs corresponded directly to the 10 required measures in the AIA COTE Top Ten for Students Competition. The larger goal of the reconfigured studio was to require students to pursue issues of performance and design in parallel; never in isolation. Ultimately, the curriculum prompted student designers to pursue the topic of sustainability as a form generator, not a technical overlay.

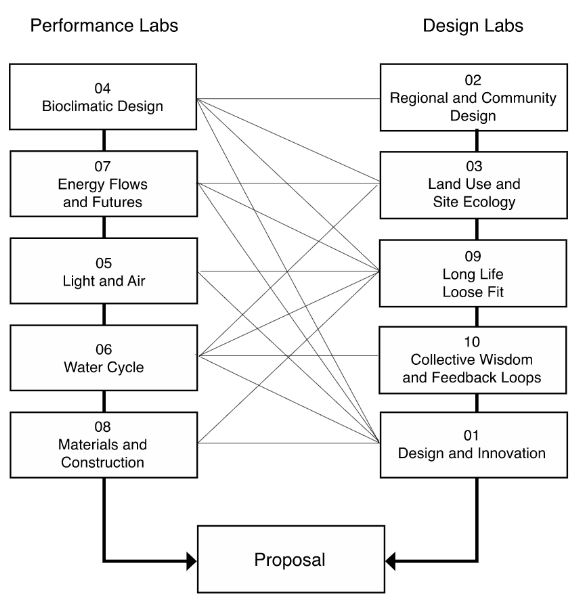

Figure 2. UTSA COTE model for Integration of building performance topics into design studio. Source: (Authors 2016)

2.2 The building performance labs

The building performance section of the studio began with a lab dedicated to "Bioclimatic Design." The students analyzed the local site using Climate Consultant software, identified and prioritized climatic issues, and finally generated appropriate passive strategies capable of minimizing energy loads while maintaining thermal and visual comfort.

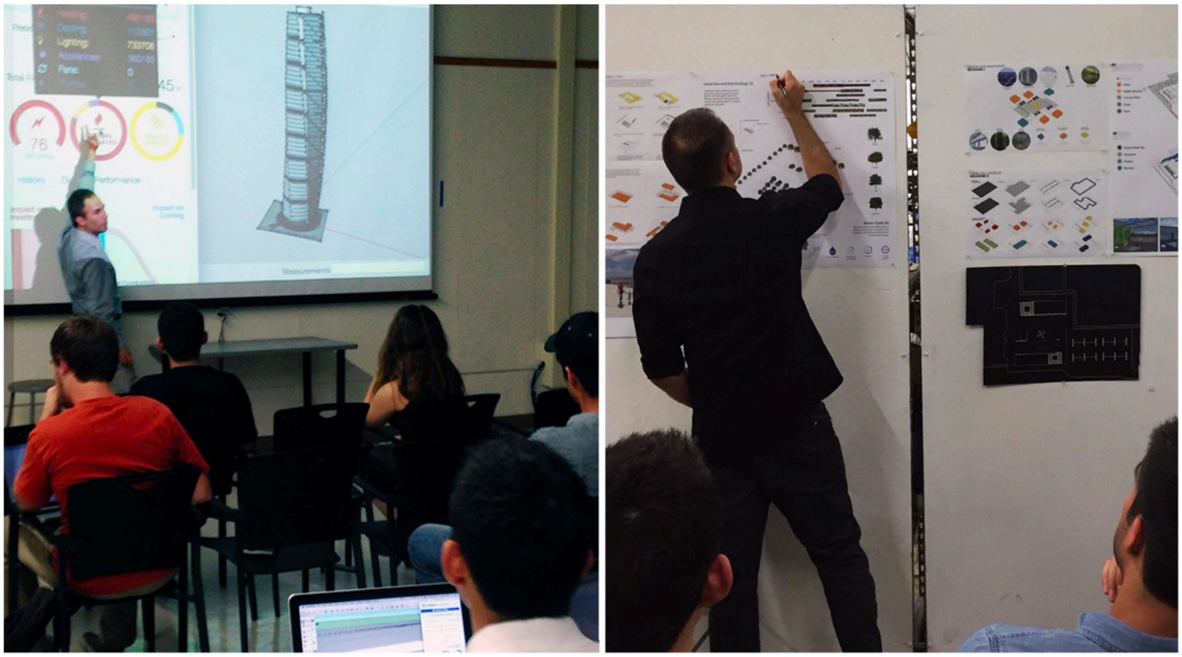

Figure 3. Dr. Azari introduces software (left) while Professor Caine discusses site ecology (right). Source: (Authors 2016)

The next two labs, "Energy Flows and Futures" and "Light and Air," prompted students to learn Sefaira, a building performance plugin to SketchUp that predicts the energy and lighting performance of buildings. Students used the complementary software packages to generate multiple design alternatives that maximized energy performance, daylighting, and passive ventilation. During this phase students leveraged a variety of metrics to measure success: the Energy Use Intensity (EUI) to measure energy use against targets from the Architecture 2030 Challenge, Spatial Daylight Autonomy (SDA) to maximize day daylighting, and Annual Sunlight Exposure (ASE) to minimize unwanted direct sunlight. Students leveraged the combination of software and metrics to initiate an iterative process that involved testing the relative efficiencies of multiple geometries, plan organizations and fenestration patterns.

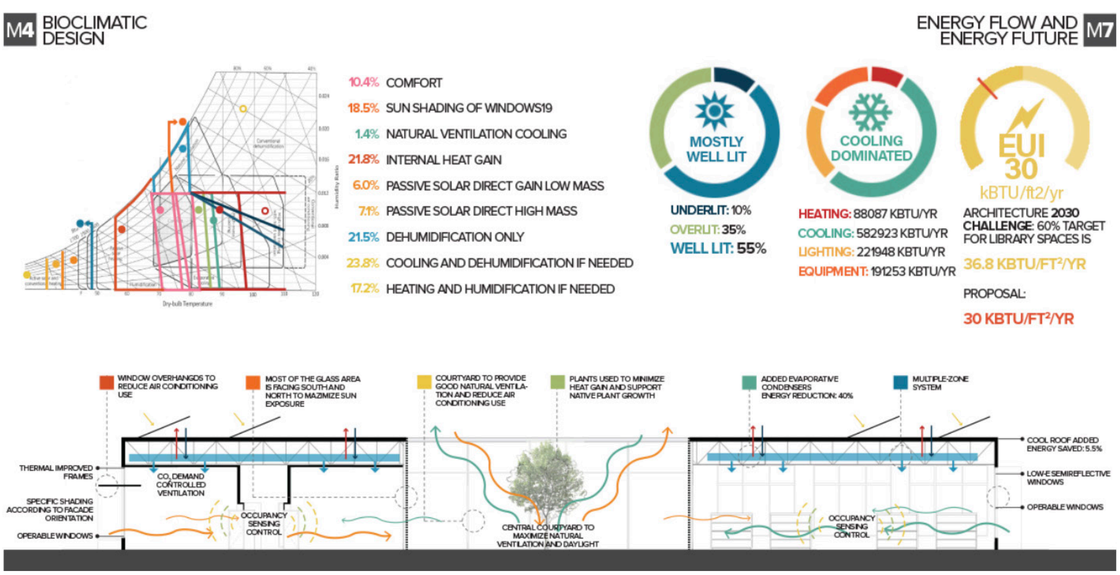

Figure 4. Student work from one of the building performance labs. Source: (Elsa De Leon, 2016)

In a subsequent "Water Cycle" lab, students learned strategies to reduce consumption through the introduction of low flow fixtures and collection, filtering and treatment strategies. Finally, a “Material and Construction” lab introduced students to Athena Impact Estimator, allowing them to quantify the lifecycle impact of materials on global warming, acidification, eutrophication, and smog formation.

2.3 The architectural design labs

The instructors ran 5 architectural labs in parallel with the 5 performance labs. The first design lab, titled “Regional and Community Design,” asked students to consider the relationship of their design proposal to the larger metropolitan context, highlighting topics such as neighborhood form, typologies, and vehicular and pedestrian circulation systems. During the housing studio, the lab required students to perform a careful analysis of existing and proposed residential densities in order to understand the potential impact of infill strategies.

A subsequent lab, “Land use and Site Ecology,” required students to consider how their site intervention might impact existing ecosystems, watersheds, flora, and fauna. Students began by selecting and mapping an existing ecosystem such as hydrology, food, or migration. Once the mapping was complete, students examined the potential impact of their design intervention on the system, identified the parts of the system that would be directly affected, and then considered potential feedback loops.

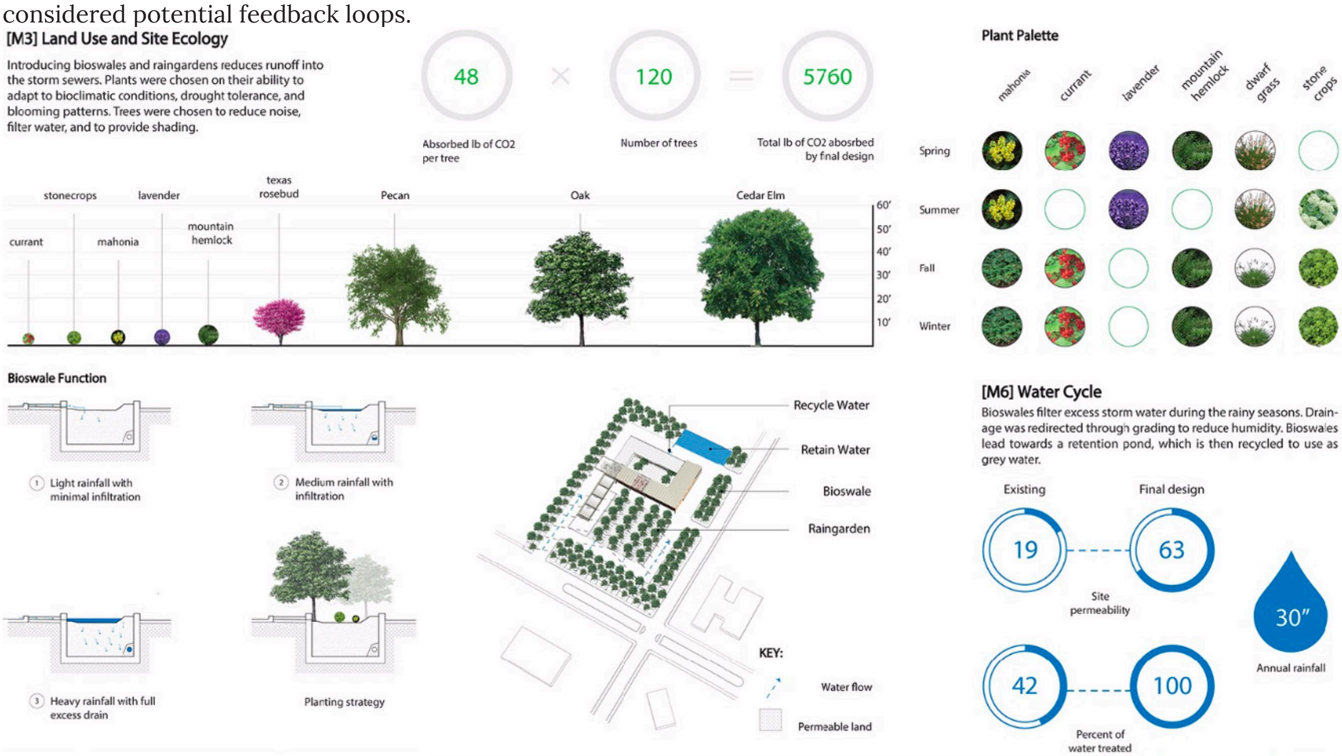

Figure 5. Student work from the architectural design labs. Source: (Reyes Fernandez and Carmelo Pereira, 2016)

The “Long Life Loose Fit” portion of the COTE rubric is intended to measure a design’s potential for long-term flexibility and adaptability. The instructors interpreted this lab differently in each semester. In the first studio, which considered the adaptive reuse of a commercial big box, students focused on the material efficiencies of the renovated structure. In this case, issues like the cost of assembly, disassembly and the durability of materials and systems over time became important. In the second studio, which dealt with suburban infill housing, students utilized the American Fact Finder to make a demographic and socioeconomic argument for increasing the diversity of housing typologies. Focusing on issues like age, income, and family type, students constructed a series of graphics that demonstrated the relationship between housing diversity and sustainable communities.

In the “Collective Wisdom and Feedback Loops” lab, the instructors asked students to document their formal decision-making process throughout the semester, retroactively evaluating the impact of various labs on their design process. For many students, this exercise revealed the enormous opportunities and potential complications of the parallel lab structure. It also prompted an important discussion within the studio about the preferred sequence of labs. It finally provoked studio members to pose critical strategic questions such as: what comes first, analysis or form? This lab generated a number of highly productive and revealing discussions amongst the students and instructors.

Finally, the “Design and Innovation” lab challenged each student to select one environmental strategy and make it the subject of an in-depth design development drawing. Popular topics included sunscreens, landscape strategies and, for the housing studio, prefabricated envelope systems. The instructors required that these drawings simultaneously illustrate architectural concept, environmental performance, and human experience, thereby illustrating the philosophical intent of the studio.

CONCLUSION

The pilot studio succeeded on a number of pedagogical levels. First, and most critically, the studio prompted students to pursue the topic of building performance as a form generator, not a technical overlay. The curriculum accomplished this by implementing a highly-structured feedback loop that advanced issues of analysis and form-making in parallel, never in isolation. To exaggerate the creative tension between these two often-opposing topics, the instructors discussed the conflicting priorities on a daily basis, with Professor Azari advocating for sustainability and Professor Caine emphasizing architectural design. Students appeared to appreciate the diverging faculty perspectives, viewing them as a source of constructive tension rather contradiction.

Second, the labs provided a solid organizational foundation upon which to structure the semester's work. We typically held labs on Wednesdays, which broke up the week and provided the studio with a useful rhythm. The course evaluations indicated that students enjoyed the intense instruction and tightly scripted exercises, which provided a break from the typically open-ended nature of the design process. The labs also provided the instructors with an opportunity teach skills related to software, metrics, drawing, diagramming and research. Skill-building is something that is often missing from design studio curriculums, which typically focus on the pursuit of ideas.

Third, the lab structure—which alternated weekly building performance and design labs-- obliged students to pursue an integrated and multi-disciplinary approach to their projects. Quite simply, it was impossible to ignore either the performative or formal development of one's project for more than one week, because every Wednesday students had to confront another set of topics and exercises.

Figure 6. Student work from one of the final COTE submissions. Source: (Reyes Fernandez and Carmelo Pereira, 2016)

Fourth, each studio participant had the opportunity to assemble and submit an entry for the AIA COTE Top Ten Competition for Students, one of the most prominent student competitions in North America related to the field of sustainable design. The students enjoyed the competitive aspect of the work, as well as the sense that they were involved in a discourse that transcended the boundaries of UTSA. Students frequently viewed and critiqued the winning submissions from previous years, while discussing how their entries might stack up against work from other universities. Many students took advantage of the (voluntary) opportunity to team up with a classmate for the entire semester. This collaboration was a first for a number of participants, many of whom had never worked on a team while in school.

Finally, the studio work and curriculum generated a significant amount of external recognition. One project from each studio received recognition from the AIA COTE Competition Jury, which selects ten winners annually from a large pool of entries submitted from the U.S., Canada, and Mexico. Representatives from the two winning teams traveled to AIA National Meetings in Philadelphia and Orlando, trips that exposed the students to multiple lectures, workshops, and thousands of architects from across the country. Additionally, leading national and regional journals like Architect magazine and Texas Society of Architects published the winning designs (Madsen and Blahut, 2016; *Texas Society Architects*, 2016).

Last year, Architecture 2030 selected the UTSA studio for inclusion in the 2030 Pilot Curriculum Project, a program committed to promoting courses that "transform the culture of sustainable design education not only within their own schools, but in architecture and planning programs nationwide" (*Architecture* 2030, 2016). The Architecture 2030 Challenge, initiated by architect Ed Mazria, calls for architects to design built environments with zero emissions by the year 2030. The UTSA studio curriculum, one of seven inaugural selections for this program, is now receiving technical, logistical and publication support from Architecture 2030.

The overall success of the pilot curriculum notwithstanding, the studio presented more than a few sets of challenges to instructors and students. The first involved the large amount of skill-building required of students. The instructors introduced a significant amount of advanced performance modeling software and metrics during a short four-month time frame. Virtually all of it was unfamiliar to students. Not surprisingly, at times the volume of material was difficult for students to absorb, which led to a decline in the quality of lab results. Other times, the in-class training and working sessions proved insufficient in scope to allow students to master the necessary software. The training sessions also consumed time—typically one studio period per week--that would have normally been devoted to more traditional drawing and model-making.

A second set of challenges involved the capacity of many students to treat building performance as an integral component of the design process. While all were quick to adopt this philosophical position, putting this motivation into action proved more difficult. Too often, when faced with a faltering or unclear design concept, students buried themselves in environmental analysis, perhaps hoping that the software would lead them to a design solution. Other times, students intuited a form-based solution, then used the software to justify their pre-conceived result. Neither of these strategies proved successful.

Perhaps the greatest set of challenges, however, involved encouraging young designers to pursue formal innovation at the intersection of building performance and architectural design. Too often, the studio members reverted to generic environmental strategies, adding sun screens, bioswales, or permeable pavers to otherwise traditional formal strategies.

The instructors are planning a series of modifications for future iterations of the studio. First, we would like to encourage students with pre-existing knowledge of advanced performance software to sign up for the studio. This would partially alleviate the burden of skill-building that has slowed the studio's progress. Second, we would like to emphasize the "Design and Innovation" lab, perhaps with an emphasis on simultaneous physical and digital modeling. We hope this will encourage students to view building performance as a catalyst for formal innovation, rather than as a post-rationalization or mere accounting of the design process. Finally, the studio would benefit from the input of other disciplines, particularly landscape architecture. This will be a challenge, given that UTSA does not sponsor a landscape program. Still, the instructors have the luxury of drawing on an excellent professional community in San Antonio.

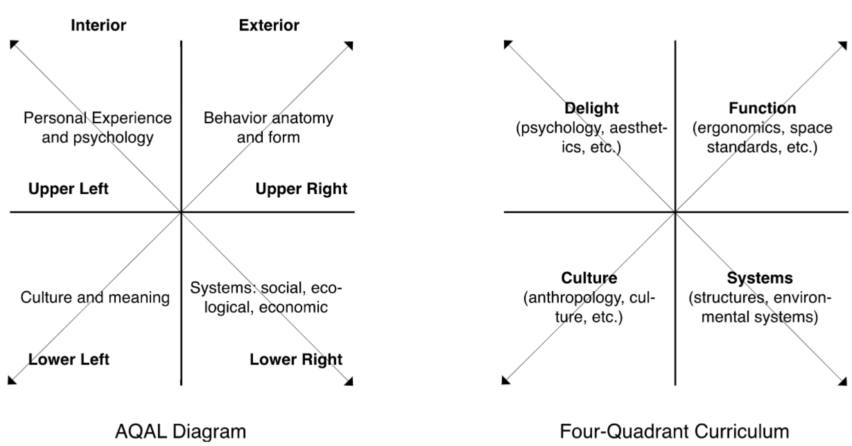

Figure 7. Wilber's AQAL diagram (left); Buchanan's four-quadrant curriculum diagram (right). Source: (Buchanan 2012)

While the curricular intervention described above is limited to a single studio exercise, and therefore limited in scope, both instructors are strong advocates of the Linked Model, which more fully integrates sustainable principles into core architectural curriculums. Still, there is another level of pedagogical integration that occurs at a trans-disciplinary scale. One recent and compelling suggestion comes from South African architect and urbanist Peter Buchanan, who proposes a pedagogical model that he calls Four Quadrant Curriculum. Buchanan's model posits that sustainability in the built environment exists at the nexus of architecture, urbanism, and landscape architecture—disciplines that became artificially separated during the modern period. Buchanan proposes a *Four Quadrant Curriculum* meant to simultaneously reintegrate the disciplines, while elevating the importance of sustainability in architectural education (Buchanan 2012).

Buchanan bases his Four Quadrant Curriculum on the Ken Wilber's Integral Theory's All Quadrant All Level (AQAL) diagram, which asserts that in order to fully understand a phenomenon an individual must develop a range of comprehension that he describes as interior, exterior, individual and collective. By doing so an observer gains a variety of perspectives that he describes as personal, behavioral, cultural and systemic.

Buchanan leverages Wilber's AQAL diagram (Figure 7, left) to argue for a year-long series of foundation courses that would be taught to students from different disciplines. The larger goal of such a curriculum would be to provide students with a broad and shared understanding of the issues related to sustainability. Buchanan goes on to diagram course requirements for architecture students (Figure 7, right). On the left side of the diagram he places courses that provide a subjective understanding of sustainability, while on the right he offers courses that cover objective issues. The subjective courses focus both on personal experience and psychology—which he calls "Delight"—and on worldviews and subjective aspects of community—which he calls "Culture." On the right-hand side of the diagram he places courses that provide an objective perspective on the sustainable built environment—he calls these "Function." These courses are primarily design studios and explore space standards and program. The right-hand side also covers different aspects of environmental and structural systems, including their impacts on building use and occupant comfort—he calls these "System" courses. This comprehensive approach emphasizes the importance of teaching not only core building performance concepts, but also the synergies and tradeoffs that are often ignored in the discussions of sustainability in built environment.

Today's architectural education, at its core, must train students to confront the environmental challenges—phenomena like sprawl, water, infrastructure, carbon and housing—that increasingly define life in the twenty-first century city. Both instructors believe that the best way to help students engage these issues is through the successful incorporation of technical coursework and studio efforts. It's only through such integration that students will develop the technical skills necessary to evaluate building performance and put them into the service of their architectural designs. We are gratified that the teaching model and materials developed in this course, soon to be published nationally by Architecture 2030, will become available to additional instructors who are working to transform their own studio culture and core curricula to meet twenty-first century environmental challenges.

ACKNOWLEDGEMENTS
The Authors would like to acknowledge the intellectual and technical support of Architecture 2030, sponsors of the highly promising 2030 Pilot Curriculum Project. Additionally, Sefaira Architecture provided software licenses to UTSA students at no charge, a gesture that added tremendous value to the students' educational experience. Finally, we appreciate the efforts of AIA and ACSA to develop the COTE Top Ten Competition for Students, which has become an invaluable venue for students to address issues related to building performance and sustainability.

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