Engaging a Critical Metric: New Strategies in Energy Literacy

"If you want to teach people a new way of thinking, don't bother trying to teach them. Instead, give them a tool, the use of which will lead to new ways of thinking."

— Buckminster Fuller

Brad Deal
Louisiana Tech University

Sustainable design has for many years been high on the list of critical issues that schools of architecture across the globe have sought to emphasize and integrate into their curricula. Once treated as a specialized topic within the field, it is becoming more difficult to find a classes and projects that are not addressing energy efficiency, resource conservation, air quality and the like. Unfortunately many undergraduate students equate sustainable design with one checklist or another because those are the tools they encounter first when reading about projects lauded for their environmental achievements. Checklists offer an array of strategies, but often the logic behind them is buried deeper than students are willing to look. For most designers espousing sustainability, global warming and its threats to future generations are a universally shared motivation. The concerns of climate change however are typically not expressed in the vague moral sensibility of students with a fleeting interest, they are assumed as common knowledge among like-minded individuals, considered beyond the scope of a given situation, or similarly marginalized for various reasons. These conditions highlight a need among students for an earlier introduction to both the larger issues that give weight to sustainable design practices as well as more versatile and informative metrics to inform design decisions.

Responding to this observation, an elective seminar course offered to third year architecture students in the winter of 2012/2013 at Louisiana Tech University introduced building energy modeling as both a gateway to understanding the larger issues of climate change and simultaneously as a tangible resource for evaluating the energy implications of design decisions. Framed in a context of political gridlock, disappointing international efforts, alarming climate models and ironically, abundant distractions from these issues, it has never been more critical for educators to foster a culture of energy literacy and global consciousness among future designers.

Reflecting on the pedagogy, methods and student work of this seminar, it is the intent of this paper to identify the challenges and opportunities presented by the early introduction of these specialized topics often reserved for graduate level courses. The successes and critiques discussed here would ideally be used to refine future iterations of similar course offerings that would provide an informed introductory perspective on climate change and introduce design tools with which students can respond. Raising these topics among mid level design students should create opportunities for deeper, more effective integration of sustainable design and research efforts in the remainder of their academic careers.

INTRODUCING CLIMATE CHANGE

Increasingly violent whether, habitat and species loss causing interruptions in the global food chain, resource scarcity, sea level rise, massive population displacement, humanitarian crises and eminent warfare are frequently found in the sequence of predictions for the next 90 years if current trends continue. Most undergraduate design students are not familiar enough with the threats of climate change to cause the array of often apocalyptic predictions for end of this century to appear cliché or overstated. So when introducing students to climate change, it is important that they are informed of these concerning predictions. The shocking nature and the abundant political controversy surrounding them provides an obvious opportunity to motivate and engage otherwise reluctant students. As with any complex issue, it is only appropriate to include some discussion on the various relevant perspectives on the topic.

In addition to political views, it's also vital that students are informed of the range of active responses. Top-down government efforts, modest projects from grassroots movements, green washed marketing campaigns, the dizzying array of product and project certifications should all be presented at some level and discussed. A key concept to be covered here is the inherent danger of the pursuit of incremental efficiency. At present, practitioners with conservative clients may be left with few alternatives, but there is clear danger in equipping the architects of the 21st century with strategies for modest incremental improvements that will be out paced by increased net consumption and population growth over the course of the century. The checklists that many undergraduates equate with exemplary sustainable design often fall into this trap by setting the performance bar to low.

Efforts toward efficiency found in current practice should be framed for today's students as the early steps in an approach that must steadily accelerate its expectations seeking a transition from being less bad to fundamentally new approaches toward resource management. Along side the pessimistic predictions and timid incremental improvements we must also highlight the perspective of visionary optimism, as seen in the enthusiasm of Saul Griffith's work or the idealism espoused by programs like Cradle to Cradle or the Living Building Challenge. While no program is perfect, setting the bar high, highlighting human ingenuity, our capacity to transform technology and overcome adversity are essential if we expect future designers to shirk any lingering sense of futility in their efforts. Ideally we need to assist students in creating an identity for themselves as contributors to a positive collective future rather than simply hoping to survive in a rapidly changing world.

ENERGY SIMULATION IN SUSTAINABLE DESIGN

Building energy consumption is one of the primary means by which architects engage and effect issues related to climate change. Schools of architecture broach energy issues often within their efforts to teach sustainable design principles, but the depth and rigor with which the topic is explored can vary depending on student and faculty interests. Energy conscious explorations of passive design strategies, on-site energy production and high efficiency building systems, etc. are often presented in the context of specific projects or a building systems course rather than framed by a discussion of climate change. Building Energy Modeling can be used as a platform for investigating the intersection of these topics while addressing climate change and the ways designers are challenged to respond. As a design tool it clearly can aid the process of integrating low and high tech approaches to sustainable design. Students can quantitatively test the effectiveness of shading devices, passive ventilation, natural lighting etc. along with various HVAC configurations, lighting, and equipment and energy production strategies.

This kind of quantitative analysis has historically been the task of mechanical engineers, and even the most advanced software offerings to date still reflect this in their interface. They challenge design students to take ownership of essential building science metrics like HSPF, SHGC and EER ratings. By borrowing engineer's tools and language, the interdisciplinary nature of energy and the value of working across industries are easily evidenced. Discussions on this topic can prompt students to explore how they can continue to reach out to other fields of study such as biology, economics and engineering in search of ways we can change the practice of design at a scale large enough and fast enough to combat the effects of climate change.

THE CURRENT STATE OF ENERGY MODELING TOOLS

As more architects prioritize energy issues and experiment with simulation tools they are currently met with a daunting array of software options from which to choose. The Department of energy currently lists over 130 programs on their Building Energy Simulation Software Tools Directory page.1 The blossoming of these offerings in recent years from both private and public developers is a clear indication of the inertia behind energy consciousness in the future of the building industry. Unfortunately, at present these tools are complex and opaque with significant learning curves. Despite extensive development most of these programs require significant training or trial and error paired with comprehensive building science and systems knowledge in order to yield dependable results.

Software developers are working to overcome these barriers to entry. Many of the more refined tools have streamlined and clarified the input process by utilizing 3D models rather than numeric inputs. Some have also begun to utilize graphic interfaces to illustrate systems, occupancy and other settings. In addition to graphic interfaces, new stratifications are emerging within the field in recent years. Energy Modeling has been expanding and developing more specialized tools to cater to specific needs. Tools focused on the ability to study energy implications early and often in the design process have become known as Design Performance Models (DPM). Simplified graphic interfaces, streamlined 3D modeling inputs and less complex systems specifications allow architects to balance issues of cost, aesthetics and energy performance simultaneously. The typical Building Energy Models (BEMs) still predict energy consumption as compared to a baseline models utilizing very specific and lengthy inputs while Building Operations Models get even more specific utilizing empirical information of existing buildings to aid in streamlining operations. And going even further, Project Resource Models (PRMs) are the most exhaustive, addressing the relationships between many resources of which energy is only one, analyzing entire projects for consumption, efficiency, and conservation data.

These trends are illustrated in a document published last year the AIA entitled "An Architect's Guide to Integrating Energy Modeling in the Design Process".2 A valuable resource for introducing any architect to energy simulation, it summarizes the current thinking, issues and uses for energy simulation among architects today as well as discussing the future of the energy modeling industry. Considering this clear emergence of energy modeling in architectural practice paired the current climate change trends, a clear case can be made to students for exploring energy simulation and integrating it into their own design processes.

ATTEMPTING ENERGY LITERACY AMONG UNDERGRADUATES

In the winter of 2012/2013 an elective seminar offered for the first time in the Louisiana Tech School of Architecture began with precisely these elements, presenting the daunting realities of eminent climate change and challenging students to equip themselves with the tools necessary to address this issue that will be one of the defining elements of their careers.

METHODOLOGY

The obvious question of software selection was not a simple one given the scattered state of the offerings mentioned earlier. Prioritizing a design performance modeling tool, flexibility and a short learning curve, the course offered students a choice of utilizing either NREL's Open Studio, a well developed platform utilizing Sketchup and the new Energy Plus simulation engine, or Solemma's DIVA for Grasshopper, a relatively new offering that includes energy and daylighting analysis developed as a plug in for Rhino NURBS modeling - the most familiar 3D software among these particular students.

The course was structured around 3 assignments: a case study designed to introduce students to energy issues, a comparison of energy modeling data to student's own empirical consumption and ultimately an exploration of energy reduction strategies in student's various current studio projects.

CASE STUDIES

The initial case study assignment was paired with introductory lectures addressing the state of climate change and Building Energy Modeling's emergence as a design tool. Students were challenged to identify and present projects with documented energy simulation in their design process. They were to evaluate how the simulation tools were used and discuss the associated, goals, assumptions and achievements. The results of this exercise revealed numerous misunderstandings of various green building concepts and vocabulary each of which offered an opportunity to properly explain the given misunderstood concept to the class. One particular assumption repeated in many of the case study presentations revealed student's fundamental misunderstanding of green building certifications. These students, many of them in their third year, blindly associated exemplary energy performance with green building certifications, most frequently LEED, without understanding the requirements of those certifications. In response, a lecture was delivered comparing an array of green building certifications including LEED, Passivhaus, Building America and the Living Building Challenge to the code minimum standards set by ASHRAE. The presentation of the certification programs' merits, shortfalls, and actual energy implications was well received among the students and led to a candid discussion of common misconceptions about these programs held by students.

PERSONAL RESIDENCE

The second assignment required students to create a building energy model of their current residence, troubleshoot the simulation results by comparing them to their personal energy bills, then experiment with orientation, fenestration, insulation, occupancy and HVAC efficiency parameters in an attempt to identify the most valuable energy reduction strategies. This exercise presented a challenge due to the sheer quantity of models generated, the two software platforms, the various building configurations, fuel types and variables being tested. The variety of projects, approximately twenty, did however provided a number of opportunities to highlight the strengths and shortcomings of the software in a way that would have been difficult to replicate had a single building been assigned to all students. Similarly, by having students present their findings to one another, as was the case in the first assignment, opportunities were created for the discussion of common questions, challenges, and solutions. As well, valuable specific building science information that likely would not have otherwise been covered in the course could be discussed in the context of the presentations.

While the discussion surrounding the assignment was positive, the results of the experiments revealed that the students struggled to grasp the acceptable range or deviation for many of the numeric input variables. About half of projects presented suspicious findings with no chance to troubleshoot the inputs on the spot. This condition of false high and low #s undermined a planned discussion of how the student's various housing performances compared to the previously discussed green building certifications' energy benchmarks. A lack of familiarity with some of the typical input values is common for students attempting energy models for the first time, but not realizing or correcting the mistakes highlights a clear lack of retention of building systems information covered in other courses. In fact, building systems classes may consider the benefits of utilizing energy modeling as a platform for introducing and comparing various building systems. Retention of the engineering oriented information would likely improve if students were utilizing it more frequently throughout their education as with CAD, modeling and graphics software.

Another clearly lacking element in the 2nd assignment presentations was a consistent format for illustrating reference results as they compared to a test case, what variable was being tested and where the effects occurred. Often only one or two of these elements were presented at a time, which made it difficult for the audience to grasp the amount of influence a given variable had on a project. In this way, creative and effective information diagraming becomes critical to effective communication of the data.

At the beginning of the second assignment, the students were almost evenly divided with half working in the Sketchup/Open Studio platform and the other half using the DIVA for Grasshopper plugin. Many were attracted by the simplicity of the Sketchup modeling tool, but the complexity of the Open Studio systems interface compared to the visual parametric interface of DIVA for Grasshopper ultimately persuaded the majority of the students to opt for working in DIVA for the final assignment.

STUDIO INTEGRATION

In the third and final assignment each student was asked to apply his or her new energy simulation abilities to their current studio design problems. The students had projects at various stages of completion across a range of different studios, and as with the previous assignment the fact that the projects varied to such a great degree in scale and completeness gave way to a valuable discussion at the beginning of the assignment regarding the ideal time to employ energy modeling in the design process. Similar to the 2nd assignment, students were asked to experiment with the same passive design and systems variables, but in addition this time there were also challenged to specifically investigate the energy saving value of shading devices and/or building skins. The assignment asked that they document their experiments, present the findings and discuss whether they would actually incorporate any of the variables tested.

Due to the lack of faith in many of the results presented in the second assignment and the fact that the majority of the class was working in DIVA, it was decided that a comprehensive master energy model would be developed and distributed in the form of a grasshopper definition. The intent was to streamline and add confidence to the findings of the 3rd assignment by removing many of the novice errors and inconsistencies that plagued the 2nd assignment results. Similarly, a master output spreadsheet and graphs were developed and distributed for this assignment to assist the students in legibly presenting the results of their experiments.

These efforts paid off in significant quality improvements in the 3rd assignment deliverables. The shared energy model and results spreadsheet paired with the fact that all students were working in the same software made the comparison of results to one another a much more manageable and informative. While some students continued to struggle with inputs and terminology in their presentations, several students were able to test and optimize fenestration and shading schemes that became primary features of their projects.

CHALLENGES

The challenges presented by a course such as this are numerous. Sensitive geopolitical issues, complex software in its infancy, and the inclusion of engineering level building science each present their own set of obstacles. But leveraging the global significance of climate change to inspire student engagement, maintaining patience for software learning curves and sharing example energy models and output formats can create influential learning opportunities for young architects.

When engaging the world of energy analysis, Instructors must explain that the industry is still young and that the tools for architects are still emerging and steadily reinventing themselves. The findings of the RMI Building Energy

Modeling summit and the AIA's Energy modeling guide provide clear indications of the trajectory of this field, the array of software offerings and the major categories of each.

Instructors preparing courses such as this are challenged to design a series of assignments that are meaningful yet simple enough to be executed by novice energy modelers. Students must be trained through repetition to recognize the established energy consumption benchmarks, building systems input standards and be able to identify mistakes and inconsistencies in their models and results. As well, Instructors should demonstrate how to present energy model output in formats that clearly show all pertinent data.

Through these processes instructors must also help students to construct arguments and extrapolate trends that relate a set of energy modeling results to the bigger picture of climate change. After all, students are much more likely to find value in these tools and remember the bigger picture if we train them to frame the data in a way that engages the gravity and urgency of climate change.

OPPORTUNITIES

Offering a course of this nature to relatively young students presents a unique opportunity to nurture the necessary culture of global consciousness and energy literacy in students who are able to continue to explore the issues that inspire them in the remainder of their academic careers. If we expect the students of today to meet the demands of climate change in the next century, their education will have to challenge them to identify clear personal motivations and take ownership of their commitments to sustainable design principles. Entire courses could be devoted to the goal of inspiration alone however by also offering the tool of energy simulation we can give students the means to quantitatively legitimize and refine their design decisions. In the end, a class such as this give us the opportunity to create a new generation of architects that are injecting the practice with a fresh awareness of the threats of climate change and a set of tools that allows them to take effective action.

CONCLUSION

Teaching that engages pervasive global issues and complex software is fraught with challenges that require significant preparation and careful composition of the assignments and lectures. It is debatable as to whether or not such specialized content belongs in an undergraduate setting. Certainly higher quality work would be produced by students at the graduate level, but the prospect of these experiences for younger designers leading to a deeper, more effective integration of sustainable design and research efforts as they complete their degree programs seems worth the risk in the face of imminent climate change. At this point schools of architecture must continue to innovate and experiment with courses of this kind, as they foster an awareness of the issues of climate change, cultivate interdisciplinary collaboration in search of solutions and provide their students with knowledge and tools that will prepare them for the coming challenges.

ENDNOTES

1. "Building Energy Software Tools Directory." Energy Efficiency & Renewable Energy. Department of Energy, n.d. Web. 01 Aug. 2013.
2. AIA Energy Modeling Working Group. An Architect's Guide to Integrating Energy Modeling in the Design Process. N.p.: American Institute of Architects, Aug. 2012. PDF.