Transforming the Design Studio to Achieve Net-Zero Ready Buildings

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In the fight against climate change, incremental improvements to the architectural design studio are no longer sufficient. The traditional studio model, which features a master/apprentice relationship, is well suited to generating "good" design solutions. However, this self-driven discovery-based learning process leaves little time or focus for achieving specific high-performance design strategies. More specifically, the traditional design studio features a distinct lack of accountability for performance-based metrics, a lack of time to pursue performance-based goals, a lack of prioritization of building performance, a lack of clarity for what constitutes a successful sustainable design process; and a lack of examples on "how to" perform simple design steps.

As a response, a new studio pedagogy is proposed to assist students to achieve net-zero performance within the typical 15-week semester. A structured collection of sustainable design approaches specifically organized by a pyramid (Figure 1) helps professors and students adopt an over arching framework for sustainable design. This paper will focus specifically on the studio methodology itself. This new design methodology formalizes activities already used in the design studio and leads students to reach higher levels of building performance for their projects. Specifically, this paper will focus on the following innovative teaching techniques: How to place "accountability" into the design studio through early and often against well-established benchmarks; How to prioritize building performance by front-loading sustainable design techniques; How to accelerate the design process through the use of "how-to" videos; and How to develop and use well-developed rubrics with learning objectives to keep students focused on both net-zero energy AND the more rewarding and more familiar design resolution process. In conclusion, this paper will spark a much-needed conversation on how design studio pedagogy itself can evolve to train students to design high-performance projects in the short-term and ultimately to mitigate the impacts of climate change in the long-term.

INTRODUCTION

The context for the education of architects and the practice of architecture itself is changing both quickly and dramatically. COVID 19, social inequity and climate change pose different challenges, each dealing devastating effects to our planet, our society and our very psyche as humans on the planet. The pace of change and the rise in the stakes of being an architect in the 2020's and beyond demand that new transformative models for teaching architectural design studio are not only necessary but critically important for the health, well being and safety for all living beings on our planet.

Studio methods have certainly evolved over the last ten years. Most professors routinely include discussions about sustainable design in their studios. Such incremental improvements are welcome but insufficient[1] in their attempts to inculcate future architects with the values and techniques necessary to fight climate change.

Over the years, design studio methods remain sacrosanct and immune to deep innovation. The inertia of architectural studio pedagogy is very strong, handed down by generations of architects dating back to the Ecole des Beaux-Arts with more recent iterations in the modern era.[2] The cornerstones of the traditional architecture design studio are well known, tacitly accepted, and can be summarized by the following: A heavy reliance on the master/apprentice teaching method, an emphasis on formalism, the unending individualized search for personal exploration,[3] the speculative nature of the design studio brief, and the limitation of constraints in the design process. Until recently, these cornerstones have worked very well to prepare architects to succeed in a relatively unchanged society and relatively static profession. However, given the rise of climate change, it is necessary to question whether these techniques are as useful or as relevant as they once were. The traditional studio model is well suited to generating "good" design solutions, but this slow, discovery-based learning process[4] leaves little time for achieving specific design metrics such as net-zero energy performance.[5] The time is right to imagine ways to transform the design studio to better address the problems of today and the impending climate collapse in the not so distant future.

PAPER

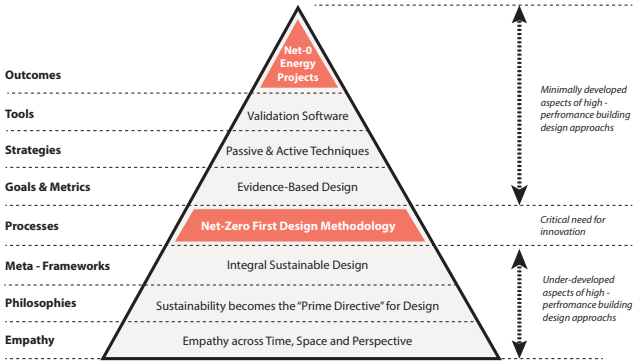

Figure 1. The Net-Zero First Method in relationship to the larger educational goals of the program. Image Source: Rob Fleming.

Two proponents of new approaches to teaching design studio are Ali Makalwi and George Gordon. Mr. Makalwi stated: "Most of the schools that I'm aware of have been trying to figure out how to do this for many, many years. Gordon and I think this is one way of doing it. I'm sure there are others. But at the end of the day, we wanted to ensure that students would understand that performance and good design go hand in hand. You're going to have to have that approach. It's fundamental, and we cannot afford not to have it anymore.[6]

Indeed, the observations and approaches shared within this paper are the direct result of two decades of failure in trying to achieve a successful, authentic sustainable design studio. It proved difficult if not impossible to routinely teach students to achieve even the most basic quantifiable goals like those offered by the LEED rating system. Or, when the students did achieve verified high performance design solutions, the quality of the design work itself was qualitatively weak. I propose that the many years of failure may have less to do with my ability as a design professor and more to do with the possibility that the traditional studio structure itself and all its associated aspects are not suited to the challenges of the 21st century.

Another proponent of net-zero energy design studios is Mary Guzowski. She states: "The ability to define fundamental energy-consumption and sustainable performance metrics, strategies, and assessment methods is often lacking in both the academy and practice, at the same time as the shifting aspiration from net-zero to net-positive energy design continues to raise the bar."[7] This statement made in 2012 remains largely true today. Studio professors struggle to juggle the competing demands of high quality design with the added agency of performative design. Our educational community has simply struggled in the task of cracking the code of how to evolve design education to adequately if not comprehensively address climate change. The Course Development Prize offered by the Buell Center and Columbia University features innovative studio themes but offers few examples of fundamental shifts in the studio format itself.[8] The Net-Zero First Method (NZFM), as proposed in this paper, is one of many studio structures that break the traditional mold of design education. Central to this task is the reorientation of the "prime directive" in studio pedagogy from: "Great buildings that include sustainability," to, "Sustainable buildings that feature great design." Indeed the authors of the Zero Net Energy Education: A Survey agree, "It is crucial that architectural education place sustainable design at the center of their core values, rather than treating it as a specialized area of study."[9]

Finally, the deliverable of this paper is not to convince the reader to adopt the NZFM, but more importantly to encourage the reassessment of current studio models and to consider the possibility that new ways of teaching are not only possible but necessary to effectively prepare future architects for the challenges they will face. The examples provided are meant to inspire innovation and to open the dialogue regarding the continued efficacy of traditional studio pedagogy.

BACKGROUND AND CONTEXT FOR THE NET-ZERO FIRST METHOD

A new studio pedagogy is proposed to assist students to achieve a reasonably well resolved building and reach net-zero performance within the typical 15-week semester. The target audience for this course is second year undergraduate architecture students and first year graduate level architecture students. However, the curriculum is written so that anyone regardless of background can proceed with the design of a building. Broadening the audience required the reorientation of how the curriculum was designed so that success was measured by learning outcomes as opposed to the professor's expectations. This shift was transformational in the development of the NZFM, and placed the curriculum squarely in line with NAAB's new way of evaluating design programs. The studio sits within the broader context of a non-traditional approach to design education through the MS in Sustainable Design Program at Thomas Jefferson University.[10] The studio is taken by a wide range of disciplines from architects, to interior designers, to non-designers, to MARCH Students. The teaching team includes 2 registered architects (Rob Fleming and Frank Sherman), an energy modeling expert (Janki Vyas) and a civil engineer (Gilberto Rodriguez) who assisted with the design and calculation of net-zero water systems. Lastly, the pedagogy and student work shown is from the third iteration of the graduate level MSSD Graduate design studio.

To provide some context, Figure 1 (above) places the NZFM into the larger context of the MSSD program and the studio sequence. Starting at the bottom foundation, "pre-conditioning" is helpful, but not required for students entering the studio. The core traits of an effective sustainable design studio are empathetic motivations, shared philosophies and accepted frameworks. In the examples discussed in this studio, it should be noted that the many of the students received extensive education around these topics prior to the studio via a lecture class, and they arrived mentally prepared for the ambitious

nature of the studio itself. Empathy across time for future generations, empathy across space for people far away and empathy across difference are subtle, but powerful underlying drivers for sustainable design. Students who have internalized those traits are more likely to care enough to push through the challenges posed by net-zero energy performance. In other words students must be connected to the deeper motivations that drive sustainable design. Without that, sustainable design becomes a long list of design strategies, often incoherently added at the every end of the studio process.[11] Shared philosophies are critical to move the studio forward quickly. Long winded discussions about the definition of sustainability only serve to confuse the students thereby wasting precious time that could be spent creating design schemes or producing energy models. In the NZFM, the students have already been introduced to the idea that "design excellence" is a subset of the broader goal of sustainable design as defined more broadly by the Quadruple Bottom Line (Figure 2 below).

Shared frameworks are critical in establishing a set of foundational lenses by which to view the design project holistically and consistently. Integral Sustainable Design[12], developed by Mark DeKay features the use of four lenses: Performance, Systems, Culture and Experience. These are broadly accepted themes under which students routinely develop "Design Ideas" throughout the process. For the Performance lens, students set performance goals using benchmarks from case studies and by referencing the AIA COTE Top Ten Framework. The Systems lens demands that students routinely engage the ecological aspects of the project with a special focus on flora and fauna, hydrologic systems, wind patterns, and sun angles. The Culture lens asks students to consider the cultural and physical context of the project and also how social responsibility is expressed in the design. Lastly, the Experience lens allows students to be "creative" and follow their own intuition in the generation of evocative design ideas. It is clear from the outset what frameworks are being used, and "worksheets" (described later) reinforce the four perspectives and build a strong mental map for students as they move through the process. This commonly shared framework is essential to accelerating the student's work flow. Without it, students often become paralyzed in a sea of possibilities and potential.

THE NET-ZERO FIRST DESIGN STUDIO

CONCEPT 1: DELAYED GRATIFICATION - FRONT LOADED NET-ZERO PERFORMANCE METRICS

One of the most ambitious and most innovative aspect of the transformed studio method requires that *the students achieve a net-zero energy building prior to the normal formalistic design process.* In other words, students must complete the design of a building that meets net-zero energy goals with verified proof via schematic energy models before engaging in the more normative "creative" design studio process. Figure 3 below lays out the steps of the process. This "pre-emptive" engineering approach, typically completed by mid-term, instills a deep level of accountability into the studio project but also into the culture of the studio itself. The process begins as most studios do, with research and analysis. Prior to the advent of the NZFM, the research and analysis processes were taught using discovery methods which led to rich insights and useful realizations, but the process is slow. In the NZFM, the research and analysis steps are highly scripted with specific outcomes (See Learning Outcomes Based Studio later in the paper). Preliminary Design, Passive Design and Building Envelope design phases follow with each phase including a computer based simulation and mini-synthesis all leading to increasingly lower EUI ratings as part of a "countdown" to zero. The active systems are then identified and the PV arrays sized to reach net-zero performance. This process is completed by mid-term, thereby setting the stage for deeper and more inventive design exercises that are performed with an energy budget already established by mid-term.

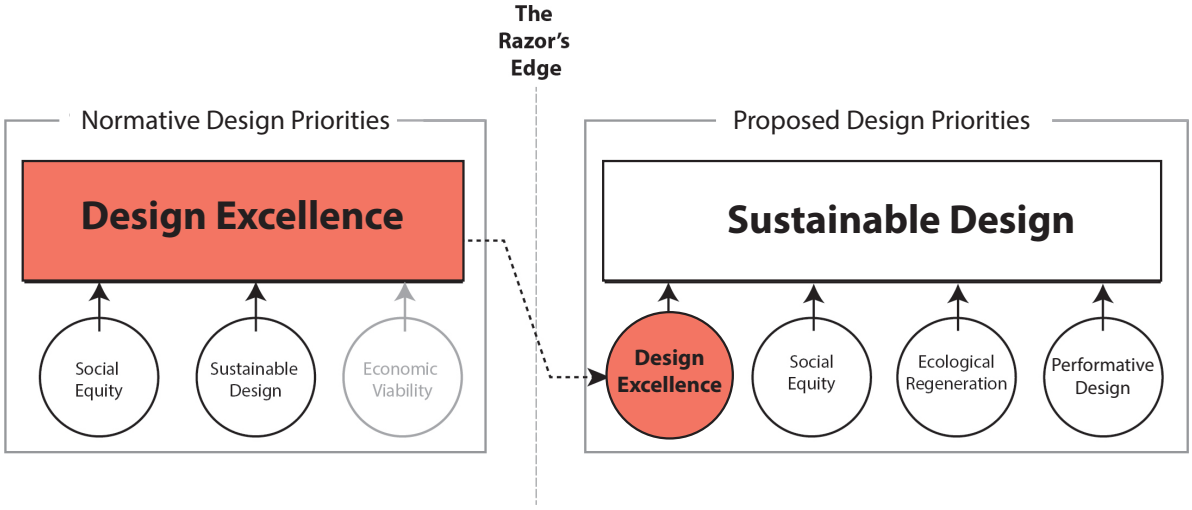

Figure 2. The Demphasis of "design excellence" as the primary driver of a successful studio project Image Source: Rob Fleming.

To accelerate the process, the students were NOT asked to "discover" how to achieve an Energy Use Intensity score of zero. Instead, they were carefully guided through a set of predetermined steps to help them achieve that goal. The discovery based learning model was therefore delayed until after midterm when the studio reverts to a more open and exploratory format. The master/apprentice relationship now becomes a relationship between the student and the goal of achieving net-zero energy. This objective focus means that the professor becomes a "coach" for the students as opposed to the dominant voice in the student's head.

Furthermore, the NZFM is designed to move students quickly through the early part of the studio steps (research, analysis, preliminary design) as fast as possible in order to leave more time for "design" later in the semester. This delayed gratification method has proven quite effective in holding students accountable to the predetermined goals, but more importantly created a platform upon which innovative and creative design moves could be made later in the studio while still reaching net-zero performance. In order to achieve this ambitious reorganization of the studio, a series of other innovations were required to support the process. They are discussed below.

STUDIO CONCEPT 2: ELEVATING IDEAS THROUGH AN EXPANSION/CONTRACTION APPROACH

A design thinking approach to successful sustainable design is warranted because an evolution in our relationship to design ideas is critical to changing the nature of the studio. A successful design thinking process uses the "triple diamond approach".[13] Design thinkers routinely expand and contract their explorations (diamond shape), constantly introducing new variables within a clearly framed boundary, without critique. In Figure 4 (next page) the diagram illustrates how Ideas are "elevated" after each expansion/contraction and ultimately lead to one idea as an overall synthesis. In other words, instead of seeing the design studio as a single grand synthesis towards a single design solution, the design thinking approach features numerous "Mini-Synthesis moments" informed by evidence. This method has proved to be quite effective as students are able to zoom into a series of limited variables and decisions while knowing that the results will eventually find their way into the overall design of the project or disappear as a vestal tail of the process. A "worksheet" (Figure 5 at the end of the paper) is used to organize the results of the validation and includes "inputs" from the research and analysis phase along with reflections on each design idea. Also notice that the design ideas are organized and governed by the four perspectives of Integral Sustainable Design. This worksheet is used at for each building simulation within each overall step in the process. The student along with the professors can interpret the results of the energy models and "elevate" the best ideas as judged via a set of "Guiding Principles" that were developed in the early part of the sequence. This allows for students to expand their sense of agency beyond themselves and their professors and relate their ideas to a broader sense of environmental responsibility.

APPROPRIATE USE OF ENERGY MODELING AND DAYLIGHT SIMULATION SOFTWARE

A critical aspect of the NZFM is the thoughtful use of energy modeling and other tools. Mary Guzowski concurs. She wrote in her ground breaking paper on net-zero energy studio: "Relax with creating the path as you go: Acknowledge that there is a lack of clarity in the design education community regarding common net-zero goals, metrics, and protocols. Invite students into the dialogue and foster an atmosphere of curiosity and exploration, while acknowledging the emerging nature of the topic".[14] While that specific quote captures the informal

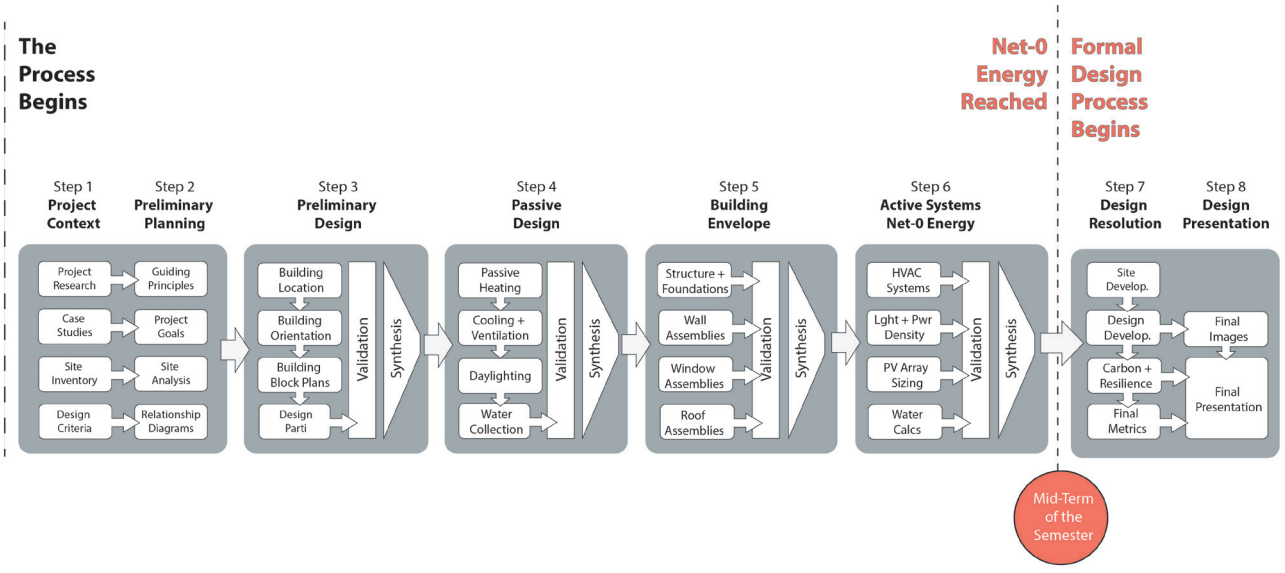

Figure 3.The Net-Zero First Design Methodology Image Source: Rob Fleming.

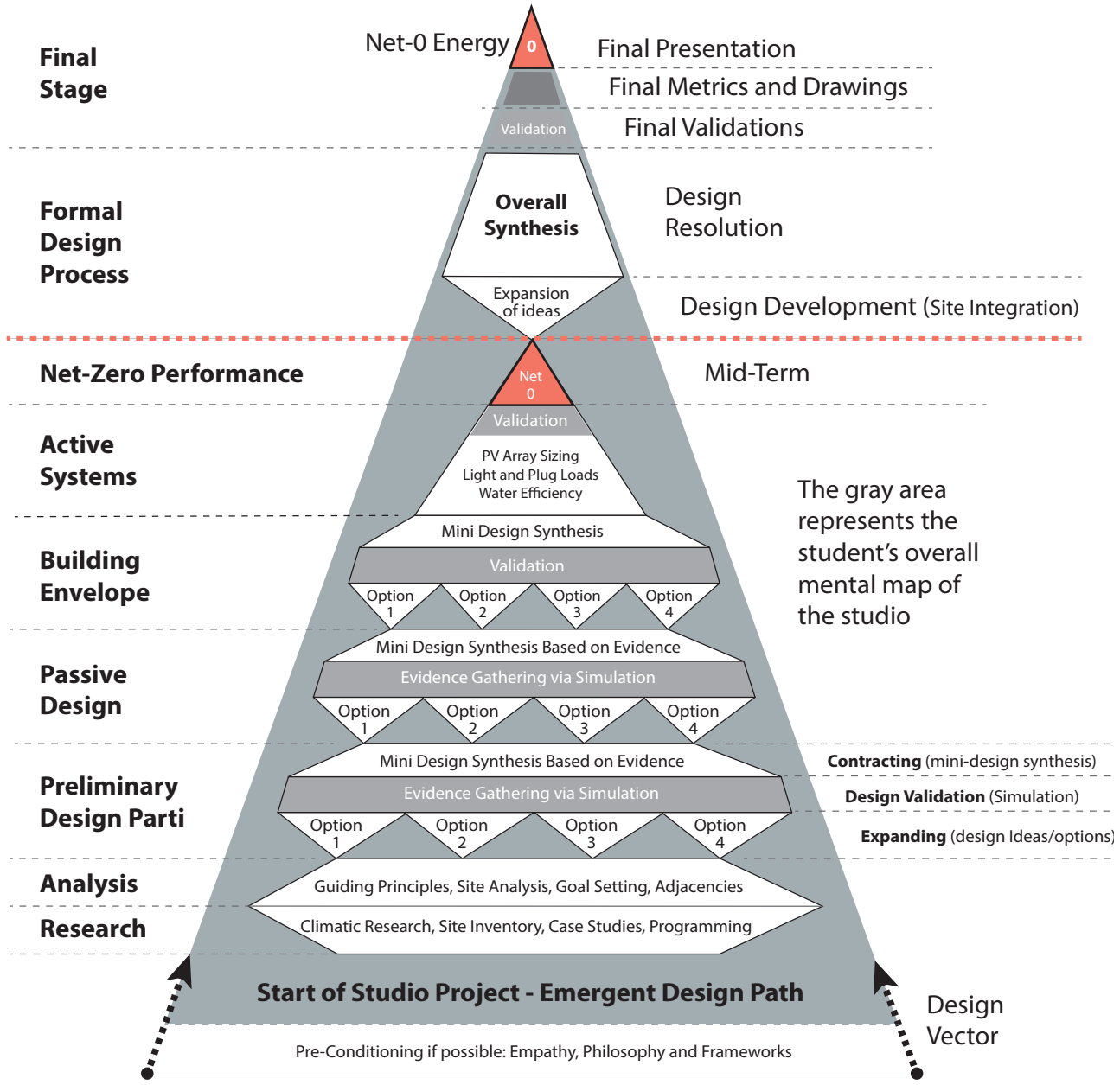

Figure 4. Emergent Design Process. Image credit. Rob Fleming.

approach many studio professors employ when it comes to incorporating sustainable design into the curriculum it rightly acknowledges the need for common "protocols" for reaching net-zero performance in the studio. Mz. Guzowski also offered the following, "Strengths and limitations of net-positive analysis and performance metrics: Sefaira (or related) schematic design software is essential in enabling students to compare early design analyses for energy, carbon, daylight, natural ventilation, passive solar, and comfort."[15]

One of the keys to making the first half of the semester successful was the use of a simplified energy modeling protocol and simplified plan and section requirements. First, because the students were going to be developing so many design ideas and knowing that so many of the design ideas would ultimately be discarded, students were allowed to draw single-line diagram plans and sections. This ended up mirroring the 3-d modeling protocols which featured only single plane 3-d models with simplified forms. Since the energy models themselves are only a means to compare different design ideas, the forms were kept simple and were quick to build. This allowed the generation of a lot of evidence for informed decision making about which design ideas would move forward. In the first half of the semester schematic modelers such as Ladybug, or Sefaira were

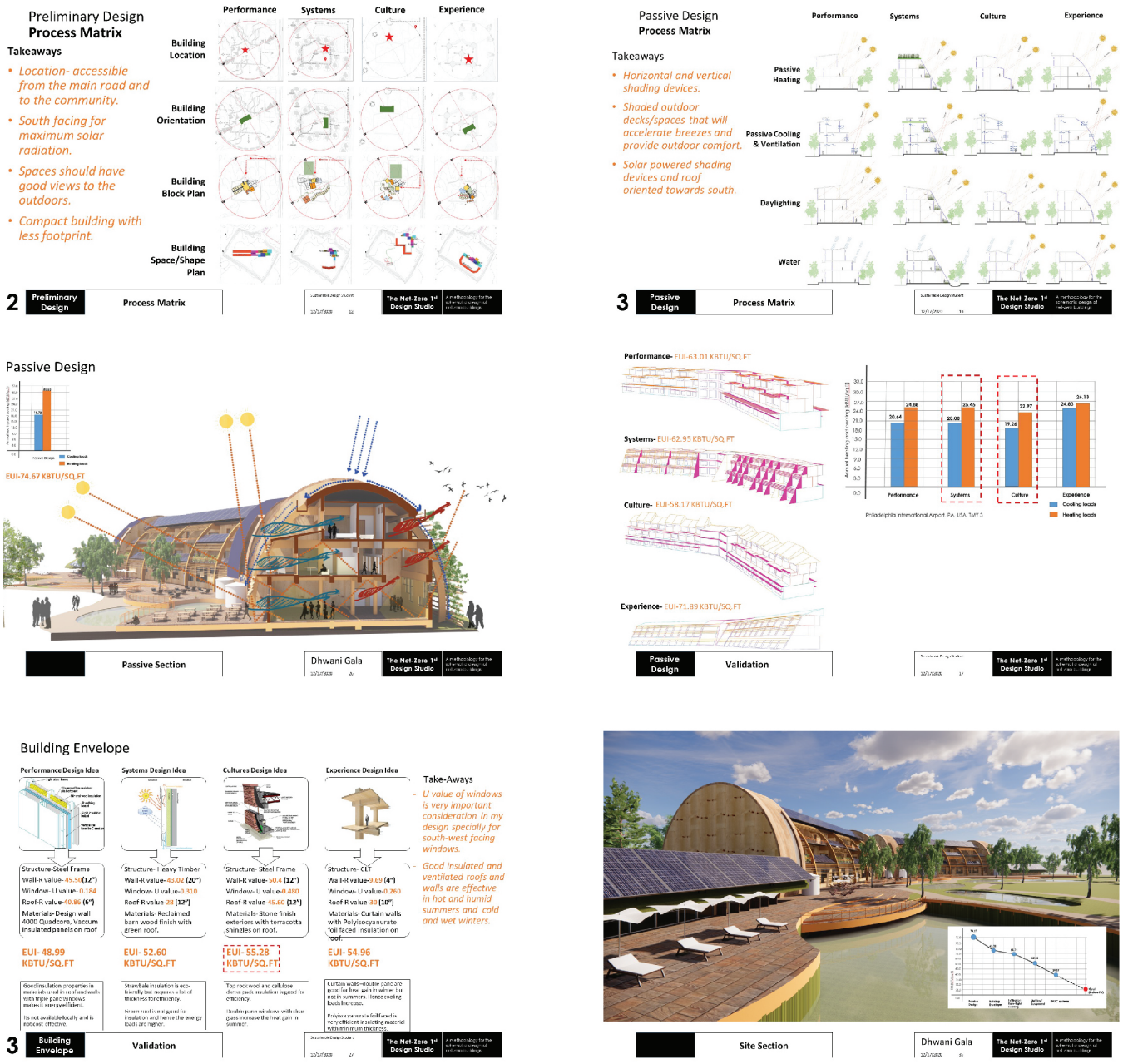

Figure 5. Dhwani Gala, MSSD Student. Image credit. Dhwani Gala.

recommended. After mid-term the students switched to Revit to develop a more fully realized architectural form with wall thicknesses. Insight 360 and Green Building Studio were used to verify net-zero performance at the end of the studio. Some students elected to use Rhino/Grasshopper/Ladybug for their simulations which allowed for more variations to be explored, but presented some issues when students were stymied by hiccups in the modeling process. It should be noted that the studio professor should also be facile with the tools. The ability to head off pending problems with the models or interpret strange results is a critical skill set for a sustainable design professor.

STUDIO IS A CLASS WITH LEARNING OBJECTIVES

Although the master/apprentice relationship has worked well to achieve well resolved buildings, the professor, that scenario, must somehow ensure that the students have learned all the lessons along the way. These lessons are often prescribed by accreditation requirements or by the overriding philosophy structure of the program itself. The success of a studio approach varies greatly depending upon the professor's sense of responsibility to teaching sustainability and upon the approach itself which often only casually addresses opportunities for environmental integration. By forcing students

to achieve a net-zero building and by going through a rigorous pre-defined process, there is a level of assuredly that students have learned the material and that the studio itself is achieving the assessment standards. All of this occurs by mid-term, so the rest of the semester is free to explore the design without encumbrances - until the end when net-zero status is re-validated. Given the changes in how NAAB is now evaluating architecture programs by assessing the assessment of programs, this highly structured, learning objective oriented design studio method may become increasingly valuable to a wider audience.

THE TEMPLATE

One of the strangest but surprisingly most effective techniques employed in the NZFM is the requirement that students use a common PowerPoint Template for their presentations. The pre-built template specifies what information goes on what slide and in what location. This may seem antithetical to the discovery-based methods studio teaching discussed earlier in the paper, but the template has solidified the mental map of sustainable design into a comprehensive and more importantly a comprehensible road map.

SHOW ME DON'T TELL ME

Moving to a set of how-to videos not only allowed more content to be delivered, it saved time in repeating the same points over and over in desk crits with different students. The videos include actual examples of work by students and professors who completed all the assignments. Undoubtedly, the discovery based method of teaching has been discarded in favor of a more direct and scalable method of communication. I miss the experience of the frequent desk crit and of connecting to each student on a regular basis in the first half of the semester, but I am willing to sacrifice that experience in lieu of the larger goals of training architects to fight climate change.

THE TEXTBOOK

To reinforce the rigorous first half of the semester, a textbook: *Sustainable Design Basics*, was written to help provide examples and explanations for students attempting to complete a certain task or aspect of the project. The Template, as discussed earlier, refers to page numbers in the text book where students can find helpful information that is specific to the task at hand.

WORKSHEETS

The use of worksheets as organized by the 4 perspectives as a common framework have proved very useful. Like the templates, it was necessary to create worksheets to help the students build mental maps of the tremendous number of often contradictory priorities and goals in a design project. The worksheets are organized by the Four Perspectives to maintain a consistent focus on environmental performance, systems integration, social equity, and experiential quality.

REFLECTIONS AND CONCLUSIONS

This semester was the third attempt at using this process. Interestingly a number of students radically altered their mid-term design scheme to find a more evocative design expression and a stronger formal expression for their buildings. This "revolt" was welcomed because the students already demonstrated their understanding of all the variables, synergies and trade-offs of reaching net-zero, and they know that they are accountable at the end of the semester to reach that goal. Finally, the reorientation of the studio as a "class with learning objectives" as opposed to a process for getting to a good building is a huge shift. The master/apprentice model is so good at helping students achieve a "good" design, but being willing to accept a less developed building from the weaker students in favor of knowing, for certain, that the students learned the material needed to fight climate change is a goal that will not only serve the students but also will serve the profession and society at large. To see more student work visit this link: https://wakelet.com/wake/_GO8a42UD8GhXeEmToczl

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