SaME Lab Activity Summary (2024)

11.11.2024

Intro

The **Simulated and Measured Environments Lab** is a research group in the New York Institute of Technology School of Architecture and Design with a focus on developing tools, workflows, and pedagogy to help architects design buildings that will perform as expected when built and operated. Our baseline big picture question is: how do we bake climate change mitigation into the mainstream architectural design process?

Why simulate?

Building Performance Simulation (BPS) is a well-established professional field of practice and research. It is typically the domain of computer scientists, engineers, and technically minded architects acting as consultants. The problem with this approach is that BPS becomes a response deployed to fix performance problems in developed architectural designs instead of a tool to empower the design process itself. To meet the ever-increasing performance demands on contemporary buildings, architects need to be designing form and performance simultaneously through an iterative workflow. As a result, BPS is a new core skill, akin to sketching, that needs to be integrated into the habitual design approach for all architects.

Why measure?

A simulation is simply a prediction, essentially meaningless without being tethered to something physical. Put another way, a simulation allows the design of performance and measurement allows the calibration of the simulation. The summary is that if architects want to simulate well, they also need to learn to measure.

Pedagogy

In order for building performance simulation and measurement to become part of the mainstream architectural design workflow, these skills need to be integrated into the undergraduate architectural curriculum. Toward that end, SaME Lab is working on a variety of curricular projects.

New Courses

SaME Lab has developed, coordinated, and taught a new required undergraduate architecture BPS course. ARCH 413 teaches a series of simulation workflows that are tied to professional code and certification benchmarks. The course is a co-requisite with ARCH 401, the comprehensive studio. Students learn to simulate performance, then immediately apply those skills to an actual project as they iterate toward performance benchmarks included in the course project program. From a practical departmental standpoint, ARCH 413 is delivering a chunk of the student work (SC5 and 6) reviewed by NAAB accreditors in its corequisite role with ARCH 401. The course is currently being run for the second year.

Existing courses

Since the goal is not to develop specialists but to enhance the fundamental architectural design workflow, we are moving to introduce BPS throughout the BArch/BSAT curriculum. Currently we have developed and are running simulation assignments for Building Construction I and II (ARCH 221 and 222) and Environmental Systems I and II (ARCH 324 and 325).

Stand Alone Interdisciplinary Modules and Workshops

Part of our approach is to develop educational modules and workshops where students improve capabilities across literacies in artificial intelligence, climate[i], data[ii], geospatial[iii], and visualization[iv]. This specialized disciplinary knowledge prepares students for increasingly sophisticated design decisions. Discrete skills-based modules can be combined into badges or micro-credentials which represent marketable skills. Through an Emerging Technologies Grant, we are developing a series of teaching modules for use in the architectural curriculum but also tweakable for other disciplines. Module assessments include post-test knowledge check.

Module 1: Comparing Environments

Goal. Hands on introduction to the variables that define and differentiate indoor and outdoor environments through measurements and analysis using sensors and apps.

Description. Participants measure the dry bulb temperature, relative humidity, and dew point of the environment they encounter for three days, then compare the results for the same days for several other measured environments.

Module 2: Designing Comfort

Goal. Introduction to how buildings create a stable indoor environment tuned to human comfort.

Description. Using provided materials and sensors, participants assemble and site small buildings then adjust to improve design performance through analysis of environmental sensor readings for the site and building interior.

Module 3: Digital Twin1 – Solar Path, Solar Shading

Goal. Introduction of the concept of “digital twins” through investigation of the solar path on a site through measurement and simulation.

Description. Participants are assigned a modeled form and provided both the Rhino model and 3D fabrication of the form. Shading patterns created by the physical model object outside, the physical model in a robotic analog sun path simulation, and a geolocated Rhino object model are compared.

Module 4: Digital Twin2 – Simulating and Measuring Photovoltaic Energy Production

Goal. Introduction to on-site energy production through comparison/calibration of measured and simulated solar electric energy production on a physical site.

Description. Participant group assembles a small solar electric production system on a chosen site and measures electrical production in different situations (facing different directions, shaded and not shaded, etc.). Participants model the system in Rhino and use a provided Grasshopper script to estimate electricity production with the array in different situations (facing different directions, shaded and not shaded, geolocated in different climates) with the goal of calibrating the model to represent the measured systems.

Module 5: Digital Twin3 – Simulating and Measuring Building Envelope Performance I

Goal. Increase design knowledge of building envelopes through measurement and simulation.

Description. Participants pick an exterior wall with operable glazing in the building where class takes place and measure its material properties (U-value: opaque and glazed; SHGC/VT: glazed; air infiltration). Using these measured values as settings in simulation, participants then model the same system in Rhino/Climate Studio.

Module 6: Digital Twin4 – Simulating and Measuring Building Envelope Performance II

Goal. Construction, modelling, and measurement of full-scale wall assembly sample from a design project.

Description. Participants choose a wall assembly system related to on ongoing design project. They then construct a wall panel for installation in our test chamber (see "The Box" below under research) and test its material properties (U-value: opaque and glazed; SHGC/VT: glazed; air infiltration). Using these measured values, participants will then model the same system in Rhino/Climate Studio and use these results as part of a full thermal analysis of their design projects.

Module 7: Analyzing the Urban Heat Islands across major cities.

Goal. Introduction of Urban Heat Island (UHI) causes and impacts on a local and global scale.

Description. Participants will develop data maps for a local site and discuss site-specific solutions to reduce the UHI. [Reference: NYC Department of Environmental Protection. (2021).]

Student Engagement & Assessment

In addition to curricular coursework, SaME Lab is creating resources to help students integrate BPS into their normal design workflow. For example, we have a YouTube channel (NYIT.SAMELAB) where two types of videos are posted: (1) introductions to course simulation workflows and (2) responses to students' questions. As a result, an extensive repository is being built. Currently the channel has almost 200 videos and over 20,000 views.

Effective assessment, based on clear goals, provides evidence of the learning taking place throughout our courses, modules, and workshops, guiding students to take responsibility as independent learners[v]. Through anonymous formative assessments, we evaluate the success of a given activity and make adjustments for future interdisciplinary sessions. Timely assessments separated from graded work develop students self-directed learning skills. To date, each module includes a knowledge check on (1) key concepts and definitions, (2) success of applying new knowledge and processes to collect data, and (3) ability to reflect and adjust when repeating the activity. Whenever possible, participants review the immediate feedback and identify knowledge gaps to review.

Research

We are actively conducting a variety of research both to create useful tools for students/professionals and to produce peer-reviewed documentation to add to the literature.

Equipment

Using funds from ISRC and Emerging Technologies grants, we have been acquiring a targeted list of measurement equipment that can measure indoor and outdoor environments as well as the performance of the building envelopes that separate them. Here is a list of what we currently own: SaME Lab. Measurement Equipment Inventory.xlsx

In Process Research

Education Hall Library as Living Lab

We have set up the Education Hall Art & Architecture library as a "living lab" allowing the study and comparison of the relationship between the indoor and outdoor environment related to the space. We have a weather station outside that is publishing continuous data as a node on the NOAA MADIS [vi]climate data infrastructure. This data is accessible to everyone through the library SaME Lab guide and GitHub page. Inside we have an array of sensors that publish air temperature, relative humidity, CO2, and lux to a wireless gateway. This data is accessible through a dashboard interface. We can also measure the air tightness of the building envelope, the U-value of discreet assemblies (different walls, for example), properties of glazing, thermal bridging, etc.

Scripting and Modelling

Scripted tools to enable performance simulation in early-stage design, testing for compliance to codes, regs, and certifications (IBC, LBC, LEED, Local Laws 92, 94, and 97).

Modelling tools to prepare geometry for simulation. For example, through planarization of curved surfaces for EnergyPlus based thermal simulation.

Robotic solar path workflow for analogue simulation of solar shading studies with built models.

Digital twins to develop workflows that calibrate models to actual performance. For example, comparing a BPS model of the Ed Hall library with the measured data collected from the Living Lab.

Root Down Hempcrete Prototype

Project collaboration with South Carolina non-profit to develop a low-income housing modular envelope system. We have placed sensors in their prototype project and will monitor a variety of variables relative to hempcrete curing and performance in a humid climate. Digital twins will allow us to calibrate digital models and compare simulation tools in commercial modelling platforms: Rhino, Archicad, Revit.

Planned Research

Precedent Retrofitting

Research and model significant architectural projects from the typical canon of precedents to understand how they perform as built and how they could be retrofitted to meet current state of the art performance standards. Background: We have found earlier examples of building performance simulation examining historical architecture, from vernacular building methods through Modernist typologies. Applying the most contemporary BPS workflows to ancient and contemporary sites and well-known projects will lead to improved precedent understanding and opportunities for student research and publishing.

Interactive New York Tech Campus map

Model and measure performance of New York Tech campus buildings for an interactive online map. In partnership with Prof Ehsan Kamel with the Energy Management grad program.

"The Box"

We are working toward the construction of a testing apparatus that the department can use to measure the performance of small sections (2'x2') of full-scale building assemblies. The design is an adaptation of the ASTM C-1363 Hotbox used by industry to determine building assembly U-values. However instead of using an artificial steady state "climate chamber", we are using the actual exterior climate as the testing baseline. The result is a MUCH less expensive and more versatile method for evaluating architectural building envelopes. Among the planned uses:

Module 6: Digital Twin 3

4th and 5th yr students build envelope mockup sections of assemblies they are planning as part of design projects, then test these to quantify important performance metrics.

Novel materials testing.

The "Box" will be a good setup for anyone wishing to test building envelope applications of materials under development, for example Christian and Athina's research.

Networked research

Once we get a functioning set-up with calibrated results, there will be opportunities to partner with other schools/projects in which we test assemblies in our climatic context.

Presentations

Snell, Clarke. (2024). *Teaching Performance: Architectural Simulation in the Studio*. Building Enclosure Science and Technology Conference. Austin, TX.

Viola, V. Williams, E. (2024). *Narrating the Built Environment. Maps and Geospatial Round Table,* American Library Association Conference. San Diego, CA.

Publications

Submitted

Snell, Clarke. “PerFORMance: Habituating Iterative Simulation in Early Stage Design Workflows for Architecture Students.” Article *submitted* (9/24).

Planned

Voxelizer: A simple tool to prepare curved geometrics for thermal simulation. *Abstract submitted* (9/24)

Analogue Simulation of Solar Shading through a Robotic Workflow. *Research underway*.

FUNDING

“Integrating Performance Simulation Software into the Architectural Workflow: a New Required Course for the Bachelor of Architecture Curriculum”, NYIT ISRC grant, 2023-4.

“Accurate Imagination: Using Physical Measurements and Computer Simulations to Teach Predictive Design Workflows”, NYIT Emerging Technology Grant. 2024-5.

PEOPLE

SaME Lab founding members and current core team are:

Clarke Snell, RA, Associate Professor, School of Architecture and Design.

Vaness Viola, Associate Director, Branch Services/Librarian III.

Elijah Williams, Digital Technology Specialist, School of Architecture and Design.

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[i] U.S. Global Climate Change Research Program (2024). *Climate Literacy Essential Principles for Understanding and Addressing Climate Change* https://content-drupal.climate.gov/sites/default/files/2024-09/Climate-Literacy-Guide-2024.pdf

[ii] Data Literacy course at New York Tech, DATA 101 - Making Sense of a Data-Oriented Society. This course introduces students to the power of data as applied to real-life problems in today's data-driven world. Students will learn basic statistical concepts, how to identify reliable data, and to think critically about how to extract meaning from data. The course will discuss various biases, including social biases, how they affect data gathering and analysis, and how to address these biases. The course will also address ethical and moral issues associated with statistics, data collection and visualization, and data analysis. Students will learn how to present a narrative supported by data.

[iii] Geospatial Information Literacy Instruction: Frameworks, Competency, and Threshold Concepts Appel, Stephen. Journal of Map & Geography Libraries Volume: 15 Issue 2-3 (2019).

[iv] Visual literacy is a set of abilities that enables an individual to effectively find, interpret, evaluate, use, and create images and visual media. Hattwig, Denise. "ACRL Visual Literacy Competency Standards for Higher Education." Association of College & Research Libraries, www.ala.org/acrl/standards/visualliteracy.

[v] Angelo, T., Cross, K.P. (1993). *Classroom Assessment Techniques: A Handbook for College Teachers*. *P3-12*.

[vi] National Oceanic and Atmospheric Association, Meteorological Assimilation Data Ingest System. https://madis-data.ncep.noaa.gov/MadisSurface/?networks=ALL.ALL&CenterLAT=40.80&CenterLON=-73.60&Zoom=11.00&StationID=G4054