Architecture Climate Change & Society

Buell Center
2021 Course Development Prize

HIGH-PERFORMANCE, LOW-TECH

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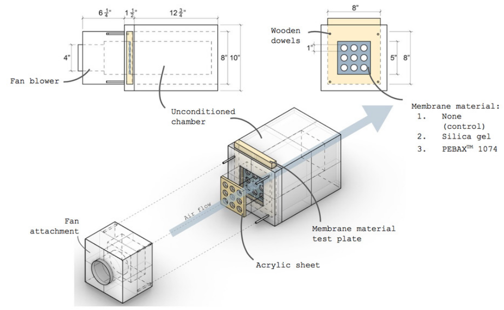

The global increase of atmospheric temperature rise combined with the rapid growth of previously underdeveloped climate zones presents a growing need for low-cost solutions that serve those without access to advanced technologies. Within the architecture, engineering, and construction industry, high-performance buildings are often associated with expensive, high-tech strategies that rely heavily on complex mechanical systems. New technologies may change the way that one designs, but they cannot replace the basic climate-specific principles celebrated by vernacular architecture. In response, students will explore the vernacular strategies associated with rapidly urbanizing regions in order to translate their character, physical qualities and thermal capabilities to a commercial scale, reducing the reliance on energy-intensive mechanical systems while developing a new, climate and culture-specific urban identity.

This course mixes historical referencing with physical experimentation to demonstrate performance metrics and explore the ways that the building systems could engage and empower the occupant. Integrated as dynamic systems, buildings could better react to fluctuating environmental conditions. By combining students from across the campus, this interdisciplinary course strives to bridge the gap between design, performance and building analytics. In the spirit of affordable, low-tech and climate-specific enclosure systems, this class will employ accessible physical testing methods to make building technology innovation more accessible.

Image: Anna Sandoval and Michelle Barrett

High-Performance, Low-Tech

University of North Carolina at Charlotte

The United Nations has identified that nine of the top ten urbanizing regions reside within the geographic tropics – a portion of the world that has historically lagged in wealth and resources[1] *(figure 1)*. In fact, only four major tropical economies – Hong Kong, Singapore, Saudi Arabia, and Venezuela – are classified as "high-income" economies as defined by the World Bank *(figure 2).* In fact, the average gross national product (GNP) per capita of the temperate zone is nearly five times higher than that of the tropical zone.

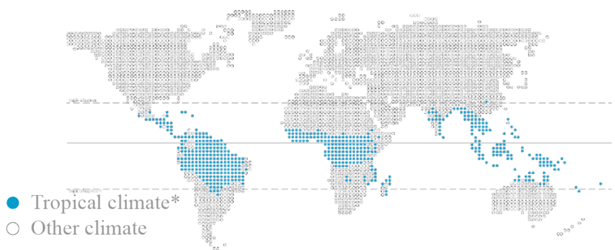

Figure 1: Summary of Tropical* Climates
Data summarized from (Peel et. al. 2007)
*defined by Köppen-Geiger's Climate Classification zones Af, Am and Aw.

Figure 2: High-Income* Economies (by GDP PPP)
Data from the (The World Bank 2013)
*defined as gross national income per capita above US$12,735

Additionally, the direct effects of climate change are expected to be most severe in rapidly developing regions, particularly those currently supporting largely rural populations, such as in the Tropics. Even beyond economic indicators, the Tropics lag in health, education, energy, productivity and technology. Many of these regions still have limited access to reliable and affordable energy services, which is a critical indicator of global development. Agricultural and health-related technologies, for example, are implicitly linked to climate and ecology and do not diffuse easily across climate zones. In architecture and construction, diffusion is evident in the ubiquitous building styles and materials emerging in urban centers across the globe - the all-glass tower has emerged in India, the Middle East, Southeast Asia and many other regions, regardless of context and climatic conditions.

The history of the built environment is quite extensive, as building typologies have typically evolved slowly over time. Civilizations have established vocabularies of vernacular styles based on cultural antecedents and climatic conditions, creating unique building styles around the world. Cold climate buildings, for example, were bulky and insular while tropical buildings were naturally ventilated and deeply connected to the environment. However, post-war modernism brought a departure from the regional aesthetic in embrace of the *International Style - an* architectural response to industry, technology, mobility and sociopolitical orders. The universal adoption of air conditioning, tall buildings, and curtain wall technology all within the span of a single generation, has created incredible impacts on the urban sense of place as well as on global energy consumption. In fact, Ian McCallum, the executive editor of Architectural Review, described the curtain wall as "the new vernacular" in 1957 - It was at this juncture in time that the façade became a thin, passive recipient of differential conditions between inside and out, isolated from cultural context.

In response, this class looks to explore the vernacular strategies associated with rapidly urbanizing tropical regions in order to translate their character, physical qualities and thermal capabilities to a commercial scale, reducing the reliance on energy-intensive mechanical systems while developing a new, climate and culture-specific urban identity.

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[1] Sachs, Jeffrey D. *Tropical Underdevelopment*. Working Paper, National Bureau of Economic Research, Feb. 2001. http://www.nber.org/papers/w8119.

Course Description:

The global increase of atmospheric temperature rise combined with the rapid growth of previously underdeveloped climate zones presents a growing need for low-cost solutions that serve those without access to advanced technologies. In response, it is important to educate both students and professionals alike to rely on simple, accessible strategies instead of overly-sophisticated designs. However, within the architecture, engineering, and construction industry, high-performance buildings are often associated with expensive, high-tech strategies that rely heavily on complex mechanical systems. Meanwhile, integrated as dynamic systems, buildings could better react to fluctuating environmental conditions. New technologies may change the way that one designs, but they cannot replace the basic climate-specific principles celebrated by vernacular strategies. **This course mixes historical referencing with physical experimentation to teach building performance metrics and explore the ways that the building systems could engage and empower the occupant.** By combining students from across the campus, this interdisciplinary course strives to bridge the gap between design, performance and building analytics.

The integration of digital simulation and energy modeling instruments in education can empower innovation, yet these increasingly user-friendly tools enable an already tech-savvy generation to lean on digital outputs without a solid understanding of the physical metrics. Additionally, advanced computational methods can be inaccessible to those not versed in the software or those without access to computers. In the spirit of affordable, low-tech and climate-specific enclosure systems, this class will employ accessible physical testing methods to make building technology innovation more accessible and democratize high-performance buildings.

Format:	Tuesday (1 hr) – lecture	credits:	3.0
	Thursday (2 hr) – workshop	prerequisites:	Environmental Systems Principles (or equivalent)

PART 1: RESEARCH & TRANSLATION

Students will choose a region identified by the United Nations as rapidly developing. They will study both traditional and modern building styles in order to establish a vernacular typology for that particular region. From there, they will study the thermodynamic principles that apply to the identified systems *within the social and cultural context of their chosen region.*

Through lectures and hands-on demonstrations, students will explore a number of basic topics (convection, conduction and radiation; psychrometrics) as well as some more advanced and emerging ideas (phase change materials, thermal bridging, etc.). Proper research methods and scientific writing will also be discussed as students develop their research question. After a research methods seminar presented by library staff, students will conduct a thorough literature review in order to situate their work within the greater dialogue of their particular topic. Proposed sessions and selected reading:

Vernacular Architecture

- Braham, William. “Erasing the Face: Solar Control and Shading in Post-Colonial Architecture” (2000).
- Fisher, Thomas. “The Well-Tempered Tropics: Design for Hot, Humid Climates” (1984).
- Asquith, Lindsay and Marcel Vellinga. Vernacular Architecture in the Twenty-First Century (2006).
- Foruzanmehr, Ahmadreza. “Vernacular Architecture: Questions of Comfort and Practicability” (2011).

Physics Basics

- Fitch, James Marston. American Building: The Environmental Forces that Shape it (1999).
- Janda, Kathryn B. “Buildings Don’t Use Energy: People Do.” Architectural Science Review 54 (2011).
- Moe, Kiel. Thermally Active Surfaces. “What your Body Already Knows” (2010).

Technological Diffusion & Modern Comfort Expectations

- Sachs, Jeffrey D. “Tropical Underdevelopment” (2001).
- Cohen, Barney. “Urbanization in Developing Countries: Current Trends, Future Projections, and Key Challenges for Sustainability” (2006).
- Brager, Gail and Richard de Dear. “Historical and Cultural Influences on Comfort Expectations” (2008).
- Lybbert, Travis and Daniel Sumner. “Agricultural Technologies for Climate Change in Developing Countries: Policy Options for Innovation and Technology Diffusion” (2012).

PART 2: FABRICATION & EXPERIMENTATION

Within early level architectural design education, work flows are tending toward digital means[2] and media-driven, production-based representation[3]. An integral part of this course will be to design experimental devices and procedures to examine the physical impacts of their strategies. This pivotal step will encourage students to develop a fluency in thermodynamic principles while acknowledging the cultural history and implications of a particular phenomenon. Research shows that there is a strong correlation between 'hands-on' projects and 'deep learning'. Specifically, this course builds on the successes learned from the 'design/build' structure – a pedagogical approach that exposes students to the technical and material implications of their designs from conception to construction. This course uses hands-on learning with low-tech, low-cost experimental procedures to improve students' understanding of basic principles and technologies in buildings. Proposed sessions and selected reading:

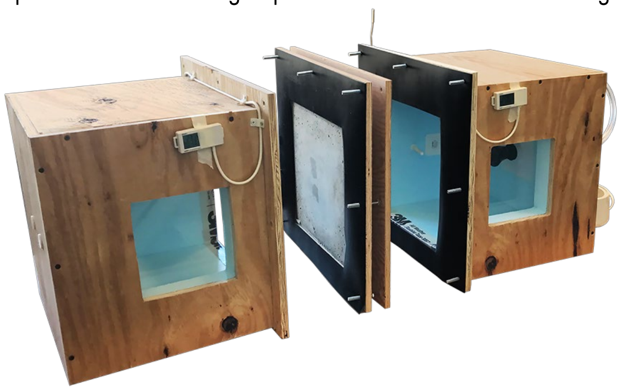

Figure 3: small-scale, low-cost hotbox apparatus to test heat and moisture flow through materials and assemblies.

Experimentation vs. Digital Simulation

- Özkar, Mine. "Learning by Doing in the Age of Design Computation." (2007).
- Blikstein, Paulo. Digital Fabrication and 'Making' in Education: The Democratization of Invention (2013).

Fabrication & Empowerment

- Gershenfeld, Neil. How to Make Almost Anything: The Digital Fabrication Revolution. Foreign Affairs (2012).
- Nascimento, Susana. "Critical Notions of Technology and the Promises of Empowerment in Shared Machine Spaces." *Journal of Peer Production* (2014).
- Thomke, Stefan H. *Experimentation Matters: Unlocking the Potential of New Technologies for Innovation*. Harvard Business Press (2003).

Testing Procedures & Methods

- ASTM Testing Standards
- Groat, Linda N., and David Wang. *Architectural Research Methods*, John Wiley & Sons (2013).

PART 3: COMMUNICATION

The goal of this phase is to teach students to communicate complex principles with simple and graphically tangible means. Students will explore data management software such as Microsoft Excel and Tableau, as well as Adobe Illustrator, Premiere and AfterEffects for visualization. Software training will also be supplemented with lectures and workshops that address the design principles behind graphical excellence and data communication. Proposed sessions and selected reading:

- Tufte, Edward. The Visual Display of Quantitative Data (2001).
- Tufte, Edward. Envisioning Information (1990).
- Mereilles, Isabelle. Design for Information (2013).

[2] Özkar M. Learning by Doing in the Age of Design Computation. Computer-Aided Architectural Design Futures (CAADFutures) 2007. Dordrecht: Springer Netherlands; 2007. p. 99–112.

[3] Canizaro VB. Design-Build in Architectural Education: Motivations, Practices, Challenges, Successes and Failures. International Journal of Architectural Research; 2012. 15;6(3):20–36.