PAPER

Transcalar Material Matters Pedagogy

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Keywords: Pedagogy, Design as Research, Transcalar, Sustainability, Local Materials.

Design as a synthesis of multiple parameters is nothing new, but how do we move forwards to integrate our real complexities into our design equations in more critical, productive directions? The premise of the author is that to begin to address our common issues of global concern we need to critique our predominant pedagogies and epistemologies into new realities connecting local and global issues at multiple scales, to enable more diverse, resilient designs and methodologies.

INTRODUCTION

Embodied carbon in building materials and construction makes up 20% of annual CO_2 emissions[1]. This implies that on a basic level architecture needs to be informed by the materials and material assemblies from which it is made, as it has been complicit in the current environmental crisis. Currently most of our methods of evaluating architecture's performance are too simplistic and do not factor in the necessary dynamic externalities to have real impacts, e.g. true costs, ecological justice, climate adaptability and issues of labor equity. This paper disseminates an upper-level undergraduate capstone design studio devoted to this inquiry.

Students work was initially directed with readings and precedents, to jump start an understanding of how material matters: understanding that the process of extraction, production, fabrication, maintenance and demolition have impacts and are connected to our environment, culture and life forms. This helped students understand the connection of architecture to key wicked problems and contemporary issues of concern. Apart from understanding that our current evaluation matrixes are often inconclusive, not incorporating as many externalities as they should, students also began to understand how interconnected all the issues are. It is important to not be technically reductive, so there included readings beyond science and techno-performativity, for example, they also read philosophy to enable them to start having a personal ethics and qualitative attitude towards the issues beyond the purely quantitative and to start understanding the benefit of not separating the two.

The assumption was made that to be more sustainable in a globalized world, generally the maximization of local resources is a positive. So, the next step for students was to select a local region and material for their future research project. The region related to where the material existed or could thrive and provided a context and focus for the physical and human aspects of the research and was explored through text, various forms of graphic and parametric analyses, physical models and tests. At this point students were also given lectures and seminars by two colleagues with expertise beyond the instructor, these were in the area of geography and material science, to help students move beyond their fairly traditional architectural education up to this point, which generally had focused on a building scale solely. It is imperative for architecture students to work across multiple scales simultaneously, beyond this typical building scale, as in this way they can understand the connections and impacts between them. Generally design at the regional or urban scale does not get into any level of detail at the building or material scale and vice versa. This siloing of scales has been detrimental to our environment on multiple levels, as these scales are interconnected, but not the same, where akin to complexity theory, the whole is greater than the sum of its parts, so their study related to each other is important.

In the state of Arizona, where this studio was taught there are a variety of existing materials and biomes that students could pick from, with three larger eco-regions of plateaus, highlands and basin and range. Students had the option of working in more rural and/or urban conditions, understanding that these two are related and that the dichotomy of human built verses more wilderness areas has blurred with the Anthropocene. Initially these studies required an in depth looking at what was really there, not what should be there, understanding what makes up the existing ecosystem. Anthropocene and posthuman layers were encouraged, understanding that much of what is needed in our design toolbox today is the ability to uncover, and connect in more circular and dynamic ways, the forces around us more clearly, including ones that relate to different time scales, labor, changing bioclimatic forces and more seemingly invisible phenomena. Specific related ecologies and their connection to every increasing climate-change natural disasters e.g. droughts and wildfires were also made.

Figure 1. Initial studies with earth. Top row: exploring mixes, stabilized vs. unstabilized rammed earth, lower row: exploring various tectonic logics and details (Aracely Cervantes 2022).

Architecture was understood,

> "as a material organization that regulates and brings order to energy flows, and simultaneously and inseparably as an energetic organization that stabilizes and maintains material forms." Fernandez-Galiano, *Fire and Memory.*[2]

Students were encouraged to identify the potentials of a given region and material at a variety of site and material scales (global, regional, district) through a process of mapping over time, precedent research, material properties (including micro scales) and physical explorations. One of the key goals of this initial phase was to determine a regionally sourced potential building material to be studied for its tectonic and energetic potentials in subsequent phases of the project.

MATERIAL KNOWLEDGE AND CONNECTIONS

Chosen materials ranged from living materials to various fibers, masonry and other biogenic materials including various local wood species. Beyond the specifics of the material itself, the studio was also an opportunity to re-look at our existing local context, construction materials and methods. Apart from looking at some of our pre-industrialized knowledge in this area, it was important to be critical of our current status quo. This required looking at our recent construction trajectories which generally has favored homogeneity in materials and form in our built environment, due to various economic, social, political and industrial drivers. Many techniques and materials have been overlooked during globalized industrialization and colonialization due to the specific ethics of those cultural sensibilities. It was not just about uncovering past indigenism, but looking forwards in more diverse ways with our environment and new technologies as partners. With additional challenges of climate change and the Anthropocene, there was also a push to understand the importance of seeing our environment as a dynamic, complex system, rather than viewing it in a static moment in time. This exploration of time and change, generally leads to an architecture of adaptability as a response.

To understand their specific chosen material and it's energy flows, work needed to grounded in physical reality and testing. Beyond tests, students were encouraged to focus on an additional four conceptual areas to tie together their transcalar material studies. These were: ***Energetic and Material***, the potential to engage the patterns and flows of energetic and material qualities at various scales in order to promote a regenerative environment (some of these are more obvious and visible than others). Secondly, ***Social and Economic***:, the potential to create settings that foster human interaction and agreement through the design of processes that connect social activity to sustainable and equitable cultural, ecological and economic conditions. Thirdly, *Tectonic*: the potential to engage the tectonic history of a place by designing a project that engages in the material conditions and everyday life through a specific mode of construction and materiality, and finally ***Infrastructure***: the potential to enhance the life of a settlement (its human and non-human inhabitants) through a systemic understanding of its built environment, public open space, transportation and naturally occurring systems. An example of these initial material studies is shown in Figure 1. The work shows a student's initial studies of her chosen material, earth. She looked at different mixes to compare stabilized verses unstabilized rammed earth, with related construction methods including prefabricated unitized systems and in-situ. She was also inspired by the work of Martin Rauch in Germany, and incorporated stones to control the future erosion of the wall.

TECTONIC ASSEMBLIES

After initial material tests and the development of the connection to a larger region or biome, students zoomed in to a specific locale within this, to further a deeper understanding of

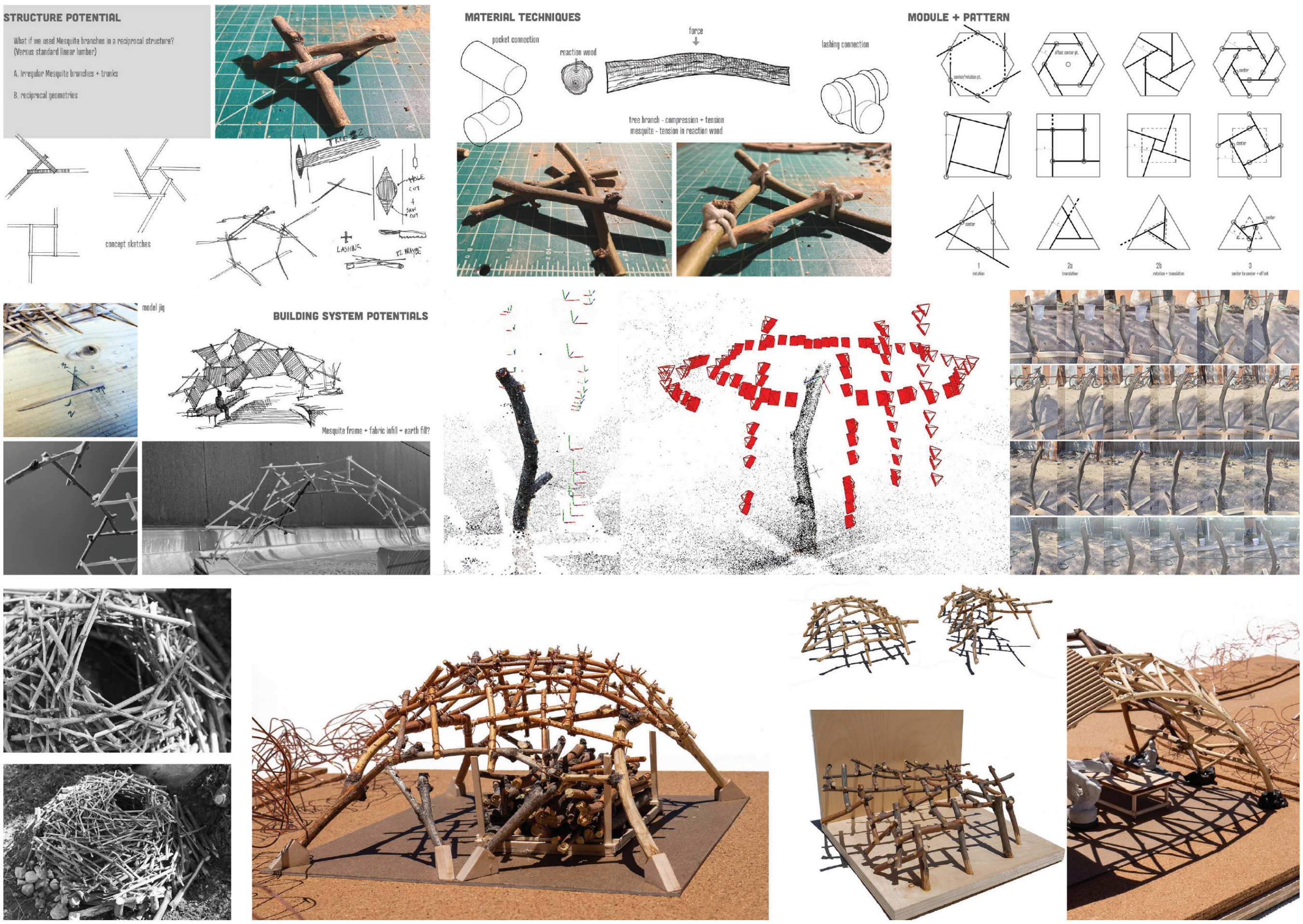

Figure 2. Analog and digital tectonic studies with mesquite. (Tayler Forsberg 2022).

the sustainable context for their proposals. They also continued to develop their material trajectory in particular through a more in depth life cycle analysis and focus on the tectonic material assembly rather than just the material properties. It was imperative to understand how the parts relate to the whole e.g., if you are looking at a unitized system, how do the parts relate to each other and what forces are they responding to? Students were particularly encouraged to look at wall to ceiling connections or continuums and at ground to wall relationships, then to understand how the system could adjust to allow for openings for light, views and air movement. Parametric logic was encouraged ideally resulting in form finding based on specific, articulated parameters, related to their ongoing research with their material, region and climate. It was not just about analog and/or digital parametric thinking and making, but also emergent speculation, based on real knowledge that impacted and connected to larger scales over time. Figure 2 is an example of student assembly logic for their chosen material, mesquite, a native desert tree, where speculation was based on advances in digital fabrication, scanning and photogrammetry to allow for forms which incorporated non-standard parts in simple rule-based connections and methods. The tectonic systems explored to produce enclosure were stacking, reticulated shells and truss systems.

In the example of some chosen materials, like fibers it was often about reversing the normative rules, which became a way of opening up more possibilities.

> "I call it a (Semperian) reversal, but that is a reversal of the order of the four elements, where the tectonic precedes the textile, I want the textile to become tectonic itself. In that case the soft elements become rigid through collaboration, by teaming up, by weaving, bundling, interlacing, braiding, knitting or knotting and through that convolution the whole becomes strong and rigid." Spuybroeck, *Textile Tectonics*.[3]

Figure 3 is an example of a student's work who begun with choosing straw and then looked at how this could be used structurally beyond the typical infill use of straw bale. This work continued to develop and later incorporated arrow weed, which had been utilized by local native American tribes, in part due to it's availability and it's properties related to waterproofing.

Figure 3.Fiber studies (Itzel Gamez, 2022)

FINAL RESOLUTIONS

Although work originated with a singular material, depending on the selection this could be made of a multiplicity of materials, that needed to be broken down into component parts. Successful students quickly realized the potential symbiotic relationship of their material to the environment around it. For example, with mycelium the food that allows it to grow is obviously part of the design equation, which could be in the form of waste materials etc. With earth, clay and ceramics, one student was interested in the relationship to the local ecology which could be created around it as an evaporative cooler and armature for more forms of life in his project titled, *Aridland Archeofuturism: Posthumanism in a Sonoran Desert Context* (Figure 4). The architectural concept revolved around the idea of inviting nature in rather than keeping it out. This desire was further developed by the articulation of the building skin to have more detail, texture and surface area, related to specific plant and other local life forms and habitats. The concept related to the idea of extending the surface of the earth and becoming a living surface or architecture, with tests relating to capillary attraction and root-friendly surfaces with actual living plants. The specific site of Molino Canyon in the Sonoran Desert, Arizona was selected as there was semi-perennial access to water. 3d clay printing and extrusion were incorporated to explore possible forms which could maximize the use of this local, abundant material. The resulting forms selected were domes and water-catching, shading pitchers. Glitches in the printing g-code were embraced to

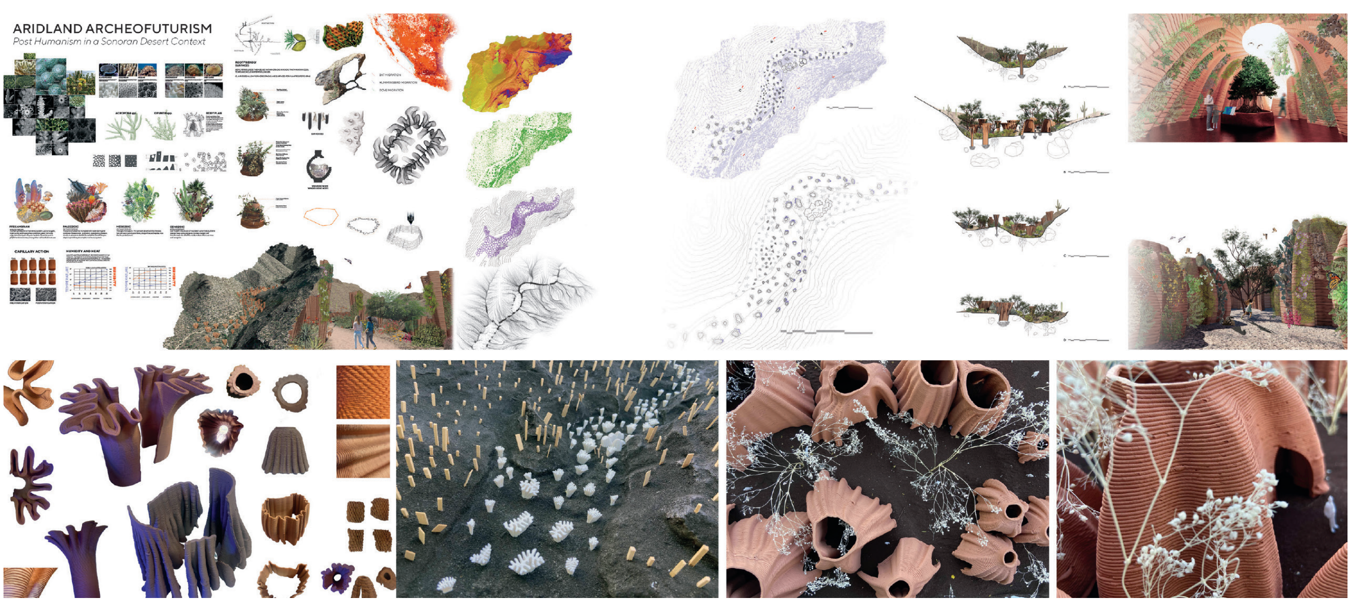

Figure 4. Earth and clay final presentation boards and physical models (Alejandro (Oli) Rueda, 2022)

Figure 5. Mesquite final presentation boards (Tayler Forsberg 2022)

enable even greater diversity. Forms and apertures responded to solar orientation and promoted air-flow throughout.

Figure 5 shows the final presentation boards of Tayler Forsberg, whose chosen material was the previously mentioned native tree, mesquite. Culturally to local native Americans the mesquite tree has been a vital source of energy, shelter, tools and food. His project forms were inspired by some of the projects by the Architectural Association's facility at Hooke Park, UK, like the Wood Chip Barn. His site location aimed at restoring a mesquite bosque, which had been destroyed with western urban development, in the 'A' Mountain watershed, close to downtown Tucson, Arizona and the Santa Cruz River. Beyond the restoration of the bosque, the built facility incorporated mesquite bean pod storage, which can be milled into flour, wood storage, workshop space and learning centers to facilitate the construction of timber structures and buildings. The speculation was that smaller nodes would expand throughout the city, to help maintain local urban trees, forests and communities supporting a richer synthesis with humans and their surrounding built environment

CONCLUSION

Student's final projects emerged out of these individual meditations and research on material, context and culture, with the goal of creating more critical, sustainable futures. This pedagogical model flipped the traditional role of architects and students, who are typically given a program and site from clients or their professors. Instead this gave them more agency to research potential project directions, site locales and materials. The most successful outcomes were speculations with multiscalar implications from the micro, to buildings, urbanism and the region, and gave agency to the patterns and flows of the energetic and material qualities in productive and sensitive ways. These projects began to question the societal role of architects and their methods, the specificity of place in a globalized world and the future role of the architect in that space.

ACKNOWLEDGEMENTS

I would like to thank the School of Architecture at the College of Architecture, Planning, and Landscape Architecture at the University of Arizona, which gave me the opportunity to teach this capstone class in the inaugural year of our new format. I would also like to thank all the faculty involved in the Material Matters cohort, but particularly Dan Hoffman and my two co-teachers, Jesus Robles and Sheehan Wachter. Lastly, I would like to thank all the participating students who made this all possible.

ENDNOTES

1. https://architecture2030.org/why-the-building-sector/
2. Luis Fernandez-Galiano, *Fire and Memory*, MIT Press 1991
3. Lars Spuybroeck in "Textile Tectonics" in *Architectural Design* Vol 76 No 6, 2006. Architextiles, edited by Mark Garcia