Pneumatic Reality: An Exploration of Inflatables as a Pedagogical Design Tool

Shawn Protz
NC State University, Raleigh, North Carolina
The School of Architecture, Paradise Valley, Arizona

ABSTRACT*: Since the 1960s, inflatable structures have captivated generations of architects and designers. This method of construction has fostered a diversity of responses in fields from architecture and visual arts to fashion and play.*
Pneumatic Reality was a course that explored inflatables as a rapid "design-build" tool in which students translated digital sketches into building-scale, spatial experiences. Through this approach, students explored a range of architectural topics including ephemerality, the mediation of environment, the notion of boundary and amorphous form. The inflatable became the conduit through which students engaged in discourse at the intervals of permanence and temporality, old and new, natural and synthetic. Moreover, this process invited students to discuss the idea of air systems and the medium of air itself in architecture and culture at large.
The Pneumatic Reality design pipeline started in the digital realm inviting students to hypothesize through modeling potential inflatable forms. The process then progressed to a study in translation via unrolled surfaces or tessellations, and finally, manifested in material through full-scale pattern making. In a matter of hours, with minimal, low-cost or even recycled materials, students were able to produce the first iteration of their design. Due to the simplicity of the fabrication method, what followed was a process of rapid iteration at an architectural scale, a form of spatial sketching.
Students tested and responded to materials while confronting questions of form and scale. The Pneumatic Reality project took on additional significance in relationship to the legacy of Frank Lloyd Wright. In a lesser-known project, Wright explored inflatable designs by envisioning a method to construct low-cost shelters. Students at The School of Architecture (at Taliesin) revived this experimentation by building their own inflatables and then inserting them into the historic architecture and surrounding landscape thereby engaging in a direct dialogue with their environment. Due to the inherent temporality of these design inventions, this project offered up inflatables as a means through which students could temporarily disrupt spaces they already inhabited.
An inflatable structure transforms the moment people begin to interact with it. This interaction is a critical component to understanding the power of the inflatable as a teaching device in terms of its relationship to the human body and permutable program. Designs are at once an object in space and an experience to inhabit. For students at Taliesin Spring Green, their inflatables became sites for community engagement. Students' projects morphed from gathering areas to placemaking markers to an interactive gallery exhibition. Therefore, the inflatables became a means through which students reimagined program. Overall, this project provided an opportunity for students to think critically about Wright and his work, and posited architecture as an ecologically based, collaborative, open-source flow of ideas and things.

KEYWORDS: inflatable, fabrication, design-build, pedagogy, ecology

1. INTRODUCTION

> Let walls, ceilings, floors now become not only party to each other but *part of each other*, reacting upon and within one another; continuity in all, eliminating any merely constructed features as such, or any fixture or appliance whatsoever as such. (Frank Lloyd Wright 1954, 20-21)
>
> To unfold, inflate and see each other in a black white red purple cloudballoon can (conditions right) help to break down people's category walls about each other and their own abilities and can be a hint at the idea that maybe maybe anybody can should must take space-making beautifying into her, his own hands. (Ant Farm)

Pneumatic Reality[1] was a course that explored inflatables as a rapid "design-build" tool during the summers of 2018 and 2019 at The School of Architecture[2] on Frank Lloyd Wright's Taliesin estate in Spring Green, Wisconsin. Graduate students gathered for group charrette sessions and then translated digital sketches into building-scale spatial experiences. Through these exercises and intensive study of texts, the inflatable became a conduit for students to engage a range of architectural topics including ephemerality, the mediation of environment, notion of boundary, and embodiment. Moreover, this process invited students to discuss the idea of air systems and the medium of air itself in architecture and culture, spanning a range of sources including Gaston Bachelard, Luce Irigaray, Reyner Banham, Peter Sloterdijk and his characterization of the 20th century as a period concerned with *making things explicit* (2016), Graham Stevens' and his *Atmosfields,* the countercultural practice Ant Farm, sci-fi novels and films, and contemporary inflatable art and fashion.

Among these conversations and within the inflatable “happenings” they created, students were able to reflect on Frank Lloyd Wright’s passive energy strategies and concept of “integral architecture”[3] that merges inside and outside – prescient frameworks to challenge the sealed architecture of today’s Comfortocene[4] (Fig. 1). With the cohort of students and instructor working as a team, the course embraced The School of Architecture’s ethos of “live architecture” promoting a model of architectural practice based in community. The following is a reflection on the process.

Figure 1: Inflatable wedged under the north porch and encompassing the hearth of the Hillside Home School (II) designed by Frank Lloyd Wright at the Taliesin estate in Spring Green, Wisconsin. Source: (Author 2018)

2. THE PROJECT

In parallel with assigned texts and course themes, the project brief challenged students to create a sequence of three inhabitable inflatables in response to the Taliesin estate, and then a stage final comprehensive installation in downtown Spring Green. Students made design choices in attempting to negotiate the constraints of site and material with an intended experience.

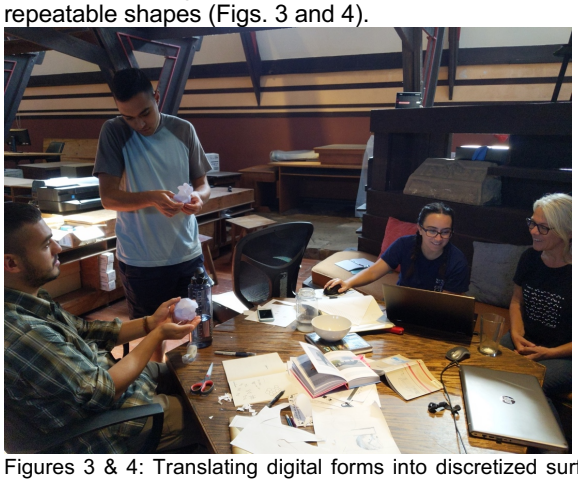
2.1 Designing the medium of air

Following guidance from Ant Farm’s *Inflatocookbook*, students first set out to make an inhabitable inflatable around the Hillside Home School (II) studio with only materials at hand. Taking cues from the surrounding landscape and architecture, and using only a box fan, packaging tape, and a roll of polyethylene – each borrowed from the Taliesin Preservation’s maintenance team – the group could quickly design and build a structure at full scale (Fig. 2).

Figure 2: Students inside inflatable positioned in Taliesin estate landscape. Source: (Author, 2018).

The design pipeline continued with sketches and flowed to the digital realm, inviting students to hypothesize potential inflatable forms through 3D modeling. Significantly, Ant Farm's (and later, Wright's) exploration of inflatables preceded software. Digitally modeling the proposed form was a new step in an inflatables workflow that allowed students to explore the relationship and often disconnection between digital model and physical material.

The process entailed a study in translation, i.e., how to discretize or tessellate the volumes and create developable surfaces that could be unrolled with the intention of taking the three-dimensional form and, like a tailor, constructing a series of flat, full-scale patterns. After testing a number of workflows, students ultimately used Rhino/Grasshopper and a papercraft software called Pepakura. They were able to approximate a range of forms including a spherical shape via a truncated icosahedron that was unrolled into a template with two repeatable shapes (Figs. 3 and 4).



Figures 3 & 4: Translating digital forms into discretized surfaces – testing with paper models and full-scale prototypes, Hillside Home School (II) drafting studio. Source: (Author 2019).

Because of the simplicity of fabricating inflatables, students were able to produce a first iteration of their design in a matter of hours. What followed was a process of development at an architectural scale as students confronted questions of form, threshold, and atmospheric effects. With inflatables, air becomes a key material and structural component integral to the function and aesthetic of the design.

Through this process of translation, students investigated the benefits and limitations of creating a computer-generated design sans forces such as air pressure and gravity. When those forces were introduced, they discovered their designs behaved in ways they didn't expect as areas sagged and needed reinforcement, and facets that looked orthogonal in Rhino were rounded under air pressure.

The system of pumping air into inflatables was also made manifest, and this aspect was used to spark conversation about the role of mechanical systems in architecture at large. Never was the impact of infiltration or air leakage more apparent than via an unintentional opening, or in pondering the necessary porosity of an inflatable membrane to allow for air exchange.

Following these physical experiments, the result was a move to more discretized/rationalized forms/surfaces for reasons of constructability (modularity/repeatability vs. custom individuated pieces) and more balance in overall air resistance. The students became less interested in form-making than the material effects, and the collective act of making and occupying a space.

2.2 The inflated object

Inflatables require only two key components: a lightweight membrane and an air flow source. Therefore, material workability is critical. Throughout the course, students tested sheet plastic, mylar, and fabric, joining them with tape, heat fusing, and sewing methods respectively.

As previously introduced, the first material students explored was polyethylene sheet plastic. This humble material was readily available and proved unmatched in its ease of manipulation and constructability. Students had to develop a methodology for construction via patterning and labeling the plastic sheets prior to carefully seaming the edges with heat and/or tape. An emphasis was placed on the level of craft and care in each seam as students found ways to avoid puckering or folding so as to create an airtight seal.

Upon inflation, it became immediately apparent where the structural stress points were located and students needed to address these intersections. They deflated the structure, reconfigured their design and then reinflated. By operating at full scale, students physically experienced the resultant consequences of their design choices such as the manner of entrance/exit, durability of materials, or the ability to transfer conditioned air. In addition, designs were informed by a sense of scale in relationship to the human body and explored a range from an individual pod to a space for group gatherings.

The second material, mylar donated from a Wisconsin company that manufactures party balloons, proved to be more delicate than the robust sheet plastic and also invited a new form of seaming. Mylar, as a material, is utilized by a variety of industries as a hygienic, sealable method for packaging items ranging from vitamins to candy, in essence, creating miniature airtight bags. Through their research, students recognized an opportunity to employ this system of sealing at an architecture scale. They discovered, prototyped, and developed a way to heat-seal the edges, resulting in a resilient seam that removed, as in the previous studies, the need for an additional adhesive component. This process proved more time intensive and less forgiving, and by extension, necessitated a more resolved design prior to the start of fabrication in addition to requiring a standing heat sealing machine. Yet, the color and translucent properties of the mylar added a sense of playfulness and celebration to the spaces encompassed by the material. In one instance, students chose to evoke Andy Warhol's Silver Clouds.

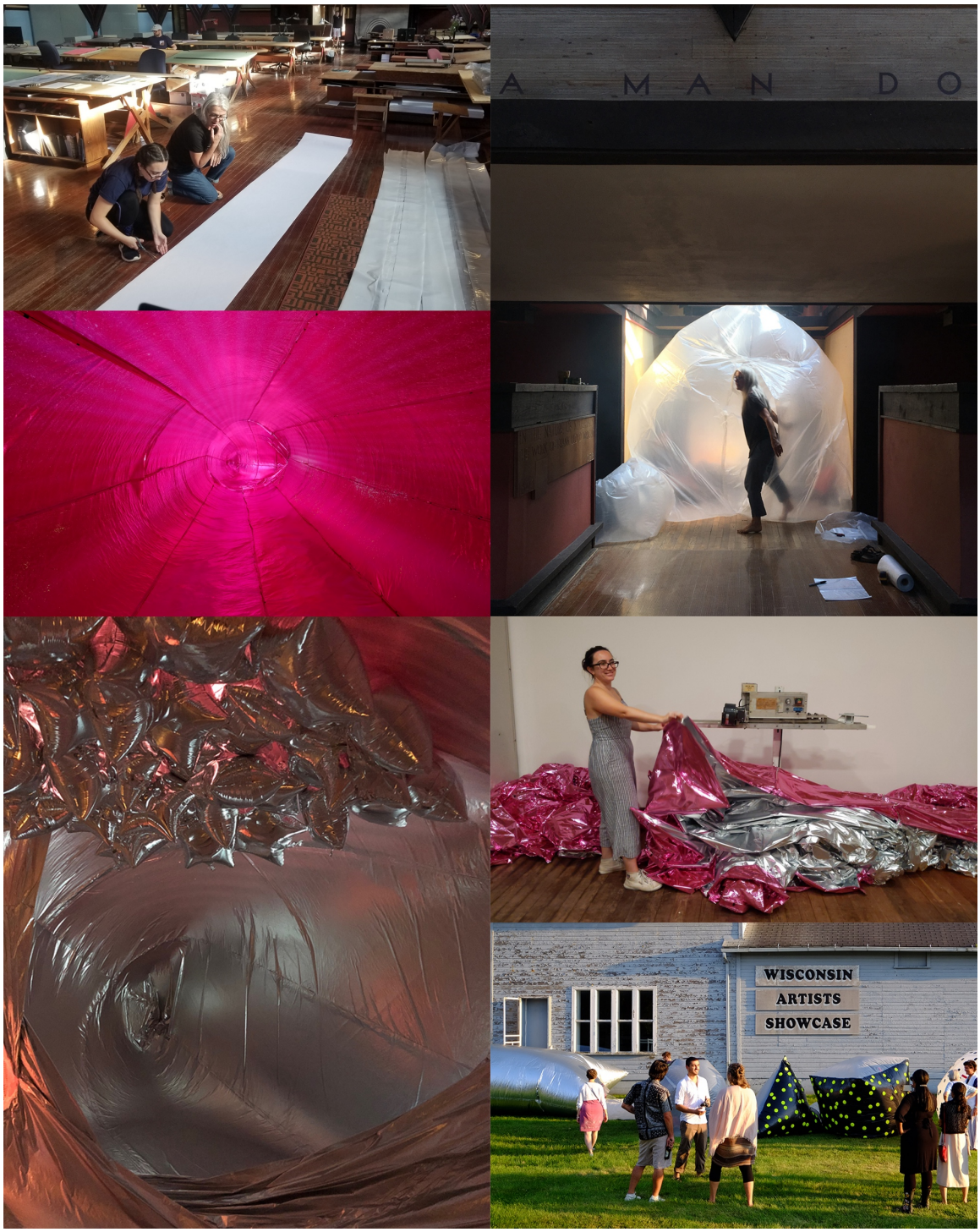
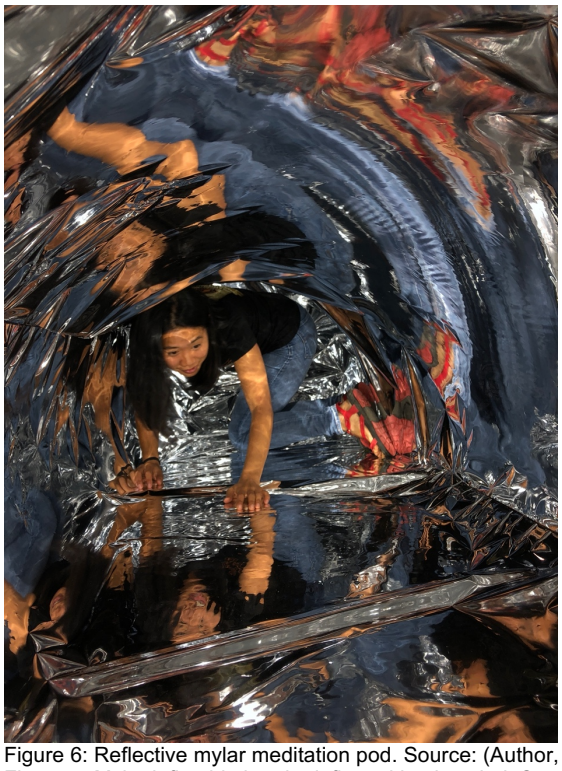


Figure 5: Installations at the Hillside Home School (II) & Wisconsin Artists Showcase gallery in Spring Green. Source: (Author 2019)

By exploring the same construction approach through multiple materials, students discovered the intricacies and nuances of how each material fundamentally impacted the experience of the structure whether tactilely, audibly, or simply visually. Differences such as the ability to illuminate the translucent plastic vs. achieving a “fun house mirror” distortion of images through the reflective mylar highlighted the significance of their material choice (Figs. 6 & 7).



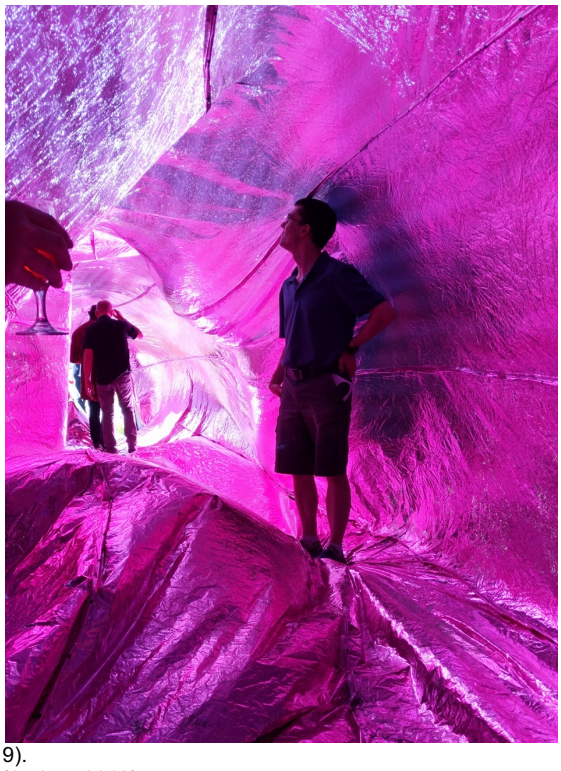


Figure 6: Reflective mylar meditation pod. Source: (Author, 2019).
Figure 7: Mylar inflatable interior inflected by the wind. Source: (Author, 2019).

2.3 Boundary, form & Wright

The *Pneumatic Reality* project was initially conceived as a deliberate juxtaposition to Frank Lloyd Wright's earthbound work generally (think, especially, of the hearth) and particularly to the Taliesin estate.The conceit took on additional significance upon discovering an obscure project by Wright envisioning a method to construct low-cost shelters in partnership with the US Rubber Company. The November 11, 1957 issue of *Life* magazine featured the Fiberthin Airhouse, a pneumatic dome fabricated from a "durable vinyl-covered nylon material called fiber thin." (Frank Lloyd Wright Foundation 2019) Programs were compartmentalized into living, sleeping, and work inflatables. Wright then expanded this vision of a single house to a community called the Rubber Village. A group of prototypes were produced for the New York International Home Building Exhibition in May 1957 and later exhibited and photographed at a Kentucky university (Fig. 8).

Figure 8: Wright's Fiberthin Airhouses. Source: (Frank Lloyd Wright Foundation/Life 2019/1957).

The Pneumatic Reality project was rooted in both Wright's own interest in technology and material experimentation, his pedagogical motto of learning by doing embraced by The School of Architecture and

perhaps best represented by the student self-build shelter tradition. In this project students were challenged to push back by inserting inflatables into the landscape of Taliesin and against/within the historic architecture of Wright, thereby creating a dialogue with their environment and raising the idea of architecture as a form of spatial intervention and climate mitigation. Students eventually weighed the inflatable against Wright's own terms: organic architecture, continuity, integral architecture, essential architecture, structure-pattern made visibly articulate, etc. (Wright 1954)

Students would be drawn to attend the Taliesin program out of a reverence for Wright's work, and would approach living and working in these historic buildings with tentativeness. The inflatables allowed them to begin to engage with the architecture more directly by inserting their design into and occupying the "empty space." They began to see the space between ceiling and floor and walls an integral to the architectural design and something they can explore through their work by creating different responses through form. The inflatable could operate more like a standalone object or if built at a larger scale be "squeezed" into the void, using the surrounding structure to distort the inflatable and draw attention to the low ceiling or angled walls. Students began to experiment with how inflatables changed their experience and perception of landscape elements by placing them under trees, over leaves and grass and even cantilevered into water (Fig. 9).

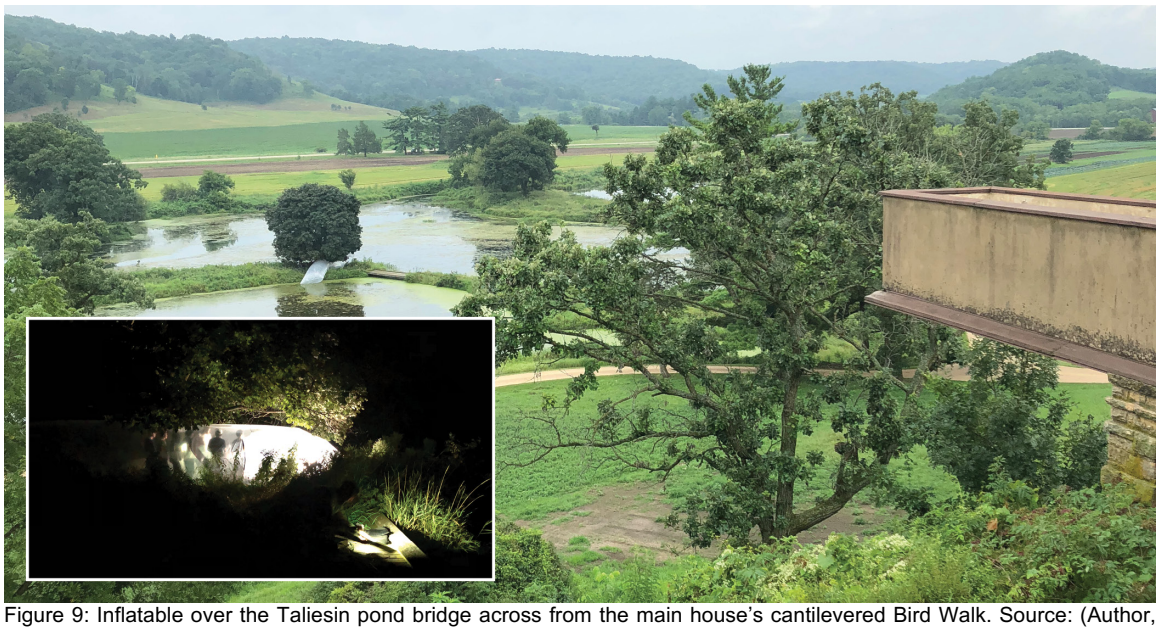


Figure 9: Inflatable over the Taliesin pond bridge across from the main house's cantilevered Bird Walk. Source: (Author, 2018).

After disassembling a prototype that was blown up for a few days on the lawn near the Hillside Home School (II), students were particularly struck by how thoroughly and quickly the inflatable membrane's coverage killed the grass below. Later, students observed inflatables responding to wind, causing them to come alive, rippling and breathing almost like a bodily organ. The disruptions and transformations brought by these interventions gifted students a new means to understand spaces they already were inhabiting.

3. CONCLUSION

Finally, as the *Inflatocookbook* describes, an inflatable structure transforms the moment people begin to act upon and within it. Interaction is a critical component to understanding the power of the inflatable as a teaching device in terms of its relationship to the human body and permutable program. Designs are at once an object in space but more importantly an experience to inhabit, a catalyst for communal engagement. Students' projects morphed from gathering areas to singular meditative spaces to place markers to an interactive exhibition adapted to the Wisconsin Artists Showcase art gallery in downtown Spring Green. Students even created an inflatable gathering space for the annual Taliesin summer formal held at the main house by hijacking the air supply from an upstairs air conditioning vent, thus literally utilizing another structure's air system (Fig. 10). The inflatable became a group agent for exploring, testing, and rethinking program. Overall, this project provided an opportunity for students to think critically about Wright and his work, and posited architecture as an ecologically minded, collaborative, open-source flow of ideas and things.

The project of *Pneumatic Reality* challenged students to notice and critically reflect upon their environment, and to work opportunistically with site and material constraints. Bridging the gap from representations of space

to full-scale interior experiences, realizing inflatable installations made manifest the limitations of digital and physical design models. Speculating on a new mode of architectural production, *Pneumatic Reality* centered community, temporality, and resourcefulness.

Figure 10: Room for the annual Taliesin summer formal leeching from the air conditioning supply from the main house. Source: (Author, 2019).

ACKNOWLEDGEMENTS

This project benefitted from the research, advice and support of Whitney Moon, PhD, Assistant Professor of Architecture at University of Wisconsin-Milwaukee.

REFERENCES

Ant Farm. 1973. *Inflatocookbook*. San Francisco: Ant Farm.
Banham, Reyner. April 1965. "A Home is Not a House." *Art in America* 2: 70-79.
Barber, Daniel. Fall 2019. "After Comfort." *Log* 47: Overcoming Carbon Form: 45-50.
Frank Lloyd Wright Foundation. Published March 29, 2019. "Frank Lloyd Wright's Inflatable Architecture Experiment." *The Whirling Arrow*. https://franklloydwright.org/frank-lloyd-wrights-inflatable-architecture-experiment/.
Irigaray, Luce. 1999. *The Forgetting of Air*. Translated by Mary Beth Mader. London: The Athalone Press.
Sloterdijk, Peter. 2016. *Spheres: Foams III: Plural Spherology*. Translated by Wieland Hoban. Los Angeles: Semiotext(e).
Stevens, Graham, director. 1971. *Atmosfields*. London: Arts Council England.
Wright, Frank Lloyd. 1954. *The Natural House.* New York: Horizon Press.

ENDNOTE

1. Title derived from the quote: "A line of poetry is a pneumatic reality." In Gaston Bachelard, *Air and Dreams*, trans. Edith R. Farrell & C. Frederick Farrell (Dallas: The Dallas Institute Publications, 1988), 242.
2. Now called "The School of Architecture" and based at Arcosanti and Cosanti.
3. For example: "Architecture now becomes integral, the expression of a new-old reality: the livable interior space of the room itself. In integral architecture the *room-space itself must come through*. The *room* must be seen as architecture, or we have no architecture. We have no longer an outside as outside. We have no longer an outside and an inside as two separate things. Now the outside may come inside, and the inside may and does go outside. They are *of* each other." In Frank Lloyd Wright, *The Natural House.* (New York: Horizon Press, 1954), 50.
4. "…an era defined by a global order predicated on manufactured interior consistency." In Daniel Barber, "After Comfort," *Log* 47: Overcoming Carbon Form (Fall 2019): 47.