Memos from an Inconvenient Studio

Unsolicited Projects for Responsive Architectures

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Computation, robotics and intelligent building/fabrication systems are finding themselves ever more prevalent within both practice and education. The assimilation of these new tools and methodologies within the pedagogy of architectural education continues to gain greater importance as we perceive their rapid evolution and integration within surrounding emergent fields. Through the model of an Inconvenient Studio, this paper examines the intersection between interdisciplinary collaboration, architectural robotics and computation as a means of gaining a broader understanding of how the architectural learning environment can be transformed into a self-organizing system for emergent solutions. The pedagogical prototype for an Inconvenient Studio was broadly focused on the topics of architectural robotics and responsive architectures interpreted through a range of robotic technologies and their manifestations such as biomorphic, mechanomorphic, polymorphic and amorphic robotics. Through a set of three "Memos" (Self-Organization, Autonomy, Sentience), this paper will describe how students created innovative technology-driven think tanks that produced design entrepreneurs.

Keywords: Interactive architecture, Programming, Intelligent environments

INTRODUCTION

Computation, robotics and intelligent building/fabrication systems are finding themselves ever more prevalent within conversations in both practice and education. However the tools, methodologies and entrepreneurial know-how necessary for their integration into and for the restructuring of the profession currently remain untested.

The growing need for architecture and architectural education to adapt to these new tools and methods of design has begun spurring a continuing debate on their effect within the discourse of design pedagogy (Senagala 1999, Senagala, Vermillion 2009). This paper investigates the intersection of design and technology and its potential to reshape architectural education through the pedagogical prototype An Inconvenient Studio.

Current Studio Typologies
The conventional design studio is typically organized as a top down hierarchy. Such authoritarian and parental organizational models can be categorized
through these five frameworks (Daas, M. & Wit, A. 2015):

- 1. Master - Apprentice (Figure 1 - Type A)
- 2. Master - Group (Figure 1 - Type B)
- 3. Master - Group or Apprentice + Outside Client or Community partner (Figure 1 - Type C)
- 4. Master - Apprentice + External Network (Figure 1 - Type D)
- 5. Master-Apprentice immersive model where the surrounding community becomes the studio’s learning environment (Figure 1 - Type E)

Although these five models of organization can allow for high levels of variation within the studio environment, they continue to be limited in the ways by which they could motivate individuals and enable new knowledge to be created while continuing to learn existing knowledge. These models also depend excessively on the teacher as the sole source of disciplinary authority, which becomes a bottleneck in a world where knowledge has been growing by the minute. With the architectural discourse now bridging the realms of robotics, biology, computer science, kinetics and beyond, the conventional studio models begin to reveal their fault lines.

An Inconvenient Studio

In this paper we discuss a pedagogical prototype, an Inconvenient Studio (figure 2). Over the past decade, the Inconvenient Studio prototype has situated itself as an innovative sub-institution within the architectural discourse, with a long-standing reputation for the creation of innovative, interdisciplinary, technology-driven design entrepreneurs rather than designers of artifacts. Utilizing self-organization strategies and student empowerment through intellectual autonomy, the studio has investigated the topics of robotics and responsive architectures and their manifestations that include amorphic, biomorphic, mechanomorphic, and polymorphic robotics (Daas 2014).

The students were allowed to create their own entrepreneurial pathways through the course. Students autonomously organized into think tanks, and developed topics, schedules, proposals and funding strategies that were all unique to their own specific goals and aspirations. Through this unique system of self-organization, the studio functioned as a sub-institution for learning where students learned from each other. Rather than supplying a syllabus and a grading rubric, faculty acted as Intellectual Venture Capitalists, providing students with a seed fund of $1, some initial materials, and access to outside information networks such as a local non-profit innovation incubator whom helped guide students through the process of creating their startup companies while aiding in the formulation of problems that could be solved through emerging digital technologies.

Acting as autonomous agents, students were immersed with all the responsibilities a start-up company would have. Students managed deadlines, budgets, raised funds, created press releases and advertisements as well as maintained a web presence all in addition to their design and research. Through this self-organizing process, three unique entrepreneurial companies were formed with projects ranging from robotic furniture to interactive global installations. This paper presents the studio experiences through a series of three memos: self-
MEMO ONE: SELF-ORGANIZATION

Self-organization is a fundamental characteristic of life that allows for the creation of global level coordination from local level interactions. This collective organization could allow for the creation of complex, interconnected bodies that possess higher levels of inherent intelligence than individuals. Although a "collaborative" environment arises from these interconnections, the system remains autonomous and extremely flexible as individual units retain the ability to strategize, design, experiment, prototype, and operationalize their inventions.

The students were given the opportunity to self-organize. We called ourselves intellectual venture capitalists, and chose not to give students projects, schedules, funding and so on. In the beginning stages two distinct levels of organization were developed by the students: The first level of organization was at the collective level as a singular think tank. This level of organization led to such responsibilities as graphic design, project management fund raising, project documentation and so on.

The second level of organization led to the founding of small, three to four person "entrepreneurial units" or companies. Through a series of small student-led robotic exercises and peer work-shops, students tested their skills, reconfigured their organization and then finalized their small group offices around a unified design philosophy located somewhere within the discourse of architectural robotics. In the end a series of three unique companies were created, each with its own unique stance and personality with projects ranging from robotic furniture to interactive global urban installations. Although initial gaps in knowledge and technology were high, each group developed specialists that could solve specific problems.

Throughout the course of the semester, this seamless flow of knowledge between individual and group while dealing with complex issues like computation and robotics within the discourse of architecture has revealed that the current studio pedagogy must reconfigure and adapt to keep up with rapidly emerging global technologies.

Emergent Systems

In complex, self-organized systems, unique, larger and more complex patterns tend to emerge from the aggregation of individual components. This process allows for the development of potentially unforeseen solutions. Throughout the course of the semester, this same phenomenon was witnessed as collaborations, projects and interdisciplinary research developed.

The student-led companies came together to initiate a series of weekly open school-wide events. The goal of these events was both to gain and disseminate knowledge while opening college wide discussions on the topics of computation and architectural robotics.

These school wide events took various forms, ranging from weekly informational workshops hosted by both outside and in class experts, a bi-weekly global video conferencing lecture series bringing in innovative leaders from around the world, monthly debates with outside faculty as well as a bi-weekly new letter and studio blog to inform the local/global community on their evolving research and projects.
Notes on Self-Organization

The power of self-organization is being widely recognized and practiced in the real world. Such companies as Zappos are shunning traditional structures of hierarchy and opting for self-organization. In the case of Zappos, the system of self-organized management is being called "holacracy" (holacracy.org).

Development over the course of the semester showed the immense possibilities within self-organization as well as frequent difficulties. One of the difficulties some of the students faced was their ability to relate to others to collaborate. Instances where strong or passive personalities came together typically struggled to solidify research directions or projects. Companies created under a diverse framework featured individuals with unique skillsets typically saw a much easier progression through their project development than those consisting of similar goals. Students learned that while the process of organization is challenging, that is how significant things could be accomplished. The power of self-organization was evident in instances where students possessed or gained a heightened sense of self-awareness and eventually actualized their full potential.

MEMO TWO: AUTONOMY

The relationship between real or perceived autonomy and a host of variables such as creativity, job performance, and innovation has been well established (Lu, Lin & Lang, 2012; Liu, Chen & Yao, 2011; Wang & Cheng, 2010; Deci & Ryan, 1987; Schwenk, Kock & GEMUenden, 2014; Gooderham, Sandvik, et al, 2013; Malouff, Calic, et al, 2012; Anderson, Potocnik & Zhou, 2014). The studio placed emphasis on individual and group autonomy by empowering them with the ability to set goals, manage their time, manage their resources, and self-evaluate their learning.

Autonomy of various kinds is a challenge to address within the pedagogical and curricular framework of institutions. Institutions and teachers who work within territorial frameworks see autonomy as an act of establishing or broadening various boundaries. However, we see autonomy as the ability for the individuals and groups to engage within a broad and strategic framework of institutional resources, intellectual context, and the context of knowledge as nodes in a network that do not need boundary definitions.

Autonomy is also a challenge for individual learners who may have become accustomed to being told what to do, how to do, and when to do. We found that individuals who are reluctant to take responsibility sometime shun autonomy. This reluctance in turn not only affects the individual, but the group as a whole as they struggle to define their values and goals. In that sense, autonomy became a touchstone of the individual's ability to think critically and hone leadership skills.

Notes on Autonomy

Within the studio, autonomy emerged in many ways. One of the most prominent was through the formation of three unique companies, all with distinctive ideals and interpretations of the relationship between the architecture and robotics. Although all beginning in the same place, the pace in which each group developed varied extremely based on the individual's willingness to operate within an autonomous environment. Where some groups flourished branching out to solve problems, others struggled as they waited for internal top down direction.

One office within the class (designFUNCTION) not only embraced the integration of the architecture and robotics, but also saw it as a natural and necessary evolution of the discipline. Rather than looking to solve typical design questions, this group looked at current local or global systems that could be innovated upon through the integration of robotics. From the creation of a robotic desk lamp that adjusted illumination and form based on external lighting conditions and occupant location to a globally interconnected, big data driven urban intervention which brought global inhabitants together through local interactions, (designFUNCTION) allowed the problems and tools to inform their processes of thinking rather
than the creation of an artifact. Over the semester, their willingness to rapidly evolve their individual philosophies of design allowed for further development of innovative projects throughout the course of the semester.

Other groups struggled much more as they maneuvered their way through the complexities within the semester. As the learning curve for the course was quite steep with the initiation of new design methodologies, computational/robotic tools and group dynamics, some groups required weeks to grasp these new concepts of design thinking. Through arduous struggles, each group slowly but surely began to bend their preconceptions, and create projects that were based on solving complex problems with innovative solutions rather than the creation of artifacts.

One such example was with the group TRANS4M. Whereas (designFUNCTION) quickly realized the need for integration of advanced technologies into architecture, TRANS4M struggled from the start to understand their connection. In addition, strong personalities within the office structure created an atmosphere that was initially not conducive to autonomous growth. Through a common interest in furniture and the advancing of flat-pack processes, TRANS4M began reformulated their office philosophy focusing on robotic furniture for dense urban environments. Through their struggles, TRANS4M was not only able to redefine themselves as a robust interdisciplinary, autonomous organization, but also help with the furthering and redefinition of their surrounding peers.

MEMO THREE: SENTIENCE

The abilities to sense, feel, and experience the world are the hallmarks of living beings. Sentience and cognition are distinctly different but related activities. A big part of design field deals with not just knowing, but also feeling. As the studio explored artificial intelligence and robotics, we also placed emphasis on sentience as a guiding principle of learning and creating. At regular intervals, the studio convened to understand the importance of sensing, feeling, and experiencing, and how such an understanding could inform their work.

Working with robotics can have the tendency to feel rather cold in their current physical manifestations and interfaces. Typically associated with mechanical efficiency, creating robotics that stimulates our senses can be quite the challenge. Throughout the course of the semester, a constant question was how could we generate reactive/adaptive spaces or objects that not only intelligently solve problems, but also stimulate the users' senses.

As current buildings and artifacts remain in a static state, experiences are initially programmed through physical manifestations and experienced similarly by each subsequent user. The varying of materials, textures, lighting conditions, etc. helps create a series of environments that portray a predefined narrative of the object to viewers, while creating low levels of sensorial variation.

On the other hand when working with reactive spaces or objects, our familiar static nature no longer exists. Standardized construction materials and methods must be reinvestigated to allow for the adaptive nature, opening up new opportunities for how individuals design and experience these new spaces. Through the integration of interactive elements such as interactive lighting, reactive surfaces and operable furniture, in conjunction with global interconnectivity and activity, students redefined our current preconceptions of how architectural robotics look and interact with their surrounding environments.

Notes on Sentience

Although we are working with robots, it is important to remember that humans are not robots. It is not necessary for information to be directly programmed into us, and many times as within the typical studio environment this tendency can hinder the student's creativity and innovative collaborative nature. Ironically, conventional pedagogies treat students as vessels waiting to be filled with information, and au-
tomatons waiting to be "instructed" by the instructors. Humanizing robots and re-humanizing students and instructors as thinking and feeling learners and co-creators is an important principle behind the Inconvenient Studio pedagogy.

**PROJECTS**
Many projects emerged throughout the course of the semester. Each further defining the direction and pedagogical framework of the offices. We will now briefly outline a sampling of this work and the struggles students faced moving through the steep learning curves associated with architectural robotics and entrepreneurial process.

**Lego-Bots + Arduino programming**
During the first three weeks, students were immersed in a series of robotic projects that would set their individual directions for the remainder of the semester. Rather than beginning with typical design problems, students were rather given a series of tools, i.e. Lego Mindstorm robotics and Arduino components (figure 4). With these tools students where then asked to think of a problem they encounter within their daily lives that could be solved through the integration of robotics. Projects ranged from robot desk lamps and operable bending active based façade systems to rain activated canopies that could track users to minimize enclosure footprints.

Through these exercises, students not only formed their offices, but also honed their programming skills while gaining a better understanding of the relationship between architecture and robotics.

**design(FUNCTION);**
With a focus on enhancing spatial experiences through the merging of urban space, human/robot interaction and emerging reactive technologies, one of the student-formed firms, design(FUNCTION), strove to reinvent not only how we design physical spaces, but also how we interact with "space" on a global scale. Through the creation of a series of globally connected, interactive "Pods" (figure 3) connected through the Internet of Things, this group designed not only the local physical/interactive artifacts, but also their user interfaces, data collection and dispersal systems, as well as a global implementation strategy.

Through local interactions such as touch, proximity, speech or smartphone apps, users were able to communicate with each other through sound, visual and physical manifestations while redefining the surrounding local environment (figure 5). On the other hand, global interaction also allowed for local players to communicate and reconfigure interconnected pods in locations around the globe while simultaneously recording and transmitting the results online.
TRANS4M:
Rather than focusing solely on the intelligence imbedded within robotics, TRANS4M investigated the potentials hidden within advanced material systems, mechanical folding and digital fabrication in conjunction with robotic actuating systems. Though their formulation of a robotic furniture system (figure 6), problems such as weight, strength, shipping and cost played heavily into the various prototypes produced by the group.

Through a series of rigorous tests, the group developed a rapid system of manufacture using subtractive CNC milling, resin-based 3D printing and laser cutting. This methodology allowed for the creation of a robotic furniture piece that could adapt to different conditions, span a maximum distance of eight feet, retain a maximum loading capability of 250 pounds per axis, yet only weighing a total of eight pounds.

CONCLUSION
As computation, robotics, and intelligent building/fabrications systems continue to find themselves ever more prevalent within both education and practice, it has become increasingly more imperative for educators to reimagine our current pedagogical frameworks to allow for the assimilation of these new tools and means of thinking about artificial and natural intelligence.

The pedagogical prototype of an Inconvenient Studio allowed students the opportunity to be immersed in not only new technologies, but also within a new mode of thinking and feeling. Through these processes of self-organization, emergence, autonomy and sentience, students were able to create interdisciplinary office structures and projects that went beyond their (or our) wildest imagination. Although the process could be trying, a strong sense of community and accomplishment arose from the students as they formulated their new collaborative frameworks.

Through the lens of these three memos within a single instance of an Inconvenient Studio, we have witnessed the potentials inherent within a self-organizing studio environment focused around cutting edge topics such as architectural robotics and computation.

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REFERENCES
BRAYER, MA 2013, *Flight Assembled Architecture: Gramazio & Kohler and Raffaello D*, HYX

Chen, XP, Liu, D and Yao, X 2011, 'From autonomy to creativity: a multilevel investigation of the mediating role of harmonious passion', *Journal of Applied Psychology*, 96(2), p. 294

Cheng, BS and Wang, AC 2010, 'When does benevolent leadership lead to creativity? The moderating role of creative role identity and job autonomy', *Journal of Organizational Behavior*, 31(1), pp. 106-121


Deci, EL and Ryan, RM 1987, 'The support of autonomy and the control of behavior', *Journal of personality and social psychology*, 53(6), p. 1024


