Building Simulation Strategies to Push Design Thinking

There are two interconnected disruptions in the field of architecture: climate change and the economy. Climate change has exposed society's inability to comprehend the modifications that the consumption and expulsion of carbon have on the ecology of the planet. The economic collapse has exposed the architectural design industry's inability to adapt their skills to stay relevant in a changing market. Both issues require a deeper study and application of improved skills, technological abilities, and predictive rather than reactive design thinking.

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The ability to use a digital design toolset is an expectation within the field of architecture. When educators evaluate curriculums to build fluency with digital design it is important to apply a similar set of standards to the coursework, toolset, and learning outcomes. This presents the opportunity to understand if students are applying the coursework to move past a baseline competency (reproduction of ideas, or production drawings), and learning to apply digital design within the higher cognitive skills of "analyze, evaluate and create."[1] One of the primary questions digital design educators should be developing with their faculty is which toolsets can build a process to help students move past a production and representation process. Constructing a digital design curriculum which engages students to analyze and evaluate architectural design builds the opportunity to push their creative design thinking. The evaluation of digital design education, specifically moving past the consideration that software is only a tool to wield, suggests the interconnection of several disruptions within architectural practice that the academy has the opportunity to evolve.

DISRUPTIONS

Disruptions are a revealing element in all aspects of work, life and design. Orchestrating the impact of modifications to an established pattern has the potential to breed apathy, chaos, or creativity. Ignoring change is only an option if your desired outcome is insulation from relevancy. Not taking the time to study the application of a disruptive technology generates results which may be either positive or negative, but are rarely replicable. Clay Chritensen uses the term "technological disruptions" as one of his major business theories that is applicable at all levels of nested operation: nations, industries, companies, teams, people and brains.[2] Working with technological disruptions builds a paradox because the time, energy, and effort invested in, do not yield immediate tangible results. The positive outcomes from an investment in a disruptive technology are typically only revealed over an extended period of time. Architects, however, are uniquely equipped through training, and often their inherent skillset, to evolve a disruption into inspired solution.

In the field of architecture, there are two interconnected disruptions that are revealing about the current state of the profession: climate change and the economy. Climate change has exposed society's inability to comprehend the modifications that the consumption and expulsion of carbon have on the ecology of the planet. The economic collapse has exposed the architectural design industry's inability to adapt their skills to stay relevant in a changing market. Both issues require a deeper study of the disruptions, their connection, and creative solutions. For architects, this means application of improved skills, technological abilities, and predictive rather than reactive design thinking. The context for the next generation of progress within digital design curriculums needs to understand process as it relates to the economy, climate change, and the client that the architecture serves.

CLIMATE CHANGE

Architecture is directly linked to climate change by the underperformance of buildings. Buildings in the United States consume 36% of total energy, 65% of electricity, 30% of raw materials, 12% of potable water, and produce 30% of our waste.[3] "A green agenda did not used to be about fashion; it used to be about survival".[2] As a design industry, we have a direct opportunity to make comprehensive change on one third of our nation's energy consumption problem, and yet we still widely regard building green as a marketable strategy rather than a design imperative for survival. While the United States Green Building Council (USGBC) and the Leadership in Energy and Environmental Design (LEED) evaluation system are gaining momentum with $97,837,000,000 in construction for 2012 (the dollar figure represents all construction under "an environmentally audited system of certification," not only LEED),[4] this work only represents 11% of the overall $856,953,000,000 of construction in within the same year.[5] While it is not entirely appropriate to suggest that only 11% of construction is environmentally responsive, it does reveal an intense amount of space for necessary growth. This presents a major opportunity for design educators to improve skillsets which allow for design that evolves through environmental computation. This maintains, and builds upon the relevance of architecture and its role in slowing climate change.

COLLAPSE

The architecture industry is experiencing very high unemployment when compared to other sectors carrying professional degrees; 13.9% unemployment for recent college graduates within the United States.[6] The high rate of unemployment prompted The New York Times article titled "Want a Job? Go to College and Don't Major in Architecture." While the architecture industry can certainly blame a weak economy and a slowdown in the construction sector, another reality that designers must observe is the limited scope in the performance of design work relating to buildings. Modifying workflow to include data collection and analysis through simulation has the potential to add scope and value to the design process. Simulation data can provide value to the client by building an opportunity for design collaboration through analysis of environmental, structural, and behavioral simulation. The process adds value to the design process by balancing visceral design thinking with analytical data that can drive, validate and inform architectural decisions. Simulation strategies, with the move to Building Information Modeling (BIM) format, are becoming quick, intuitive, and part of an iterative process. This methodology is capable of informing compelling design that is responsive to data, informs the concept, and becomes an integral part of the design expression. Environmental (energy) simulation, structural simulation, and behavioral simulation are all areas capable of generating both visual and analytical data within a BIM environment.

TECHNOLOGY

BIM technology has the potential to connect both the economic and environmental disruptions in the field of architecture. Phil Bernstein FAIA, (former principle with Pelli Clake Pelli, Adjunct Professor at Yale and Princeton, and a Vice President at Autodesk) described in his lecture at the Yale University BIM Symposium Peter Rowe's take on the academy's three primary obligations to the profession of architecture: First, advance the art and science of practice. Second, prepare students to be practitioners. Third, educate the public on the fundamental values of architecture.[7] Bernstein goes on to describe a paradigm shift in the fundamentals of architectural representation, which have not significantly changed since the 16th century. In his view, if the academy does not spend the time necessary to work with the "BIM imperative," we will fall short of our responsibilities to both prepare students for practice, and advance the profession with thoughtful application of technology.

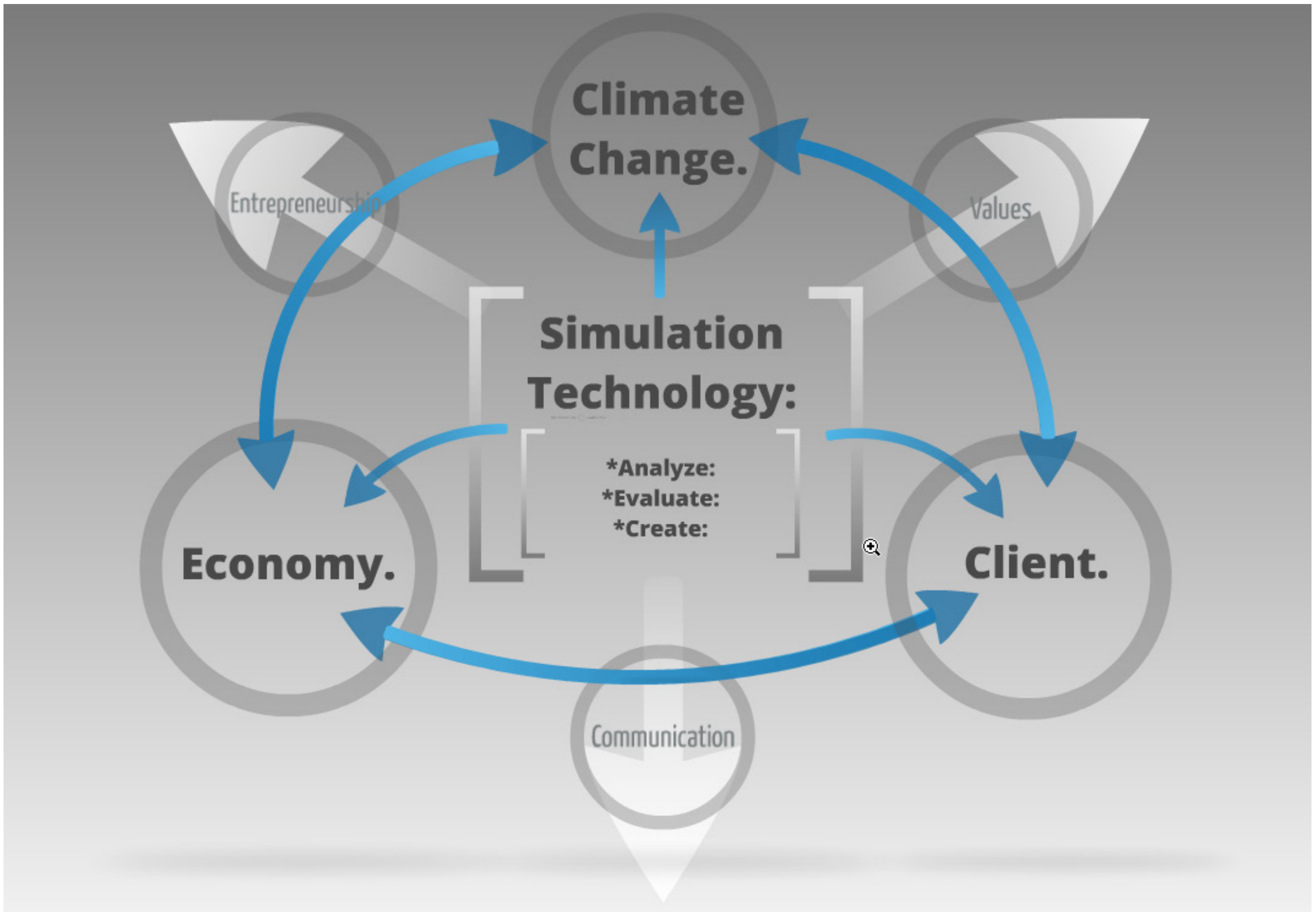
What is often considered a disruption in its own right, BIM has formed a division amongst academics striving for traditional teaching methodologies and proponents of developing a curriculum invested in technology. Because the term "BIM" is often mistaken as a term to define a piece of software, Finith Jernigan provides clarification that "BIM is the management of information and the complex relationships between the social and technical resources that represent the complexity, collaboration, and interrelationships of today's organizations and environment."[8] Software is used to manage the complexity of the data generated to help navigate the design process. Managing the data requires critical thinking through a workflow that emphasizes constant evaluation through all phases of the design process. It is a process that most every designer strives for, while acknowledging a desire to define a simplified method of practice. Maintaining design criticality throughout the entire process however requires acknowledgement that architecture is not a linear process. This is the causality of responding to the multiple factors that inform process, and shape the project from concept to manifestation of form. While on some level most designers would like a formula for the process to become a quantifiable linear expression, the reality is that will never happen. As a designer we are better served by the ability to manage and effectively utilize the amount of data that we are presented with by thoughtful critical analysis. The goal then is to not just see a non-linear mess (a plate of spaghetti), but what each twist and turn represents during the design process. Critical thinking allows for the positive collaboration of analytical and visceral design thinking to push, pull, and to inform the process of design. Embracing and learning to navigate the information gracefully through criticality requires the right toolset (both in terms of knowledge and software) to generate, visualize, and respond to design data.

OPPORTUNITY

To consider a new approach to inform design through the process of iterative simulation, it is important (especially for students) to see the context in which they are applying information. Professor Henry Sanoff has been building methods of design thinking to engage the community and client into collaboration by building games. The application of game terminology resonates particularly well with the contextual understanding of the next generation of designers, and Sanoff's writing is directly applicable to a modern technological approach. "Gaming is an approach to problem solving that engages a real life situation compressed in time so that the essential characteristics of the problem are open to examination. This technique is particularly appealing for designers because it permits learning about the process of change in a dynamic environment requiring periodic decisions. Essentially we are identifying a complex problem and abstracting its essence, a process referred to as simulation."[8] The understanding of relationship between simulation and game can begin to establish an iterative experimental quality to a process with the capacity to engage project stakeholders, and shape design decisions.

Two important surveys continue to clarify the opportunity that the academy has to help shape the profession of architecture by expanding our ability to help teach a process that leverages technology to expand design thinking and create client value propositions within the industry. In "Thinking Like a Client" published by the American Institute of Architects (AIA), Kevin W. C. Green's research explains that while the architecture community views design as a process, the perspective of a client is quite different. "Clients view 'design' as a product - a noun.... As a result, clients do not recognize the value of architects until it is time to produce (the documentation for) 'the design,' well after the formative stages of a project." Kevin Green also outlines the perception of a client toward an architect when a project does not meet their expectations: "Clients' (have a) negative perception of architects as 'monument-building' artists with little practical or technical expertise....(M)ost clients perceive architects as having been inadequately prepared during their architectural education to work corroboratively with clients, properly manage a business, and understand the construction process."[9] The second survey relevant to the topic is in the National Council of Architectural Registration Boards (NCARB) publication "Practice Analysis of Architecture" surveyed just under 10,000 architects to "obtain descriptive information about the tasks performed in a job and the knowledge/skills needed to adequately perform those tasks." Two questions at the end of the survey requested designers to make predictions as well as address concerns for professional development. Over 51% listed environmental design and technology as the "knowledge/skills (that) will be needed to meet changing job demands." Just under 49% listed the business of architecture and computer technology as the top two areas for "improving your performance in the field of architecture."[10] The results of the survey point to a weakness in practice that is tied to client values and perceptions. Improving technical expertise through the expanded use of creating data using simulation tools builds the opportunity to modify client perception, improve communication through the formative issues during design, and build client value propositions.

The opportunity that exists when applying simulation strategies to push design thinking impacts both practice and pedagogy. Digital simulation technology can provide the designer new opportunities in navigating between the environment, economy, and client/constituent. Graphically explained in Figure 1, the diagram



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outlines a core concept on how both pedagogy and practice can begin to apply simulation strategies to push design thinking.

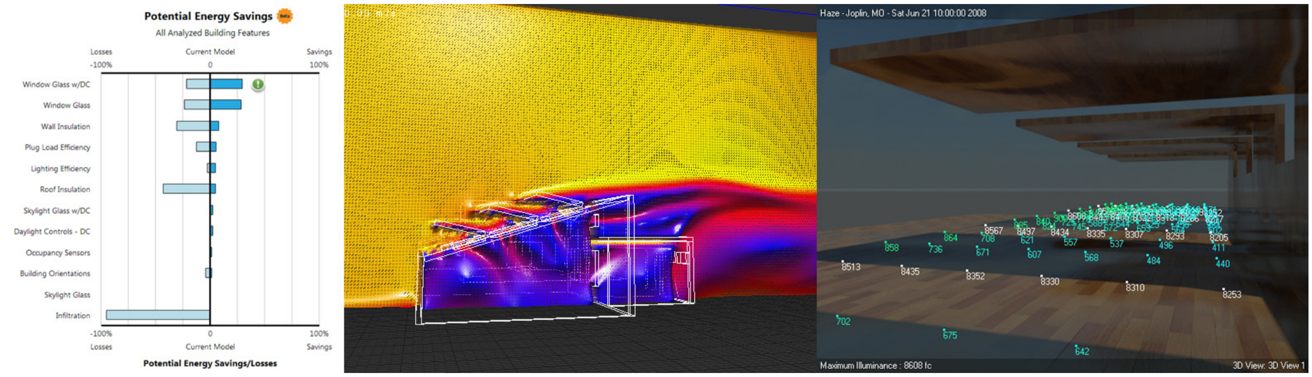
OPPORTUNITY: PEDAGOGY - PRACTICE

The application of simulation tools move student design thinking to the upper levels of Bloom's Taxonomy. Through the application of course work that outlines an understanding of human needs and environmental considerations students are then given the data through simulation work to analyze conceptual design, evaluate potential opportunities, and create design solutions in an iterative process that allows for experimentation and discovery.

Navigating the relationship between the environment and the economy, students learn:

- How to analyze the connection of facility operation costs and their relationship to design decisions.
- The evaluation of building program, enclosure, use, and form as they relate to energy consumption.
- The creation of formal qualities that work to solve environmental design conditions at the conceptual level, rather than meet environmental needs by the selection of systems or materials.
- Building an understanding of an integrated design process.

Figure 1: Simulation navigation diagram.



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The same simulation strategies in an architectural practice have the potential to be positive disruptions by providing modifications to the design process and client communication. Professionals establishing the relationship between the economy and the environment have opportunities to evolve their business through data based design thinking.

- Building new markets in facility management by applying simulation and design thinking to existing (post occupancy) facilities.
- Working through the balance of design values in the triple bottom line; social, economical, and environmental sustainability.
- Evolving pre-design strategies to include simulation and energy analysis early in the process. Joseph Romm - "When just 1 percent of a project's upfront costs are spent…up to 70 percent of its life cycle costs may already be determined."[11]

Tool sets are evolving that allow designers to navigate the relationship more seamlessly between initial construction cost, building performance, and design. As part of an iterative workflow, energy analysis can be continually updated within a BIM workspace with notation on what areas have the most significant performance impact. Daylighting studies quickly inform the design team the efficiency of an enclosure to bring in and modify natural light to appropriate levels. Wind analysis through cross sectional areas can provide air flow information, which can be used to determine acceptable interior temperatures ranges as a means to reduction of forced air ventilation.

At the academic level, introducing concepts that work with both the client and the economy are difficult to achieve. The goal is often to push creative thinking and allow students to invent client values and design projects without a budget. However, introducing simulation strategies that relate the client and economy opportunities exist to help engage student work with issues they will work with on a regular basis as a professional.

- Cost analysis of multiple conceptual options as a factor in design decisions.
- An understanding of how a client uses cost information to evaluate their decision making process.
- The formal creation and modification of spaces that respond to the human conditions and behavioral goals of the project.

Clients care about the cost of their projects, and the work they are investing in from their design team. It is necessary for the architect to build customer value

Figure 2: Screen captures from left to right: Potential Energy Savings diagram from Ecotech®, cross section wind study from Project Falcon®, and lighting analysis from 3ds Design®.

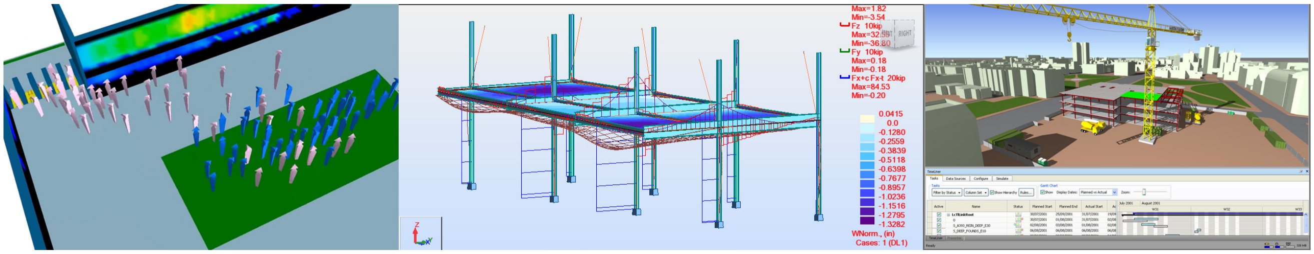

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Figure 3: Screen captures, left to right, from Mass Motion® (http://www.oasys-software.com/products/engineering/massmotion.html), Autodesk Robot®, and Autodesk Navisworks® (http://www.hydratecinc.com/images/AutoCAD/Enhanced_4D_Sequencing.jpg).

propositions to help educate the client on the decisions regarding the project. Providing data through simulation and an analysis on how it informs the design provides the opportunity to improve design communication, and raise client's understanding of technical expertise in the architectural process. Using simulation to help the client resolve economic issues with a project the architect can:

- Improve the level of communication with clients regarding potential expenses and investments on a project.
- Convey expertise to the client by generating multiple predictive syntheses of design options.
- Building conceptual cost analysis early in the design and programming phase rather than relying on value engineering post design completion.
- Simulating the construction process to help educate the client on sequence, process, and the ramification on project cost and time.

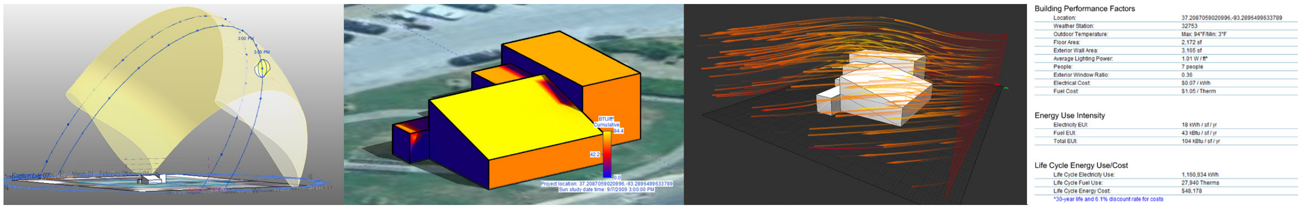
The primary tools that are emerging (tools that are available, but require a high level of expertise to be run efficiently) work within the design development phase. Behavioral simulation has the ability to improve the directly relationship between spatial design and human interaction. Structural simulation tools working off of an existing BIM model allow for the architect to have an earlier understanding of structural performance and potential. Construction simulation (4D BIM) tools build the opportunity for sequencing, clash detection and construction coordination.

It is imperative that methods of engaging the client with environmental issues are developed at the academic level. By simulating a design's response to environmental conditions students can learn skills to construct data to build, rather than sell, client values. The process of building simulation to understand the relationship between the environment and client primarily respond to the evaluation learning object from Bloom's Taxonomy.

- Preparing a summary of evaluation with recommendations on a design direction.
- Critique of the fundamental design ideas for the project as they relate to building performance.

One of the core responsibilities of the design community is to build values by educating the clients and constituents about architecture. Relating the client to the environment with the use of simulation engages the client in the decisions that will have the strongest bearing on both the short term and long term sustainability issues on their project. This gives the design team the ability to:

- Help the client understand the impact of their building on over time.
- Build a value system with the client that evaluates design decisions based on design performance and environmental impact.



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- Increase the sense of ownership by the client in the design process and the completed building. This decreases the perception of "monument building."

The core tool(s) currently available within a BIM environment that students and practitioners are likely to integrate into their workflow are in simulation packages that work at the conceptual mass modeling level. Working at a conceptual level on simulation generates data early in the design phases that meets the requirements of building higher level cognitive thinking that can inform the design process. Detailed modeling programs (working at a high level of design replication) is informative in regards to how a design will perform, but are less iterative in their ability to impact design thinking in the early phases of an architectural process.

GARDENING WITH TIM BROWN

Tim Brown, a leader in explaining the creative process and design thinking describes a change in the design world full of disruptions and connections as follows:

> "The old assembly-line metaphors of the Industrial Revolution won't help us design the future. Our world is complex. Like a garden, we must tend it, cultivate it, steward it, and encourage it to meet our needs instead of always trying to be in control of it. Our solutions must accommodate the competing needs of humans and the rest of nature. Successful design, like successful gardening, is never finished and is constantly changing. Tim later goes on to use the metaphor that building creativity and leadership at his design studio, IDEO, is more like gardening than being an architect. "An architect makes the physical world obey. A gardener helps living things thrive through attentiveness and dialogue."[12]

In both perception and reality, the industry of architecture needs to begin investing further in disruptive technology. The architectural design community is often being viewed as a very narrow profession as identified in the NCARB survey. Architecture as a profession has been slow to embrace the technology to inform design. The current disruptive technologies build the opportunity that will address issues of environmental design, a changing economy, and a client that is requesting more expertise than a traditional package of construction documents. The best scenario for allowing architecture to find new processes with disruptive technology is at the university. The role of the university is the preparation of professionals, the advancement of the art and science of design, and the promotion of the architectural industry to the public. Each item within the academic realm of responsibility places an emphasis on working with our students to find ways to augment design methodology to be informed by disruptive technologies. The current set of digital design tools, specifically building information through simulation, has the ability to help our students develop a process that builds higher cognitive skills that are identified with knowledge. Fluency in these tools build opportunities to inform the

Figure 4: Screen captures from Autodesk Vasari®. Left to right: Shadow study, solar radiation study, wind study, and energy analysis on conceptual massing model.

design process, drive the physical elements of the design, develop relationships with clients and navigate a difficult economy within a profession built on creative problem solving.

ENDNOTES

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