RE:THINKING BIM IN THE DESIGN STUDIO

Beyond tools… approaching ways of THINKING

MICHAEL A. AMBROSE[1] AND KRISTEN M. FRY[2]
1 University of Maryland
Email: ambrosem@umd.edu
2 Associate, Ayers Saint Gross Architects + Planners
Baltimore, MD
adjunct faculty, University of Maryland
Email: kfry@asg-architects.com

Abstract. The application of digital design methods and technologies related to BIM and *Integrated Practice Delivery* are altering the ***how*** and ***what*** of architectural design. The way contemporary architecture is conceived and made is being transformed through the digital methods, processes and applications used in BIM. How architectural education and the design studio model evolve to reflect, interpret, translate, or challenge the multiplicitous and simultaneously variable modes of contemporary practice present opportunity and risk to this generation of digital scholars, educators and practitioners. Might we re-conceive the design studio as a venue in which a critical dialogue about how the many facets of architectural design practice are engaged? The possibilities afforded by BIM and *Integrated Practice Delivery* and digital design technologies are increasingly affecting ***what*** we make and simultaneously ***how*** we make as architects. Digital modeling of both geometry and information is replacing (or displacing) digital drawing. We see diminishing returns of the value of transforming three-dimensional spatial/formal ideas into two-dimensional conventional abstractions of those complex ideas. This comprehensive thinking promoted by BIM processes is one of the key advantages of using BIM leading to true design innovation. The reiterative learning process of design promoted in BIM promotes a rethinking of design studio education.

1. Beyond Tools – approaching ways of THINKING

Architectural professional services are being redefined by the implementation of Building Information Modeling (BIM). This paper frames and ongoing line of research that seeks to explore the boundaries of BIM and its ability to visualize, document and coordinate space, understand the concepts and techniques of digital modeling and explore design opportunities in digital media at all phases of architectural practice to fundamentally rethink the application of BIM in the design studio. The primary exploration resides in just how the design studio can be (re)constructed to develop a progressive process of reiterative learning within the development of a working knowledge of BIM/CAD and general understanding of the design principles, ethical and legal responsibilities as well as technical applications. The research is focused on ways of exploring architecture by developing collaborative forms of communication that re-prioritize ways of seeing, making and most importantly, thinking.

The challenge is to understand the opportunities presented when digitally driven design, process and production technologies are envisaged more comprehensively than as mere tools, (Kolarevic, 2003) to fully embrace them as ways of thinking in and of themselves. One of the dilemmas of tool thinking is that it undermines the additive value of skills and intentions working together when conceptualized as a working methodology with its own rules and boundaries to be played within and against. A tool, such as a chisel, provides one way to remove material. As a tool of removal, a chisel is limiting. BIM is not a tool, but a way of thinking, a conceptual position that frames the way one operates within architectural design. BIM is not the chisel, not a tool, but, more precisely, it is the concept of removal that the chisel represents. Understanding and positioning BIM as an engaged process or method of design and a way of thinking is far more powerful than limiting it as a tool. Understood as a progressive process of reiterative learning it can be developed and dissected into and throughout a curricular structure. It positions a way of thinking that seeks to simulate the construction of a building. The method by which the model is constructed (Cheng, 2006) must be considered as a design decision. Students must understand not only the model geometry but also the implications of the ways the model is constructed and conceived to develop a rigorous process of critical evaluation to understand the elements not only through building convention but also design intent.

What might happen if, as Daniel Friedman posits, "...schools acknowledged design as an epistemology more than a skill; reoriented the development of individual expertise to the ethos of team; expanded studio as the laboratory for all academic activity in architecture..." (Freidman, 2006) Perhaps academia might hybridize existing educational models with the goals of Integrated Practice and reformulate the underlying value of technology and process and the comprehensive nature of architectural design. Key questions might include: How does architectural education prepare students to understand abstraction within a model-centric medium? What are the issues and what is the knowledge that academia should now address to enable the digital design process? Many academics and scholars favor a reductionist approach (Guidera, 2006) that seeks to mediate the complexities and simultaneities that BIM brings to bear. If curriculum expands to develop critical thinking in the management of 3D and 2D representation, or hybridization of documentation, the student would be given the skills to both model and draw simultaneously, one overlaying the other, each mode informing the other.

Perhaps a design studio that embraces a progressive process of reiterative learning might not end with the design of a building but might begin with a complete model of one already designed. The lessons might have to do with 5D logistical planning for construction, staged building processes, cost models, and post-occupancy modeling and management. Perhaps detailed investigations or analyses of the performance of structural, mechanical or technical systems in consultation with allied disciplines and consultants would set the agenda for a design studio. Fabrication of steel frame and composite wall systems at 1:1 scale from CNC processes could be the conceptual vehicle for the pedagogical lessons in addition to drawing or modeling. As stated by Clayton, et. al.; "Adoption of Building Information Modeling (BIM) disrupts the patterns of education that have been used throughout the past century. When understood as not merely a technology but also a rigorous process of design, BIM enables the emergence of new premises and patterns for design education that can address the critical technical and social problems of the 21st century." (Clayton, 2010) The promise of BIM applications is that simulated and actual construction might be intelligent products derived from the close collaboration of architects, engineers and consultants all working in their respective design studios, yet simultaneously and continuously sharing information within the BIM construct. If design studio began with the complete model of the building, the design exercises could be focused on coordination, collaboration and redesigning individual components and entire systems. The possibility of starting with a building rather than ending with a building might radically reposition curricular goals, concepts and knowledge in the design studio. This idea of reverse engineering an existing model allows objective evaluation of the building and challenges students to develop critical thinking skills to reconceptualize how a building is understood as a comprehensive act of interdependent design decisions that can be best tested and explored in the BIM environment.

The comprehensive design studio experience begins with the distribution of a fully realized (Figure 1) BIM model. The first two weeks of the term students participate in a series of workshops with the architects, engineers, and specialty consultants that developed this model. Each discipline presents the design process and design resolution of their components within the model. The students work in small teams with the professional consultants to understand how the systems have been integrated, how each discipline frames and understands the model and how their contribution contributes to the whole. In these first weeks, the students are getting to know their way around the model but also learning a tremendous amount about how an actual architectural project exists as the convergence of different design solutions to specific disciplinary focus.

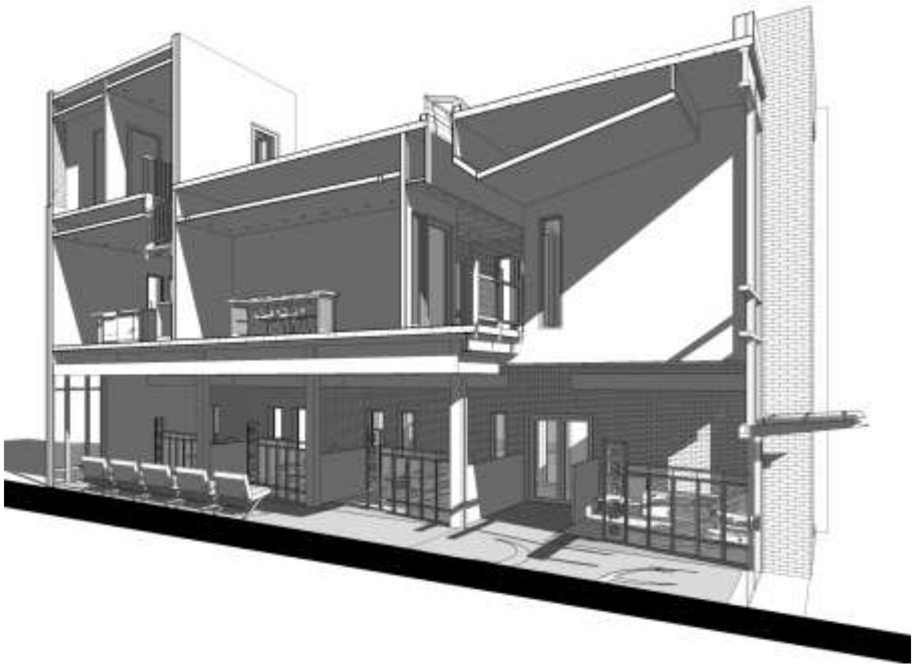

Figure 1. fully realized BIM – student work Nick Aello

The second phase of this design studio involves the students re-presenting what they have learned about the constituent parts of the building. This is the first step in the realtor to learning process. The students have been learning about the building, about the building technologies, and the design processes that have led to design a building in its current state. They have gained familiarity with the model. At this point the design studio focuses on radically changing one of the fundamental systems, structure. The original building was designed for steel frame construction. In the first weeks students came to understand how the dimensional requirements of the system led to a series of subsequent decisions made by the architects in the development of the program, the primary spaces of the building, and the external building skin. At this point the students will spend the next few weeks reintegrating and collaborating with the structural engineering consultants to redesign the building with concrete frame. One group of students within the studio will imagine the building has precast concrete considering the logistics of delivery and erection. Another group of students will imagine the building as site formed cast concrete. They will re-develop the building model in consultation with architects and engineers to adjust for new dimensions, new construction restrictions, and collateral design affects.

In the third phase of the studio, each student will work individually to re-imagine the curtain wall system of one facade of the building. Each student will have a particular environmental response, technological application and performative requirement that will guide the design of this new wall system. Wall system will have to work within the redesign structural system and connect to the existing building envelope conditions on the adjacent exterior walls. The performative requirements of the façade design will require adjustments on the internal spaces adjacent to the vertical surface. Each student will have to test several iterations of design solutions to fully imagine a range of possibilities to solve the environmental response. Part of this exercise will result in physically produced digitally fabricated models that will probe and test the constructability of one component of this curtain wall system. The ability to develop physical models while simultaneously testing and simulating the environmental systems in the BIM model will allow the students unique vantage point to explore the reiterative nature of architectural design.

With each subsequent phase of the studio a new design parameter is introduced that requires significant modifications to the original model while focusing the students on collaborative experiences with professional consultants and the classmates in the studio to develop a range of design possibilities. In contrast to conventional design processes rooted in successive refinement of initial design abstractions and dependence on tacit knowledge (Clayton, 2010) this design studio relies on a BIM-aided process that comprehensively interrogates the base case study through subsequent alternative developments of building components and interrelated technologies. The new design studio model emerges through explicit analysis of the BIM artefact through the cross-disciplinary exploration and continual redevelopment of the model by the entire studio. The projects are designed and scaled in such a way that the students are encouraged to explore as many design possibilities as possible. The goal is to not develop a single way to solve any design problem but instead to develop a range of ways to explore the problem. Privileging dynamic explorations of modeling, animation, and design diagramming each project challenges the studio to work collaboratively within the BIM environment. With each subsequent design change the building oscillates between completion and dismantlement. But with each wave development the design evolves, and the process progresses. With each progression the studio has a new opportunity to reiterate previous lessons, collateral effects of each discipline and develop a design process that embraces the reiterative learning developed through the continued exploration of the building model.

The Integrated Practice or Integrated Project Delivery (IPD) model promotes a working process which lends itself to the simultaneous and fluid development of program, site, technology and performance. Design constraints are prioritized, can be tested and retested to understand the influence on the outcome. The project can be fragmented (Figure 2) and isolated into manageable "components" of architecture that can be studied, tested and designed in isolation. Historically, design professionals employed a linear process in the production of drawings, evidenced by processes of layering. Whether sepia mylar, background files or CADD x-references, each new sheet represents a design discipline overlaid on the predecessor's framework, and the design considerations were developed in a reactive, rather than collaborative manner. Within the BIM paradigm, communication and information exchange is now iterative, responsive, involves simultaneous design centered on collective performance of the assembly.

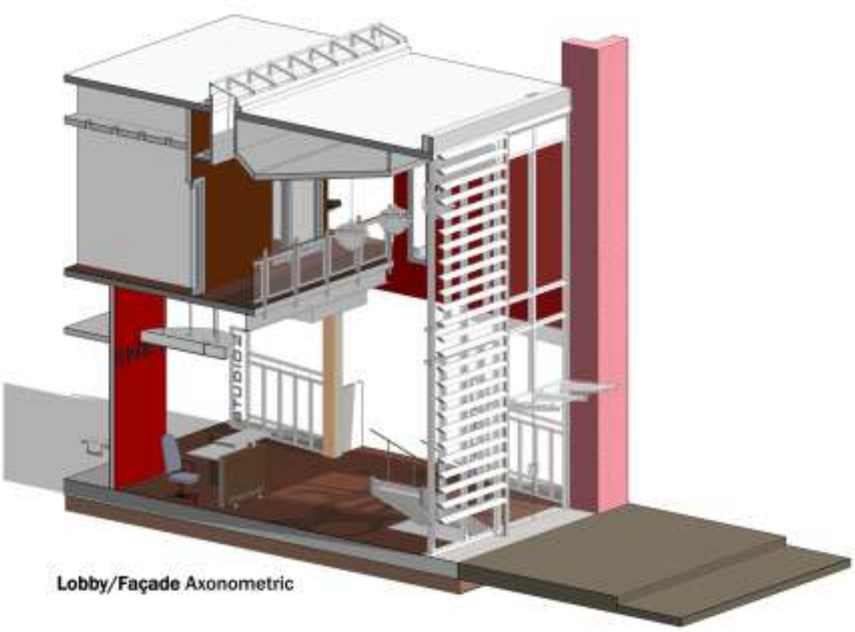

Figure 2. IPD working process of fragment isolation – student work Nick Aello

2. Integrating Integrated Practice into Academic Practice(s)

This newly envisaged architectural design studio is based on continued operations on and within building modeling. Working on a live dynamic model in an interdisciplinary collaborative environment challenges the student to operate beyond the drawing centric view of most design studios. The traditional means of visual communication are supplanted by a continual development of the shared model. Sometimes a placeholder from one discipline, structures perhaps, requires that architectural decisions remain tentative until the Allied disciplines provide appropriate information. In other instances architectural design decisions ripple through the project requiring responses from several systems. Contemporary architectural education assumes a traditional set of communicative visual conventions, orthographic projections, at varied scales and levels of detail, that when taken in concert signifies a whole, complete idea of a building. Contemporary architectural practice tests a one-to-one correspondence between design intent and interpretation, between the representation of ideas and the interpretation of the design of buildings.

Construction documents reveal the residue of tradition and conventional ways of working. These abstract, fragmented representations of the building and its components rely on reductive syntactic connections (Pérez-Gómez, 1997) where by each abstraction is a part of a dissected whole and when taken as a summation, these fragments exceed their individual abstraction and constitute a literal description of the complete building. BIM, conversely, begins with the virtual construction (simulation) of the whole, which is then viewed as a series of synthetic assemblies of constituent components. BIM represents a design process that re-prioritizes the abstract representation or fragmented and scaled conventions within the contextual construction of a formal/spatial systemic intelligent simulation.

Design documentation hybridizes modeled elements and drafted components. BIM is not a comprehensive simulation of building components. File size and schedule are at odds with modeling each and every element. Items such as flashing, for example, are not modeled. The real challenge for the practitioner: understand the 3D vs 2D threshold. What is the value added by modeling a tectonic and the efficiency gained by drafting over it to complete the detail? A complex condition may require any drawing typologies, including axon or perspective, to communicate design intent. For example, in the current workflow, steel lintels are not modeled at every window head of a brick-on-metal-stud assembly. If a condition is repeated, the detail can be produced once in a drafted view that overlays the model and then referenced to typical locations. These drafting components are not simply lines, but have inherent data that helps contractors to identify patterns in construction assemblies and simplify construction costing.

Other design endeavors might require more modeling to understand the performance of an assembly or product. The parametric nature of BIM allows exploration and optimization of design options. When avant-guard practioners such as Thom Mayne proclaim; "…I haven't drawn a plan in five years…" (Mayne, 2006) they expose a significant issue of BIM's effect on education. BIM fundamentally subverts plan thinking by prioritizing a three-dimensional view of the world. While seasoned practitioners may not need to work in plan, does their education in abstract thinking still serve them well? And if so, does it bear continuing its prolific dissemination even at the chagrin of today's avant-guard? To find a way forward, academic design studios might be well served to expose debate or hybridized transition in the projects themselves. The pedagogical discourse around a design project's conception might very well accelerate design thinking and embrace simulation and its emergent conventions over the conventions of the past.

To reflect the pedagogical shift represented in BIM the modern design studio must develop teaching methods that reprioritize ways of seeing, thinking and making in the design process. BIM's technological affect is outpacing the ability to respond. It is this gap between design theory and digital practice that exposes an opportunity for engaging digital design media in education that explores how BIM might fundamentally reshape the design process and conceptually shift to production of architectural ideas and objects like nothing has since orthographic and perspective projection (White, 1958) in the fifteenth and sixteenth centuries. Focused on the virtual building model simulation as the primary means of communication and representation in the emerging concept of IPD, architectural educators must take pause to critically engage and conceive outcome-driven educational models.

Is there an inherent value in the translation of ideas into abstract representation (Figure 3) or is there a greater value a transcription of ideas in to a simulated construction? Acutely aware of the impending cultural shift that BIM represents to the professional practice of architecture some leading practitioners, Paul Seletsky of Skidmore Owings and Merrill, mused about the opportunities and consequences for the transition from traditional practice to digital practice with BIM. As Seletsky has said, "Properly ignored, the results [of BIM] may very well promote Construction Managers into a lead decision-making role…" (Seletsky, 2005) presumably out-pacing the architect's ability to leverage the profession's knowledge base to regain lost ground. Architects can perhaps re-gain lost territory taken by the contractors, construction managers, interior designers, facilities managers, and others. BIM affords architects the opportunity to 'deal themselves back in' to the knowledge management of a project from beginning to end.

BIM shifts the focus away from representational development (drawings) and towards formal and spatial development (ideas) through the development of the information construct (model). At the current time too much attention is being paid to the 'quick' extraction of relatively simple two-dimensional drawing/representational information from three-dimensional digital models.

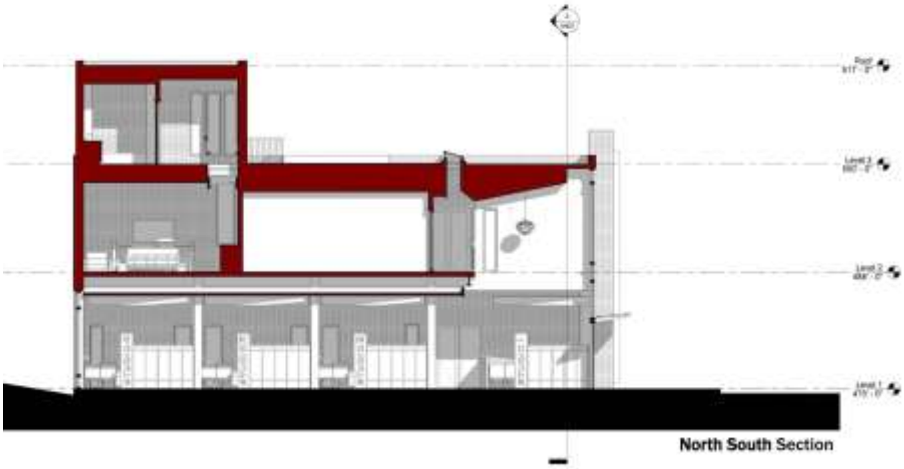

Figure 3. section development for representational value – student work Nick Aello

3. Conclusion

The way we make architecture is being transformed through the very digital tools, processes and applications we use. Educators must seek out new educational models that expose creative new methodologies for exploring architecture that embrace a pedagogical shift through BIM as process by developing teaching methods that reprioritize ways to reconcile the traditions of abstraction and the opportunities of synthetic simulation. The design studio must now reflect new reiterative relationships between design, data and communication. Design studios should focus on new ways of teaching and addressing emergent digital design methods and processes that critically engage and leverage their immediate effects and possibilities in architectural production.

As architects move beyond drawing-centric practice into a dynamic process/component oriented integrated practice, a new conceptual foundation for architectural thought and production that focuses on a fluid relationship between design, construction and maintenance in which information, not drawing, as the medium will emerge. Students must be taught that architecture is more than simply applied knowledge and skills. Architecture is a way of seeing and thinking that requires understanding of BIM beyond the idea of tool to one where it is conceived of as a means to conceptualize the systemic development of multiple design processes from different disciplinary perspectives.

Acknowledgements

The authors would like to offer a special thanks to the students enrolled in the *ARCH 678i* course at the University of Maryland in the Winter and Summer terms of 2011. The authors would also like to acknowledge the support of the University of Maryland architecture program in the School of Architecture, Planning, and Preservation with the continued support of research in digital design media, BIM and pedagogical/curricular development in this area.

References

CHENG, R., 2006. *Suggestions for an Integrative Education. In: M. Broshar, N. Strong, and D.S. Friedman 2006. American Institute of Architects: Report on Integrated Practice.* Washington DC: The American Institute of Architects. Section 5, 1-10.

CLAYTON, M.J.; OZENER O.; HALIBURTON J. FARIAS F. 2010. *Towards Studio 21: Experiments in Design Education Using BIM*. SIGraDi 2010_Proceedings of the 14th Congress of the Iberoamerican Society of Digital Graphics, pp. Bogotá, Colombia, November 17-19, 2010, pp. 43-46

FRIEDMAN, D.S., 2006. *Architectural Education and Practice on the Verge. In: M. Broshar, N. Strong, and D.S. Friedman 2006. American Institute of Architects: Report on Integrated Practice.* Washington DC: The American Institute of Architects. Section 0, 3-7.

GUIDERA, S.C., 2006. *BIM Applications in Design Studio. In: G.A. Luhan, P. Anzalone, et. Al. 2006. Synthetic Landscapes – ACADIA 2006 Conference Proceedings. Mansfield; The Association for Computer- Aided Design in Architecture, 213-227.*

IBRAHIM, M., KRAWCZYK, R., SCHIPPOREIT, G., 2004. *eCAADe 2004: Two Approaches to BIM: A Comparative Study. In: K. KLINGER, ed. ACADIA22,* The Association for Computer Aided Design in Architecture, 173-177.

KOLAREVIC, B., 2003. *Architecture in the Digital Age – Designing and Manufacturing.* New York: Spoon Press. 3-10.

MAYNE, T., 2006. *Change or Perish. In: M. Broshar, N. Strong, and D.S. Friedman 2006. American Institute of Architects: Report on Integrated Practice.* Washington DC: The American Institute of Architects. Section 1, 1-11.

SELETSKY, P., 2005. Digital Design and the Age of Building Simulation. *AECbytes* [online], Viewpoint #19. Available from; http://www.aecbytes.com/viewpoint/issue_19.htm [accessed 20 October 2011].

WHITE, J., 1958. *The Birth and Rebirth of Pictorial Space.* New York: Thomas Yoseloff. 112-134.

PÉREZ-GÓMEZ, A. AND PELLETIER, L., 1997. *Architectural Representation and the Perspective Hinge.* Cambridge: The MIT Press.