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There's a Storm Brewing in the Construction Industry... are you Ready?

BIM, Education and the Global Economy

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BUILDING INFORMATION MODELING (BIM) will soon deliver the AEC to the global economy, ushering in many opportunities as well as challenges. Increasingly, project teams will be comprised of consultants from around the world as firms vie for projects and resources with global competitors. New degrees of collaboration with international players will become possible. Building assemblies will be manufactured all over the world and customized manufactured building components will permeate the industry, sustaining new economies of scale and quality. While these claims may seem far from the industry of today, we can already see the beginnings of this transformation within the construction world and must ensure that the next generation can skillfully wield the technologies now reshaping the industry on a global scale.

BIM AND THE DEMAND FOR RESOURCES

"BIM in China", an article published by Autodesk[1], made reference to an Architectural Record[2] report that China was spending over $375 billion a year on construction(16 percent GDP); consuming 55 percent of the world's production of concrete; 36 percent of the steel and 30 percent of the coal in the process. China's own Ministry of Construction estimates that the country will double its current building stock by 2015, which according to the World Bank, indicates that approximately half of the world's new building construction will take place in China.[3] While developing economies such as China's are exploding, the U.S. is clearly not slowing down. The U.S. federal budget for construction alone is $385 billon a year and it is estimated that over the next 27 years, the U.S. will "renovate 150 billion square feet and build 150 billion square feet" [4], intensifying the demand for resources and the impact on the global environment.

Architecture 2030 has calculated that buildings are responsible for roughly 40 percent of global carbon emissions and analysts now warn that if we don't act now, we will miss an opportunity to reduce the carbon footprint of buildings in the U.S. and abroad. [5] Essentially, if the world continues to build to the inefficient standards of the U.S. today, the demands on earth's resources will not be sustainable and we will face a crisis of unprecedented global proportions. But what if tools and processes existed that could eliminate inefficiencies and predict building performances ***before*** construction; in fact, as an integrated part of the ***design*** process, thus cutting down on waste and the demand for resources? This is one of the promises BIM holds out to us.

PROCESS RE-ENGINEERING THROUGH BIM

BIM re-engineering also promises to restructure the AEC itself, now a dauntingly complex industry, plagued by what has been called a "fragmented supply chain"[6], in which new technologies that

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allow for multi-disciplinary teamwork on one side, clash with century-old processes, business models, legal contracts and compensation schemes that impede knowledge-sharing and cause needless rework, on the other. BIM will push the industry forward by demanding that our teams learn to work in advanced 3D, information-driven environments, where the sharing, capture and reuse of knowledge is common practice and building performance is predictable from the earliest design phases on. BIM's key facets of integrated practice, sustainability and life-cycle management will optimize reduction of waste, cost and time from total project delivery.

THE CALL FROM INDUSTRY TO ACADEMIA

The same concepts that aim to transform the industry also call for change in education within the AEC and the role that academia will play in BIM's success is critical. Due to the typically small size of firms in the AEC, private investment in research and development has been hard to come by. In1998, a report on construction identified many of the problems that we still face today due to the lack of research and development in the industry worldwide, noting that the construction industry, "invests little in research and development"; that R&D had fallen by 80 percent since 1981; and that capital investment was a third of what it had been twenty years earlier in the UK. That lack of investment, the author lamented, was damaging the industry's ability to keep abreast of innovation in processes and technology.[7]

This continues today, because, R&D is typically left to the realm of academia, or to a handful of industry champions and even employers are typically unwilling to do any in-office training, citing high cost and risk of employee turnover. What this attitude generates is a vicious cycle which renders firms less profitable and less efficient and erects barriers making the adoption of new technologies and processes such as BIM more difficult. To offset these limitations and to reach the high level of adoption needed to transform the industry, it is vital that industry have local training grounds in BIM- enabling technology and that educational institutions join in providing accessible training now.

BIM IN EDUCATION

Education in the AEC needs to become more efficient, because, obviously, we need students to do more in less time, if we expect to develop professionals who do the same. The design process as traditionally taught in the classroom is painfully time-consuming and labor intensive, with the student often trapped in rudimentary and mundane processes, such as manual drafting, that take valuable time away from exploring design solutions and do nothing to teach real world content.

BIM replaces this sluggish and fragmented process with an interdisciplinary approach that consolidates effort. BIM allows students to explore projects in greater depth than ever before, because a single intelligent model can be used to generate construction documents, explore building assemblies or constructability, estimate costs, simulate building performance and even build physical models using the latest in rapid prototyping.

The primary threat to implementing BIM's integrated process is interoperability and educators of BIM technology need to be aware of this and strive instead to support open standards. Interoperability is a man made problem and one that the industry can no longer afford to tolerate. The National Institute of Standards and Technology (NIST) Report on Interoperability shocked the industry when it stated that interoperability alone was responsible for $15.8 billon in waste in the U.S. Capital Facilities Market, which if extended worldwide, represented some $60 billion of waste.[8] We need open standards in the AEC such as the Industry Foundation Class (IFC), otherwise file exchanges will become vendor specific, or poor performing, causing data loss and rework and preventing the industry from harnessing the full potential of BIM.

INTEGRATED PROCESS IN SCHOOLS

If we are to someday have widespread integrated practice within the industry, it must first be adopted in the classroom. Design education in architecture, for example, could be taught from the perspective that since it takes an interdisciplinary team to design and construct a building, the same team effort must be experienced in school, with project teams grouped to represent the different disciplines of the construction industry.

One of the best examples of this approach in practice is the Center for Integrated Design and Construction (CIDC) at the University of Utah. The CIDC's stated mission is, "to conduct research in building information modeling and related technology specifically as these transform the exchange of information among the various groups involved in the design and construction of the built environment".[9]

David R. Scheer, director of CIDC, when tackling the question of what an architect today should know, explained that current architectural training remains focused on form, whereas BIM, which he defined as 'digital design' demands that architects think ***simultaneously*** about materials, bidding, construction and project management.[10]

THE NEW INGREDIENTS

Interdisciplinary teams require interdisciplinary managers. The concept of a new profession dubbed the "construction modeler"[11], now referred to as the BIM Manager", was explored back in 2004 and it was clear even then that the scope of the modeler's work would straddle four specific areas: constructability analysis, estimating (cost modeling), sequencing (4D and 5D simulation or process modeling) and fabrication (design to manufacturing).

Today, specific knowledge of the discipline being modeled is also required. This calls for all schools in the AEC to explore BIM's application to their particular discipline and then make efforts to integrate their process with other disciplines. "Planning constructability analysis needs insight into how an element is assembled, including the space requirement of the equipment needed for its assembly…Estimating requires knowledge of the properties of each building element on which the estimating formula relies. ..Sequencing depends on an understanding of the possible sequences involved in constructing each element. Fabrication requires knowledge of shop drawings and/or the CNC machinery involved in the fabrication of each element…".[12] And so on. Soon we will see modelers and managers emerging from every discipline to coordinate synchronization efforts.

INTEGRATIVE CURRICULAR STRUCTURE

Renee Cheng, of the University of Minnesota, adds much insight when she postulates that to move from "competence" to "excellence," a BIM operator must count "critical thinking" as their most important aptitude. Critical thinking defined here as "the ability to simultaneously envision multiple aspects of a problem and their relationships before proceeding toward a solution".[13]

Cheng's report includes a wonderful matrix of suggested proficiencies in representation and construction when emphasizing an integrated approach. Comparing the two categories across this matrix, the trend is that in an integrated curriculum, 3D expands while 2D contracts. Geometry and 3D modeling skills move to the forefront while Formal composition and Stereotomy and 2D drafting take a backseat.

Cheng's matrix mirrors the observations in the book Re-fabricating Architecture, that BIM technology is now blurring the edges between disciplines, between thinkers and builders and between the virtual and the actual.[14] As a result, construction is now a major focus for the architect who will participate in integrated practice (IP). I think this will be received by many in the industry as a welcome change. After all, does it make sense that in the 21st Century, the construction industry is still largely a paper-based management system trapped in a 2D paradigm? Any educator who is considering the teaching of BIM really ought to examine this matrix closely.

According to Cheng, not since the master builder era, have materials, sequences, processes and ethics been major focal points of an architect's education. Construction materials and the understanding of the manufacturing process, not stressed since the Bauhaus, have become relevant factors once more.

I would like to think that proportioning systems might also make a comeback, especially now that many BIM programs are able to capture and express relationships in a model which can in turn, become design drivers. In essence, one could run the Fibonacci sequence or the Golden Section as a design constraint and explore a project from a purely proportional perspective. Never before have we had the power to explore so many variables/variations at the design stage. Technology may have changed our industry, but it is *information* technology that is driving the BIM revolution.

DESIGN AS A COLLABORATIVE PROCESS

I heard it said once that if you design through consensus, you start out to

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design a horse and end up with a camel. But working in a collaborative does not mean you have to operate without a vision. What it means is that input comes from the whole design team early on and is tested in the model, evaluated and then retooled if necessary, following a process of nonlinear thinking I like to refer to as a design loop, or "spiral", where as the project moves forward, issues that were addressed early on are revisited over and over again, refined each time from a higher plane of knowledge. BIM enables this process.

Collaboration in a BIM -enabled integrated process is aimed at producing a better product, generally meaning of higher quality, in less time, consuming less resources and more sustainable than a project developed in a traditional process. The BIM process lets the entire project team share in the knowledge, risk and reward.

Centers of higher education in the AEC have to recreate this collaborative experience in the academic world, not only within the school, but extending to other institutions around the world to reflect the presence of global economy and to cultivate human relationship globally. This new work environment free of time zones, regional and national boundaries, yet constrained by cultural differences, must be grappled with and understood by the design professionals of tomorrow.

GLOBALIZATION, DESIGN ANYWHERE BUILD ANYWHERE

Like it or not, globalization is happening in the world and it's just a matter of time before it hits the AEC. Ironically, while our current low- tech process keeps us insulated from globalization, it also keeps us out of global markets.

The cocktail mix of global projects, international project teams, off- site manufacturing, construction assembly and shorter-than-ever floor cycles, calls for an entirely different approach in the industry and if we wish to survive in the global economy, we simply cannot continue to teach and practice in the AEC in the same old way. Neither can we expect that the preparation for the global market can come entirely from within the industry.

Take for example the advent of off- site manufacturing in the AEC. Building components are built in controlled environments; higher levels of quality, cost and control are achieved; there is less disruption to the community near the site; more than one shift is possible; and finished components are exportable anywhere in the world. Presto, buildings can now go up faster than ever before! In the past, when we applied manufacturing to housing we gave birth to the trailer park, which most design professionals would today decry as a failure. Revisited with new tools and fresh perspectives though and we see the arrival of custom-built luxury homes built in controlled facilities, offering design within economic reach and customization for a particular site.

Students must be trained to design for assembly and perhaps disassembly as we recycle/reuse buildings in the future. They need to understand what design constraints exist when you manufacture versus construct; how to visualize the construction sequence and the site logistic and even consider the martial flow as part of the design process. This can only happen by applying BIM tools and processes throughout the AEC academic community.

CLOSING THOUGHTS

Anyone who thinks of BIM as just another tool has totally missed the boat. It is my hope that this article will provide a more comprehensive understanding of the real forces driving the industry to change. Moreover, I hope that my fellow educators will awaken to the need for this change and make their own personal forays into these issues within the context of their courses. This article also reaches out to the students of today who are being asked to do more than any other generation before, to remind them that our future has always depended on those who showed courage and embraced change with optimism; join the BIM revolution! ■

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