"So, Can You Revit?" Historic Preservation Design Education and Digital Media

The impact of computer graphics and digital media on architectural design cannot be overstated. In the last fifteen years, design and construction in architecture and engineering have completely changed due to significant advances in technology. Today's students no longer use pencils, templates, vellum, or even the antiquated AutoCAD. Rather, they practice integrated design and Building Information Modeling (BIM), an emerging design methodology that is radically changing architectural practice. It will also change architectural education, creating the need to integrate construction technology and design. This is truly the case when historic preservation is integrated into architectural design education, where accurate documentation and depiction of existing historic resources is essential. As students race to implement new design ideas within a historic resource—whether it is an adaptive use project, rehabilitation, or restoration—do they and can they understand how the resource is constructed? Is there an understanding of what is "real" and what is virtual? Teaching historic preservation using integrated design and BIM creates both challenges and opportunities in the design studio.

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Every spring at architectural schools, career fairs or “expos” draw architectural firms from across the country to set up booths to distribute literature and employment applications. Students, professionally dressed and with portfolio in hand, seek the promise of a job after a graduation. Employers ask students about their knowledge of building and architecture; they may even be interested in learning about ideas students are developing in their theses. But, according to graduate students in architecture, it appears that they are looking for graduates who are proficient in the latest digital media and can produce renderings using the latest technology in Building Information Modeling or BIM. It is during this professional courtship that the inevitable question is asked: “So, can you Revit?” “Yes, I do,” replies the twenty-first century architectural student.

The December 2008 McGraw Hill Construction Smart Market Report, entitled Building Information Modeling, notes that 43 percent of American Institute of Architects (AIA) member architectural firms now use BIM software. Revit, a three-dimensional building design software platform made by Autodesk, is one of many digital media being used for BIM. It is anticipated that BIM use in the architecture profession will increase dramatically; experts in BIM predict that by the end of 2009, 54 percent of AIA member firms will be using it to design buildings. BIM has been widely accepted by the architectural profession, and the AIA is promoting it outright. As noted BIM expert Harvey Bernstein states: “Your career and the prosperity of your company depend on becoming familiar with the tools, processes and value propositions of BIM” (Young, Jones, and Bernstein 2008). During this period of change, architectural firms face an immediate and difficult choice: outsource BIM work or hire staff familiar with the new technology. Today’s architecture students who have grown up with computer technology, have embraced digital design media and are now ready to help the design profession implement BIM. But the question remains: Do they have the basic architectural education foundation needed to design buildings that will actually be built?

BIM is not just a new computer-generated graphic tool; it is the database facet of an entirely new way of designing and building called integrated practice. Integrated practice is the construction industry’s response to the marketplace mandate for buildings that can be completed faster, cost less to design and construct, and are more sustainable. Integrated practice is collaborative; it relies on a free exchange of information among all parties involved in the building process. This includes not only design professionals and contractors but also cost estimators and vendors, code officials, and outside reviewers (e.g., review architects in a SHPO). But BIM does not stop at the completion of the project; it can be used to manage the building after occupancy. Today, more and more facilities managers are benefitting from BIM. They envision facilitating building lifecycle management, even from remote locations. BIM has the potiental to transform the construction industry, and it is beginning to be embraced as a teaching tool in academic architectural design studios (Reams 2009).

In most architectural schools, basic computer graphics such as AutoCAD are introduced early in undergraduate studios and laboratories. Since graphics is rarely the focus of advanced architectural design studios, today’s computer-savvy students learn the latest computer graphics, such as Revit, either in other classes, in studios, or outside the classroom.

Students are attracted to Revit as the preferred product for BIM for its dimensional graphic abilities, as well as for its accessibility in schools.

BIM is much more than the latest computer drafting package; it is the departure point into a completely new realm of architectural design, practice, and documentation. The basic concept of BIM is to develop a "virtual building model" that will guide its own building process; as the physical building is assembled, changes in the field are documented in the virtual model. As the actual building is completed, the virtual building is used to document operations and maintenance (paper documentation may even vanish). Distinct phases of design will be merged, and the process of both design and construction will become fluid, blurring the traditional distinction between architect and contractor.

Design professions have struggled to adopt and implement BIM; only recently has the AIA addressed this new trend in a series of papers to its board and membership (Walbridge 2007). Although the premise of BIM was conceptualized by Charles Eastman at Georgia Tech in the 1970s, the term was coined by software vendor Autodesk in 2002. Like Computer Aided Design (CAD[1]), developed in the 1970s, BIM's development stems from mass manufacturing, not from architecture. Its strength lies in its immediate integration of design and fabrication and its abilty to describe architectural design in three dimensions. Its 3-D capabilities made it attractive early in the 1990s to abstract Modernist architects such as Frank Gehry, who relied on BIM to piece together his audacious designs, such as the Guggenhiem Museum in Bilbao, Spain, and the Experience Music Project in Seattle, Washington. Initially, Gehry and his firm used a BIM software developed in France called CATIA. After several years of adapting and revising the software in their office, Gehry Partners started their own BIM software company, Gehry Technologies--which is now a leader in BIM technology. Gehry is considered a leading practitioner and innovator in BIM; he believes that BIM's greatest attribute is its abilty to accelerate the design and construction process through immediate design and construction integration and its ability to facilitiate collaboration (Hill 2006). Designers are linked to the BIM design and to a wide range of diverse "design team" members, such as cost estimators, marketing professionals, product vendors, and others. This allows manufacturing to remain flexible; efficiency is improved with the merging roles of designer and fabricator. But in the construction professions, the blurred divisions of services for building delivery become problematic. Who is truly responsible for the design, and who is responsible for execution and construction? Where do vendors fit into the design building process? Finally, whose design is it when everyone has a role in the process? Are students in traditional architectural schools being taught to be team members for this bold new world?

The possibilities of BIM are limited only by the power of designers' imaginations and the limitations of computer software; designers are not restrained by the normal conventions of graphic depiction (plan, section, elevation) in architecture. Instead, they have the ability to build and manipulate a three-dimensional model in the actual specifications of the building (albeit on the computer screen) and can import details from vendors. Designers can link their models to the International Building Code. Code analysis can occur instantaneously, while heating and cooling loads are readily calculated. Engineers can work simultaneously with architects to design a building, while estimators can readily determine if the design is financially feasible. Another benefit? This can all be done remotely.

So, how can BIM work within the context of a historic resource? After all, historic resources are existing buildings; they were not developed in a virtual world, and their conditions and parameters are real. Moreover, no two historic resources are exactly the same. The passage of time allows buildings to evolve; unfortunately, changes in time are not documented graphically until a design project makes it necessary to do so. What are typically preserved are often unique architectural components that were crafted exclusively for the historic building or artifact. How are these buildings documented within the framework of BIM? This question is fundamental for those of us who teach historic preservation and architectural design. There is an urgent need to better integrate historic building technology, materiality, and construction practice in the design studio using BIM.

RISE OF THE MACHINES

Those who studied architecture and designed by hand on drafting tables can easily become Luddites in the face of the new generation of architects and the powerful digital tools that allow them to produce an astonishing amount of work. Most historic preservationists are attracted to historic buildings because of their love of handmade craft. Students of the last century enjoyed the art of drafting and were enamored of architects of an earlier time who eloquently depicted designs on linen sheets using ink pens. Old copies of trade magazines such as Pencil Points were references. Although some architecture schools, such as Notre Dame, have made these traditional graphic depictions a primary aspect of their program, it is unrealistic to believe that today's design professional can avoid digital technology.

As a whole, the academy has been slow in implementing digital design in the architectural studio. Initially, this delay was due to the high cost of computer technology for cash-strapped schools. Twenty years ago, it was generally expected that universities could provide computer laboratory space for students through student fees and tuition. Computers in the architecture studio were bulky, and CAD software was expensive, slow, and prone to crashing (University of Illinois at Urbana-Champaign 2002). However, the advent of the laptop and the rapid development of graphic software have changed everything. Now it is commonplace for students to create their designs on their own laptop computers while in studio. In addition, wireless internet allows students immediate access to information, including technical data that had previously required hours of research in the library. Finally, architecture schools no longer look at computer labs as overhead. Instead, computer printing laboratories have become lucrative business ventures supported by user fees.

BIM AND THE HISTORIC PRESERVATION DESIGN STUDIO

In a historic preservation studio at the School of Architecture at the University of Illinois at Urbana-Champaign during the 2008 fall semester, students explored the application of BIM in historic preservation design. The studio comprised fourteen first-year graduate students, all of whom had undergraduate degrees in architecture and were pursuing a Master of Architecture degree. Half of the students had declared historic preservation as their study option, and all of them had a working knowledge of BIM, using Revit as a computer platform. The design assignment was two-pronged: the expansion of the Carolina Inn and the adaptive use and rehabilitation of Whitehead Residence Hall, both on the campus of the University of North Carolina at Chapel Hill.

The Carolina Inn is a historic luxury hotel (Figs. 1, 2) that serves the University and the Town of Chapel Hill; Whitehead Residence Hall (Fig. 3) is a dormitory located directly to the south of the inn. These two buildings are listed on the National Register of Historic Places, both share common stylistic traits (early twentieth-century Collegiate Colonial Revival), and both are contributing resources to a national and local historic district in Chapel Hill. The challenge was to make Whitehead Hall part of the hotel complex. Students were asked to reprogram Whitehead for luxury suites and new hotel rooms and to add new services to the inn, such as a swimming pool and a new dining facility. Finally, students were asked to address a significant grade change between the two buildings, involving infrastructure and the preservation of sizeable trees. A main aspect of the problem was to understand and use "as-built" (building documentation based solely on the construction of the design of a building) and "as designed" (construction drawings and specifications used for bidding and construction that do not document any changes made in the field) (Figs. 4, 5).[2] Students had full access to original construction documents and all site, infrastructure, and UNC Facilities Services documentation.

Students chose Revit, one of the more popular BIM software,[3] to develop virtual models of the Carolina Inn and Whitehead Hall. Because they were unable to make onsite measurements, the model developed in Revit was based solely on the documentation they were able to obtain. Students

Fig. 1. The front façade of the Carolina Inn, May 15, 2009 (Photograph by Dan Sears).

Fig. 2. The motorcourt of the Carolina Inn, May 15, 2009 (Photograph by Dan Sears).

Fig. 3. The front façade of Whitehead Hall, University of North Carolina at Chapel Hill, May 15, 2009 (Photograph by Dan Sears).

analyzed the architectural and historical significance of the two buildings and the overall context of the site within the historic district; they developed a program, a zoning analysis, and a building-code analysis. The most frustrating aspect of the assignment was the time consumed in accurately depicting the Carolina Inn and Whitehead Hall in detail. The students were quite skillful in using the graphics provided by Revit. But they quickly learned that Revit requires its users to accurately design every feature of a building at a bid and construction-ready level. In a white paper written for Autodesk, Professor Lachmi Khemlani of the University of California at Berkley explains how Revit software and BIM differ from both traditional design practices and three-dimensional computer graphic applications:

> Revit requires more communication and more collaboration than working with AutoCAD, which some people resist. Revit is a 'designer's tool,' it is more tactile and requires as well as facilitates a complete understanding of the project both at the micro and the macro levels. In current practice, several people working at only the micro levels feel threatened by the application's demand for a broader understanding of the project. Revit also is anathema to those who are not used to rigor in design. With Revit, you cannot cheat or fake the form of a design, and you cannot get away with missing information. All parts of the building are required to co-relate with each other. Folks who use traditional 3D modeling applications often create images that don't coordinate with the project at all, and such folks end up resisting the rigor and honesty that Revit imposes (Khemlani 2004, 9).

Students learned that missing information had to be confronted in order for the model to work. What could not be learned from the existing documentation would have to be verified in the field, which was impossible since the project was near the East Coast. Students requested information from the owner (UNC), the town planning and inspections departments, and from the UNC archives, architects, and engineers who had previously worked on either the Carolina Inn or Whitehead Hall. What could not be gathered through research would have to be determined by an understanding of basic construction technology and materials use. This immediately exposed their true lack of understanding of how historic buildings are built and raised the issue of how in-depth the design problem should actually be.

As noted by Dr. Khemlani, the need for collaboration with other design team members was realized using BIM in the historic preservation design studio. Students were required to thoroughly study and understand the documentation, then use it to build a virtual model in Revit. In order to facilitate the process, several students built the virtual model while others built site models. The need for model calibration challenged the students to work in design teams. This opportunity for collaboration is one of the most appealing aspects of BIM; however, team building remains counterintuitive in most design schools, which traditionally promote individual creativity and competition. This is especially true with first-year graduate architecture students.

The lack of material accurately describing the Carolina Inn might not have been so problematic if the project were handled at the traditional schematic design

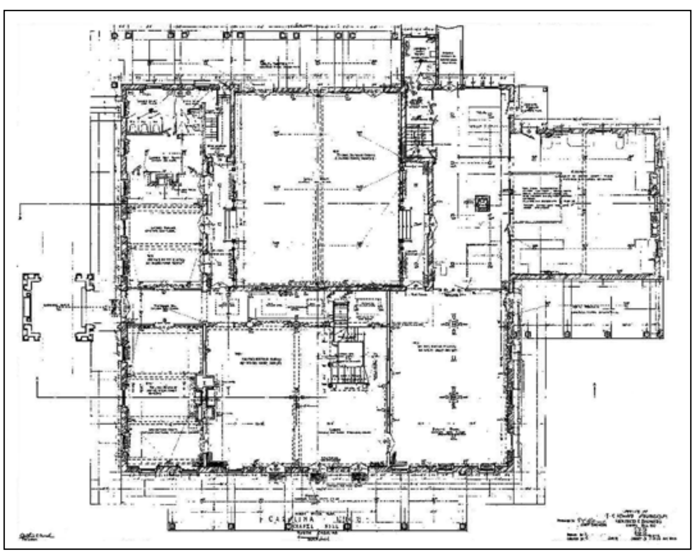

Fig. 4. First-floor plan of the Carolina Inn (as designed), 1924, Arthur Nash, Architect (UNC Facilities Planning and Construction Plan Room).

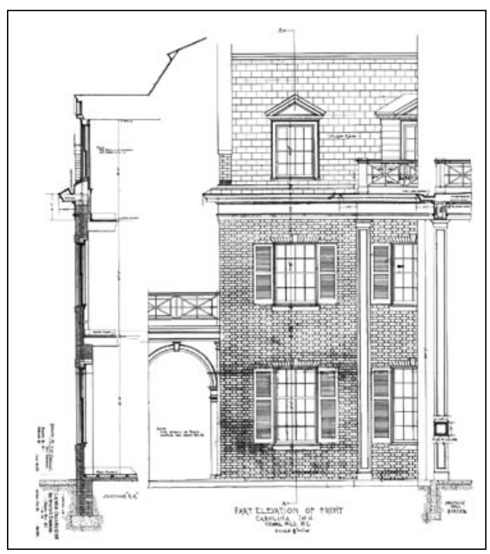

Fig. 5. Partial elevation drawing of the Carolina Inn (as designed), 1924, Arthur Nash, Architect (UNC Facilities Planning and Construction Plan Room).

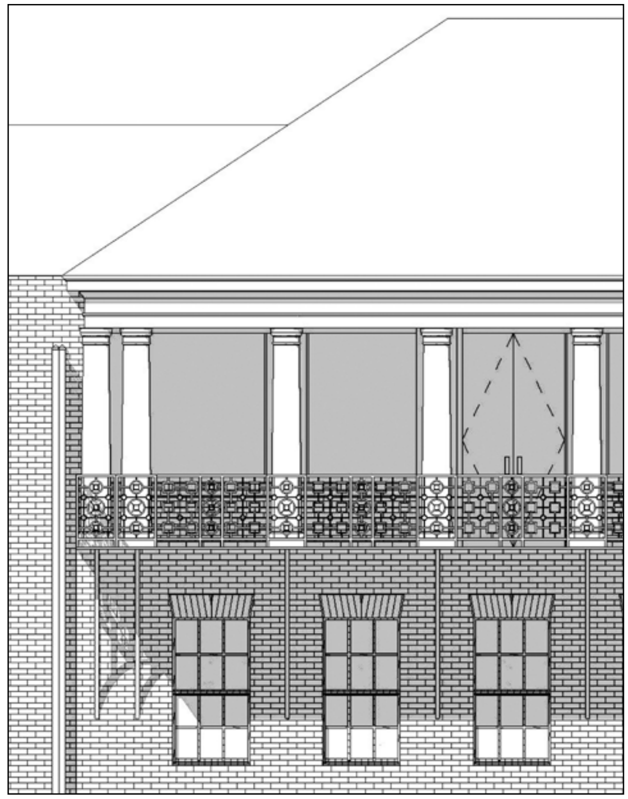

Fig. 6. Partial elevation digital drawing of the Carolina Inn addition, December 5, 2008 (Meghan Roller, Master of Architecture candidate, University of Illinois School of Architecture).

Fig. 7. Rendering of the proposed Carolina Inn addition, December 5, 2008 (Meghan Roller, University of Illinois School of Architecture).

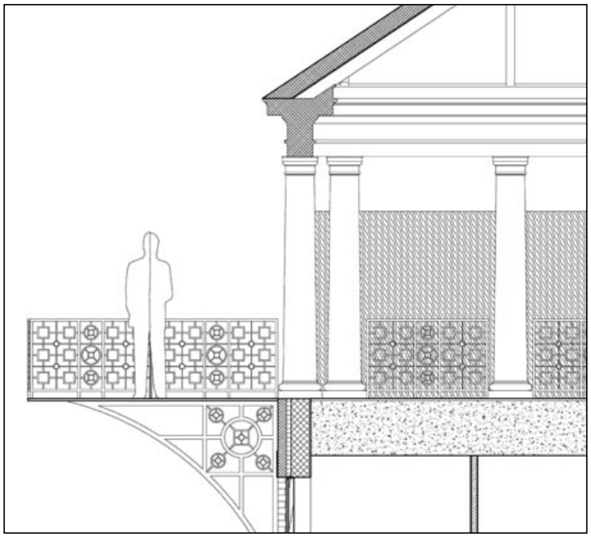

Fig. 8. Section of the proposed addition to the Carolina Inn, December 5, 2008 (Meghan Roller, University of Illinois School of Architecture).

level but, by using BIM, the level of design immediately jumped to the level of construction documentation. The issues of design level and model calibration imposed impossible demands on first-year graduate students. With BIM, calibration becomes the primary challenge for a successful design both in the academic studio and the professional office. It requires that the BIM operator understand building technology. Calibration also takes time and access to the existing building (Cavallero 2006, 33).

During this project, two key opportunities were missed by both students and faculty: the ability to collaborate with others beyond the walls of the architecture school and the ability to present and critique solely in BIM. The students could have easily engaged in online presentations with offsite experts. Furthermore, by requiring students to present only paper drawings of their design in plans, sections, elevations, three dimensional-drawings, and models, the faculty missed an opportunity to learn how BIM can be taught.

Dr. Khemlani's assertion of the honesty found in Revit is somewhat misleading. Since Revit relies on a library of building assembly details and graphic representations of materials imbedded in the software, the "honesty" she refers to is based only in the reality that is found in Revit and not necessarily in the actual artifact. This became problematic in documenting the two historic buildings. For example, brick wall surfaces in Revit were based on standard brick sizes and American running bond patterns; both the Carolina Inn and Whitehead Hall are built of oversized brick in an English bond pattern. Moldings typically found on early twentieth-century Colonial Revival buildings were also not found in the Revit library and could not be readily "pasted" into the model. Difficult intersections and corner junctures typically found in buildings with traditional moldings were non-existent in the Revit software, which was conceived to design modern buildings. In order to accurately depict the existing conditions of the two buildings in Revit, students had to research how traditional materials were assembled, draw them orthographically in AutoCAD, and import them into their virtual model. Students also used technical reference books of the period to gain an understanding of the way these buildings were constructed (Fig. 6).

The use of Revit for a historic building using "as designed" and "as built" documentation changed the objective of the design problem; what originally was intended to be an eight-week design of additions and adaptive use had changed into a problem of construction and materiality. Students were confronted with how the role of structures, materials, and systems impacted initial design decisions (Figs. 7, 8). Dr. Khemlani acknowledges the problem of too many design variables at the outset of the design process in professional practice:

Hand in hand with the ability of Revit to not fake—a plus during the detailed design and subsequent phases—also comes the inability for abstraction, which all firms in the research study found to be a negative during schematic design. As discussed in the last section, Revit requires complete modeling 100% of the time. This requirement does not match the needs of most architectural design processes at the preliminary design stage. It does not support the design flow, and is too restrictive and thereby off-putting to those who actually conceptualize the designs. This made several firms question whether Revit should be used by a design principal at all, given that it is not particularly `sketchy' (Khemlani 2004, 9).

REVIT CITY

Clearly, the internet is no longer just a user-friendly system of corporate and informational websites; it is consumer-driven, with users "building" their own cars, chatting live with other users, or creating their own blogs and web pages. It is not surprising that Revit has its own blog—Revit City. Interestingly, it was not created by Autodesk but rather by a communications company called Pierce Media in 2003. Pierce Media intended the blog to be a community website allowing Revit users around the world to share their ideas. At Revit City, Revit users display their three-dimensional work, add and use an ever-expanding library of building details, discuss the future of Revit in architectural design, and share "snazzy workarounds."

Today's architecture students gravitate to Revit City. It is a reflection of their generation, it supports the competitive nature of architecture students by giving them a perceived edge over their peers, and it allows them to impress design faculty and perspective employers. What is surprising – and to some disappointing—is the lack of discussion regarding actual design and construction. For example, Revit bloggers discuss the graphic representation of a virtual storefront rather than how it is assembled in the field. Part of this can be attributed to the fact that students are not building in the field; they are designing in the academic studio. Also, users who are professionals simply need instruction on the latest architectural software rather than advice on building. Furthermore, the purpose of this software program is just that; it is a computer design tool, not a building aid. Real world applications have no place here.

However, the phenomenon of Revit City cannot be overstated. Similar to Wikipedia, Revit City demonstrates the fluidity of ideas found on the internet. Unfortunately, not all information is factual or reliable. Rather than consulting the numerous online technical briefs from accredited organizations, such as the Brick Institute of America (BIA), Sheet Metal and Air Conditioning Contractors National Association Inc. (SMACNA), and even the Secretary of Interior's Standards and Preservation Briefs, students often rely on Revit and Revit City exclusively for design guidance. Apparently, the attractiveness of graphics trumps the need for technical understanding, especially when building a historic building. An emphasis on researching historic construction to make informed decisions should be brought back into the academic design studio. Only a grounded and integrated foundation of understanding in construction and historic building technology can address the problems that have been exposed while using Rivet (Figs. 9, 10).

Another negative aspect of Revit (and other BIM products) is, as mentioned, the lack of historic resource graphics. When students could not find Colonial Revival moldings or English bond brick patterns, they simply created their own. Actually, not so simply. Creating a virtual historic detail in Revit is laborious, even more so than in other design software. If Revit is to be used successfully in the academic studio, then design problems need to be tailored for use with BIM programs such as Revit.

It is interesting to note that at this moment in the BIM revolution there is a generational divide in the acceptance and use of digital media as a design methodology. Design professionals are resistant to change and are not comfortable discarding the traditional track of project delivery: schematic design, design development, construction documentation,

Fig. 9. View from the balcony of the proposed addition to the Carolina Inn, December 5, 2008 (Meghan Roller, University of Illinois School of Architecture).

Fig. 10. Partial axonometric section of the proposed addition to the Carolina Inn, December 5, 2008 (Meghan Roller, University of Illinois School of Architecture).

bidding and construction—even though all of the professional design associations are embracing this new technology.[4] Other design professionals (especially the new generation) embrace this technology and are motivated to produce impressive graphics. While the next generation of architects may be able to say, "Yes, I can Revit," will they be able to say the same for the more important question, "Do you understand how to design? How to build?" And, more importantly,"Do you understand the fundamental ideas of historic preservation?"

THE FUTURE

At what point should all facets of building technology—historic building construction, structural integration, environmental system integration, and Building Information Modeling (BIM)—be integrated into the design curriculum? Early and succinctly in the education of an architect. The market demands it. As the design and construction industries continue to transform into the new fluid model called integrated practice (using BIM), today's architecture and historic preservation students will be thrust into the forefront of the revolution. But the market is not just demanding "BIM operators"; it is demanding competent designers on the cusp of being licensed professionals in architecture or engineering. Never has a design tool demanded so much knowledge from its users. In order to truly master BIM, one must have a sound understanding of all facets of materials, construction practices, and the mechanical, electrical, and plumbing systems found in buildings. The ability to make such an immediate leap from sketch to building changes the entire dynamic of the architectural design process from a question-driven method to an answer-driven one (Cheng 2006) This paradigm shift in thinking runs against the way architecture has always been taught— as a process of discovery—in the academy.

The challenge of using BIM in a historic preservation design studio is even more problematic. Calibration between the existing building and the computer model immediately becomes an important issue. Students will need to adjust their expectations of finding all they need either in software-provided detail libraries or by visiting sites such as Revit City; they will have to continue the "old" practice of searching for archival documents, drawings, and images. Instructors in historic preservation will have to challenge their students to see past the impressive, often misleading graphics. The objective is not to teach a new graphic design tool (which will surely change) but to teach critical thinking in both architectural design and historic preservation, never substituting "why" with "how to" (Cheng 2006).

Physical historic resources should not be forgotten when designing in a "virtual" world. In a July 1972 article in the National Trust's monthly newspaper, Preservation News, Bob Stipe stated it best:

> First we seek to preserve our heritage because our historic resources are all that physically link us to our past. Some portion of that patrimony must be preserved if we are to recognize who we are, how we became so, and, most importantly, how we differ from others of our species. Archives, photographs and books are not sufficient to impart the warmth and life of a physical heritage. The shadow simply does not capture the essence of the object (Stipe 2003, 13).

One should add "computer-produced virtual model" to Stipe's list. The relationship of physical object and designer is vital to successful design in historic preservation, whether it is a rehabilitation, restoration, or an adaptive use project.

As technology accelerates the design process, it should not accelerate our methods for teaching preservation. Although it can be argued that the concept of integrated practice is both real and attainable, one cannot make the same conclusion about an integrated practice curriculum, which, at this point, has proven to be unrealistically demanding on students (Cheng 2006). Preservation instructors should continue to emphasize how historic buildings work and help students develop the analytical skills needed to preserve them. Important issues of design and preservation, such as architectural integrity, should not be jettisoned to allow students time to develop impressive graphics of designs that they may not even understand.

One must also not lose sight that BIM/Integrated Practice will provide numerous professional opportunities for future generations of preservationists. As a tool for design collaboration, BIM allows preservationists to access the design process early and often; this can provide great benefits in preserving the integrity of historic resources in the design and construction process. As a product of a global economy, BIM/Integrated Practice allows both the student and the professional to collaborate more, not only outside the studio walls but with other students and professionals across the planet.

The possibilities of an integrated practice and opportunities for collaboration are more difficult to simulate in the academic studio. The ability to accelerate the design process, the primary pitch for using BIM by its proponents, may not be such an attractive attribute for teaching students design and preservation. "Real world" situations using BIM may not be the best way to use this design tool when teaching design with historic resources. This may especially be the case as students learn the importance of building documentation in the preservation process. Calibration between what is real and what is virtual will continue to become an important aspect of teaching historic preservation using BIM. Unlike new building design in which a relationship exists between virtual model/design and the construction/physical manifestation of the building, historic preservation design adds an entirely new level to the design process—that of existing conditions; the chain of calibration in preservation should be: existing building, virtual model, and construction. The need for rigorous building investigation and verification, which is often time consuming, is extremely important. BIM does not provide shortcuts in the process; it simply states the deficiency of information.

BIM requires a high level of expertise in designing with historic resources. Only through fundamental learning, understanding the potential of BIM in historic preservation projects, and years of experience can that expertise be attained (the latter conclusion applies to any media in design). In using BIM as tool in the academic studio, one must respect its capabilities but also be mindful of its limitations; BIM is answer-driven not question-driven. Helping students develop their analytical skills and judgment in historic preservation lies at the core of historic preservation education. BIM should be used only as an analytical tool, alongside sketching, drafting, and hand measuring, enabling the architecture student to understand the process rather than allowing “the machine” to do the work.

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ENDNOTES

1. Computer Aided Design products include Autodesk, ArchiCad, and Bentley Systems.
2. Students had access to “as designed” drawings and specifications of the original 1924 Carolina Inn by Arthur Nash, Architect; the 1971 addition to the inn by Archie Royal Davis; and the 1991 addition to Inn by Glave, Newman and Anderson Architects. Students also had access to “as built” documentation compiled by the UNC Engineering Information Office.
3. Several companies produce BIM software, such as Rhinoceros, Bentley, Graphisoft, and ArchiCad.
4. In an article entitled “The Bim Revolution,“ architect H. Michael Hill (2006) writes “CAD drawings are very useful, and they clearly have contributed a great deal in terms of efficiency, process, and scope. Yet when you get right down to it, they represent little more than electronic applications of the age-old pencil-and-paper system that architects, specifiers, engineers, and others have been using for centuries.” He supports noted architect Frank Gehry, who makes the assertion that BIM provides the opportunity for collaboration and that it also introduces the fourth dimension—time—to the design process.

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