Integrating BIM into the Comprehensive Design Studio

JERRY STIVERS
Oklahoma State University

INTRODUCTION

This paper discusses the successes and failures of integrating Building Information Modeling (BIM) into the Comprehensive Design Studio (CDS). As a 25-year practitioner turned full time educator, my motivation for discussion is rooted in a deep concern for the "pedagogical value of BIM as holistic design tool in architectural education and to prepare students of architecture for the inevitable use of BIM in practice."(1) That being said, it is important to look at this issue from the different perspectives of those involved in the CDS experience: educators, practitioners and those who find themselves in the middle, the students.

BIM offers many benefits to practice and is fast becoming the standard for the design collaboration and delivery of professional services within the AEC industry. From my observation, benefits for practice, however, do not always translate into benefits for education. If the purpose of CDS is to create a bridge for today's student to cross over to tomorrow's profession, and BIM is becoming standard practice, it is not a question of "if", but rather "how" BIM should be integrated into a CDS.

At first glance, the request to integrate BIM into CDS seems plausible; new tools have been integrated in the past (CAD, pin-bar overlay drafting, etc), however, from studio observations, this is different. BIM not only affects students design communication, but also their design process. The integration of new tools and processes comes at what and who's educational expense?

The thesis of this paper suggests that, without strategic control, adequate software support, new teaching methods, and a more collaborative team-based studio experience; BIM has the ability to overwhelm and limit the individual students' creativity as well as change the overall learning experience within the CDS from a semester about comprehensive design, materials assemblies, and systems integration to a frustrating semester of software manipulation.

COMPREHENSIVE DESIGN STUDIO

Comprehensive Design Studio at Oklahoma State University's School of Architecture has a rich history and has long been considered the peak of an architectural student's educational experience. CDS occurs at the end of a student's formal education and draws upon all that has been taught and learned throughout their architectural education. It is designed to create an environment and experience that bridges the traditional academic studio to that of professional practice.

There are several unique aspects of the CDS at OSU. First is the combination of architectural design and architectural engineering students and curriculums into the same studio. Another unique aspect of the class is the "team teaching" concept. Team teaching provides continuity to the semester by reinforcing a more collaborative process which students will discover in their future professional practice. The inclusion of structural and building systems faculty from the start reinforces to the students that, when considered early, technical aspects of design can become a catalyst for investigative thinking and not merely a submissive response to a conceptual ideal.

There are many challenges to overcome in CDS outside of the integration of BIM into the studio. First, is the limited time frame imposed by a single semester. A second challenge for students is the development of their time management skills. Up to this point, students are accustomed to a studio experience with multiple projects in a given semester. Given the overwhelming requirements, limited time frame, and new design development territory students face during CDS, the integration of BIM overlays another aspect to what some already consider "a perfect storm".

BUILDING INFORMATION MODELING

So, what is BIM? To some, it's just a tool; to others, a new process, but no matter how you perceive it, BIM demands change for those who incorporate it. "At it's most basic, Building Information Modeling (BIM) is the representation of building information in a computer-readable form. Like the manufacturing industries before it, BIM changes the representation of a building from drawings to become a virtual computer model of the artifact being designed."(2)

There are many widely accepted benefits, specific to the AEC industry such as:

- Design Accuracy: better coordinated drawings, reduced errors, accurate bill of materials, and integrated clash detection,
- Real time analysis for design justification: visualization, sustainability, energy, daylighting, constructability, costing and scheduling
- Better service: construction cost savings, fewer change orders, shorter construction time, and better team collaboration
- Building performance: outcome prediction before a building is built, less manufacturing / construction waste and inefficiency
- Design process and delivery: better integration of design processes, more time spent in early design, less in construction documentation, and model translation directly to fabrication process

With all the above professional benefits, do they apply in the same way to students and their use of BIM in the academic studio?

PRECEDENT

The most relevant precedent is the introduction of Computer Aided Design (CAD) during the 1980's. As a long time practitioner, and specifically one that was educated (1980's) with traditional tools and trained professionally (1990's) with the computer, I have first-hand knowledge and experience of being "caught in the middle" of a technology evolution. I can remember as a young enthusiastic graduate being put in the "CAD room" for hours in the dark, packed with computers, printers, and piles of user manuals, in hopes of becoming our firm's "quick fix" to technology.

There are parallels to today. Students and young interns are still a firm's most cost effective way to research new technology. They function as a bridge, because of their "enthusiasm" for the profession, "openness" towards new ideas / technology, and their lack of "indoctrination" from years of being told "how we do things here at the firm".

The same questions were being asked by the faculty of most architectural schools during the CAD revolution: "Whose responsibility is it to introduce and train new technologies, academia or the profession? If it's ours, what part of the curriculum do we leave out? Is it best for long term development of our students?"

"Critical or design thinking"(3) was and still is the central concern for most faculty, being careful to not allow digital trends to replace what was and is central to fundamental growth and nurturing of the next generation of design professionals. CAD was seen as a great way for young graduates to "make their mark" early in their career path. Unfortunately, like today, when considering new employees to hire, firms often filter and hire new grads by their experience and knowledge of software rather than their problem solving / design skills. In today's recessive economy, students feel a certain "marketability" pressure to have the latest and greatest technology tools in their tool box.

There is a difference, however. The technology gap between faculty and students today is much smaller than in the past. Most mid-career faculty and firm leaders today have practiced with the computer and seen how valuable technology has been to the success of their own careers.

DISCUSSION

To facilitate, focus and document the discussion of how to integrate BIM into the CDS, questionnaires were distributed to all three groups (educators, practitioners and students) involved looking at seven key areas: experience with BIM, design process, design communication, systems integration, creativity, time management and design culture. Student work examples, in studio observation, as well as practitioner and faculty interviews were also considered to develop the implications for pedagogical change.

Experience with BIM

Students began using BIM in the CDS during the spring semester of 2010 having also had a separate computer class prior to CDS during the student's junior year. CDS faculty have had little "hands on" experience with BIM other than working with students over the last 2 years or perhaps some limited self exploration during the summer months. Practitioners surveyed had been using BIM for approximately 3 years in their respective firms.

The learning curve for all three groups was very steep. All respondents said their proficiency increased with use; however each group had other more specific concerns that may have affected their learning curve. Students struggled with the rigor of the course as well as the unfamiliar design development and construction documentation process. Practitioners battle firm culture / traditions or "the way we've always done it" attitudes from senior employees not to mention their firm's short term profitability. With the already overwhelming criteria in CDS, faculty question BIM's educational value and the "trade-offs" needed to make room for it in the course curriculum as well as their own inability to offer software support to their students.

Design Process

Many want to categorize BIM as simply a new design communication tool (initially, myself included), and although it is, BIM is much more. BIM is changing the design process. Cheng states, "The potential affect of BIM on the design process is unprecedented and the ease in which it can translate directly into built form can equally be viewed as exciting or alarming. . . . . BIM will increasingly influence project delivery and the interactions between architects and other stakeholders."(4) In an opposing view, Seletsky states, "when BIM is defined as a process - as it should be - it begets performative information and simulative environmental conditions into design, placing an emphasis on "the underlying logic of design."" (5)

Practitioners surveyed suggested that using BIM during the design process allows them to have "real time" quantitative and qualitative feedback to help justify a concept beyond its subjective functional or aesthetic qualities. Designers need to analyze and track the inherent advantages and disadvantages of a given scheme during the design process until enough information has been studied to choose between them.

BIM has been considered to facilitate a more collaborative and integrative process and culture within the AEC industry. This new "Integrated Practice" model calls for buildings in our sustainable future to be designed and constructed for lower costs with higher quality. Thru building virtual models in the computer and not simply drawing representational images of buildings, design professionals could reassume the key position of creator and manager of design information. BIM has also changed the traditional design and delivery schedule. Because of the ease with which construction documents are produced, BIM has re-allocated larger amounts of time to the beginning design phases (schematics and design development).

Students however are still a "work in progress". Their personal design processes are still very fluid, open and receptive to new ideas, methods and technologies. When students were asked if BIM improved their design process, their responses were just above neutral, suggesting a level of ambivalence or uncertainty. More often than not, the students iterative design process of analyzing and choosing between design alternatives was crowded out because of BIM's complexity to operate. From studio observation, students often got caught in the trap of simply admiring or editing the same "artifact" and not comparing and prioritizing between the different iterations.

As faculty, we have our work cut out for us. If BIM creates a new design process, how will our traditional teaching methods need to change? In today's studio, so much of a student's design process is hidden by the computer. Since the introduction of CAD into the design process in the 80's, it has been difficult for design faculty to fully engage a student's design process, always wondering, "What's going on inside the box?" The computer can visually swindle student, and their faculty into thinking an undeveloped design has been consciously resolved. Now, to add another element such as BIM which by its intended power masks many of fundamental design and analysis processes, faculty become even more skeptical of a student's critical thinking abilities and their progress. This becomes very evident that a student is detached and lacks understanding of the inner workings of their own designs when they respond during a critique with "that's what the computer gave me!"

Knowing "when" to insert BIM into the overall CDS design process is also a concern for faculty. From observation in studio, as well as acknowledgement by the student and faculty surveys, traditional analog processes during the early conceptual phases of design utilizing physical models, hand drawings, etc. help make a better transition to the later digital phases utilizing BIM. Physical making and drawing during the early phases of the design process helps a student's understanding of scale.

Finally, trying to develop ways of promoting conversation about the student's design, whether pinup sessions, project meetings, digital critique stations, etc. getting the student's work out of the computer and into a physical (not virtual) environment would be beneficial to the design process. Perhaps less isolated and individual effort and more interactive team assignments would clarify the design process promoting collaboration and dialogue about the project. Not just the student against the software, but now a collaborative team working and dialoguing together towards a solution.

Design Communication

BIM improves the design communication process by giving (with relative ease) architects and their clients the ability to predict how a building will look and feel prior to construction thru accurate virtual images. In our analogue past, it was much more difficult to produce renderings with traditional communication tools because of the specialized skills and time needed. BIM technology emphasizes design process by taking some of the more mundane design communication tasks during construction documents and automating them.

Students are exposed to many different design communication methods, both digital and analog, to accomplish their work while at school. Having a well stocked "toolbox" gives them the ability to compare their unique processes and final products with other students using different tools. Overwhelming response from students suggests that BIM was very helpful in creating and organizing both their formal and informal presentations to faculty and practitioners starting with the schematic phase. Even though BIM was widely used, students still commented that traditional methods of drawing and model building and CAD should still be an integral part of the CDS, especially in the early conceptual phases of design where less is known about their designs and maximum freedom is desired.

Figure 1. Hybrid design communication studies – Laith Nabilsi, Nick Conner [7]

Critics are often frustrated with the rendering process because of the "visual swindle" which can occur. Students become so focused on the "image" as artifact, spending hours and hours of their precious design time rending underdeveloped designs. Knowing a student's design process became extremely important because it was difficult to distinguish between a conscious design decision made by the student or what was automatically created by the BIM software. A false sense of resolution was given to both students and their critic. In the past, studio critics were able to be more "hands on" with students, teaching the traditional mechanics of drawing and representation. Today however, because of the variety of design communication methods and number of software used in the CDS, it's virtually impossible to be versed in them all.

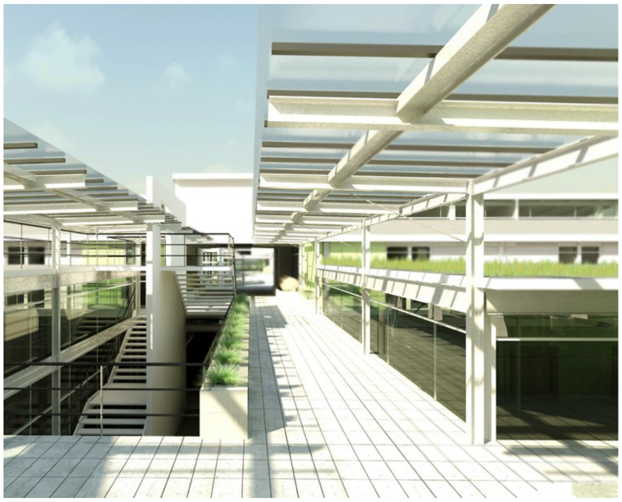

Figure 2. BIM generated presentation images – Jessica Shelton [7]

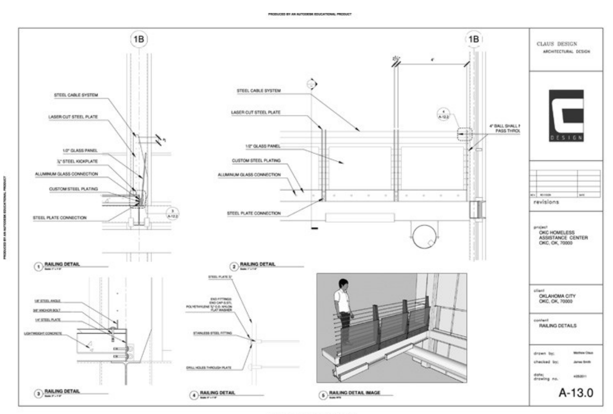

Figure 3. BIM generated construction documents – Matt Claus [7]

Systems Integration

Using BIM results in fewer errors and change orders, better cost estimates, and a more consistent and coordinated set of drawings. Unlike in the CAD past, BIM software allows the architect to find building systems conflicts in the virtual model while "in the office" and not as they surface "in the field".

Sixty-five percent of the students responded that BIM was very helpful in their understanding of how building structural and MEP systems were integrated into their designs. "Making" (how things go together), whether real or virtual, helps young architects to develop a more comprehensive understanding of the design / build process, not to mention presents them with the reality of when things simply don't work or fit together.

Sounds easy, but in reality, this part of the semester is very difficult and confusing for students because of the limited knowledge and experience with the realities of construction. Most students have had very little "on-site" construction experience and little exposure to building systems and materials other than their required coursework or perhaps a summer internship in the field. Because the students had to construct the building systems in a virtual environment rather than just draw a representation of them, they became much more sensitized to their subsequent impact and integration into the spatial qualities of their design propositions. Students began to think about how structure and building systems (even at early stages of design) can integrate with the architecture systems and in some cases become a catalyst for design rather than simply a response. Faculty observed that many students who used BIM in CDS developed a much clearer understanding of how their buildings went together than those students who did not use BIM because of virtual construction of their buildings.

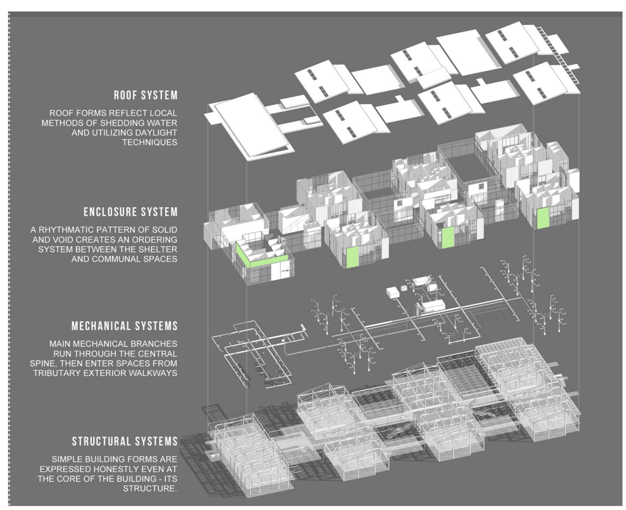

Figure 4. BIM generated building systems drawings – Jessica Shelton [7]

Creativity

Most designers are comfortable with a certain level of ambiguity during conceptual design so that they can draw upon their instincts, life experiences and research to shape initial design concepts. Eighty percent of the respondents who tried to use BIM felt that their personal creativity was limited because they were required to "know" too much about their designs too early in the design process.

BIM automates many design tasks requiring less understanding and involvement from the student in how it actually works. Because of BIM's complexity and their limited time frame, students typically took the path of least resistance using drop down menus of standard details, assemblies and materials rather than creating unique designs relevant to their own concepts.

Faculty acknowledged that BIM and the computer belong in CDS; however it is important that drawing by hand and physical modeling be kept in the design process to help students reclaim and develop a better understanding of the size and relationships of and between objects in the spatial environments they create.

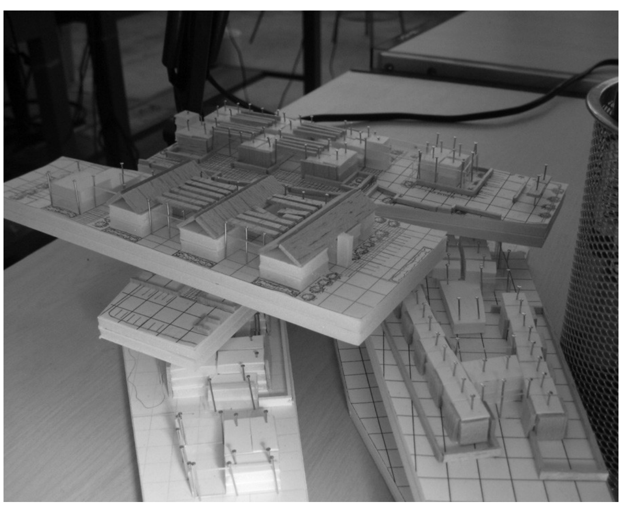

Figure 5. Conceptual study models – Jessica Shelton [7]

Time Management

Answers to this multi-faceted question vary greatly based on the user's experience level with BIM. On a very basic level, BIM is considered to do a much better job at creating a coordinated set of construction documents than traditional CAD. As opposed to a traditional CAD approach, project workflow and man-hours are reversed and re-allocated from a typically "heavy" construction document phase to "front loaded" earlier phases. That workflow and man-hour re-allocation is reflected in the CDS with construction documents only taking the final two weeks of the semester.

Almost ninety percent of the students surveyed thought BIM helped those meet deadlines and fulfill the requirements of CDS. In some cases, however, students were surprised to find out how much more time they had to develop their studio projects once they overcame the initial struggle of learning BIM.

Design Culture

Architecture firms, schools and their students all have the same desire to be successful. Firms utilize cutting edge technologies, methodologies and materials to produce award-winning designs. Faculty utilizes curriculum and experiences to produce successful students who have relevant skills, attitude and work ethic. Students strive for success in their coursework and want to leave school knowing that their hard work will pay off and provide a bright successful future. To foster a culture of success in the CDS where BIM is used, two areas within the class structure should be evaluated for change: collaborative based design teams and faculty/student relationships.

BIM was created for collaboration and the sharing of information and expertise between team members. At present, much of the student's CDS experience at OSU is isolated and independent of interaction with others except for their respective design critics and practitioners who sit in for formal jury presentations. For BIM to realize its full potential in CDS, a collaborative team structure should be developed to share information and foster a more diverse, "critical thinking" dialogue between students, thereby giving each team member a greater understanding of the overall project rather than their individual experience. In the ACSA 2010-11 BIM/IPD Survey Results, when respondents were asked, how they are using collaborative design strategies in BIM integrated studios: "77% teamed architecture students at the same level." [6]

Another opportunity area for reinterpretation within the class structure is to have faculty become a more "practice-centered" mentor for the design team rather than an "academic-centered" critic for the individual student. BIM requires both the understanding of how buildings go together (faculty) and the operation of the software (students). The mentoring process develops a more collaborative work environment breaking down communication barriers between team members, thereby creating interdependence between students and their faculty for the overall project success.

Implications for pedagogy

Educators are at a beginning point in the process of integrating BIM into the design studio. The process will be frustrating. The following list of implications for pedagogical change is by no means exhaustive or authoritative, rather observed and to be considered.

- **BIM is changing the profession.** Acknowledge the inevitable changes BIM poses to pedagogy.
- **There is no standard way to integrate BIM into the Comprehensive Design Studio.** Each school must develop an approach appropriate and supportive to their mission and pedagogical position**.**
- **Focus on the students' long term development.** Don't allow the profession's short-term technological demands to compromise academia's long-term objectives – the development of the next generation of architects.

Experience with BIM

- **Knowledge and ease of use comes with time and experience.** Only limited proficiency can be accomplished in the student's short undergraduate curriculum.
- **Students should be introduced to BIM prior to CDS.** Look for ways to integrate BIM into other courses.
- **Faculty should learn how to use BIM.** Knowing BIM promotes collaboration and builds a generational bridge between faculty and students.

Design Process

- **BIM is much more than a new design tool; it also changes the design process.** Be careful not to allow the complexity of learning and integrating BIM (the how) to compromise critical thinking (the why).
- **Informed alongside intuitive design**. Capitalize on the BIM's inherent strengths of simulation and analysis to help justify a concept beyond the subjective.
- **Encourage the use of physical models in conceptual design.** Physical models in early design phases provide a better transition to and integration of virtual models in later design phases.
- **BIM may require new teaching methods for successful integration.** BIM cannot simply be added to CDS, teaching methods should be evaluated for effectiveness.

Design Communication

- **Encourage students to explore new ways to communicate construction detail and dimensional information.** Construction documents of the future will evolve to take advantage of BIM's "3D" capabilities.
- **It's ok to live in both digital and analog worlds.** Encourage the use of all types of representational tools to reinforce a students' critical thinking.

Systems Integration

- **Promote more collaborative dialogue between "A and AE" students teams by running interference checks on their design solutions.** Presents the realities of when things simply don't fit.
- **Encourage students to consider how structure and building systems can become a catalyst "for design" rather than simply a submissive response "to design".** Making rather than simply representing helps students to develop a clearer understanding of how buildings go together.

Creativity

- **Encourage an adventuresome spirit in the students and their projects.** Don't "dumb the class down" from the limitations or complexity of the BIM software.

Time Management

- **Timing for the introduction of BIM is critical.** Conceptual ambiguity early in the design process is essential for the designer to pose questions and not simply having all the answers.

- **Re-evaluate the course calendar.** BIM front loads the design process. Capitalize on BIM's strength in construction document assembly.

Design Culture

- **BIM was created and designed for collaboration.** Find opportunities to make the studio a more team-based environment.

- **Reinterpret the traditional faculty/student relationship.** Use a "practice oriented" mentoring model of senior designer/junior designer.

- **A healthy design culture within the Comprehensive Design Studio is balanced and breeds success for all involved.** Foster a respect for past design methodologies (analogue), a commitment to the present hybrid design condition (analogue/digital), and a vision which challenges students toward their sustainable future (digital).

ENDNOTES

1. Christopher Livingston, "From CAD to BIM: Constructing Opportunities in Architectural Education," AEI National Conference: Building Integration Solutions, (2008)
2. Chuck Eastman, Paul Teichholz, Rafael Sacks, and Kathleen Liston, BIM Handbook: A Guide to Building Information Modeling for Owners, Managers, Designers, Engineers and Contractors, (Wiley and Sons Inc., 2008)
3. Renee Cheng, "Questioning the Role of BIM in Architectural Education," AECbytes, Viewpoint #26, (2006)
4. Renee Cheng, "Questioning the Role of BIM in Architectural Education," AECbytes, Viewpoint #26, (2006)
5. Paul Seletsky, Questioning the Role of BIM in Architectural Education: A Counter-Viewpoint," AECbytes, Viewpoint #27, (2006)
6. Association of Collegiate Schools of Architecture, "BIM/IPD Survey", (2011)
7. Student Work Examples