BIM and the Charrette: Technology and the Design Process - Results from the Interdisciplinary Course

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INTRODUCTION

This paper describes the crafting, development and implementation of an interdisciplinary course focused on providing a charrette based design-build environment for the delivery of concept design solutions. Studio work allows for the exploration of design throughout an academic session. The world of practice recognizes the charrette as the boiler room for design. The charrette holds fond memories for the profession, deriving its nature from the École des Beaux Arts in Paris during the 19th century[1]. The furious cart ride down cobbled streets knocked loose more than a few mind blocks and gave rise to the vast array of design produced from the school. Rather than alter this time honored collaboration, this class co-opted the scenario, introducing stakeholders normally outside the design process and integrating technology to enable more analytical insight into the design process.

The cyclic nature of integrated design is time-compressed during the charrette process, during which a variety of design decisions are made with the input available from a wide array of disciplines. These decisions are typically couched and evaluated in terms of economic return. Quantitative analysis is more randomly applied due to the nature of how architects have traditionally performed design. The thought was that this course could provide an environment where design decisions could be rapidly informed by quantitative analysis through integrating technology evaluation and interoperability.

While it is true that technology courses are typically taught in lecture format, design knowledge is incorporated through application. The instructional designs of skill based courses are typically immersive. Once again, the charrette provides a medium to introduce and incorporate technological process into the design process.

To verify performance based on design intent, technological systems require quantitative evaluation. The articulation of the exterior closure in order to produce passive offsets for mechanical systems is fundamental to achieving environmental goals. These decisions, however, must be balanced with aesthetic results. The term "technology" in architecture must be broadly applied in terms of this course. The technological solutions relating to materiality and systems shares space with computer technology based solutions in the design process, which coincidentally inform the decisions to apply those technologies. For purposes of this paper, we will use the term "technology" to imply both the Building Information Model (BIM) solutions and the materiality and systems components of the design.

Exterior closure constitutes approximately 10-20% of the project budget. The delicate dance between aesthetics and quantitative evaluation weaves itself within the design process. While intuitive knowledge can be garnered over a lifetime, even fundamental "rules of thumb" can become outmoded with the advance of technology and understanding in a world of change.

The focus of the course was the understanding that a quantifiably sustainable and economically feasible concept design can be developed during the charrette. The charrette was simulated using an eight day course that was designed to successively develop team building skills; convey an operational understanding of the sustainable design strategies utilizing the U.S. Green Building Council's LEED criteria; software training on the development of concept modeling techniques and quantitative analyses utilizing AutoDesk REVIT; and finally training on the interoperability of REVIT models with the DesignEst estimation interface and Primavera scheduling support software. This course won the National AIA Technology in Architectural Practice award for Higher Education at the 2008 National Convention.

Multiple tasks were assigned to reinforce and apply these techniques in a simulated charrette environment through the development of: 1) a concept design for a small design-build office and 2) the modification of a prototypical retail development model to achieve a LEED Certified rating. The course was designed to enable students to better understand Building Information Modeling in a hands-on, collaborative environment. The roles of the architect and contractor, and their coordinating role in project design and construction, were explored throughout this process. Each session utilized case study reviews to help the students assimilate and apply the information learned. Pre-testing and Post-testing were conducted to evaluate course effectiveness. The knowledge outcomes of the class enabled students to critically contribute to the development of environmentally responsible projects. Students came to recognize the need for quantitative analysis of design decision, understood the technology and its integrated nature to the design process. Eventually, the enabling and integrating technology of BIM became secondary to the design, estimating and scheduling process.

INSTRUCTIONAL DESIGN

Session 1

The first class utilized the National Institute of Building Sciences' National Building Information Model Standard overview of Building Information Models.[2] Various interactive discussions were held regarding how BIM works, what it can and cannot do and how interoperability can facilitate the development of more accurate estimates and schedules.

Participants formed self-selected two person teams of one architect and one constructor. Team building exercises helped establish lines of communication and assignment of areas of expertise. These team building exercises were directly reflective of practice in the initiation phase of the charrette.

The first afternoon was devoted to an intensive workshop presenting the U.S. Green Building Council's LEED criteria. Each team competed to develop a LEED certifiable strategy for projects in both an urban and rural setting. Feedback was given regarding feasibility and verifiability of points assigned by each team. The goals were multi-dimensional in that these exercises further reinforced team coherency in addition to exploring and developing the skill sets necessary to produce a successful sustainable design concept.

It is important to note that while software skills were introduced, the outset of the class was not software oriented. Skill sets are informed through the integration of knowledge and decision making strategies. It was important for the students to understand that knowledge strategies inform the selection of toolsets.

Session 2

The second session was primarily for the development of software proficiency and to introduce students to the multiple dimensions within the system. The system students used in this class included 3D graphics, 4D time, and 5D cost estimating, which were integrated and supported in a platform representing the disciplines of architecture and construction. AutoDesk REVIT training was conducted to establish operational efficiency with the software with regard to the development of concept models. The availability of quantitative assessment of design decisions regarding materiality, daylighting, and energy analysis was enabled by the software technology. This training was followed on by the interoperability and database design of the DesignEst Pro software and Primavera P6. The integrated system added the multiple dimensions of the BIM model for analysis in 3D, 4D, and 5D. The idea that design decisions could be evaluated on an ad hoc basis with quantifiable analyses was fundamental to the adoption of the software to the toolset of design. The analyses, which linked design decisions to cost and schedule was extremely enlightening to the students. The exposure of architectural design students to cost and schedule feedback and conversely the constructors' awareness of design decision making proved to be a fundamental resultant for the class.

Session 3

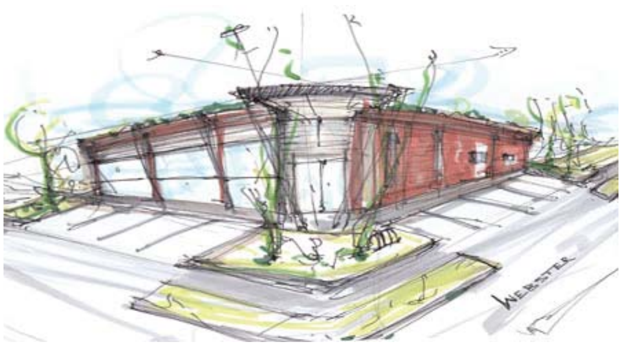

Figure 1. Conceptual Hand Sketch Solution

This session initiated the core focus for the remainder of the class - the application of knowledge and the development of conceptual design skill sets. Tasks were introduced that built upon the teaming concept of the first sessions. Task 1 asked the teams to develop, on paper, a concept design and estimate utilizing a simple program and site for a small Design Build office to house the team. Auxiliary training in online municipal GIS systems and planning information gathering were introduced to assist students in understanding the larger role concept design plays in the development process. It was imperative that the teams achieve a LEED Silver rating. Teams competed to get the most LEED points for the least cost.

BOX Design/Build Office
Site
15' easement from alley
20' setback from Webster
5' setback from other lot lines
8 parking places, assume 300 sf per
Structure cannot encroach easements/setbacks
Assume existing building flush with Webster and Alley easement/setbacks
Program
1,600 SF max
PM/Designer's Office must have exterior window
PM/Estimator Office must have exterior window
Staff/work room
Library/Conference Room
Copy Room
Reception/Business Office
Men's Room
Women's Room
LEED Silver

Table 1 – Design/Build Office Program

Sessions 4 and 5

Task 2 then asked the teams to develop a project concept utilizing the same program but this time using Autodesk REVIT, DesignEst Pro and Primavera. Again, it was imperative that the teams achieve a LEED Silver rating and the teams competed to get the most LEED points for the least cost. It is

Task 1 Results	Description	Estimate	$/GSF	LEED Score
Team 1	utilized existing building	$265,000	175	34
Team 2	did not use existing building, $9.10/sf green roof, rainwater harvesting, solar hot water heating	$364,633	234	38
Team 3	used material from existing building, green roof $64,000	$276,589	198	34
Team 4	utilized existing site characteristics	$240,422	190	35
Team 5	did not use existing building	$209,000	130	33

Table 2. Design/Build Office Results

Figure 2. Conceptual BIM Based Solution

interesting to note that we believe that the competitive nature of the teams enhanced the learning process. Studio can be a highly creative and supportive environment, but there is always a fundamentally competitive aspect to the presentation. Just as athletes are spurred to greater performances at meets, architects and constructors learn from and challenge themselves with those they share presentation space.

The results of the second task were striking. Students incorporated the lessons learned from the previous exercise and manipulated sustainable design strategies to achieve greater "points for the buck". Furthermore, and perhaps more importantly, the interoperability of the REVIT and DesignEst software allowed the teams to capture higher costs associated with the actual wall sections necessary to achieve the energy efficiencies in order to meet

BOX Design/Build Office Task 2 Results				
	Description	Estimate	GSF	LEED Score
Team 1	utilized existing building	$330,000	1,498	34
Team 2	did not use existing building	$325,400	1,553	35
Team 3	used material from existing building, green roof, solar hot water heating	$475,370	1,395	35
Team 4	utilized existing site characteristics, and altered existing building	$274,000	1,260	35
Team 5	did not use existing building, deleted overhead and profit to achieve score	$209,000	1,600	33

Table 3. Design/Build Office BIM Results

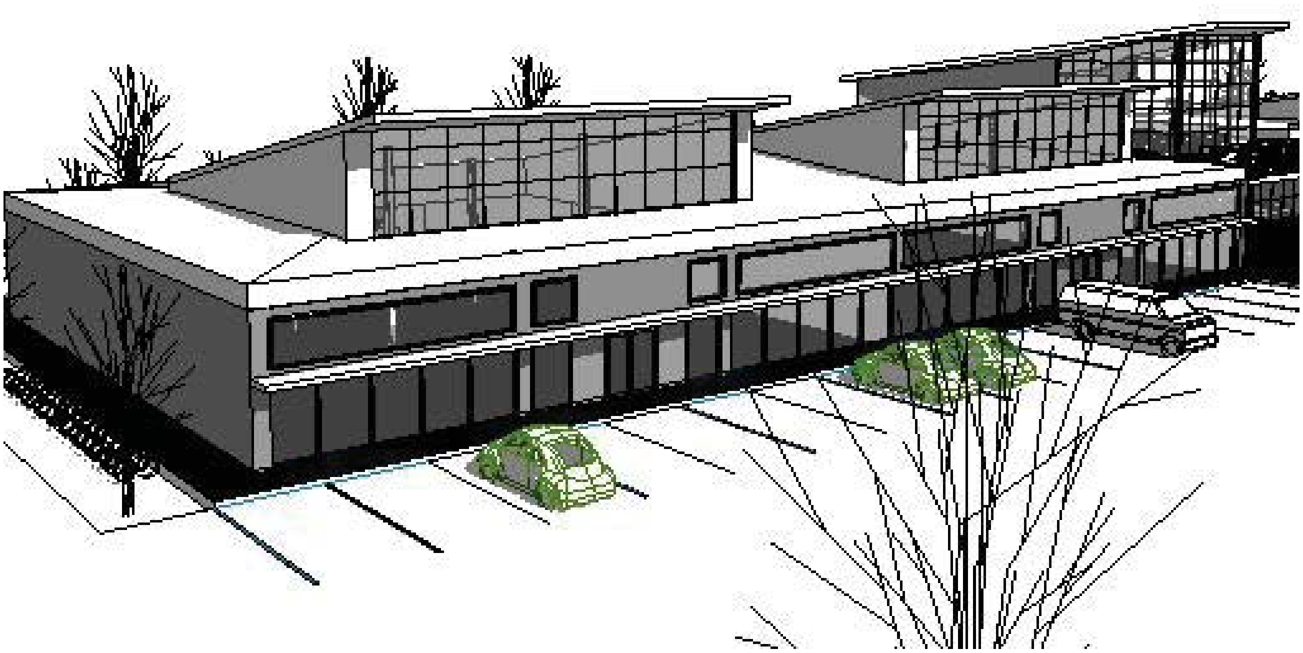

Figure 3. Roof Monitor Sustainable BIM Solution

LEED criteria. The REVIT software allowed the development of concept designs that included floor plans, site plans, sections and perspectives that had been superficially developed for the "paper only" task. Ongoing feedback regarding the costs of design decisions was possible due to the interoperability of the software.

Sessions 6, 7 and 8

For the final Task, the Teams were given a REVIT file that contained a model of a prototypical retail development. The Teams were asked to manipulate this model to not only achieve a LEED Silver rating but to also incorporate daylighting in the retail spaces and meet energy criteria. Submittals required for this final Task included a REVIT presentation with all files on CD (REVIT, EST, Schedule, Report, and JPG images) including an explanation of approach and LEED strategies, imagery and cost/schedule analysis. Additionally, a printed report was to be submitted that included the LEED Checklist with a minimum of two sentences describing how each point was obtained.

Imagery required at a minimum:

- Marketing Rendering – aerial perspective with site or other (REVIT/JPG)
- Site Plan with Roof Plan – with North arrow and scale
- Floor Plan(s) – with North arrow and scale
- East-West Section - with scale
- North-South Section – overlay daylighting penetration into retail sales
- Typical Wall Section – show materials, R-values
- Other Images as may be necessary to fully describe project

Prototype Model Task 3 Results	Description	Estimate	GSF	Parking Spaces	Construction Time	LEED Score
Team 1	impervious paving	$3,170,000	29,125	107	13 months	33
Team 2	deleted second floor, insulated CMU, roof R40	$2,391,658	26,300	96	405 days	34
Team 3	greywater recycling, impervious paving, solar panels	$3,298,000	30,000	135	8 months	34
Team 4	solar panels, skylights, polished concrete, no ceiling material (open)	$2,400,000	29,700	117	13 months	43
Team 5	did not use existing building, deleted overhead and profit to achieve score	$2,305,864	31,111	118	15 months	35

Table 4. Prototype BIM Results

Once again, the results of this task were remarkable. The sustainable design strategies that each team employed demonstrated a thorough understanding of the application of LEED principles. The sophistication of the designs was enhanced by the capabilities of the software and made the final presentations a huge success in terms of student satisfaction and ultimately increased the understanding of the projects' direction.

Figure 4. Shaded Entry BIM Solution

It should be noted that the teams had to work outside of the 9am to 3pm scheduled class session timeframe in order to fulfill the requirements of the class. The typical design studio desire to extend the schedule was outweighed by two person teams subject to each other's deliverable. The correlation with charrette delivery timetables and work outside the typical work day tracked directly with the students and their delivery requirements. For example, if the architecture student's REVIT model was under-developed, the constructor failed to create an accurate cost and schedule. Conversely, in order to achieve a least-cost/sustainable design, cost and schedule impacts had to be generated for the architecture student. The multi-dimensional nature of the analyses allowed for design decisions to evolve at a rapid pace in keeping with course requirements.

In the final review, the software technology became secondary and supportive to the strategic design decisions being made. The software was integral to the design process. This is not to say that hand sketching was not present. In a typical design "what if" scenario, both the sketch and the building information model were fundamentally linked as ideas were tested and refined. Communication between team members focused on both the sketch and the screen with optimal result.

CONCLUSIONS

It is important to note that, with the exception of one of the construction students, none of the participants had any experience using the REVIT modeler, analysis suites, or the DesignEst estimating interface. In addition, only one construction science student was familiar with the P6 scheduling software. Furthermore, the construction science students had not participated in a charrette pro-

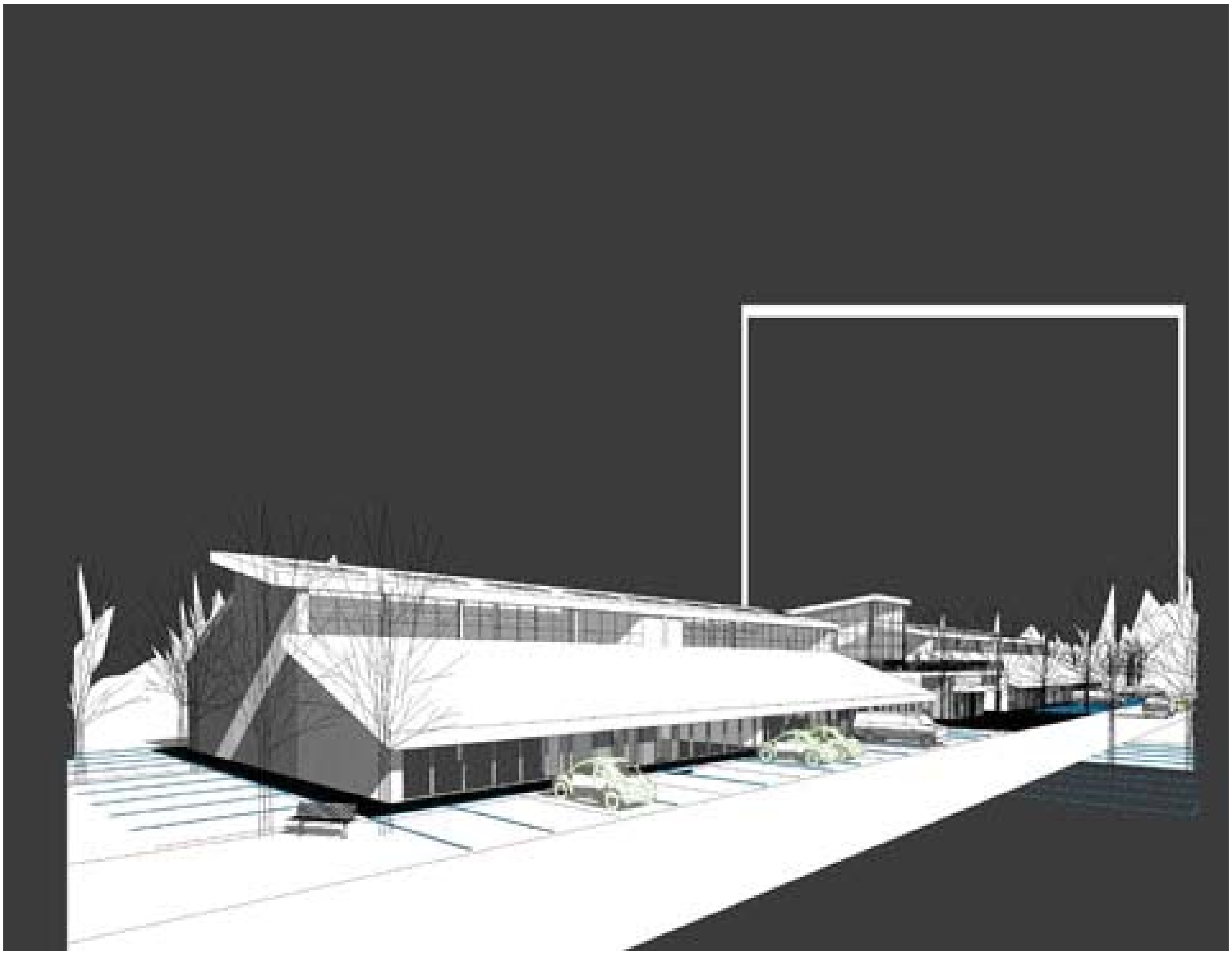

Figure 5. Fully realized BIM Solution

cess with an architectural designer. Conversely, the architecture students had not had the opportunity to test their concepts with a feasibility analysis.

The immersive nature of the course was highly successful for a variety of reasons. One of the ideas is that the architectural design studio could be reorganized on a project by project basis. The interaction of interdisciplinary teams, forced to work together through a BIM software model has a great deal of consequence. The caveat that this program was reserved for upper division students is important. BIM technology integrates as a quantifiable adjunct to the design process. BIM technology cannot establish design process, nor create aesthetic results without the trained eye of the user. The BIM technological process, however, can contribute to data flow organization. The rapid response of quantitative analyses can also contribute to the exploration of alternative design solutions. Furthermore, fundamental design principles, typically organized around "rules of thumb", can be tested through quantitative results.

A typical example would be the architecture student's love of the "magic arrow" describing air flow through a building. With BIM software technology, ancillary analyses of the model can utilize computational fluid dynamics to accurately reflect the success or failure of ventilation strategies. This is especially true of energy simulations, nearly automatic with a building information model, where quantification of passive building envelope decisions can be tailored to localized climate conditions. Whereas typical building modeling software, without the information content, can demonstrate daylighting throughout a building, the capabilities of a BIM can not only demonstrate the daylighting solution but quantify lighting levels. If you draw the natural conclusion that these passive offset design solutions necessarily inform the HVAC systems selection, the BIM readily demonstrates the efficacy of the sustainability inherent in the overall solution.

The development of this course, with its emphasis on the interdisciplinary team development and the utilization of BIM, reflects the movement in industry toward an improved method of design and construction that integrates technology and facilitates more effective and efficient processes in the built environment and the professionals responsible for such.[3] The foundation for these changes is in improving the processes that include all stakeholders across the entire life cycle of a facility and as such improve decision making for the built environment.[4] This class has had multiple outcomes. The least of which being the use of the BIM software technology to achieve a more sustainable and economically feasible design solution. It would seem that perhaps the cart ride of days gone by had more to it than just graphic representation, and it was the interaction with peers that contributed to its evolution just as the renaissance brought together knowledge previously compartmentalized by distance.

ENDNOTES

1. National Charrette Institute. “What is a Charrette?” 10 Sep. 2008 http://www.charretteinstitute.org/charrette.html

2. National Institute of Building Sciences. NIBS National BIM Standard Project Committee. “Overview National BIM Standard” 15 December 2007 http://www.facilityinformationcouncil.org/bim/publications.php

3. National Institute of Standards and Technology. NISTIR 7417. “General Buildings Information Handover Guide: Principles, Methodology and Case Studies”. August 2007.

4. Jernigan, Finith. “BIG BIM little bim”. 2007. 4 Site Press. Salisbury MD.