GIS + BIM = Integrated Project Delivery @ Penn State

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1 Introduction

In 2007, at the American Society of Landscape Architects Conference in San Francisco, Jim Sipes of AECOM presented, “Applying Building Information Modeling to Landscape Architecture.” There he shared a recent survey by the American Institutes of Architects showing that three-quarters of architecture firms in the country are using 3D and building information modeling (BIM) in their practices. Moreover, clients are increasingly requiring that BIM be a part of the qualifications when selecting design teams. Unfortunately for landscape architects, the current BIM software and standards were developed for the modeling of buildings—not sites. Sipes advocated that the profession needs to leverage software vendors and standards committees to further develop BIM technologies to incorporate site elements—and suggested that this new technology be called site information modeling. He later added that landscape architects need to be proficient in this ‘new’ technology or be left behind (SIPES 2007).

The challenge then is if BIM is not designed for site modeling, how do we educate landscape architecture students in BIM? The answer might be in the delivery process and not in the technology.

2 Methods

2.1 BIM and Integrated Project Delivery (IPD)

Owners, designers and contractors are exploring BIM as a way to change the design and construction process to produce more coordinated buildings at lower life-cycle cost with less risk, shorter project schedules and, potentially, facilitate more sustainable designs. Many companies are actively seeking graduates who can effectively work on these types of projects. To meet these evolving demands of the design and construction processes, universities have implemented a variety of courses to expose students to the new BIM software platforms. While BIM is a powerful digital tool, its effectiveness can be severely limited if it is not applied in an efficient and collaborative process. To this end, students should be exposed not only to the new software, but should also have an opportunity to utilize this new software in an integrated collaborative environment to design a project to meet certain specific project performance goals.

In 2007 the American Institute of Architects (AIA) National published the Integrated Project Delivery (IPD) Guide. The Guide defines IPD as a project delivery approach that “integrates people, systems, business structures and practices into a process that collaboratively harnesses the talents and insights of all participants to optimize project
results, increase value to the owner, reduce waste, and maximize efficiency through all phases of design, fabrication, and construction” (AIA 2007).

2.2 The Studio Collaborative

The architectural design and construction process is highly interdisciplinary. The accrediting boards of the allied disciplines require collaboration as a learning component. While they do not specify how this collaboration occurs they only ask that is achieved (POERSCHKE 2011). The IPD/BIM Collaborative Studio involves students and faculty from architecture, landscape architecture and four distinct architectural engineering disciplines in a design studio project, which explores BIM technology as a collaborative design tool. The studio is organized around the IPD process. Thus the IPD/BIM Collaborative Studio is providing an opportunity for students to not only become proficient in new digital tools, but perhaps more importantly, exposing them to a more “real world” collaborative design process.

The studio began three years ago as a small size interdisciplinary studio format (eighteen students from the architecture, landscape architecture and architectural engineering departments). Today, the studio has expanded to thirty students (five teams of six). Tasks undertaken include architectural, landscape and engineering design, energy analysis, cost estimating, scheduling, constructability, coordination and clash detection. Course content also includes an overview of BIM and its application to the design and construction process (including organizational and application challenges and potential legal issues), current BIM software as well as BIM trends in the design professions and construction industry.

Landscape architecture students apply their knowledge of site analysis, site engineering, and site design to that of building systems and performances. For example, they learn to appreciate that their goal to provide shading to the site directly impacts the program of mechanical architectural engineer who aims to increase the natural daylight to an interior space.

2.3 Studio Space

2.3.1 Integrated Studio

The physical studio space for a successful IPD/BIM collaboration is a challenge. It is not a matter of appropriate hardware and software, but the physical space. The studio is held in a student computer lab where the hardware and most software are available, but the workstation configuration is not conducive for team collaborations. Workstations in University labs tend to be arranged for individual research or classroom learning – not for team collaboration. Preferred arrangements are planned, but not yet implemented. Another constraint is software. Architectural engineering students working in an architectural and landscape architectural lab do not have access to specific engineering software. The workstations are equipped with the latest versions of Revit Architecture, Revit MEP, Revit Structure, ArcGIS, AutoCAD Architecture, Civil 3D, Ecotect, Navisworks, Project Vasari, and SketchUp. They are not equipped with specialized architectural engineering software such as ETABS, DAYSIM, RISA-2D, STAAD Pro, Trance Trace, eQUEST, and AGi32. Therefore, students wishing to use those specialized products must use alternate labs or load on mobile workstations.
2.3.2 Virtual Studio

To accommodate the needs of the growing studio and to allow greater access to specialized software, students are encouraged to work independently in their preferred spaces, but collaborate with the studio via enabling technologies such as Autodesk’s Project Bluestreak, TeamViewer, and Adobe Connect. Each landscape architectural student is equipped with an Asus Slate notebook to facilitate team collaboration. Using the Slates, students can utilize their preferred space and remotely interact with their studio colleagues via displays and multi-touch surfaces.

2.3.3 Presentations

Teams present their projects in three phases, BIM Execution Plan, Schematic Design, and Design Development, to their peers, faculty, clients, and outside professionals (Fig. 1). Professionals unable to travel to the University are accommodated to jury presentations via online collaboration tools such as Adobe Connect. The outside jurors can watch and listen to live presentations and type questions for the teams to respond to. This allows the studio to invite highly qualified jurors to the presentation regardless of their location.

![Fig. 1: Student team graphic illustration of their BIM Execution Plan](image)

2.4 Project Selection

The project is carefully selected for the IPD/BIM Studio, as the program must be complex enough for a semester-long endeavor for all disciplines. This is often a challenge for landscape architecture. The original request for proposals for building projects seldom includes a detailed site program for the team to work with. Therefore, site programs are enhanced for the studio.

The availability of a real client, project team and detailed design information for the actual project greatly enriches the experience.

The project should also be local so that students can make regular site visits (although this need may be mitigated with better online maps). Through the success of the 2010 studio offering, the ideal building size is around 20,000 S.F., though buildings have ranged upward to 100,000 S.F. in size. The optimization of building size is primarily to accommodate the time constraints of a semester studio.

In order for the students to work toward an integrated model, their designs must be completed midway through the semester. Otherwise, there is not enough time for the BIM integration and performance analysis to occur.
To date the projects types have all been academic institutions. The first was a prototyped elementary school, the second an on-campus daycare facility, the third an elementary school added to an existing school site, and this year an intramural sports complex addition.

According to Sipes, campuses are one project type where landscape architects could be using BIM. These types of projects involve the integration of buildings with a large site and from a master planning process also typically involves developing an understanding of the condition and capacity of academic and residential facilities and infrastructure; open spaces and landscape features; pedestrian, vehicular, and parking networks; academic needs; and the interface between a university and the larger community (Sipes 2008).

2.5 Team Selection

According to the AIA IPD Guide, “The project team is the lifeblood of IPD. In IPD, project participants come together as an integrated team, with the common overriding goal of designing and constructing a successful project.” This is true for all projects, but when complications arise in traditional teams individual discipline groups tend to “batten down the hatches” to protect their financial interest. In contrast, IPD demands that the team works together to resolve the issue. Because of this, the composition of the integrated team and the ability of team members to adapt to a new way of performing their skills within the team are critical (AIA 2007).

For the IPD/BIM Collaborative Studio this semester we have formed five student teams, each with a full complement of disciplines (architecture, landscape architecture and the four AE options: construction, structural, mechanical and lighting/electrical engineering). Our goal was to not only find thirty students, but to find thirty highly-motivated students with at least minimal background in REVIT or other BIM platform programs. Each student submitted their academic credentials along with a statement as to why they wanted to take the BIM Collaborative Studio. To establish the team assignments each students was to complete a survey of three questions: (1) whom do you not want to work with; (2) what is your level of BIM experience; (3) whom do you want to work with? Generally, this has worked well in establishing collegial and BIM competent teams.

2.6 Faculty and External Collaboration

The IPD/BIM Collaborative Studio is essentially three discrete courses collaborating on a single project. There is a course in architecture, landscape architecture, and architectural engineering each assigned a faculty member in the respective department. Additionally, a teaching assistant from architectural engineering and a research assistant from architecture are assigned to this course. Additional faculty members from architecture, landscape architecture and architectural engineering attend studio work sessions and formal project reviews. While input by faculty members at presentations and critiques is valuable, there is a need for on-going professional discipline support for the students in order to gain maximum benefit from the IPD/BIM studio.

Outside practitioners who are working on the same project as the students are invited to participate in both formal presentations and studio critiques. One studio activity that really benefits the teams is an activity we call “speed consulting.” In these sessions, professionals from several disciplines (e.g. civil engineering, construction engineering, architecture,
landscape architecture, and architectural engineering) move from team to team and provide feedback at a timed interval. This both enlightens the students with professional advice and energizes the practitioners with a satisfaction with the understanding that what they struggle with in their daily practice is also a challenge in academia. Practitioners also provide instructional models on subjects such as code and energy modeling.

A BIM Wiki previously developed at Penn State is also made available as a resource for students in both the BIM Collaborative Studio and other departmental initiatives (BIM Wiki).

2.7 The BIM Integration

The BIM and IPD process is a natural fit. One can say that the IPD process is only possible with the implementation of BIM and the success of BIM is only possible with the IPD process. This is true for the architects and architectural engineers in building projects, but BIM is a challenge for the students in landscape architecture.

Landscape architecture students are highly proficient with CAD, GIS, and 3D modeling, but few join the studio with BIM experience. They learn BIM from their architectural engineering teammates who have learned BIM in their earlier coursework. The landscape architectural limitation is not because of the lack of BIM education, but rather the lack of site-specific BIM software. The tools are not designed for their needs. “While Autodesk provides almost a limitless library of building, structural, and mechanical components, its landscape components are limited” (FLOHR 2010). Autodesk representatives at conferences have proposed Revit Site or Revit Civil, but none have made their way to the retail Revit suite. Therefore, the landscape architecture students have utilized other software applications to contribute to the BIM model including Civil 3D.

Landscape architecture students are using Autodesk Civil 3D to generate topographic site models. These models feature existing and proposed contours for their grading plans and include stormwater management elements. These final TIN models are not easily exported and imported to Revit, therefore they are simplified as 3D polylines and the TIN file is recreated in Revit (Fig. 2). This process works well for creating more detailed context to the architectural building, but does little for the building analysis.

Fig. 2: Civil 3D terrain imported into Revit
2.8 The GIS Integration

Landscape architecture students performed suitability analysis for last year’s proposed elementary school by inventorying and analyzing slope, views, linkages, vegetation, and existing infrastructure. The resulting map was converted to vector shapes to drive the location and orientation of the building in the Revit model.

This year’s project of an intramural building addition will likely not warrant detailed suitability analysis for siting a building, but context mapping of circulation systems and infrastructure, along with site views to and from building, will be evaluated.

In a campus setting, this project has potential of being a GIS-centered BIM project, where the Revit models are located on the GIS, rather than traditional BIM-centered workflow where the map elements are exported to the Revit models.

2.9 Other Technologies

In addition to GIS and BIM software, students utilize additional software tools for conceptual design and presentation in the IPD/BIM Collaborative Studio. Students take full advantage of the simplicity of SketchUp for conceptual design. SketchUp allows students to quickly generate concepts that are then imported into Revit. The building’s structural and mechanical components are designed in Revit and then exported back to SketchUp for further conceptual modeling before being returned to Revit for the final model. In the past, several teams utilized this ‘round tripping’—especially those with limited Revit experience (Fig. 3).

The teams utilize Autodesk 3ds Max to render interior materials and lighting scenarios for their final presentations. Teams also rendered site plans in the past studios with 3ds Max, but never with full integration of the BIM model. Instead, students touch-up their views or simulate landscape plans with the tools of Adobe Photoshop (Fig. 4). This year’s studio aims to explore more integrated approaches to site rendering without the need to perform photo simulations. Navisworks is also used for systems integration (clash detection) and 4D modeling.
3 Conclusions and Future Studios

Although the IPD/BIM Collaborative Studio has received a NCARB Award (2010), an ACSA Award (2010), two National AIA Technology in Practice Awards (2010, 2012), and an Autodesk Experience Award (2010), it is not without its shortcomings. The three areas for improvement of this studio are software, interoperability, and space. The software is not so much a shortage of the studio, but of the industry. The studio utilizes Revit products for the architectural modeling. Unfortunately, out of the box, Revit products are very little for the practice of landscape architecture. A lot of work is required to create basic landscape object libraries in order for the software to benefit the work for the landscape architecture students. Perhaps Revit libraries can be purchased or students can utilize other BIM products for their tasks (e.g. Vectorworks Landmark or Land F/X). The interoperability of BIM and GIS data is a challenge. Translation of this data is not perfect. Information is lost and workarounds constantly need to be invented. In an academic enterprise experimentation is welcomed. In practice, experimentation is most likely unbillable. Lastly, the studio requires a more collaborative workspace. Creating virtual collaboration is an option for some days, but having a studio configuration with shared projected displays would foster greater team collaboration.

References

AIA, AIA California Council. Integrated Project Delivery Guide.