Orchestrating the Knowledge Suite

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Abstract

A Building Information Model (BIM) has distinctively interdisciplinary contours. It is something more than a suite of interdisciplinary tools. It is also a process, more aptly described as virtual design and construction. A new paradigm flows from this process: The built environment can now arise from the modeling of knowledge, collected from collaborating partners, in a virtual process. In this new paradigm, the importance of individual skills yields to the primacy of collective knowledge. Tomorrow's students need collaborative sense because a BIM demands collaboration for its viability as an organism.

An intriguing research question explores and perhaps reverses the causal relationship between the organism and what sustains its viability: If the virtual design and construction process were to be imposed upon interdisciplinary student teams, would collaboratively induced knowledge arise as a consequence? In other words: Is BIM the topic of pedagogy or the tool with which to transform pedagogy?

Cal Poly's Interdisciplinary Project Delivery Studio (IPD Studio) is populated with students and faculty in Architecture, Architectural Engineering, Landscape Architecture and Construction Management. Enrollments exceed 72 students per quarter, three terms per year. The IPD Studio employs an integrated curriculum that traverses site design, adjacencies and stacking, mass modeling, schematic architectural and landscape design, conceptual structural design, construction sequencing, day-lighting studies, energy modeling, probabilistic scheduling and estimating of design and construction, construction logistics, value planning, and life-cycle costing. Among its other qualities, the IPD studio is a unique incubator of collaborative skills.

This paper will describe a classroom initiative that employs a virtual design and construction schema to attempt to understand the effect that BIM has upon collaborative knowledge development.

Keywords

Building Information Model (BIM), Macro-BIM, Integrated Project Delivery (IPD), Collaborative Knowledge Development, DProfiler.

1. INTRODUCTION

The College of Architecture and Environmental Design (CAED) at the California Polytechnic State University in San Luis Obispo, California offers a unique, multi-disciplinary course for 4th year undergraduate students from four departments within the CAED: Architecture, Architectural Engineering (Structural Engineering), Construction Management, and Landscape Architecture. The course, called the Interdisciplinary Project Delivery Studio (IPD Studio), is taught by a team of four professors in the disciplines of Architecture, Architectural Engineering, Construction Management and Landscape Architecture.

Its instructional design provides students with short lectures and informal desk critiques, augmented by site visits, analytical exercises, and case studies. Guest lecturers are engaged to provide topical information within their areas of specialization. Students present their work throughout the term, typically to a panel of external clients. The studio meets in five-hour sessions, three times a week, over a 10-week term. Meetings are in two, large laboratory spaces, each featuring a common area suitable for lectures and presentations, and separate work areas for student partnerships. The laboratory is open 24x7. New sections are taught each term (quarter) with three terms per academic year. Enrollments have been growing and now exceed 70 students each term.

2. PAST PROJECTS

Recent sections of the IPD Studio have undertaken, among other projects, a residential infill project focused on the rebuilding of the Broadmoor neighborhood of the City of New Orleans; design of portions of a master pan for the Sedgwick Reserve, a 4,896-acre parcel located in the Santa Ynez Valley in the coastal region of California; conceptual design of a new hub for digital fabrication within an existing suite of historical buildings on the campus of Cal Poly in San Luis Obispo; and a best value design-build proposal for 34,300 assignable square feet of new buildings and facilities for the College of Creative Sciences on the University of California Santa Barbara campus.

The challenges presented with those projects included high visibility, ADA compliance, hurricane-resistant design, LEED certification, universal design, cost constraints, schedule and phasing constraints, energy efficiency, historic preservation and adaptive reuse, sustainability, linkages between buildings and outdoor spaces, and innovative technologies.

Deliverables typically include an executive summary, project overview, program description, a site planning and development summary, conceptual design, schematic design drawings for buildings and site, structural design and analysis, a probabilistic cost estimate and project schedule, a cost model, a value planning analysis, a summary of relevant codes and standards, and other deliverables to meet the requirements of each specific project.

3. PROBLEM STATEMENT

Each quarter, students of the IPD Studio are organized into as many as twelve interdisciplinary partnerships. When these partnerships of engineers, architects, and construction managers are cast together they do not necessarily get along together. They come from different academic cultures. Notwithstanding the stereotyping, engineers are analytical, construction managers methodical, and architects are reflective.[1] On the interpersonal level, partners are strangers when first grouped together.

It is only when partners work together over time that they become cohesive enough to evolve into self-managed and truly effective learning teams (Michaelsen, Knight & Fink 2004). Team development occurs through a series of interactions that enable individual members to test the extent to which they can trust their peers to take them seriously and treat them fairly (Michaelsen, Knight & Fink 2004). Newly formed partnerships tend to engage in small talk; members displaying skill at navigating around debate so as to avoid disagreements. Usually the most competent member will dominate at first, leaving untapped the experience and knowledge of the other members. It takes most groups in excess of 20-25 hours of working together before that pattern starts to change (Watson, Kumar & Michaelson 1993).

Cohesive, effective learning partnerships have members that are willing to challenge each other to find the best course of action. The key to developing productive behavior is to cause students to work together, face-to-face, for a sufficient amount of time. Students will risk

[1] Preferences testing (a testing method acquired from research authored by Allen F. Harrison and Robert M. Bramson (2002)) of 209 IPD students over 4 quarters suggests that while students' preferences defy all stereotypes, a plurality within each discipline conforms to an ARCE as analyst, CM as methodical, ARCH/LARC as reflective (LARC more so than ARCH) characterization. Wherefrom, it could be argued that the disciplines form their cultural identities by subordinating their differences to the majority view. In that event, the cultural norms become whatever the plurality prefers.

challenging each other as they get over their initial concerns about creating a bad impression for themselves by being "wrong". The willingness to engage in productive intergroup dialogue– as opposed to win/lose debate or its counterpoint, the avoidance of all conflict – arises as students stop having to worry about being misunderstood by the other members of their partnership (Zuniga, et. al. 2007). Dialogue fosters understanding and from understanding comes trust. With trust, communication becomes more open. When this occurs, studies have shown that 98 percent of partnerships will outperform their own best member on learning-related tasks (Michaelson, et. al. 1989). It is this outcome that we seek. Yet face time alone does not guarantee that outcome. A high-performance partnership takes more than sitting in the same room together. However, sufficient face time is a prerequisite for high-performance partnering, for without it there is little opportunity for trust to grow.

It has proven difficult, however, to accumulate sufficient face time, early enough in each quarter, for cohesion to take hold within student partnerships. Part of the problem can be attributed to hardware. The studio meets in two large laboratory spaces. While those laboratory spaces are large enough, there are no computers except for student laptops to be found there. Students need specialized software such as Primavera P6, Timberline Estimating, Revit Architect and Revit Structure, and more powerful computers for "rendering" with Adobe Photoshop. Unwilling to tie up their laptops for extended periods of time, students prefer to render on university computers. For access to specialized software or to render, students retreat to the labs in their home departments. They complete their work in the home department laboratories but they complete it only by sacrificing the face time needed to develop a cohesive partnership.

Another part of the problem has to do with the configuration of furniture within the studio. Furniture is arranged in U-shaped bays. It is quite common to see teams of 4 to 6 students working in a bay, each student diligently working on his/her laptop, but all with their backs to each other and not a word being spoken between them. Yet students should not be criticized for this behavior. They have been given no other choice but to work with their laptops if they want to work in the same space together. So when they work together with their laptops they do what we ask of them and the absence of personal contact is the consequence. To foster intergroup dialogue we must reconfigure computers, monitors for group viewing, and furnishings in such a way as to turn students toward and hopefully talking to each other.

Yet another part of the problem has to do with finding a central focus to engage all of the disciplines, particularly during the first few weeks of the term. CMs and ARCEs are reluctant to contribute to a discussion on massing for their unfamiliarity with that concept. Even when a CM attempts to contribute, they are expected to comment on costs. However, CMs do not enter the studio with conceptual estimating skills. ARCH and LARC students tend to model with Google SketchUP and Rhino. ARCEs prefer Revit Structure. CMs are likely to know either Revit Architecture or ArchiCAD. Because their tools are different they develop separate models. Later, they hope to show that the ARCEs model was close enough to the ARCH model to validate the structural system's design. Students might want to build something together but they need material in their wheelbarrow if they are to have something to build with.

4. HYPOTHESIS

The complex, multi-disciplinary project deliverables required by the IPD Studio tend to allow students to work separately on task. Accordingly, tasks are readily divided up with little or no

comparison or feedback. Low team accountability is the consequence of rewarding individual effort (Porter, et. al. 1994). Team-based learning, by contrast, is a particularly good instrument to help students to learn how to work collaboratively (Michaelsen, Knight & Fink 2004). Moreover, as an instructional strategy, team-based learning generates a very powerful level of educational energy (Birmingham & McCord 2002). Not only does this enhance the quality and rigor of student learning but it teaches students how to form and sustain collaborate relationships. In other words, they learn collaboration by collaborating.

The instructional design of the IPD Studio has two levels. On one level there are large, complex project deliverables. On another level there is a stream of team-based instructional assignments that teach content and engage the student in understanding collaborative behavior. The hypothesis of this instructional design seeks to determine if the collaborative know-how gained at the assignment level will inform student successes at the complex project level.

5. METHODOLOGY

> *"Once [a partnership] is implemented, the growing body of shared information and mutual knowledge should enhance trust between the partners, because it increases their ability to understand each other better and hence predict each other's actions. Eventually, the experience of working together may produce a sense of shared identity and personal friendship. In short, the partners develop trust through the repeated experience of working together, making joint decisions and other contacts which generate familiarity and then bonding."*
>
> (Child, Faulkner & Tallman 2005)

The research methodology is designed 1) to increase opportunities for collaboration between the disciplines through the use of hardware and collaborative furnishings; and 2) to create the necessity for collaboration by deploying BIM as a central focus at a critical interface between the disciplines.

5.1. Hardware

Two iMac 3.1GB 27" large-screen i7 computers running Windows 7 will be provided in each of 12 student workstation bays in the two studio spaces. This new, i7 iMac is robust enough to

handle heavy Adobe Photoshop use, BIM design and heavy rendering or photo editing work. The software build of each iMac will include all the specialty tools employed by the students, including but not limited to Google SketchUP, Rhino, Adobe Photoshop, Revit Architecture, Revit Structure, Navisworks, ArchiCAD, and Primavera P6.

5.2. Collaborative Furnishings

Furnishings and computer/monitors will be reconfigured in a way to promote collaboration and intergroup dialogue. An iMac 27" computer can also be an external monitor, a very expensive external monitor but an external monitor nonetheless. Keyboard controls on the Mac enable the user to toggle the display input back-and-forth between different computers. Atlona AT-DP400 Dual-Link DVI-I to Mini DisplayPort Converters will be provided. This device converts DVI to mini-Displayport. With this device, student laptops PCs with high-resolution signals should be able to drive the high-resolution display of the iMac 27". Lower resolution PCs and older Macs should drive the iMac27" display with varying degrees of success.

Student partnerships will be situated to face each other while displaying their work on a pair of 27" iMac monitors. They will be able to display any combination of the own, personal laptops or the university-supplied iMacs side-by-side. This sort of open, comparative display facilitates group learning and decision-making.

5.3. BIM Deployment

Beck Technology, a wholly-owned subsidiary of the Beck Group, provides BIM software and services to contractors, architects, and owners. Beck's DProfiler™ is a Macro-BIM solution used in the planning and conceptual design phases to produce an accurate, simultaneous cost estimate. Licensed versions of DProfiler will be provided to the IPD Studio teams. Its deployment is expected to create the necessity for collaboration by constituting a central focus at a critical interface between the disciplines.

Traditional BIM solutions deal with Micro-BIM models that provide value in downstream processes, such as the production of construction documents and clash detection. DProfiler™ is used specifically to help project teams make better, more informed decisions earlier. It is also at this early stage of a project that instructors must facilitate the development of more collaborative behavior patterns within their students.

The DProfiler software suite is interoperable with both native Revit files and employs IFC protocols[2] it complements all other BIM platform, in particular Revit, ArchiCAD, Navisworks and Tekla (see Figure 2). SketchUP and Rhino files, what ARCH students prefer to create with, can be uploaded to DProfiler. Models can be downloaded from it in the form of native Revit Architecture, Revit Structure, or as IFC files for ArchiCAD and other open interface software such as Tekla and Navisworks.

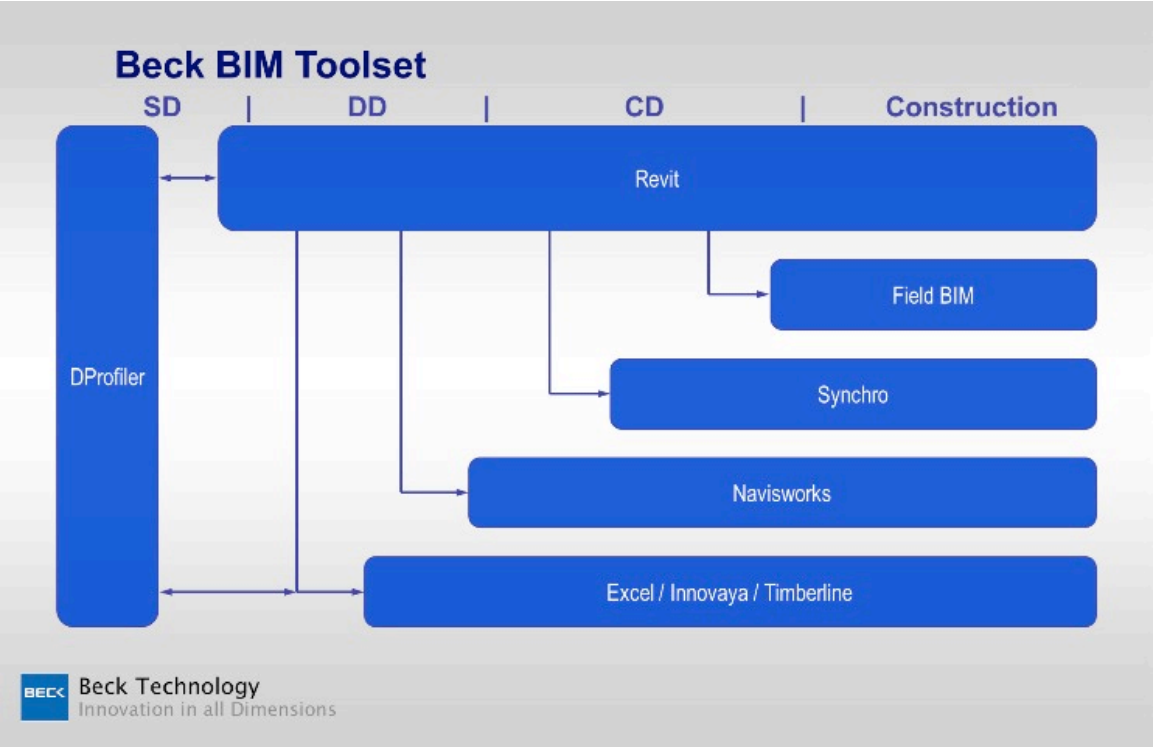

Figure 2 – Market positioning and interoperability of DProfiler

6. SUMMARY

Each term, Cal Poly's IPD Studio students undertake a challenging project that exposes them to integrated project delivery. Collaborative learning helps students to succeed at these challenges. Seeking to determine if collaboratively induced knowledge would arise as a consequence of the imposition of BIM at a critical interface, the studio will be providing each of twelve student teams with, among other things, dual iMac 27" computers running an extensive suite of software; furnishings, collaboratively rearranged; and DProfiler conceptual estimating software. Desired outcomes of this initiative are: superior group learning, more collaborative behavior, and

[2] Industry Foundation Classes (IFC) is a neutral file format that makes it possible to exchange information between different disciplines and different software in the building industry. IFC is an object-oriented file format with a data model developed by the International Alliance for Interoperability (IAI) a working group within the Build Smart Alliance.

improved decision-making.

The IPD Studio's faculty will be tasked to compose the methodology and to test the research hypothesis: does collaboratively induced knowledge arise as a consequence of imposing BIM on student teams? This paper describes the initial steps in the orchestration of that knowledge suite.

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