Digitally integrated practices: a new paradigm in the teaching of digital media in architecture

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Abstract *Promoted by a trend toward Integrated Practices (IP),* ***Building Information Modeling*** *(BIM). can provide instrumentation for the design, representation, documentation of the projects, and the exchange of information among designers and other stakeholders. A growing number of disciplines in the design and construction industry are embracing the use of BIM and consequently the academia is addressing related training needs. This paper presents the accumulative experience of the authors over the last decade regarding digital media integration and our current plans for addressing future demands and opportunities.*

Background Computer Aided Design (CAD) technology has been perceived as a potential mean for the integration of domain knowledge in the design process. Following the lead of software applications in other design and engineering disciplines, in the late 80's it was envisioned that multi-parametric modeling software would allow the modeling, of not only the geometric parameters of building projects, but also, of a wide variety of additional parameters. In 1993, the annual conference of the Association for Computer Aided Design in Architecture (ACADIA) was hosted at the school of architecture at Texas A&M University where a prototype of Electronic Design Studio, equipped with an early generation of multi-parametric modeling software was demonstrated. More than a decade later, this paper reports on the follow-up of that and other prototypical implementations and our current approach to using BIM as the instrumental platform for the integration of multidisciplinary content in the architecture curricula and design studios.

BIM as a Tool for Multidisciplinary Integration and Curricular Articulation The gradual incorporation of BIM to support integrated practices is still a process in the making and that also affects the way we incorporate BIM in our curriculum. Many look with optimism this transitional process ratifying the many promises made by BIM and IP, while others have started identifying the challenges for an optimal realization. For instance, Birx (Birx, 2005) has described several advantages of BIM benefiting architectural offices, among them: better project coordination, less man-hours in the production of the project, greater productivity, better quality design and detailing, control of architectural project information, and new markets for other specialized services (cost estimating, scheduling, and imaging). While, Scheer (Scheer, 2005) has discussed some of the challenges that the design and building industry will face to make BIM the tool for integrated practice, among them: To solve the interoperability among computer applications, to offer enough creative freedom, to export information to fabrication tools, to define the ownership and maintenance of the BIM information among design/construction partnerships, to create new business models for firms using BIM, to modify the culture in the profession and the industry, to foster new project delivery paradigms, to enforce the application of new model verification tools, to support "what if" scenarios, and to create a sophisticated data management system at the building object level.

Since the incorporation of BIM in the IP is not yet resolved, at the academic level we also face similar issues than in the practice. We have addressed two important challenges for the use of BIM as a tool for multidisciplinary integration and curricular articulation, namely, interoperability among computer applications, and creative freedom during design stages.

The Issue of Interoperability and the Integrated Curriculum

Since 2005, we have adopted the BIM software Autodesk REVIT for our freshman digital media course; we expect that the students will use this or other BIM programs to produce projects more thoroughly developed and refined than with 3-D tools alone. Since the BIM tools are not necessarily more expensive or more complicated to use than more widely deployed CAD systems, the students can focus more on learning to design by integrating building systems instead of just focusing on unrelated techniques for drafting and 3-D modeling. Yet, it will be required that students learn more about how building components and systems can be integrated into the functional/formal design. They also need to learn about fabrication (manufacture), construction, and new way of communicating and collaborating with other members of the design/construction team. This training can take place within design studios and at curricular level.

Beyond integration in the design studios, schools of architecture have been frequently asked by accreditation organizations about the possibility of providing the same level of integration at curricular level. In this case the issue is that in theory our curricula have been designed in order to facilitate that integration but in practice it is not happening. Our structure of pre-requisites is articulated with that objective but the absence of instrumental support has limited its implementation. In actuality the most common case is to find courses on environmental systems, structural systems, materials & building systems that are implemented in complete isolation between each other and in collective isolation from the design studios. A common instrumentation environment can be a powerful resource for integration. BIM is demonstrating that potential in the articulation of multidisciplinary content in design studios and it is predictable that it can be of similar benefit at curricular level. Nevertheless, the challenge in the process of identifying the most adequate instrumentation platform for a program curriculum is very demanding due to interoperability issues.

We agree with Jonassen that no single BIM available software platform addresses all the needs. Even if one did, the likelihood that a total project team will all use the same platform is negligible and likely to remain so. Nevertheless, much integration can be achieved with combinations of currently available software and BIM technology, and cultural changes. It should be understood that the use of the term model(s) in the BIM context refers not to a single, seamless database, but to a managed set of models that usefully integrate quantity, geometry and sequence (Jonassen 2006).

Thus, we have addressed the complex issue of interoperability among computer applications by applying a similar process than the one we used a number of years ago for deciding about the software that our CAD laboratories should offer. We will use combinations of accessible software that prove to be operational with each other. The following table illustrates the current level of interoperability that we have identified *(Table 1)*. Based on this information and our current agreements with many of the software vendors involved we are currently designing in further detail the future subjects of our Multidisciplinary Studios.

The issue of creative freedom during design stages

According to Clay Risen many see parametric modeling (PM) and BIM as the future of the profession. Neither PM nor BIM is wholly new. Gehry and a handful of other architects have been using PM software for over a decade, while the firm SOM has been using a rudimentary form of BIM for almost 25 years. The two fronts are not wholly distinct: most BIM software platforms contain limited parametric capabilities, while Dassault's Digital Project, as an example of a PM platform, can deliver some BIM functions. But their relative strengths are different, and those differences are drawing more clearly the distinction between service- and design-oriented firms. (Risen, 2005)

In the case of embracing the actual BIM open platform of software applications, the advantage is that we can probably address most of the content we need to integrate and in most cases it will be by using software components that the instructors of courses and studios are already familiar with. At the same time, our decision in the academic environment will probably have a good match with the kind of mainstream instrumental platform in the building environment. On the down side, it can be

Table 1: Interoperability among Software Applications

BIM DEVELOPER	AUTODESK	BENTLEY	NEMETSCHEK	GRAPHISOFT	OTHERS
Solutions	REVIT	Microstation	Vectorworks All Plan (Europe)	Archicad	
Analysis	Green Building Studio			Green Building Studio	Architectural Data Systems, E-Specs, Specificad
Structural	Robobat, Etabs, Risafloor Risa-3D	Ram, Staad	Links to structural Programs	Links to Structural Programs	
Mechanical, Electrical and Plumbing	MEO Revit	MEP Bentley			
Automated Estimating and Construction Managment	Innovaya, USCost Primavera	Bentley USCost		Graphisoft Constructor	
Code Analysis					Solibri Model Checker
Facilities Managment	FMDesktop	Bentley Facilities			

The NBIMS (National BIM Standard) is still being developed by the National Institute of Building Standards to create guidelines for all the software companies to integrate their data through the entire building lifecycle. The integration will be done through IFCs (Industry Foundation Classes)

SOURCE: H. Edward Goldberg, AIA, NCARB (Goldberg, 2006)

argued that current BIM implementations with minimal PM capabilities may still limit the creative freedom during design stages. Some may argue that the only actual limitation is the designer's creativity but in practice BIM environments are being first embraced by large firms that provide integrated services (e.g., design-built) and are not in particular known by the uniqueness of their architectural expression. In the case of embracing a PM environment that attempts to be all-inclusive (e.g., may include engineering specialty modules, among other workbenches and translators) the problem is that is not as much part of the mainstream as BIM may currently be and therefore the number of industry partners you can find is likely to be substantially smaller. On the up side, a number of signature designers are using different PM platforms with substantial success and no one can question the uniqueness of the design work coming out of those offices. The PM platforms may provide the necessary creative freedom during design stages, but not without the inherent additional effort of mastering the complexity of parametric tools.

In academia, the decision of using a collection of BIM components or a single PM platform for the articulation of technical courses and design studios will largely depend on the nature of the school and the firms that hire their students. For the most, a set of compatible BIM software components is less expensive than a PM software platform but this may not be an issue in schools of architecture that may have free access to both kinds of instrumentation.

BIM in the Multidisciplinary Studio The Integrated Practice Issues Forum that took place in Frank Lloyd Wright's Unity Temple in Oak Park, (Strong, 2007) was one of a series of events aimed to create a vision regarding future educational models in response to the accelerating trends of sustainability, technology, and collaboration in practice. Several interesting conclusions were stated by the different groups, among them:

That the students needed to experience developing design concepts within collaborative team approaches, where students for the period of a semester would take on specialist design roles.

That the "curriculum as required" is a format that explains the degree to which it would be studio and project based, drawing on multiple forms of expertise and providing multiple forms of experience.

That critically important for studio and other courses are "collaboration core competencies": Ability to work successfully in interdisciplinary creative teams, write and speak effectively on professional topics, and to be skilled in the arts of negotiation and facilitation.

We have already applied similar methodologies for the implementation of design studios as a spin-off from our experience in the implementation of virtual design studios. Since 2004, we have brought together students and faculty of the Department of Architecture, the Department of Landscape Architecture & Urban Planning, and the Department of Construction Science. In our multidisciplinary studios we have addressed built environments that call for a robust interaction of disciplines. En every case these studios have counted with the participation of a multidisciplinary group of faculty that have lead their students through the protocol that a professional environment is likely to address in the execution of a similar design and construction projects.

On instrumental terms, CAD has always provided support in the process of project documentation in these studios but during the 2006 implementation of this multidisciplinary studio some students with competency in the use of Autodesk REVIT have started to use it in combination with other BIM compatible applications. This is a new dynamic that was largely initiated by the students. Following this initiative, faculty has started discussions on how we can provide instruction on related best practices.

Our experience in the use of BIM as instrumental support for integration in multidisciplinary studios has been very positive. The students that have used BIM as decision-making instrumental support have been able to articulate levels of content integration that are clearly superior to those achieved by students using traditional CAD instrumentation in support of process documentation. This has been in particular obvious in the articulation of design decisions, construction scheduling, and building budget.

Conclusions Based on the authors' experience regarding implementation of design instructional environments assisted by digital tools, we may be approaching a potential shift of paradigm on the way we support knowledge integration in the design studio and across architectural curricula. The editorial line of the paper makes the following statements:

Architectural schools are currently called to address instructional needs at fundamental and pragmatic levels. At fundamental level students need to learn to integrate domain knowledge and multidisciplinary awareness. At pragmatic level students need to understand and know how to use digital technologies that will support their ability to integrate data, information, and knowledge in the practice of architecture.

We can effectively promote multidisciplinary awareness by means of multidisciplinary studios using BIM and/or PM technology as instrumentation platform. Preliminary experimentation with the use of REVIT and other BIM compatible pieces of software has been positive in the task of integrating design, construction and budget decision-making by multidisciplinary teams of students (Architecture, Landscape Architecture, Planning, and Construction Science).

We can effectively promote curricular integration between technical courses (Environmental Systems, Structural Systems, Material & Building Systems, and Professional Practice), Communication courses (Computer Aided Design), and Design Studios (Architectural and Multidisciplinary), using BIM and/or PM technology as instrumentation platform. Preliminary experimentation based in the teaching of related CAD tools within the design studio has been positive.

The question of using BIM or PM as instrumental platform for the integration of knowledge within multidisciplinary studios and across architecture curricula can be addressed as a de facto decision or as a concerted decision. In any case, the most critical issues to be address are:

- Institutional cost, if the software houses are not providing free access to their software.
- Mainstream usage by potential employers.
- Personal preference by individual instructors.
- Perceived/actual future development of the BIM / PM software environment.

At this time it is predictable that the mainstream of mid-size schools of architecture is likely to endorse the BIM platform. A smaller number of schools closely related with signature practices are likely to endorse the PM platform of the offices that hire their students. Finally, large schools of architecture are likely to endorse both platforms and continue to evaluate their potential future development.

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