

# Towards Studio 21: Experiments in Design Education Using BIM

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## ABSTRACT

Explorations conducted in university-based design studios suggest that Building Information Modeling (BIM) technology invites the adoption of a dramatically different design process. In contrast to conventional process rooted in successive refinement of initial abstractions and dependence on tacit knowledge, the Studio 21 BIM-aided process relies upon a complete and comprehensive base case and subsequent alternative schemes that are subjected to explicit analysis to support choice of the final design. The Studio 21 process can boost the objective level of performance that is achieved. It is teachable and may be a better process for addressing 21st century imperatives.

**KEYWORDS:** design, process, education, BIM, studio.

## Design Process and Information Tools

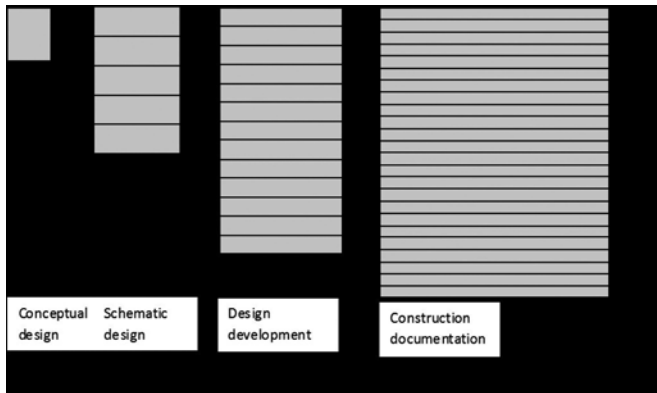
Architectural design process, in its general outline, has been static for decades or even centuries. However, the tools available to support that process have changed dramatically in the past three decades, transitioning from manual drafting to 2D Computer Aided Design software (CAD) to 3D CAD, and most recently to Building Information Modeling software (BIM). The premise behind this research is that the design process should change with the tools. Our conclusion is that there are profound benefits to rethinking the fundamental design process and aligning it with the capabilities of BIM and related tools.

The conventional design process is explained in numerous texts. The AIA handbook describes phases of a comprehensive design project as a sequence of program analysis, schematic design, design development, and construction documents—a pattern little changed in four decades (AIA, 1969, 11). A similar model consisting of successive phases of pre-design, conceptual design, schematic design, design development, construction documents, construction and occupancy has been presented as the fundamental process for contemporary green design (Kwok & Grondzik, 2007). Deeply ingrained in much of design education and design practice is the notion of a “parti” or guiding, simple and abstract design idea that is the prod-

uct of conceptual design (Clark & Pause, 1985). Simplification of the design problem into high levels of abstraction and then reduction in abstraction in each subsequent phase is a typical approach.

From a cognitive perspective, the warrant for decisions in the early stages of the conventional process is one in which “intuition alternates with experienced judgment” (AIA, 1969, p. 8). Multiple researchers have drawn distinctions between “tacit” knowledge that is undocumented, difficult to express, difficult to communicate, and practical, and “explicit” knowledge that is codified, conveyable and often generalized (Ambrosini & Bowman, 2001). Professional behavior of architects depends upon “tacit knowing-in-action” in which the actor cannot articulate or describe the motives behind nevertheless genuine and impressive skills that were obtained through experience (Schön, 1983).

The process of abstraction and successive refinement and the reliance upon tacit knowledge are both strategies for dealing with problems that are ill-defined or lack complete information. For discussion purposes, it is useful to name this mainstream design method the “Studio 20” process to emphasize its connection to patterns and tools of the 20th century. Figure 1 diagrams the Studio 20 process and its stepwise refinement of an abstract design into a detailed design (Fig. 1).



From a perspective of the history of information systems, the conventional design process arose from a period with comparatively crude information systems. When the information systems were paper, pencil, slide rule, and file cabinet, drafting dominated the billable time of a project. It was natural to take shortcuts in the process and base decisions on professional judgment. Similarly, the overwhelming tedium of engineering calculations, energy analysis, cost analysis and other forms of performance testing induced designers to rely upon their experience and judgment. The development of 2D CAD systems replicated the tools of overlay drafting without challenging the process of design (Clayton, 2005). In response to dissatisfaction with the conventional process, critics have suggested new, more integrated and comprehensive practices that make use of advanced information technology (Kieran & Timberlake, 2004; Krygiel & Nies, 2008).

The exponential rise of information technology has made accessible much more information that can be applied to a design project. BIM software provides objects that represent architectonic elements, parametric 3D modeling, rendering functions, automated drafting, rich graphic and non-graphic information stores, and interoperability to analysis programs. Nevertheless, it is in many ways advantageous to focus on BIM as the process of modeling a building rather than the model itself (Smith & Tardiff, 2005). The reduction in effort and the acceleration of activities provide the designer with an opportunity to collect more information and evidence to support design decisions. Design, responding to the demands of higher performance and the opportunity produced by better tools, may be evolving away from a “stepwise process” toward a more integrated, collaborative, and better-informed process (Vallero & Brasier, 2008, pp. 6 and 14). We have hypothesized that a new “Studio 21” design process need not depend upon strategies to reduce complexity but instead may apply powerful information systems to make explicit knowledge more readily available to the designer.

## Experiments in Integrating BIM into Design Studios

Several design studios at two institutions have been exploring the development of a Studio 21 approach that takes advantage of 21st century information tools (Ozener, 2009).

In our initial efforts to introduce BIM tools such as Autodesk Revit, after being introduced to Revit and given instruction in how to use Revit, students were allowed to choose their tools and decide on their own processes. Students mostly employed a conventional Studio 20 process, simply substituting Revit for AutoCAD. Schematic design was conducted using paper and pencil at a high level of abstraction, leading to a choice of a single scheme to develop further. Decisions continued to be made largely based on tacit knowledge. BIM was used in the late stages of the project when documentation and rendering began to dominate the process. The performance of the designs considering criteria such as energy use, construction cost, lighting or structural integrity were not assessed. Nevertheless, students were appreciative of the capability of the BIM software.

The mild success of these efforts led us to more aggressive experiments that reformulated the studio process. In a second trial, the researchers devised a course with a seminar format with a heavy emphasis on BIM theory, training, and process. We substituted the leisurely pace of the conventional studio with an intensive experience once a week. We arranged studio projects to be group efforts rather than individual efforts, defining expert “consultants” who would advocate for particular technical viewpoints. Nevertheless, when left to their own initiative, students slipped back into a conventional process of successive reduction of abstraction.

Recognizing that the students were following a path that we had already led to a disappointing end, the research team intervened in the process and imposed a requirement for a “base case” that prevented the students from using successive reduction of abstraction. The base case was an initial complete BIM model that solved the design problem in an obvious and simplistic way. (The base case concept is derived from a design method taught by Dr. Murray Milne at UCLA for many years and incorporated into the SOLAR 5 software for energy simulation.) Students created new Revit families and established parameters to support parametric modeling. Views were created to fully document the base case with plans, sections, elevations, perspectives, diagrams, and schedules. The base case was then thoroughly analyzed using software simulation packages for multiple design criteria, illustrated in Fig. 2. The interfaces and processes for automation and interoperability were documented so that they could be reused.

The base case then served as a benchmark that allowed comparison of the performance of additional schemes. A “Project Information Model” (PIM) derived from the base case consisted of custom parametric families, standard views and schedules,

and interoperable connections to analysis programs complete with ancillary files such as weather data and cost data, as illustrated in figure 3 (Fig. 3). Once the PIM was completed, a new scheme could be developed, usually within a matter of a few hours. Comparison charts helped the designers to track the improvement of designs from one scheme to the next. Figure 4 illustrates the Studio 21 process (Fig. 4).

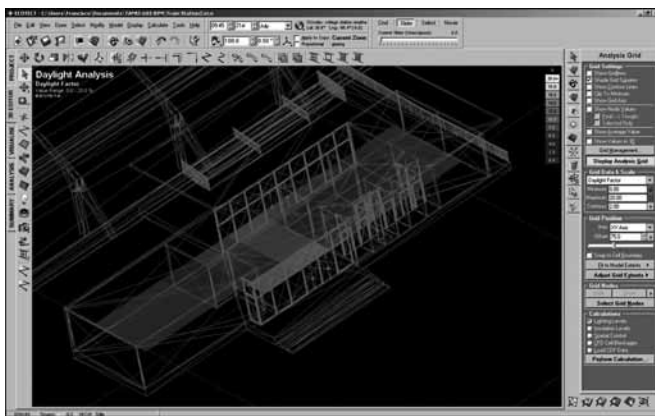
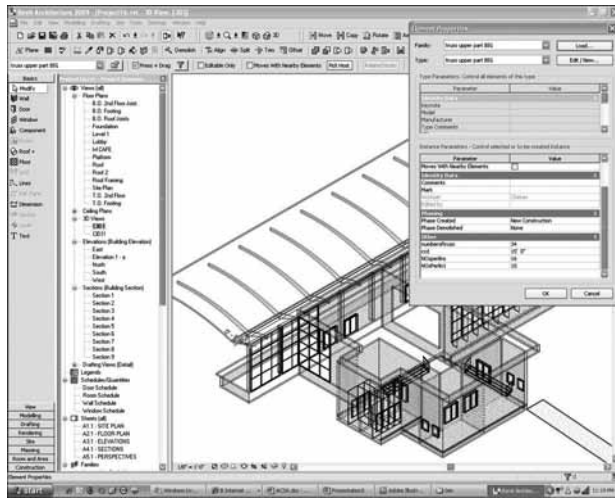


Figure 1. Successive reduction in abstraction in the Studio 20 process

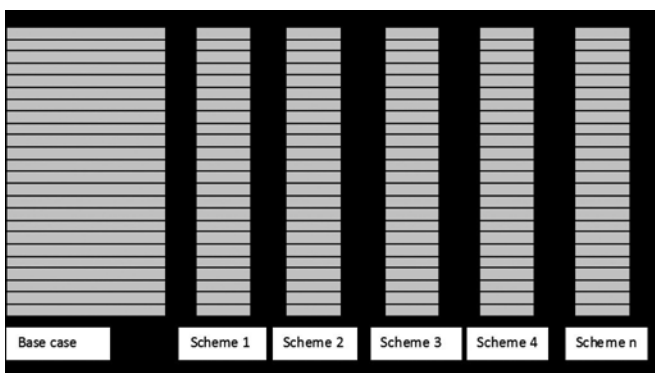


Figure 2. Scheme based on PIM template

Figure 3. Example of an interoperable analysis program (Ecotect)

Figure 4. Detailed design and testing in the Studio 21 process

The method led to high satisfaction and even excitement among the participants. Subsequent trials in other design studios and seminars at an additional university have shown that the new process can produce designs in comparatively short time periods that are objectively high quality and high performance. Furthermore, the conceptualization of a design process presented here can be taught and adopted successfully by students in many settings.

### Consequences of Studio 21

The Studio 21 approach radically changes the design process in terms of time devoted to particular tasks, definitions of schemes, and decision warrants. In the conventional Studio 20 process, the conceptual phase is relatively short, the schematic phase is somewhat longer, design development is longer still, and construction documents consumes the bulk of the time. In contrast, the Studio 21 approach is “front-loaded” so that much of the time is spent building the extensive base case and Project Information Model, as diagrammed in figure 4 (Fig. 4). Once the PIM is constructed, the design development and construction document phases can be done extremely fast, as they derive from the automated drafting systems of the BIM software.

The concept of a scheme is different between the two processes. In the Studio 20 process, a scheme is a fairly coarse abstraction. The designer must choose among several abstract schemes and then elaborate the choice into a single finished design. The schemes are not analyzed rigorously for performance but may be subjected to “rules of thumb” or tacit assessments of quality. In the Studio 21 process, each scheme is a complete design with a comparatively high level of detail. Each scheme is well-documented with respect to performance.

The warrant for decisions is also different between the two processes. In Studio 20, decisions are based largely on judgment, expertise and tacit knowledge. In Studio 21, decisions are based upon objective, even quantified measures of performance that derive from simulations and analytical calculations. The designer chooses a scheme among several alternatives based on examination of the performance. The designer may also refine a scheme to achieve higher performance targets.

The Studio 21 process is clearly different from the Studio 20 process. Arguably it can produce designs with higher performance by enabling the designer to rely upon objective measures of performance rather than tacit knowledge. Arguably it can be taught more quickly as it relies less on the slow acquisition of tacit knowledge through experience and more on explicit knowledge that can be transferred in a classroom setting or through written documents.

Beyond these advantages, the Studio 21 approach may have enormously beneficial consequences in the context of the many projects executed by a firm. As firms adopt and implement sophisticated modeling and analysis tools, their design processes

will shift also. A PIM is likely to be reusable on other commissions of the same building type or even on different types. The PIM begins to convert the tacit knowledge held by architects into explicit, reusable and transferable knowledge that can become the basis for marketable intellectual property.

It is important to note that neither a Studio 20 process nor a Studio 21 process in itself addresses issues of architectural art and expressiveness. Architecture that is poetic and entrancing is likely to continue to rely upon tacit appreciation of ineffable qualities that derive from experience and insight.

## Conclusions

Our experiments prove that “there exists” a process that is alternative to the conventional process. The new process is likely to produce better solutions more reliably and more rapidly than the conventional process. Adoption of Building Information Modeling (BIM) disrupts the patterns of education that have been used throughout the past century. When understood as not merely a technology but also a rigorous process of design, BIM enables the emergence of new premises and patterns for design education that can address the critical technical and social problems of the 21st century.

We suggest a BIM-enabled design approach that employs the development of an extensive base case and rigorous analysis of the performance of each scheme. The Studio 21 process can prepare students to produce high performance designs at significantly reduced effort. Design decisions can be founded upon concrete evidence rather than tacit and conventional expertise.

Nevertheless, within the context of conventional education, effective use of BIM requires substantial “unlearning” of patterns of thought and behavior that were suited to social and professional patterns of the 20th century. The challenge is for a school of architecture to devise and implement a complete curriculum that is equipped to exploit contemporary tools and meet the demands of the 21st century.

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