Design + Virtual Modeling: Course Integration on a Large Scale

KYLE TALBOTT, GIL SNYDER and JAMES DICKER
University of Wisconsin – Milwaukee School of Architecture and Urban Planning

Starting in 2001 a group of faculty at the University of Wisconsin – Milwaukee School of Architecture and Urban Planning undertook a three year effort to integrate introductory studio with introductory computer-aided design. Each year 160 incoming sophomores begin their first design studio. They also receive a laptop computer and begin concurrent enrollment in an introductory computer course entitled Virtual Modeling. Students participate in studio projects, computer assignments, hand drawing tutorials, computer tutorials, studio course lectures and computer course lectures. This takes the dedicated effort of four faculty members and five graduate teaching assistants.

The goals of this paper are 1) to describe the evolution of this large-scale integration effort, 2) to identify key success factors, and 3) to describe the impact on our students' beginning design education. The paper provides a balanced perspective by discussing both benefits and challenges. It begins with more concrete information and moves gradually into deeper issues.

Year One – Coordinating Schedules and Sharing Course Content

Because the studio instructors had a well-developed approach with a strong track record, and because the computer course was new, integration occurred primarily by planning the computer course around the needs of studio. However, the computer course benefited equally from the collaboration. The computer course used studio project work as the content of computer assignments. In each assignment students built a digital model of their current studio project, and then visualized it using various drawing and rendering techniques. This helped portray the computer as a creative tool, and it allowed technical procedures to support a broader framework of digital design principles.

The studio instructors facilitated the integration by providing a detailed schedule of projects and lecture topics. Because the projects were already well tested, this information was provided over a month in advance of delivery. With the inauguration of the computer course, studio instructors also redeveloped a series of studio-based drawing tutorials. Computer instruction was removed, and instead, the tutorials focused on hand production of measured drawings using a variety of media.

Year Two – Refining the Sequence and the Message

After the first year, we observed numerous points of disconnect between the courses, which we sought to eliminate. Many were sequencing problems. For instance, when discussing hidden line images, the computer instructor might assume that concepts of line weight were already introduced in the hand drawing tutorials. Or, when asking students to produce a printed floor plan, studio instructors might assume that students know how to use the computer to print to scale. In both cases, the prerequisite knowledge was not yet in place at the time the companion course needed it. Although such misalignments might seem trivial, they had a significant impact on the students' experience. At some points students voiced confusion and frustration.

At other times misalignments were more insidious. For example, after receiving an introduction to the nature and construction of perspective images in the computer course, students began producing perspective images in studio. A printed perspective might facilitate communication at a desk crit or act as an underlay for sketching. While studio instructors encouraged this practice, they also noticed that the perspectives were often distorted, which hampered their usefulness. Although the students had learned how to *generate* a perspective, they had not absorbed some key principles about how to *compose* one. In this case, the sequence of topics was right, but the emphasis was wrong.

Identifying misalignments and altering course content to repair them emerged as one precursor to integration success. The process also revealed a key advantage for the computer course. Studio became a second test-bed for the development and refinement of computer lectures and tutorials. The computer instructor could gauge the penetration of a certain message by witnessing its effect on studio activity as well as student performance on computer assignments.

A third kind of misalignment posed a different challenge. Here, an optional sequencing emerged. For example, at one point students produced a shadowed site plan by hand and by computer. Either technique could come first without a conflict, yet students' perception was different depending on the sequence. In the first year, the computer site plan was made first, followed by the hand-drawn version. The computer technique is more time-consuming and tedious than most computer work, and many students found it burdensome. However, the hand technique is even more time-consuming. Students realized this only afterward. Because of the sequence, however, they perceived both as distasteful, and retention suffered. In the second year we reversed the sequence, introducing the hand-drawn site plan first. Students appreciated the hand technique because it introduced concepts of shadow casting and hand shading. When subsequently taught the computer technique, they appreciated the increased speed and level of detail. Both techniques were better valued and remembered just by changing the sequence.

In some cases misalignment was deliberate. For example, computer assignments were never due on the same day as studio projects, which reinforced the idea of the computer as a facilitator of creative thinking rather than final drawing production. Later in the semester when studio projects increased in length, students confronted issues of iterative design modeling. They would build a computer model one week, then update and refine it in the next week, as they continued to work on the same studio project. By producing models and images in various states of development, students grasped implicitly that a computer model, when used in design, evolves in parallel with one's thinking, just like a material study model.

When these and other sequencing constraints combine, they form a fairly complex network of interrelationships. Finding a sequence that satisfies all constraints requires a critical path-like mapping of the teaching schedule. One topic can be assigned a parametric relationship to another. For instance, "Topic A must be covered at least one week before topic B;" "Topic C may come before or after Topic D, but both must be covered before Topic B," "Topic E may be covered at any point between Topics A and D." This example specifies the relationship between only five topics with three constraints, and it is already difficult to visualize. Diagramming helped, and it would have gone faster with scheduling software.

The critical path approach might seem overly scientific, but, just like conventional critical path scheduling, it illuminated where pivotal dates fell and where we had unanticipated flexibility.

Year Three – Balancing Freedom and Structure

Instructors shared a belief about the appropriate balance of students' freedom to explore and their need for a systematic introduction to design. Both courses emphasized the later, using tightly constrained, short-duration assignments to explore focused principles of design and computation. Although exploration and personal expression were encouraged, they were contained within narrow boundaries. The high value placed on systematic introduction can be seen in the student work, which has a consistent character (Figures 1 through 4). The figures show examples of computer assignments three through twelve, which used studio projects as content.

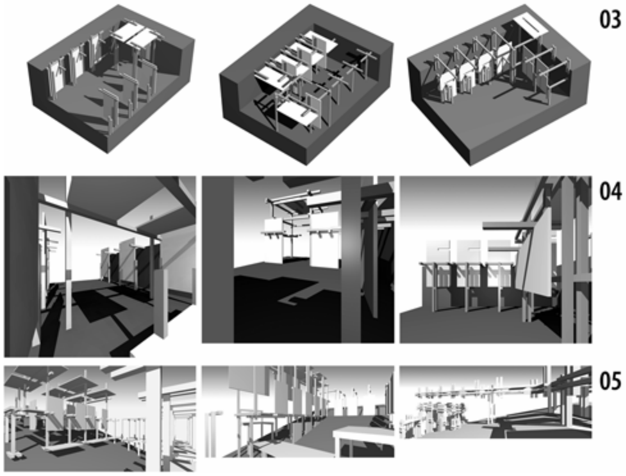

Figure 1

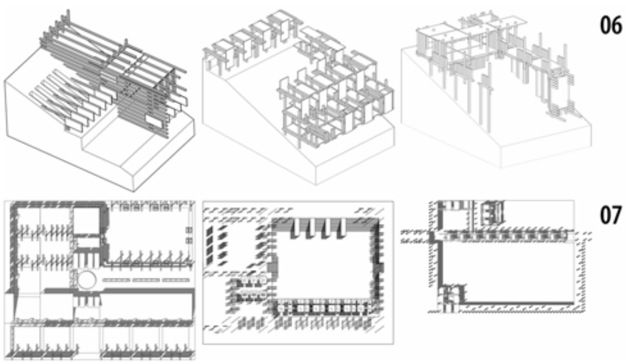

Figure 2

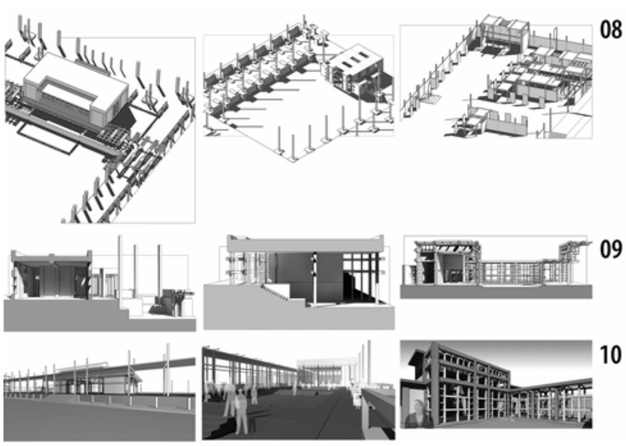

Figure 3

11

12

Figure 4

Systematic instruction was compatible with the large-scale nature of the effort. The system allowed 1) ample individual student feedback, 2) consistent standards for fair grading, and 3) evaluation of a huge volume of student work, included approximately 3,500 images in the computer course, and 1,100 projects in studio.

Since constrained projects can protect students from making poor decisions, it might be thought that the structured approach hampered an empirical process of learning by mistakes. In the computer course, however, the structure actually increased opportunities for empirical learning. Teaching an introductory computer course with a 160 to 1 student-teacher ratio normally precludes laboratory teaching and one-on-one dialogue. However, by limiting the scope of each assignment, communicating clear evaluation criteria, and defining a rhythmic cycle of activities, students were able to participate in hands-on, laboratory-based learning and get significant individual feedback. For each weekly computer assignment, students went through the following cycle: 1) turn in an assignment, 2) get it back the next week with a grade and written comments, 3) get further feedback and clarification at a weekly discussion session, 4) rework the assignment based on feedback, and 5) resubmit it for an improved grade. This cycle further aligned the computer course with studio by reinforcing the studio method of iterative learning through a make – review – revise cycle.

Wherever possible, the structure was allowed to relax. Studio and computer course lectures remained independent. This created opportunities for unexpected lateral associations. On any given week, a studio lecture and a computer lecture might discuss similar topics from a different point-of-view, or two seemingly different topics. Less apparent similarities began to surface, and the ideas presented in both courses were usually reinforced. For example, most beginning students would not consider the relationship between formal archetypes and digital object types, but students actually asked questions related to this after hearing contiguous lectures. In another instance a studio lecture on layering and phenomenal transparency was serendipitously coupled with a computer lecture on the accentuation of depth in digital images by layering foreground, middle-ground and background. On another occasion a lecture on figure-ground in the computer course followed shortly after a lecture on the space-object distinction in studio. In each case students recognized a single underlying principle, despite different terminology and context. In fact, the shift in context seemed to deepen understanding of the principles. It also introduced a useful repetition, allowing the same principle to resurface for a second consideration.

Loosening the integration of lectures yielded benefits, but this strategy could not always be used. While all instructors agreed that coursework should be tightly structured, the particular conceptual framework that optimized learning in each subject was not the same, and in fact, they were partly incompatible.

In studio, the conceptual framework emphasized the primacy of architectural space, and project constraints accentuated issues related to space-making. For instance: 1) student compositions must be orthogonal, and 2) student compositions must use a given kit-of-parts. These rules limited form in order to emphasize space, and they focused students on spatial concepts including the space-object distinction, implied spatial boundaries, multiple spatial readings, hierarchy of spaces, and sectional development of space. Despite their appropriateness in studio, these constraints undermined the conceptual framework used in the computer course. There, teaching was organized around five fundamental methods of digital making, including aggregating, carving, extruding, molding and skinning. The combination of orthogonal form and kit-of-parts construction meant that all digital models were aggregations of rectangular objects. This eliminated most opportunities to practice four of the five methods of digital making.

This obstacle could only be circumvented by compromising one conceptual framework or the other. Since the computer course acted as an adjunct to studio, it was altered to accommodate the needed studio constraints. A balanced survey of five methods of digital making was replaced by an in-depth investigation of a single method, aggregating, which was supported by the studio work. Carving, extruding, molding and skinning became the focus of an intermediate digital design course.

Results and Conclusions

In the years prior to course integration, most students segregated computer work from design thinking. After three years of integration, the design culture of the school changed. Establishing a shared learning environment with a cohesive teaching method encouraged students to build associations between design and computation. Also instrumental in building this conceptual bridge was the instructors' attitude toward the computer. Rather than present it as a revolutionary force capable of redefining architecture, it was presented as one component of a broader toolset. The whole toolset needed to be mastered, and the computer had no greater or lesser status than hand drawing or material model-building. Although design-computer integration did not ignite a design studio revolution, it did have an impact. Students are beginning to think *through* the computer, just as veteran architects think through sketches and cardboard study models.

Students benefit from a more diverse repertoire of visual skills. Difficult hand techniques like perspective, for instance, become fast and intuitive with the computer, which allows students to effectively study a human point of view earlier. Prior to course integration, perspective drawing was rare in the short-duration projects of a beginning studio. Or, if they did occur, they appeared at the end of a project, after the design was fixed. By inserting perspective representation into the design process, first-person experience gains a new voice, and some kinds of rationalistic thinking are curtailed. Computer model-building directly in perspective is a related technique that takes the perspectival power of the computer one step further. This technique is gaining popularity with some of our advanced students. It subtly shifts the focus of design away from overall organization in plan and section to the tectonics and materiality of space-defining boundaries.

The most interesting benefit of the integration could be the lateral associations. By placing students in an environment rich in opportunities for lateral discoveries, compartmentalization of the subjects broke down further. It should be noted, however, that students were motivated to search for these connections *only because coursework was integrated*. Segregating coursework in the usual manner does not reward or punish such cross-topic connections, and consequently, students learn to ignore them. When students' grades in one course depend on what they learn in another, and when lessons from one course must be applied to complete the work from another, students become highly motivated to bridge any apparent differences between subjects.

Student motivation was generally enhanced. Both students and instructors noticed a catalytic effect, in which each course became more intriguing through the collaboration. By building computer models of their own designs, students became emotionally invested in computer assignments that might otherwise seem dry and technical. And likewise, integrated computer skills helped students see more compelling images of their designs, encouraging them to push it further in studio.

As mentioned previously, lateral associations seemed to help students grasp principles more effectively through repetition and context-shifting, but perhaps more importantly, it seemed to help them grasp what a principle *is* and why principles as such are needed. Instead of accepting the importance of a certain principle in the abstract or on faith, students saw more tangible examples. They saw how a principle explains numerous, divergent aspects of the world, and they experienced more intensely the power of a principle to reveal a unity in seemingly different phenomena.

Large-scale course integration does have disadvantages that should be sensitively mediated, but the benefits seem to make it worthwhile. Key success factors in our case were: 1) a willingness to substantially alter course content to make coursework seamless, 2) an ability to share detailed schedule and project information well in advance of delivery, 3) an ability to identify and eliminate sequencing errors, 4) an ability to find a comfortable balance between tightly coordinated coursework and loosely coordinated principles, 5) a willingness to impose a structure on student design exploration, and 6) a willingness to adjust the conceptual framework used in one or both of the subject areas.

Acknowledgements

Image credits in order of appearance: Carl Brickbauer, Ned Derksen, John Court, Kyle Kinney, Soraya Villarreal, Ryan Sands, Adolfo Jimenez, Ryan Sands, John Court, Beth Hansen, Craig Thran, Daniel Merkel, Joshua Mory, Adolfo Jimenez, Justin Wagner, Debra Zandt-Stastny, Daniel Merkel, Ryan Sands, John Court, Daniel Kohlmann, Carl Brickbauer, Kyle Kinney, Christopher Love, Carl Brickbauer, Jonathan Turek, Mistie Rodberg, Alex Fortney, Mistie Rodberg, Carl Brickbauer, Mistie Rodberg.