Digital Design Pedagogy

STRATEGIES AND RESULTS OF SOME SUCCESSFUL EXPERIMENTS

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Are there design techniques unique to digital design software that should be explicitly taught or should one leave it to serendipity for students to discover these techniques? A review is provided of the experience of different teaching strategies for digital design pedagogy over a four-year period and, on the basis of this experience, recommendations for successful strategies are given. The teaching strategies presented assume prior training in basic three-dimensional digital modeling and hence represent a first exposure to digital design methodology. The three areas in which digital design provides unique strengths are: a) a three-dimensional design process; b) curvilinear and geometric design; and c) simulation to test the effectiveness of a design from various points of view, with particular emphasis on natural lighting. A brief overview is provided of the theoretical content of the course, the nature of the in-class design exercises, and the term project; all are visually illustrated with examples. The endeavour to reach an optimal pedagogical strategy was both enriched and complicated by the constant change in functional ability of digital design and simulation software and the availability of new software. Nevertheless, it was possible to draw some useful conclusions.
1. INTRODUCTION

When designing digitally, there are techniques to explore and to teach that are different from traditional, hand-drawn techniques that one should not leave to serendipity for students to discover. There are three ways in which digital design, as proposed here, is different from traditional, hand-drawn design. In the first place, it differs most fundamentally in that design progresses by assembling components in three-dimensions rather than by drawing two-dimensional representations. At the same time the design iterates through alternatives as the design evolves from a simple massing model to a highly detailed one. That is not to say that design evolves in a linear way; design aspects at different levels of detail can be explored at any time, but in an overall way there is a progression to greater levels of detail. Design iteration and progression from a low level of detail to greater detail is not unique to digital design, but it is greatly facilitated by digital design. Plans, sections and elevations are by-products of three-dimensional design. In traditional design it is the other way around, in that it is the two-dimensional representations of a three-dimensional form that are used to develop a design. In the second place, digital design differs from traditional methods in that it is possible to design and document shapes with complex geometries far more easily than by traditional means. Indeed, if the software is sophisticated enough, it is possible to set all kinds of geometric and proportional constraints that will allow geometry to play a far greater role in design than in the recent past. In the third place, digital design allows one to simulate how a building will perform before it is built. Most commonly, designers use three-dimensional modeling to create numerous renderings to test the appearance of a design. Physically accurate lighting simulation, for example, goes beyond rendering in that one can accurately predict both natural and artificial lighting levels in the interior of a building and one can predict both quantitatively and visually in terms of accurate renderings. There are many other areas in which the performance of a building can now be tested by digital means, if there is an appropriate three-dimensional model of a design, such as a Building Information Model (BIM), available. These areas, which are beyond the scope of this paper, include prediction of natural air circulation (using computational fluid mechanics), acoustic performance (with binaural simulation where a designer can actually hear how a space will sound), stress analysis, cost analysis, people movement and temperature/energy performance throughout a day.

Although computers have been used in practice for a generation, design methodology has remained largely unchanged in most architectural practices. Current design practice is really an adaptation of traditional, two-dimensional design methods based on plans, sections and elevations to digital tools. When three-dimensional modeling is used, it is used primarily for rendering. There is therefore a need to teach new methodologies of digital design that capitalize on the potential for improving and enriching design that is inherent in the use of digital design tools. The profession can be enhanced and ultimately led by a new generation of digital designers graduating from schools of architecture.

In order to illustrate the teaching of digital design methods in each of the three ways that digital design differs from traditional design approaches, the following sections describe the theoretical components of a course designed to teach these methods. In contrast to a conventional/traditional architectural design studio, where each student should develop his or her design methodology in a way that most suits his or her personality, in the course described here, basically a mini-studio, each student is required to try the various techniques taught in class exercises and in the term project. The hope is that, once the students have internalized the techniques, they will appreciate their worth and use them when appropriate. The course is structured as a weekly lecture and demonstration of about one and a half hours followed by a digital mini-studio of three to four hours in the school’s computer lab (currently consisting of Macintosh Pro G5s). In addition there is a small term-design project to put the design methodologies into practice. Thus the emphasis in the course is on doing, hence the many in-class exercises and the term project. Achieving this emphasis within the lab contact hours and the limited time available outside class has been problematic, particularly with respect to the term project. Although the course assumes that students are already conversant in three-dimensional computer modeling (formZ in our case), most of the digital design methodologies taught go hand-in-hand with the teaching of digital software techniques that are new to the students. The course is predicated on the understanding that solid hands-on experience in digital software techniques go hand-in-hand with digital design strategies, just as a musician needs to learn the technique of playing his or her instrument thoroughly.

2. DIGITAL DESIGN METHODOLOGY

The following is a description, illustrated with examples, of the successful design methods that have been taught in the course. With experimentation it has been discovered that some of the topics require two or even three classes to begin to be mastered by the students. Consequently, while all the material presented below has been covered in one iteration of the course or another, it
is not possible to include all of the topics in one twelve-week course. Topics that have been expanded include curvilinear design and day lighting. The latter has become an especially important ingredient in the design of more humane and energy efficient buildings (“more humane” buildings are here intended to be ones in which a broader range of social, psychological and physical issues are addressed than is usual thus leading to a higher quality of life than would otherwise be the case).

2.1 DIGITAL DESIGN PROCESS
This topic provides an overview of what it means to design digitally in three-dimensions. It makes the point that most architectural practices manifest the “horseless carriage syndrome” whereby architectural design proceeds much as it has before the introduction of design technology. To emphasize the need to try alternatives, it is useful to bring up the characterization of design as puzzle-making that was introduced in a memorable paper in 1986 by John Archea. To summarize, one might say that, architectural design involves seeking a fit between a set of parts (architectural components) and how they are put together (rules), and the resulting effects that are achieved (visually and spatially, for example) when the parts are assembled in a certain way (Archea 1986). The architect, in this analogy, makes puzzles (designs) in which each part has a pleasing relationship to the whole. To describe how the parts are put together as being on the basis of rules may seem instrumental or downright prosaic to some but it has been long established in research on digital design that style can be encapsulated in the form of rules as can construction detailing (Stiny 1975; Gero and Radford 1985; Seebohm and Wallace 1997, 2006). It is also clear from the puzzle-making analogy that we are not talking about a given puzzle but rather that the architect is, in effect, designing a puzzle when designing: The architect designs both the pieces and the puzzle. Different puzzles with different puzzle parts correspond to different design alternatives. Neither the kit of parts nor the effects that result when the puzzle is assembled are fully or explicitly described in a building’s design program. To emphasize the importance of developing design alternatives (alternative puzzles), this lecture also introduces the concept of design space, a term well known among digital design theorists, but not known amongst architects. Design space simply refers to all the design alternatives that have been developed. The alternatives can be completely different overall designs or they may be alternatives for parts of a design. In any case, to keep track of the alternatives in the design space, a “space” of file folders must be designed. It turns out that the few architectural offices that have been practicing digital design as proposed here, have each developed for themselves a system of filing that goes beyond a filing system for the design space but includes all design data from initial conception to final design. Some examples of how to structure a filing system for digital design information (including naming conventions for folders and files) may be found in the Art Institute of Chicago study of current digital design practice, “Collecting, Archiving and Exhibiting Digital Design Data” (The Art Institute of Chicago 2004). This study was carried out to determine what documents architects were using in digital design practice in order to determine what digital information a museum of architecture should archive, but in the process the study evolved to include how different firms actually practice digital design. The study contains several case study projects by firms practicing digital design showing the various stages of a design from initial conceptions to the final design. Several of these case studies are shown in class. Some of these architectural offices combine hand sketching and physical sketch modeling with three-dimensional digital design. That certainly should not be discouraged because the act of sketching on paper and physically with models is a powerful method for design exploration that has not been improved upon with digital tools for the early stages of the design process. Nevertheless, at some point the three-dimensional digital design process must begin. In the first iteration of the course students were asked to create simple sketch models of their term project in formZ (Figure 9). Most recently, Sketchup was introduced for this purpose, to the delight of the students. The combination of ease of use, architectural quality of the images (with real-time shadows if desired), and dimensional precision make the software ideal for design exploration (Figure 1). Figure 1 shows an example of a sketch exercise for a garden pavilion.

To emphasize the continuity of three-dimensional digital design from sketch modeling to working drawings and construction management, one class and a mini-studio was devoted to an ArchiCAD workshop in which the students learned enough to model a simple building. ArchiCAD is one of three software packages (the others are Revit and Allplan) that are fully predicated on the development of an underlying three-dimensional model as the design proceeds. In other words, these packages are Building Information Modellers (BIMs). Although the three-dimensional model is actually mostly constructed from the two-dimensional floor plans that one draws with the software (indicating that, in fact, the two-dimensional plans, are often needed to position three-dimensional entities such as walls), ArchiCAD develops a detailed three-dimensional data base which tracks all the building components that
make up a building. Thus, when the time comes to produce dimensioned working drawings these are easily produced at any desired scale with appropriate cross hatching, line thicknesses, dimensions and title blocks. In addition, tables of bills of materials can be extracted for cost estimating because the three-dimensional model is able to track what a building is made of. Furthermore, the three-dimensional model can be being linked to energy analysis software. Being able to produce energy performance simulations is becoming critical for energy efficient design. Europe has already in place a directive that requires energy analysis of all buildings starting in 2006 (European Union 2006). ArchiCAD has partially implemented the export of BIMs in the IFC (Industry Foundation Classes) format and it exports to the Green Building Council’s gxml format. Ecotect, a software package for the early stages of energy efficient design (among other simulations), will be able to import gxml models in its next release.

2.2 CURVED SURFACE DESIGN
The objective of designing buildings comprised of curved surfaces, based on examples that we all know of from the recent past, is to develop pleasing and striking forms. In that sense curvilinear building design is like sculpture, the major difference being that the forms have to accommodate a program. Consequently, coordination is required between outer form and inner space that can only be achieved by iteratively varying the forms. As is well known, Frank Gehry is the most prominent and successful proponent of this kind of architecture.

While the process of arriving at beautiful curvilinear forms is largely an intuitive one, nevertheless, there should be a more rigorous basis to digital curvilinear design than pushing and pulling on control points of Non-Uniform B-Spline (NURBS) surfaces to manipulate form and to study alternatives. A more rigorous basis would also be needed if such curved buildings are to be documented for construction and for systematically studying alternatives. Insight to a way out of this dilemma was gained from the way curvilinear forms are created with Bentley’s Generative Components as developed by Robert Aish and collaborators (Aish 2004). With this software, curved surfaces are generated from three-dimensional splines that are created either directly or as a result of the intersection of curved surfaces. The shapes of the splines (and hence the surfaces) may be varied systematically by changing parameters that directly control the shape of the splines such as points on the curves or control points off the curves. For an undergraduate course, where curved surface design is only part of the course, becoming conversant in Generative Components is too much to cover in a short time. Instead, the course continues to use formZ and its curvilinear functions. With the insight gained from Generative Components, however, the course now emphasizes control of the curved surfaces by focusing on the design of the three-dimensional spline curves and saving alternate versions of these splines on separate layers, one layer per alternative. Thus, while formZ does not allow parametric variation of generating spline curves (without extensive investment in scripting with formZ’s C-like scripting language) one can manually generate alternatives somewhat systematically. It is also useful to construct the generating splines within a three-dimensional rectangular geometric framework to further assist in systematic variation and to provide some overall proportions among the parts. The assumption is, if the three-dimensional rectangular framework, that is the assembly of bounding volumes, has pleasing proportions, then the overall curvilinear design will tend to be pleasing also, even though curvilinear forms do not themselves have obvious proportions. Figure 4 shows a simple building, a bus shelter, following these principles. From these insights, the following approach to curvilinear building design is suggested. First, think of the shapes that are to be created. Second, determine the three-dimensional geometric armature or bounding volumes to contain the splines that are to generate the curved surfaces. Third, systematically vary the armature and the splines to obtain a family of different curved surface designs. This family can then be used to determine the most pleasing shapes and those which most effectively accommodate the program. While this is a very linear description of the process, there is nothing to say that one could not jump out of a loop to try different armatures and splines. This, more systematic approach, was adopted in the most recent iteration of the course.
where students were also asked to document the process they used in an accompanying text file. Prior to that the course requirements for curvilinear form were not so rigorous but some good designs were, nevertheless, obtained. This is because the most important part of learning to design curvilinear forms is to develop skill in creating three-dimensional sculptural forms. Experience has shown that at least three sessions are needed to begin to impart this skill. The first assignment has usually been to design some glass objects inspired by the works of Finnish designer Tapio Wirkkala as shown in Figure 3 (Aav 2000). The next design, in the most recent version of the course, was a small kiosk of which the bus shelter (Figure 2) is an example and the third exercise was a chair (Figure 4).

2.3 GRIDS
Some of the digital design methods presented here originate in traditional design theory but are much more easily applied when designing digitally. It is as if these methods were developed in anticipation of digital design software.

The use of grids is one such example. Underlying the adoption of this approach to digital design is the understanding that we are designing in three dimensions by assembling architectural components in three-dimensional space. The components are placed in relation to geometric references in the form of three-dimensional grids. To be more precise, the components are placed in relation to the intersection points of the lines in the grid. In digital design it is convenient to convert the components into instances (of blocks or symbols) so that the origins of these instances are what is placed precisely in relation to the intersection points of the grids. To use a linguistic analogy, one could say that the components are the words and the syntax is the way the components are placed in relation to each other by means of the grid. Tectonic expression (symbolic and tactile) results, as in language, from the expressiveness of the shape of the components (words) and how they are used in relation to each other (syntax). Examples of the use of two-dimensional, rectangular grids are shown from the work of Palladio and Le Corbusier in the comparison of the plan of the villa Malcontenta and the Villa Garches in Colin Rowe’s famous essay (Rowe 1976). Frank Lloyd Wright’s Usonian Houses, in particular the Jacobs House of 1936 and the Hanna House of 1933, show how components are positioned in the drawings in relation to a three-dimensional grid. In the case of the Jacobs House the grid is rectangular in plan whereas in the Hanna House it is hexagonal. By positioning components in relation to the grids Wright was able to avoid dimensioning altogether. It is also shown that rectangular grids do not have to imply rectangular buildings as in Herman Hertzberger’s Vredenburgh Music Center in Utrecht. In fact, grids do not have to be rectangular at all as can be seen in Alvar Alto’s designs for the Wolfsburg Cultural Centre and for Finlandia Hall where combinations of rectangular and fan-shaped grids are used. In digital, three-dimensional design software it is easy to set up grid lines on separate layers and then to insert instances of components so that they snap into position in relation to grid intersections. Given that students already have the ability to use grids and symbols there are no specific exercises on this subject but the method is encouraged for the term project.
2.4 Proportion

Proportion is another area of traditional design methodology and one that goes far back in architectural history. Proportions are more easily applied in digital design than in traditional design because one can set up underlying proportional systems in the form of tartan grid lines that are easily changed. In more sophisticated software one can even set up parametric relationships between the forms and the underlying proportional grid systems, thus allowing one to experiment with different proportions. The proportion lecture begins with the use of regulating lines as described by Le Corbusier in *Towards a New Architecture* (Corbusier 1972). Here he shows applications of the regulating lines both to historical examples and to some of his own designs such as the Villas Schwab and Garches and the 1923 studio house in Paris. Then Le Corbusier’s Le Modulor proportioning system and its relation to the Golden Section and the Fibonacci Series is explained with examples of how Le Corbusier applied measurements from the Blue and Red Series to his designs. The lecture then turns to Schindler’s use of the Row system of proportioning as recently discovered and described by Lionel March and Jin-Ho Park (March 2003; Park 2003). Schindler preferred a proportioning system with simple whole numbers as had been commonly used throughout the centuries particularly in the Renaissance as in the floor plans of Palladio’s Villas. Schindler preferred simple whole numbers because he was able to visualize three-dimensional designs based on them in his head (contrary to lesser mortals, he did not require three-dimensional modeling software to design!). Although March had previously shown a preference for whole number proportioning systems, rather than the irrational number system of the Modulor, he has recently, with Jin-Ho Park, come to the remarkable conclusion that it is possible to set up a proportioning system in which the Row and the Modulor systems are reconciled forming a continuous sequence of proportional dimensions. Examples of designs in which Schindler used the Row systems of dimensions are the How House, where the ceiling joists explicitly show the Gnomonic Diagrams from which the Row systems of proportions are derived, and the Braxton Shore project. Figure 5 shows a shelving system designed with the Red and Blue Series.

The proportion exercise was done with formZ, but ideally this should be done with a constraint-based parametric software package (perhaps in the spirit of Sketchpad, a geometry package) so that by changing parameters one could study changes in proportions.
2.5 DAYLIGHTING
Without appropriate lighting, the best colour designs will remain unappreciated. Lighting design is another area that can be greatly facilitated by designing digitally. The focus of the lighting component of the lecture is on day-lighting. The various sources of daylight that enter a room through a window are explained: direct sky component, direct sunlight, externally reflected light such as light reflected off buildings and the ground, and internally reflected light which is light reflected off walls, ceiling and floor. Considering that lighting design involves both a quantitative and a visual side, basic lighting terminology is introduced, particularly the difference between luminance and illuminance and the units that are used to express each. To obtain a feeling for the quantitative aspect of light, the intensities of various light sources are given as are the design light levels for different tasks. We then show images of a few naturally lit spaces and a room lit by natural light as rendered by physically accurate rendering software, Radiance (Ward Larson and Shakespeare 1997), so that students know what to expect.

After some experimentation, Cararra and Ecotect/Radiance (run in emulation on the Mac G5s) were selected for day-lighting design because of their ability to calculate global illumination, that is, physically accurate lighting simulation and rendering including the inter-reflection between surfaces. Ecotect’s interface to Radiance now makes it easy to use this software albeit without a simple way to specify material surface properties other than colour. The objective of the lighting exercises is to design a room with fenestration that produces quality lighting (in terms of atmosphere) and sufficient light levels where needed for specific tasks, such as writing. Designing sun shading to reduce summer heat loads while still allowing sun to enter in winter and to provide adequate natural light was another objective (Figure 6 and Figure 7).

2.6 LIGHT AND COLOUR
There is a great deal of theoretical background that could be provided here but, unless this theory is tied to some assignments it is of no great benefit to students. Colour theory has therefore been limited to the basics of human colour perception including how the human eye works in terms of the lens, and the cones and rods on the retina. There is a discussion of colour spectra, colour spaces and colour gamuts. This is followed by additive and subtractive colour mixing to give the students an understanding of what they are looking at when they see colour. The focus then shifts to design issues, one of the most important of which, is the relativity of colour. For example, in a room whose walls are painted white, why is it that they appear grey when patches of direct sunlight fall onto them? The reason, of course, is that the sun patches are so much brighter in luminous intensity, that the portions of the walls not in direct sunlight appear dark relative to the bright sun patches because the light intensity there is so much less. Case studies in colour design strategy beginning with the work of Le Corbusier are subsequently considered. While Modern Architecture of the classic period in the first half of the twentieth century is thought in some quarters to have been black and white, a look at Le Corbusier’s work quickly dispels that notion. For example, the Villa Roche of 1923, although completely white with black window frames, on the exterior, includes an art gallery where none of the walls are white. Instead we see beige, bluish grey, and brown: evidence of Le Corbusier’s intense involvement with colour as seen in Polychromie Architecturale, which shows the colour keyboards that he developed between 1931 and 1959 (Rüegg 1997).
keyboards allowed Le Corbusier to study colour relationships, that is, groupings of colours to use in designs. The second part of the light and colour lecture introduces Christopher Alexander’s colour theory as it is presented in *The Luminous Ground* (Alexander 2004). His theory does not guarantee good colour designs but it does provide eleven “Colour Properties” that he considers to be necessary conditions for good colour designs. Given that colour is so easily changed when working digitally, trying alternate colour schemes based on colour groupings like Le Corbusier’s keyboards combined with Alexander’s colour properties makes digital design fertile ground for colour creativity.

2.7 MOTION THROUGH SPACE

Animation is a component of the course, but rather than being a technical component, which it was in the 2004 edition of the course, in the 2005 edition, animation was introduced as a design tool along lines influenced by Darlene Brady who was the first to introduce the idea to my knowledge (Brady 1997). Modern architecture, as developed in the first half of the twentieth century, was largely concerned with a new sense of space: a feeling of openness, of spaces flowing into each other and demarcated by planes (both solid and transparent), curved surfaces, and columns. The implication was that this flowing space was to be experienced by the observer moving through it. Yet there were no design tools to test the experience of moving through these Modern spaces other than the mind’s eye. Digital animation software allows one to simulate motion through space, to show the user what will be seen as one moves through architectural space and to test design alternatives. One can, for example, design for the way planes and columns, at different distances from the eye, move past each other in specific rhythms as one moves through space. Designing for particular views that appear as one moves through space is important because these views determine where people move. Such emerging views can be tested with animation.

2.8 DIGITAL PRESENTATIONS OF ARCHITECTURAL PROJECTS

When designing digitally as taught in the course, plans, sections, elevations, section-perspectives and renderings are by-products derived from the three-dimensional model developed during the design process. Special lectures on presentation methods have been found necessary. One reason is that it is not sufficient to simply take a hidden line of orthogonal views as presentation elevations. Similarly, sections though a three-dimensional model at a standard height above the floor are not equivalent to presentable floor plans. It is necessary to demonstrate how the hidden line views must be enhanced with changes in line thickness and other enhancements to convert them into presentation draw-
ings that are legible. Among the possible panels that one might show in a presentation is one that gives an overview of the design. We have focused on this panel in particular because one panel is needed to give the viewer an overall understanding of a project. Such a panel requires a combination of suitable renderings, drawings and text. To best understand how to compose this introductory panel, a tradition has been followed that was first introduced by John Marx (Marx 1998), of showing a number of posters designed in the early part of the 20th century by artists and architects (Figure 8).

3. TERM PROJECT

The real measure of the course is the design quality of the term projects whose objective is to incorporate the lessons of the course with special emphasis on designing iteratively in three-dimensions proceeding from a sketch design to greater levels of detail. Evaluation was based on the degree of iterative exploration, the clarity of structure, interior day lighting quality, quality of digital modeling (use of layers, symbols, economy of means, structure and clarity of digital documentation), appropriateness of digital strategies, landscape and/or modeling of context, quality of final presentation including clarity of drawings, quality of renderings and layout of the presentation (which in some years was a PowerPoint presentation whose first slide was an introductory overview panel).

Different methods for assigning the term project were tried. For two years the term project was completed entirely outside class time. One year it was integrated into the in-class assignments and, most recently, students were able to submit their studio project as the course’s term project as long as it met the objectives of the term project in the course with evaluation according to the criteria just noted. When the term project was done entirely outside class time the milestones were set as follows:

The first milestone was a series of hand sketches. The next milestone is a preliminary 3-D model (Figure 9). The purpose of the preliminary 3-D model is to show design intent in a very simple way. Next is the 85% model. It is intended for a formal mid-term review providing opportunity for feedback not only on digital strategies but also on design from critics not necessarily familiar with the details of three-dimensional modeling. Further milestones called final model, poster mock-up, and final renderings are simply deadlines to pace the class so that the presentation for the final review is not attempted the night before. Figure 10 shows images of final projects from the 2004 offering of the course while Figure 11 shows images of the final project from the 2005 offering of the course. Ideally, the digital design course would be run in parallel with a studio and the studio project would be the term project. One student in 2005 decided to follow the major principles of digital design (i.e. fully 3-D and iterative) in his studio project and therefore, as an experiment, he was permitted to submit the studio project as a term project (Figure 12). Figures 13, 14 and 15 show some projects from earlier in this year when all students in the course submitted their studio projects as the term project.

![Figure 9 A AND B Examples of a preliminary 3-D model (canoe camp)](image)

![Figure 9 A AND B Examples of a preliminary 3-D model (canoe camp)](image)

![Figure 10 Term project: a music pavilion from the 2004 course](image)
4. CONCLUSIONS

One measure of the success of the course is the quality of the in-class assignments however, as noted, the most important measure is the quality of the term projects. Integrating the term projects with the in-class assignments did not work as well as when the term projects were completed entirely outside class time. This is because it is difficult to mandate that creativity occur during specific time periods and that creativity be focused on the specific digital design strategies taught that day. When completed outside class it was important to move the project along with milestones and a mid term review. The milestones also allow opportunities for feedback. The disadvantage is that the students considered the workload for the course to be high when the term project was completed outside class time.

The ideal is to have the lessons from the course integrated immediately into the design studio project running in parallel with the course. The result of attempting this integration this year showed some room for improvement that could be resolved with the co-operation of the studio instructors. For example, it would be very helpful if the studio requirements included the term project requirements for the course. Under pressure of deadlines, students do tend to fall back on old ways designing two-dimensionally and creating 3-D computer models only for rendering purposes. Furthermore, because sustainability was not an explicit requirement of the main studio project (a high rise hotel in downtown Toronto) students did not incorporate the day lighting and shading studies for their hotel rooms from the course assignments, with building elevations that were the same for all compass orientations. It also appeared that when difficulties arose with digital design strategies it would have been helpful if the course instructor had been part of the full time studio teaching team. Consequently, when difficulties arose, digital design methodologies were some times abandoned. At the same time others took risks. It was amazing to see some students use ArchiCAD (Figure 13) to design their entire project and thus produce plans and renderings all from the same computer model with plenty of time to try design alternatives (I had always thought of ArchiCAD’s true value becoming more evident in the later design phase which academic studios rarely approach).

Overall, the students seem to like the course as attested to by the quality of the work and by their appreciation for design methodologies that were new and interesting to them. It is likely that even closer integration with a design studio will produce even better results.
REFERENCES


