The Constructed Image

KYLE TALBOTT
University of Wisconsin - Milwaukee

INTRODUCTION

The production of computer renderings is now commonplace. In some ways, this has led to a dramatic rise in image quality, but the transition has also caused problems. Some complain that computer renderings are rigid and cold,[1] too precise,[2,3] or creatively biased.[4] This paper investigates the impact of computers on the making of presentation images. It considers how a rendering engine effects the application of long-standing graphical principles and the teaching of these principles to students of architecture.

Graphical principles can be divided into two categories: depiction and composition. Principles of depiction cover such issues as foreshortening, illumination and texture, which establish a visual correspondence between image and subject. Principles of composition, on the other hand, describe visual relationships between graphical elements, regardless of depicted content.[5] Principles of composition cover such issues as figure-ground, repetition, balance and contrast. Whether we choose to follow or undermine them, these principles allow architects to express a graphical intent, rather than naively adhere to the path of least technical resistance.

Drawing instruction for architecture students traditionally includes both kinds of principles. However, the adoption of computer rendering seems to have eroded this focus, replacing it with an affinity for the technology itself, its technical procedures, and its novel graphic product. Much like the old controversy of using calculators in introductory mathematics, a question arises about the substitution of technical skill for principled understanding. The advocates of principled understanding often imply a moral corruption, and implore teachers to shake off the seductive effects of the medium and regain their discipline. However, there is a technological factor. It comes from fundamental differences between hand and computer, which erect a difficult barrier to teaching graphical principles through the new medium.

This paper identifies some fundamental differences in the process of making a hand drawing and a computer rendering, which if not recognized and addressed, could undermine students' ability to comprehend wider principles. The paper then presents teaching methods created to address the problem. The methods were developed in a unique environment in which beginning architecture students participate in tightly integrated design studio and computer aided design courses.

THE SHIFT FROM INTEGRATED TO SEGREGATED IMAGE-MAKING

Skill at depiction has always been highly valued, and it often inspires awe and admiration from laypersons.[6] Mastering depiction in traditional media is a challenge, requiring years of training in life drawing, perspective construction, color theory and illumination. Because depiction involves an external referent, which provides a standard of precision, its techniques can be systematized.[7] Principles of composition, on the other hand, are normative and often abstract. They are difficult to articulate, and it is often effective to embed them in instruction geared to depiction. In this way, compositional ideas *remain implicit* in the work of depiction, and they are *acquired* by students in an indirect but meaningful way.[8]

This was an effective method of instruction because the two considerations unfold simultaneously in the act of drawing. In one moment pencil marks capture features of the subject. In the next, they further the self-sufficient beauty or stability or tension of the form. This simultaneity is disrupted by the computer, which segregates depiction and automates it extensively.[9] With such powerful capabilities as geometry modeling, light calculation and on-the-fly perspective, the computer generates depictions with speed and precision beyond any hand.

With the effective automation of depiction, its principles are rarely taught today. Such subjects as descriptive geometry, perspective construction and shadow casting have either been eliminated or substantially curtailed to accommodate computer instruction.[10] Because depiction was often the vehicle by which composition was conveyed, the erosion of instruction in depiction has also eroded instruction in composition. Although the removal of the former might be justifiable, the removal of the later is not. The computer has no corresponding ability to automate the assessment or adjustment of composition. For instance, it cannot compensate for the balancing effect of light. From one viewpoint a certain shadow might need to lighten, to achieve a balance in the distribution of values, whereas, the same shadow might need to darken when seen from another viewpoint. The computer's lighting calculations remain true to its rules of simulation regardless of the viewpoint and the need for compositional balance.

The loss of instruction in composition is not only the result of this package deal. The nature of computer rendering makes it difficult for students to understand and master compositional principles. Two attributes fundamental to rendering engines contribute to this. Each is described in the following sections.

THE SHIFT FROM LOCAL TO GLOBAL CONTROL

When drawing by hand, an architect relies on a local decision-making process to assess both depiction and composition. As his eye examines the subject matter, he selectively captures visual attributes at a succession of points, transcribing them to a corresponding position in the drawing. If a particular edge seems important, it is recorded with a line. If another edge seems tertiary, it is deemphasized or ignored. In this way an architect enjoys a great freedom of selectivity, in which every visual attribute is evaluated before it is recorded.[11]

On the other hand, computer rendering is a global process. An architect controls a set of variables that effect like attributes across a scene. He cannot choose to accentuate or filter a particular edge or tone, and instead is asked to determine an overall distinctness of edges, as well as a general amount of illumination affecting all.[12] The result is a uniformity of treatment uncharacteristic of hand drawing.

Global variables offer powerful and unprecedented depiction control. Consider transparency. By defining the transparency of glass as a category applied to all glass objects, this aspect of depiction can be iteratively refined with little effort. Once the exclusive province of skilled illustrators, transparent effects are now commonplace.

Unfortunately, global variables often produce detrimental compositional side-effects. Despite correct depiction, things can look awkward or flat or empty in some places. However, if an architect attempts to correct the problem by manipulating variables, he cannot isolate the change. He can probably correct it, for example by muting colors or shifting the sun position, but doing so will also cause a host of changes across the image, inadvertently disrupting desirable effects at other locations.

Because global control is based on a classification system relevant only to depiction, it cannot effectively control composition. In hand drawing, compositional adjustments are isolated and undertaken for their own sake, not rationalized through a system of depiction.

THE SHIFT FROM INCREMENTAL TO FINISHED DISPLAY

When drawing by hand, an architect builds up an image in passes. Because it is an incremental process, she adjusts as she draws. If a certain area lacks depth, for instance, she might darken an already depicted shadow. Or if a particular edge seems weak, she can thicken it slightly. Or consider the reflectivity of a polished surface. It would normally be added after other effects are laid down. In this way architects make adjustments that are not only local, but build gradually. In contrast, they cannot alter a computer rendering until the calculation is complete. They see only the finished depiction - the summative effect of all visual attributes.

Although some compositional adjustments can be made after the fact in image-editing software, such opportunities are limited. It is difficult to selectively darken and lighten shadow regions, for instance, because it is difficult to isolate them. Because the RGB color value of each pixel is the sum of all visual effects operating on it, it is an indivisible unit that cannot be adequately distilled after-the-fact into its component effects. The post-processing of images is a crutch used to regain some semblance of compositional control in an image-making process dominated by concern for depiction.

Even if every visual attribute could be isolated during post-processing, the bias would remain. When depiction precedes composition, its precise and complete presence camouflages compositional weaknesses. In hand drawing, perfect depiction is a theoretical state never encountered because of an iterative dialogue with composition. On the other hand, the computer presents us with a tangible perfection. Seen immediately in a finished state, any alteration made for compositional purposes seems to degrade the perfection.

EFFECT OF THE SHIFT

The power of depiction still awes us, and this is the "seductive effect" of the computer rendering. Acquiescing to the seduction, some students learn to devalue composition. They come to believe that the "know how" of the rendering engine makes it unnecessary to scrutinize its product. They expect to push a button and produce a finished rendering. Others try to resist. They spend long hours juggling global variables and performing clumsy post-processing, only to be dissatisfied with the result. Some eventually resort to cosmetic effects such as fog, solar flares, and extreme reflectivity to make images look stylized and expressive. Willingly or reluctantly, students eventually bow to the authority of the rendering engine, and visual literacy stalls.

A craftsman who specializes in rough carpentry never develops the sensitivity needed for finish work. The same is true for students who do not practice the scrutiny needed for compositional control. When students see images as wholes and adjust them indirectly by means of global variables, they lose the opportunity to develop a discerning eye.

A tool exclusively designed to depict cannot much help a student learn to compose, and therefore principles of composition cannot be taken for granted when teaching computer rendering. The process of computer rendering, when conducted in the conventional manner, leads to a loss of practice, resulting from a lack of opportunities to differentiate and evaluate visual attributes and to adjust them in reference to compositional goals.

PRINCIPLE OF THE CONSTRUCTED IMAGE

Studying composition requires local and incremental image control. The pedagogical principle of the constructed image states: *In order to learn about composition using a digital medium, a student must construct an image in parts and in stages, using a computer rendering as input to a substantial additional effort, in which the raw depiction is disassembled, recombined, and adjusted for compositional purposes.*

This principle is implicit in some contemporary approaches to image-making, but it is often a "workaround" used to regain some semblance of compositional control. Because a workaround deviates from normal procedure, it is usually assumed to be aberrant and temporary. In this case, however, the workaround results from a deep need reasserting itself. The effort to reengage composition cannot survive if it is relegated to workarounds. It must be reformulated as a new principle, asserted explicitly and taught systematically. By identifying the principle and understanding its demands, a teaching approach can be built around it. The following sequence of studio exercises provides an example of a systematic introduction to the principle.

EXERCISE 1: RECOGNIZE THE INCOMPLETENESS OF A COMPUTER-GENERATED IMAGE

Because it only depicts, a rendering engine produces a half-considered image, which cannot stand alone as a final product, and which instead must be actively altered to breed an image of quality composition. Students must grasp this before any other facet of the principle is conveyed. Integral to this effort is the need to overcome the initial seduction of a seemingly perfect depiction. As effective as a computer is in generating depictions, its simulation is imperfect. Only if students can see a computer rendering as incomplete and flawed can they learn how to take control of the machine.

This is difficult, since most beginners take it for granted that computers "draw" better than they ever will. To grasp the principle, it is insufficient to simply tell students to be critical. A teacher must show them the imperfection, and help them become unsatisfied with it, so that they *want* to improve it. Until students can see the weakness and identify its undermining effect, they will not really accept the principle of the constructed image.

Sunlight makes an excellent topic for such an exercise, since students usually believe the computer depicts it flawlessly. The first exercise requires a student to construct a large-scale foam and gesso model of a row house built of concrete block. The site and construction method make it difficult to access natural light, and the design of beautiful, subtle and varied light is imperative.

Students are encouraged to view the massiveness and opacity of the masonry as an advantage. The effect of light passing through a thick opening and washing across a surface is examined in detail. Students learn to appreciate subtle qualities of light through a series of visualization exercises and lectures. The common assumption that direct light is superior slowly gives way to an appreciation for reflected light.

As they study light with foam models, students simultaneously build computer models (Figure 1). Using both, they are asked to explore the quality of light from the perspective of an inhabitant. They photograph the foam models to explore lighting at different times of day and year. Additionally, they use the computer model to produce a similar set of studies. The students then compare the results, using their new awareness of light to critically evaluate the relative success of the images.

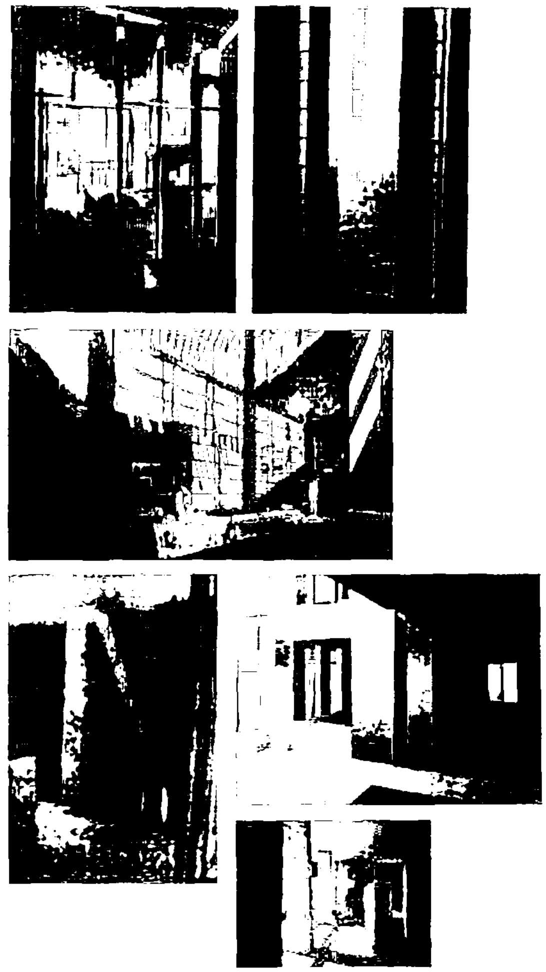

Figure 1. Finding Flaws in Computer-simulated Light

Remarkably, most are strongly dissatisfied with the digital images. They complain that the images look flat and washed out or are too dark. They complain that walls appear too smooth, free of the subtle irregularities that contribute to a rich wash of light. They notice that gradations are too uniform, appearing almost diagrammatic. Although students also recognize shortcomings in the photographs - such as insufficient depth of field and the inability to get a camera in tight spaces - most prefer the photographs over the renderings.

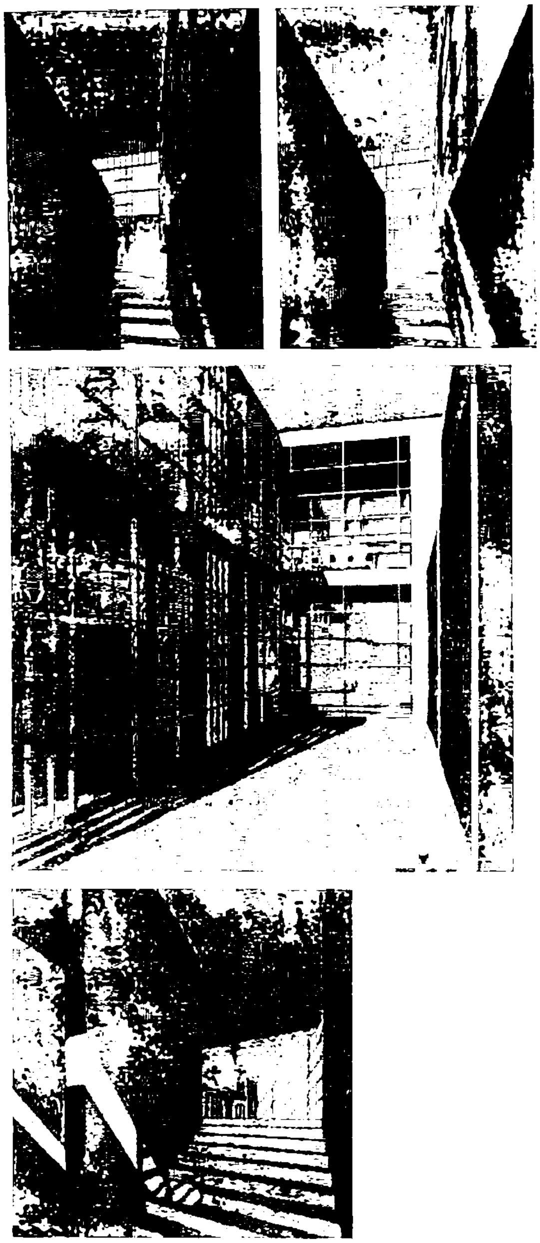

Figure 2. Correcting the Flaws in Computer-simulated Light

Next, students are required to fix the computer renderings by adding freehand pencil shading on top of a printout (Figure 2). This part of the exercise is presented as a scientific matter of meticulously transposing the subtle light qualities captured in the photographs onto the printout. Students make a single image with the advantages of both.

EXERCISE 2: TOUCH AND ALTER EVERYTHING IN A COMPUTER-GENERATED IMAGE

Once students recognize the incompleteness of a computer rendering and build some confidence in their ability to improve it, they are encouraged to extend this critical eye to every part of an image, gradually learning to take nothing for granted in raw computer output. To progress, students need to experience the nuances achievable through local image control. Image adjustments should be as fine-grained and pervasive as possible, requiring students to reconsider and adjust a wide range of visual attributes distributed across an image.

Because of its apparent finality, the "hidden line" image is an excellent place to push a student's critical image-making further. A hidden line image is the result of a transcription of each visible edge in a model to each line in an image. It does not depict its subject realistically, and therefore, it avoids the deficiencies encountered in the first exercise. Here the depiction is purposefully essentialized, capturing only quantifiable attributes of extension, boundary, solid and void. How can the computer be incomplete or flawed in this kind of image-making? Again, students are shown how the computer rendering falls short.

In the weeks preceding this exercise, students are introduced to concepts of line weight, shade and shadow composition, and diagramming strategies. They are shown examples of masterful applications of these principles. Students are then required to create a hidden line image documenting the final design of the row house.

Students use the rendering engine to produce a typical hidden line image. They are asked to compare it to a collection of drawings produced by master architects. With some assistance they begin to see the weaknesses of the computer renderings. They complain that the renderings lack a sense of depth, since only one line weight is used, and since they have no tonal information. Although they initially admire the intricacy of linework depicting mullions and other details, they later notice that such intricacy, pursued indiscriminately by the computer, often overwhelms the drawing.

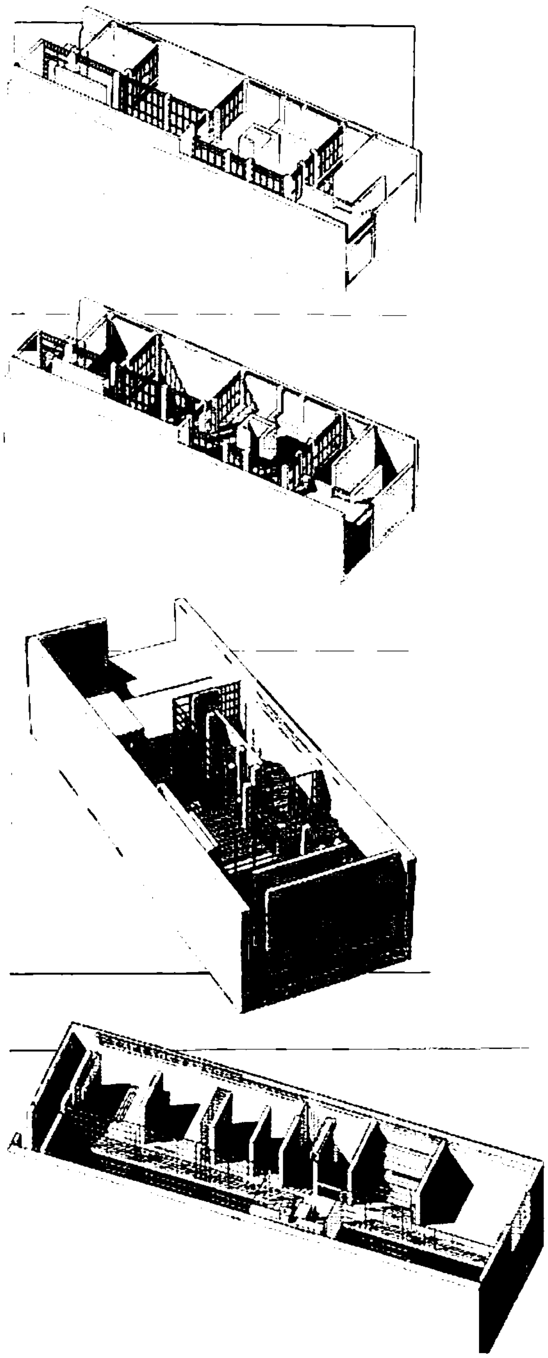

Figure 3. Discovering Local Control of Line and Tone in a Computer-generated Drawing

In the next stage of the exercise, students correct the noted problems (Figure 3). First, they add line weights to the image. Each line is individually evaluated and classified as a profile edge, convex edge, concave edge, or coplanar edge. Second, students add shadows by tracing them into the image from a second rendering. Each shadow outline is then filled with a gray tone. Third, shade is added, which requires students to understand its distinction from shadow and the orientation of shaded surfaces relative to the sun. Through repetitious editing of each line, shape, and fill, students practice localized visual scrutiny.

After completing these enhancements, virtually no point on the image retains its original appearance, yet it depicts the same subject. This reinforces the all-permeating influence of composition, and dissolves the misconception that a depiction is harmed by compositional adjustments.

EXERCISE 3: DECOMPOSE A COMPUTER-GENERATED IMAGE INTO COMPONENTS THAT CAN BE MANIPULATED INDEPENDENTLY

Compositional control requires the isolation of visual attributes, but by default computers fuse attributes together. Even though it uses separate algorithms to calculate shadows, diffuse light, reflectivity, and texture, it produces one summative image. Re-isolating these visual components is difficult or impossible after the image is generated.

A rendering engine could offer better compositional control by producing a composite of independent layers each dedicated to one visual attribute, such as an edge layer composed of hidden line information, a shadow layer, a shade layer, a reflected light layer, a color layer, a texture layer, a reflectivity layer, and so forth. The engine could automatically compile the layers into a single image with the layers intact. Much like a multi-layer Photoshop document, this would allow the independent display and adjustment of each kind of attribute. Even without automated support, architects can approximate this with appropriate techniques. Called *compositing* techniques, they are standard practice in the advertising and entertainment industries.[13]

The third exercise introduces compositing (Figure 4). Two renderings are generated from the same viewpoint, a hidden line image and a ray trace image. These images isolate line and tone information, and are then layered together in Photoshop to allow independent manipulation. Thickness, continuity and darkness of edges are adjusted. Filters are applied to line and tone independently. Further layers are added. Color might be spliced into the image in selected areas for emphasis, by generating a third computer rendering. Digital photographs of the site might also be spliced into the image.

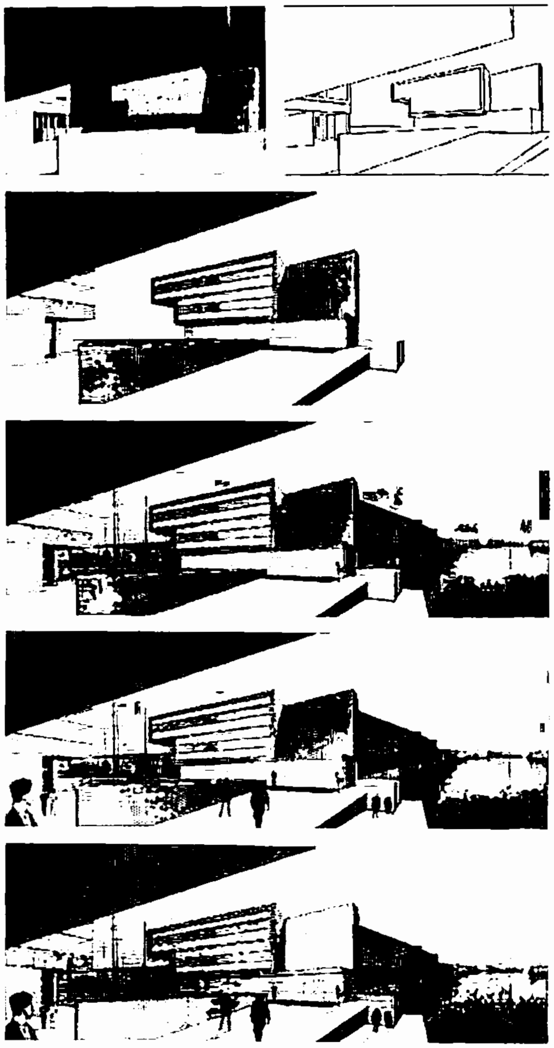

Figure 4. Image Compositing in Five Stages

After substantial alteration, the composite image is printed. The printout then acts as the foundation for an addition layer of information. Students are required to use pencil and/or pen drawing techniques to further enhance the image and repair qualities lost in the printing process.

CONCLUSION

Rendering engines diminish compositional control unless architects compensate with appropriate image-making methods. These methods are not obvious, and they should be taught as part of a systematic program of visual literacy. However, this is only part of the solution. Architects need a concept of the constructed image. This is a new need of the digital age, in which architects grapple with a medium that possesses no inherent compositional control. The concept helps define the granularity and types of image control needed, and it could be used to guide software engineers in the production of appropriate rendering tools. Lacking such a concept, architects have relinquished compositional control, or made due with crude workarounds, because of the value of automated depiction.

From radiosity to procedural textures to motion blur, software engineers produce a seemingly endless stream of depiction-enhancing algorithms, but when will they address compositional control? How photorealistic do depictions need to get before some consideration is given to this other set of issues? Software engineers are unlikely to incorporate compositional control unless architects demand it. But architects do not demand it because they cannot articulate the scope of their need in a language software engineers can understand. The concept of the constructed image can bridge this gap. Not only does it clarify the relationship between architect and medium, it does so in terms of a tangible workflow that can be captured in computer tools.

ACKNOWLEDGEMENTS

Student work produced by Christopher Ludwig, Cassie Heckman, Christopher Shoewe, Tarah Raaum, Amber Christensen, and Nicholas Moen.

NOTES

1. Andy Brown, Mike Knight and May Nahab, "Computer Generated Architectural Images in Practice: What Kind and When?" in *Education for Practice: 14th Proceedings of the Conference of Education in Computer Aided Architectural Design in Europe*, Lund, Sweden (1996), 79-86.

2. Julie Dorsey and Leonard McMillan, "Computer Graphics and Architecture: State of the Art and Outlook for the Future," *Computer Graphics* 32/1, (Feb 1998): 45-48.

3. Hector Giro, "Drawing the Map: About the Way Freehand Drawings Look in Computer Models," in *Spatial Simulation and Evaluation - New Tools in Architectural and Urban Design: Proceedings of the 6th European Architectural Endoscopy Association Conference*, Bratislava, (2003), 91-100.

4. Alberto Perez-Gomez and Louise Pelletier, *Architectural Representation and the Perspective Hinge* (Cambridge: MIT Press, 1997).

5. Iain Fraser and Rod Henmi, *Envisioning Architecture: An Analysis of Drawing* (New York: Van Nostrand Reinhold, 1994).

6. Betty Edwards, *Drawing on the Right Side of the Brain* (New York: G P Putnam's Sons, 1989).

7. Robert W. Gill, *Creative Perspective* (London: Thames and Hudson, 1975).

8. Nathan Goldstein, *Figure Drawing: The Structure, Anatomy and Expressive Design of Human Form* (New Jersey: Prentice-Hall, 1976).

9. B. J. Novitski, "Once and Future Graphics Pioneer," *Architecture Week*, September 13, 2000, 1-6.

10. Antonieta H. Angulo, Richard J. Davidson, and Guillermo P. Vasquez de Velasco, "Digital Visualization in the Teaching of Cognitive Visualization," in *Reinventing the Discourse - How Digital Tools Help Bridge and Transform Research, Education and Practice in Architecture: Proceedings of the Twenty First Annual Conference of the Association for Computer-Aided Design in Architecture*, Buffalo, New York (2001), 292-301.

11. Goldstein, *Figure Drawing: The Structure, Anatomy and Expressive Design of Human Form*.

12. Ilka Ruby, Andreas Ruby, and Philip Ursprung, *Images* (Munich: Prestel, 2004).

13. Jeremy Birn, *Digital Lighting & Rendering* (New York: New Riders, 2000).