The Craftsman

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-ing, however, modern machinery is not static; through fee-bac... -hines can learn from their experience. Yet ... is misused ... -ives people themselves from ... -ough repetition. The s... can separate ... -ntal understanding from repetitive, ... learning. When this occurs, conceptual human powe...

Since the Industrial R... the ... century, the machine has seemed ... the work of artisan-... The threat appeared ... industrial machines never tired, they ... work ... hour without complaining. The modern mac... developing skill has a different character.

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An example of this misuse occurs in CAD (computer-assisted design), the software program that allows engineers to design physical objects and architects to generate images of buildings on-screen. The technology traces back to the work of Ivan Sutherland, an engineer at the Massachusetts Institute of Technology who in 1963 figured out how a user could interact graphically with a computer. The modern material world could not exist without the marvels of CAD. It enables instant modeling of products from screws to automobiles, specifies precisely their engineering, and commands their actual production.[25] In architectural work, however, this necessary technology also poses dangers of misuse.

In architectural work, the designer establishes on screen a series of points; the algorithms of the program connect the points as a line, in two or three dimensions. Computer-assisted design has become nearly universal in architectural offices because it is swift and precise. Among its virtues is the ability to rotate images so that the designer can see the house or office building from many points of view. Unlike a physical model, the screen model can be quickly lengthened, shrunk, or broken into parts. Sophisticated applications of CAD model the effects on a structure of the changing play of light, wind, or seasonal temperature change. Traditionally, architects have analyzed solid buildings in two ways, through plan and section. Computer-assisted design permits many other forms of analysis, such as taking a mental journey, on-screen, through the building's airflows.

How could such a useful tool possibly be abused? When CAD first entered architectural teaching, replacing drawing by hand, a young architect at MIT observed that "when you draw a site, when you put in the counter lines and the trees, it becomes ingrained in your mind. You come to know the site in a way that is not possible with the computer. . . . You get to know a terrain by tracing and retracing it, not by letting the computer 'regenerate' it for you."[26] This is not nostalgia: her observation addresses what gets lost mentally when screen work replaces physical drawing. As in other visual practices, architectural sketches are often pictures of possibility; in the process of crystallizing and refining them by hand, the designer proceeds just as a tennis player or musician does, gets deeply involved in it, matures thinking about it. The site, as this architect observes, "becomes ingrained in the mind."

The architect Renzo Piano explains his own working procedure thus: "You start by sketching, then you do a drawing, then you make a model, and then you go to reality—you go to the site—and then you go back to drawing. You build up a kind of circularity between drawing and making and then back again."[27] About repetition and practice Piano observes, "This is very typical of the craftsman's approach. You think and you do at the same time. You draw and you make. Drawing . . . is revisited. You do it, you redo it, and you redo it again."[28] This attaching, circular metamorphosis can be aborted by CAD. Once points are plotted on-screen, the algorithms do the drawing; misuse occurs if the process is a closed system, a static means-end—the "circularity" of which Piano speaks disappears. The physicist Victor Weisskopf once said to his MIT students who worked exclusively with computerized

experiments, "When you show me that result, the computer understands the answer, but I don't think you understand the answer."[29]

Computer-assisted design poses particular dangers for thinking about buildings. Because of the machine's capacities for instant erasure and refiguring, the architect Elliot Felix observes, "each action is less consequent than it would be [on] paper . . . each will be less carefully considered."[30] Returning to physical drawing can overcome this danger; harder to counter is an issue about the materials of which the building is made. Flat computer screens cannot render well the textures of different materials or assist in choosing their colors, though the CAD programs can calculate to a marvel the precise amount of brick or steel a building might require. Drawing in bricks by hand, tedious though the process is, prompts the designer to think about their materiality, to engage with their solidity as against the blank, unmarked space on paper of a window. Computer-assisted design also impedes the designer in thinking about scale, as opposed to sheer size. Scale involves judgments of proportion; the sense of proportion on-screen appears to the designer as the relation of clusters of pixels. The object on-screen can indeed be manipulated so that it is presented, for instance, from the vantage point of someone on the ground, but in this regard CAD is frequently misused: what appears on-screen is impossibly coherent, framed in a unified way that physical sight never is.

Troubles with materiality have a long pedigree in architecture. Few large-scale building projects before the industrial era had detailed working drawings of the precise sort CAD can produce today; Pope Sixtus V remade the Piazza del Popolo in Rome at the end of the sixteenth century by describing in conversation the buildings and public space he envisioned, a verbal instruction that left much room for the mason, glazier, and engineer to work freely and adaptively on the ground. Blueprints—inked designs in which erasure is possible but messy—acquired legal force by the late nineteenth century, making these images on paper equivalent to a lawyer's contract. The blueprint signaled, moreover, one decisive disconnection between head and hand in design: the idea of a thing made complete in conception before it is constructed.

A striking example of the problems that can ensue from mentalized design appear in Georgia's Peachtree Center, perched on the edge of Atlanta. Here is to be found a small forest of concrete office towers, parking garages, shops, and hotels, edged by highways. As of 2004, the complex covered about 5.8 million square feet, which makes this one of the largest "megaprojects" in the region. The Peachtree Center could not have been made by a group of architects working by hand—it is simply too vast and complex. The planning analyst Bent Flyvbjerg explains a further economic reason why CAD is necessary for projects of this scope: small errors have large knock-on effects.[31]

Some aspects of the design are excellent. The buildings are laid out in a grid plan of streets forming fourteen blocks rather than as a mall; the complex pays allegiance to the street and is meant to be pedestrian friendly. The architecture of the three large hotels is by John Portman, a flamboyant designer who favors such dramatic touches as glass elevators running up and down forty stories of interior atriums. Elsewhere, the three trade marts and office towers are more conventional concrete-and-steel boxes, some faced outside with the Renaissance or Baroque detailing that has become the stamp of postmodern design. The project as a whole reaches for character rather than anonymity. Still, pregnant failures of this computer-driven project are evident on the ground—three failures that menace computer-assisted design more largely as a disembodied design practice.

The first is the disconnect between simulation and reality. In plan, the Peachtree Center populates the streets with well-designed sidewalk cafés. Yet the plan has not actually engaged with the intense Georgia heat: the outdoor seats of the cafés are in fact empty from late morning to late afternoon much of the year. Simulation is an imperfect substitute for accounting the *sensation* of light, wind, and heat on site. The designers would perhaps have done better to sit unprotected in the midday Georgia sun for an hour before going to work each day; physical discomfort would have made them see better. The large issue here is that simulation can be a poor substitute for tactile experience.

Hands-off design also disables a certain kind of relational understanding. Portman's hotel, for instance, emphasizes the idea of coherence, with its inner drama of all-glass elevators running up a forty-story atrium; the hotel's rooms look outward over parking lots. On-screen, the parking-lot issue can be put out of mind by rotating the image so that the sea of cars disappears; on foot, it cannot be disposed of in this way. To be sure, this is not the computer's inherent fault. Portman's designers could perfectly well have put in an image of all the cars and then viewed the sea, on-screen, from the hotel rooms, but then they'd have had a fundamental problem with the design. Whereas Linux is set up to discover problems, CAD is often used to hide them. The difference accounts for some of CAD's commercial popularity; it can be used to repress difficulty.

Finally, CAD's precisions bring out a problem long inherent in blueprint design, that of overdetermination. The various planners involved in the Peachtree Center rightly point with pride to its mixed-use buildings, but these mixtures have been calculated down to the square foot; the calculations draw a false inference about how well the finished object will function. Overdetermined design rules out the crinkled fabric of buildings that allow little start-up businesses, and so communities, to grow and vibrate. This texture results from underdetermined structures that permit uses to abort, swerve, and evolve. There is thus missing the informal and so easy, sociable street life of Atlanta's older neighborhoods. A positive embrace of the incomplete is necessarily absent in the blueprint; forms are resolved in advance of their use. If CAD does not cause this problem, the program sharpens it: the algorithms draw nearly instantly a totalized picture.

The tactile, the relational, and the incomplete are physical experiences that occur in the act of drawing. Drawing stands for a larger range of experiences, such as the way of writing that embraces editing and rewriting, or of playing music to explore again and again the puzzling qualities of a particular chord. The difficult and the incomplete should be positive events in our understanding; they should stimulate us as simulation and facile manipulation of complete objects cannot. The issue—I want to stress—is more complicated than hand *versus* machine. Modern computer programs can indeed learn from their experience in an expanding fashion, because algorithms are rewritten through data feedback. The problem, as Victor Weisskopf says, is that people may let the machines do this learning, the person serving as a passive witness to and consumer of expanding competence, not participating in it. This is why Renzo Piano, the designer of very complicated objects, returns in a circular fashion to drawing them roughly by hand. Abuses of CAD illustrate how, when the head and the hand are separate, it is the head that suffers.

Computer-assisted design might serve as an emblem of a large challenge faced by modern society: how to think like craftsmen in making good use of technology. "Embodied knowledge" is a currently fashionable phrase in the social sciences, but "thinking like a craftsman" is more than a state of mind; it has a sharp social edge.

Immured in the Peachtree Center for a weekend of discussions on "Community Values and National Goals," I was particularly interested in its parking garages. A standardized bumper had been installed at the end of each car stall. It looked sleek, but the lower edge of each bumper was sharp metal, liable to scratch cars or calves. Some bumpers, though, had been turned back, on site, for safety. The irregularity of the turning showed that the job had been done manually, the steel smoothed and rounded wherever it might be unsafe to touch; the craftsman had thought for the architect. The lighting in these aboveground car-houses turned out to be uneven in intensity, dangerous shadows suddenly appearing within the building. Painters had added odd-shaped white strip lines to guide drivers in and out of irregular pools of light, showing signs of improvising rather than following the plan. The craftsmen had done further, deeper thinking about light than the designers.

These steel grinders and painters had evidently not sat in on design sessions at the start, using their experience to indicate problematic spots in the designs plotted on-screen. Bearers of embodied knowledge but mere manual laborers, they were not accorded that privilege. This is the sharp edge in the problem of skill; the head and the hand are not simply separated intellectually but socially.

Conflicting Standards
Correct versus Practical

What do we mean by good-quality work? One answer is how something should be done, the other is getting it to work. This is a difference between correctness and functionality. Ideally, there should be no conflict; in the real world, there is. Often we subscribe to a standard of correctness that is rarely if ever reached. We might alternatively work according to the standard of what is possible, just good enough—but this can also be a recipe for frustration. The desire to do good work is seldom satisfied by just getting by.

Thus, following the absolute measure of quality, the writer will obsess about every comma until the rhythm of a sentence comes out right, and the woodworker will shave a mortise-and-tenon joint until the two pieces are completely rigid, needing no screws. Following the measure of functionality, the writer will deliver on time, no matter that every comma is in place, the point of writing being to be read. The functionally minded carpenter will curb worry about each detail, knowing that small defects can be corrected by hidden screws. Again, the point is to finish so that the piece can be used. To the absolutist in every