A Prospectus on Computers Throughout the Design Curriculum

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Computer aided architectural design has spread throughout architecture schools in the United States as if sown upon the wind. Yet, the proliferation alone may not be a good measure of the computer's impact on the curriculum or signify the true emergence of a digital design culture. The aura of a relatively new technology may blind us from understanding its actual place in the continuum of design education. The promise of the technology is to completely revolutionize design; however, the reality of change is perhaps rooted in an underlying connection to core design methods. This paper considers a transitional phase within a School reviewing its entire curriculum. Lessons may be found in the Bauhaus educational program at the beginning of the 20th century and its response to the changing shape of society and industry.

The era of computer based design methods as a separate area of academic inquiry may be quickly fading, if not already obsolete. Yet, it may be misleading to quantify progress in terms of numbers of computers in use, courses on the web, or digital images displayed in studio. The mere presence of computer-based media in studio does not ensure that our underlying approach to design is transforming or that a new critical perspective on design has been added. Moreover, the built environment as we knew it is beginning to co-habit a virtual world of new communications infrastructures and methods of personal interaction, all of which could be considered in a changing architectural design curriculum.

Information technology is today the subject of bold prediction about fundamental changes to society and living patterns, and the need for educational institutions to reform in preparation for a changed world.[1] Similarly, at the turn of the 19th century in Germany, Emil Rathenau described the AEG electric company vision of a new world interconnected by copper wires "that would become the blood of the economy and would stimulate its movement and growth ". The technology effected "changes in the structure of populations as communications took on a new form … changes which had not been fully realized." [2] This radical vision of the future created a new context for architectural commissions at AEG. A number of scholars link the beginning of the Bauhaus educational program to the designs for AEG by Peter Behrens, especially given that both Gropius and Mies worked in Behrens' practice, although the nature of this connection is indirect.[3] The Bauhaus curriculum became increasingly focused on the production processes of modern industry, partly as a question of the School's strategy for getting income, and partly as a genuine evolution in perspective. [4] The movement claimed for architects not just a utilitarian purpose, but rather a more fundamental imperative to practice at the highest levels of aesthetic principal in shaping the whole physical environment of the modern world.

The present era of computer technologies also provides an opportunity for radical change to our infrastructure, communications, and the nature of social interaction. A new planning concept of the "Intelligent City" has emerged based on the technologies of broadband, satellite, and fiber optic communications, and focused on the marketplace of the information economy. [5] Yet, the prediction of evolution towards an "Intelligent City" today seems somewhat reminiscent of AEG's forecast on the twentieth century. The infrastructure changes and new work patterns embody fiber optic rather than copper wires. New communications media are increasingly housed within a built environment that was once based on the dominance of face-to-face communications. The Dean of the oldest school of architecture claims that urban life will not be life as

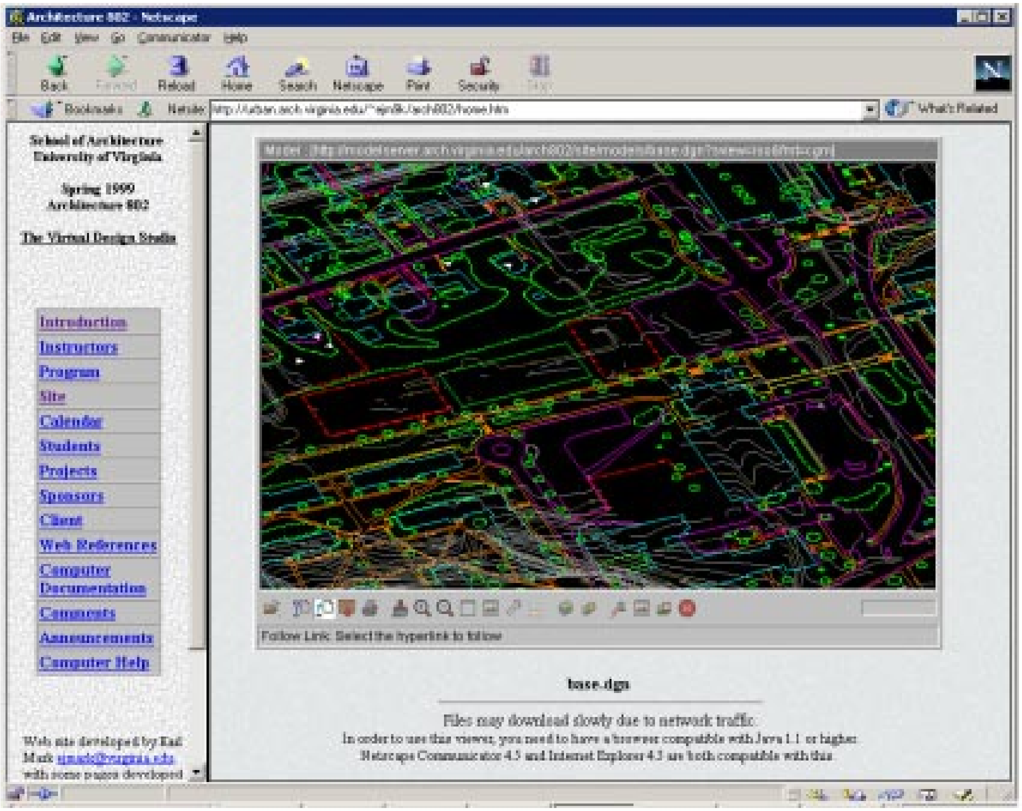

Figure 1:
Interactive site plan displayed with viewing controls on studio Web page

we know it, but examines carefully the evolution of the change and cautions against utopian predictions based on way out science fiction scenarios.[6]

There are two areas related to computer technology that an architectural curriculum may need to address. One curriculum area is learning to design by means of the formal, spatial and data analysis that are enabled by computer technology. The second curriculum area is learning to design for a built environment and infrastructure that incorporates new methods of commerce and computer mediated social interaction. The new media for design exploration and the new cities may share a common characteristic of representing infinitely plastic space, but this characterization seems too loose and inadequate to describe the changing context for a design education.

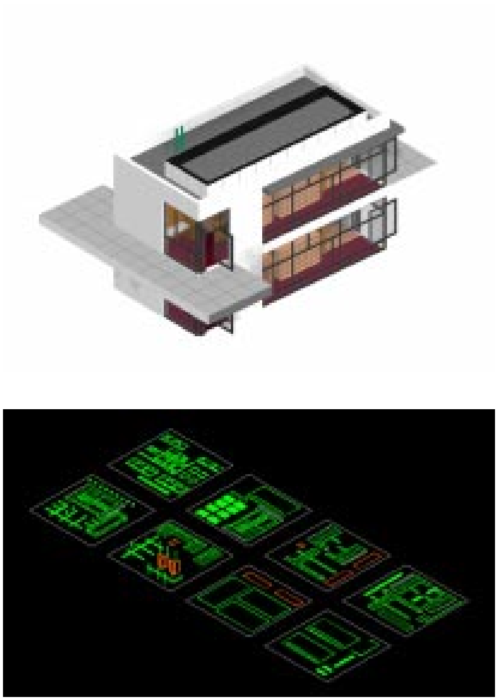

Figure 2a and 2b:
Digital model of classroom unit divided into parts for three-dimensional printing

The applications of the computer within the architecture design program at the University of Virginia include geometrical modeling, three-dimensional visualization, animation, energy and lighting analysis, finite element modeling, GIS, digital terrain modeling, and some computer graphics programming of more complex architectural geometry. Within the core studios, and for analysis and visualization in the study of architectural history, the use of the computer is mostly ad hoc. Typically four to five studios per semester go further in making computer-based media required in the design exercises in any one term. The "virtual" design paradigm has been tested by the use of video teleconferencing resources directly integrated into the studio setting. Furthermore, Web based interactive methods of drawing on the same "white board" and methods of sharing three-dimensional models have been used.

A so-called "virtual design studio" was taught in the spring of 1999 at the University of Virginia in collaboration with MIT. A three-dimensional site and a digital terrain model were shared on the Internet, where any remote user can move about and in future redline the model.[7] The model itself is based on data acquired over the Internet.

A personal digital conference system linked a remote design critic to the studio with shared access to images, white boards, physical and computer based models.[8] In addition, digital models in Virginia were sent over the network for three-dimensional printing at MIT based on a process that builds the model in layers of a plastic polymer compound. The novelty was more noteworthy than the result expedient to the design process due to some of the time delays in printing, but the techniques predictive of how remote design collaboration can incorporate physical models.

While a number of these separate applications have been innovative, and some uses productive, it is still the case that the basic design methods within the School are guided by traditional approaches to criticism, drawing and physical models.

It may be relevant here to refer to the original Bauhaus education program and its context of relating to new mass manufacturing industries. Although a primary objective of the program established at Weimar was preparing designers for machine methods of making objects, the Bauhaus still put emphasis on working by hand with physical materials in a more traditional workshop setting. Johannes Itten, the first master of the Bauhaus preliminary course, established that one of the main tasks was to ensure that working materials by hand would guide students in their choice of future career options. He wrote, "exercises with materials and textures provided a valuable aid. In a short time each student found out which materials appealed most to him; whether wood, metal, glass, stone, clay, or yarn best stimulated him."[9] After Itten's departure, Josef Alber's maintained in the preliminary course that "the approach to form was based on the exploration of the qualities and the potential of materials."[10]

At the same time, there was also the Bauhaus vision of architecture unbounded by existing material restrictions on space. Marcel Breuer wrote "The pieces of furniture and even the walls of a room have ceased to be massive and monumental, apparently immovable and built for eternity. Instead they are more opened out, or so to speak, drawing in space. They hinder neither the movement of the body nor the eye. The room is no longer a self-bounded composition, a closed-box, for its dimensions and different elements can be varied in many ways."[11]

Breuer's reference to variable dimensions suggests the infinite modeling space and parametric variations of geometry possible within current computer based media. That is, modification of the basic form of a building can easily achieved by changing

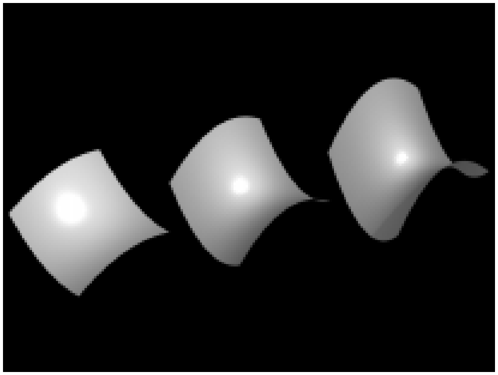

Figure 3:
Variations of a hyperbolic parabola surface under parameterized control

a few optimized parameters on a computer. In figure 3, we see the result of varying parameters on a hyperbolic parabola surface controlled by a short computer graphics program.

Similarly, the following illustration in figure 4 is based on a computer description of sexpartite and quadripartite vault geometry expressed in the Java programming language and harnessed to a CAD system. The components to the vaults are controlled by master parameters, including the basic trigonometric relations, expressed in a Java program. A medieval mason might be familiar with the geometrical steps of the Java program if translated into a set of manual operations by carpenter's strings. The computer-generated surfaces may lack the nuance and sophistication of a mason setting bricks in an adaptive orientation to construct a vault, however, the computer procedure makes a case for understanding all surfaces in terms of a few general parameters. The computer model seems more plastic than traditional modeling media where the sizes of the parts are more difficult to vary.

Another example of variation in spatial composition is taken from the following reproduction of a student rendering completed in the Bauhaus advertising class taught by Joost Schmidt about 1930.[12] Three-dimensional space is explored within the advertising sheet, a formal exercise not unlike stud-

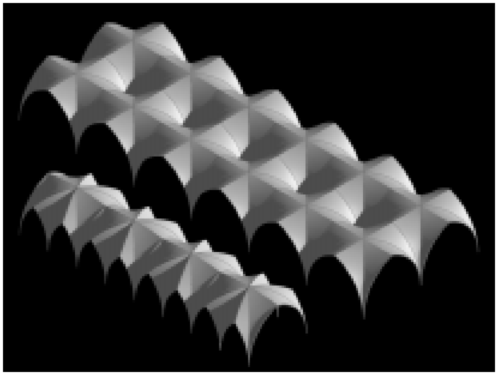

Figure 4: Variations of vaulting under parameterized control

ies on basic three-dimensional Platonic form, texture and shape developed in the core course under Itten at the Bauhaus. Here the composition of the image has been taken as a point of departure for backward engineering the three-dimensional computer model. A more accurate assessment of lighting and shadows reveals flaws in the initial image, where inconsistencies show up in the orientation of each form to apparent light sources.

When viewed within a true three-dimensional medium from an alternative angle in figure 5b, however, the composition seems less well balanced. Here the forms in the composition lose a bit of their symmetry, reminding us of the fallacy of designing from one point of view. It was clearly not the intention of the initial Bauhaus drawing to generate a three-dimensional model, but the possibility to explore abstract objects in three-dimensional space is suggested by it. We can rapidly progress through experiments in materials, exploring contrasting qualities in shape, color, texture, reflectivity, transparency, roughness, smoothness, and testing effects of different combinations of these attributes. Within figure 5c, copper, chrome and a mirror material are used on the I-bean, hexagonal tower, and square respectively.

The foregoing examples demonstrate the use of computer-based media to represent simple to complex geometry and materials. The computer does not provide a substitute for working with the physical properties of real materials, but can be used to quickly expand upon a range of experiments perhaps guided by working with real materials.

The preceding example of figure 5a explored by Schmidt's student in the Bauhaus illustrate an interest in three-dimensional composition on two-dimensional paper based media. The Bauhaus painting workshops also examined abstract investigations into space and form under Kandinsky and Klee. As an extension of these methods, the computer can be used to multiply and vary three-dimensional forms, and to investigate these forms relative to the virtually unbounded distances of three-dimensionally modeling space. If the abstraction is impossible to construct in three-dimensional coordinate geometry, then other kinds of digital media that allow for two-dimensional scaling, copying and rotation of pixels on the screen become useful (e.g., digital paint systems).

The earlier parts of a design curriculum may focus on simpler computer-based extensions of basic tectonic, formal expression and composition. These approaches correspond to the early phases of an architecture education in traditional paper based and other non-computer media at the University of Virginia. Intermediate years might incorporate more rigorous representations and methods of modeling light and geometry. The final years for a design program could consider advanced preprofessional areas of spatial and data analysis, inquiry into new design methods and visualization techniques, with options to more fully acquire expertise and experiment in specialized areas.

There is not a single grand idea that would tie together these different areas of the curriculum. The Bauhaus sets an important precedent in that despite differences among the faculty in both pedagogical objectives and methods, there was a consensus in the stripping away of past constraints on what constituted the media and curriculum for a

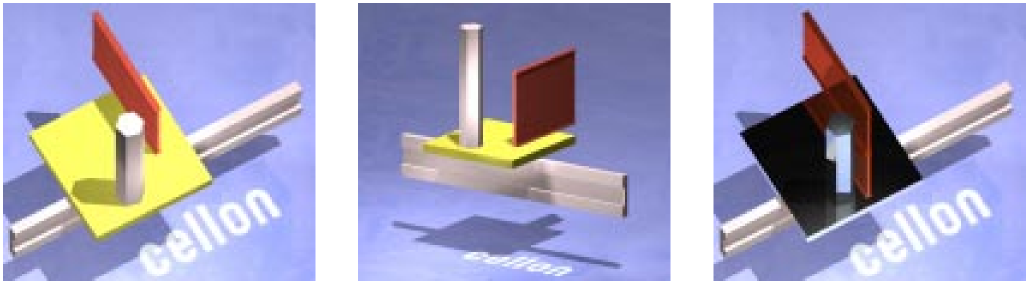

Figure 5a, 5b, and 5c: Computer model developed after original Bauhaus student drawing

design education. The craft coming out of the traditional guilds were retained, but the students of the Bauhaus were preparing for the complex processes of industrial production that had been developed in the early 20th century. The preliminary course exercises dealt with universal design issues of form, color, texture and materiality. Gropius maintained that the purpose of the School was "not to propagate any "style", system, dogma, formulae or vogue". [13]

Computer based media also provide an opportunity to re-engage formal and tectonic exercises in some photo-realistic representations, and computer based three-dimensional perspective and axonometric projection could compliment more traditional drawing methods. Traditional and computer based media are not antithetical to each other, but rather ground and extend the range of possible design inquiry.

A digital design culture may be one where the means to computer visualization and spatial analysis have been greatly expanded in a way that is complimentary to and informed by working with direct physical media. Whether the point of reference is new industrial technology at the beginning of the 20th century or the virtual technology of today, the value of knowing materials seems as relevant now as it was during the first years of the Bauhaus program within Itten's preliminary course. Students must relate real materials to build-able structures, and at the same time, understand the new demands placed upon architecture and urban design within an era of "Smart Cities". To be relevant to design practice today, computer based media must be integrated and grounded in the realities of real materials and construction processes, and, at the same time, represent more abstract notions of space related to visually connected but physically distant communities linked on the Internet. The integration of computer media with direct exploration of real physical materials seems likely to enhance every level of a design education program.

Notes

1 Michael Benedikt's Cyberspace: The First Steps, MIT Press, 1992. This book forecast numerous scenarios that relate to information technology, perhaps more in the spirit of imaginative inquiry than highly probable accuracy.
2 Naylor, Gillian, The Bauhaus Reassessed, London: The Herbert Press, 1985.
3 Winger, Hans, The Bauhaus, MIT Press, 1962. There are many threads here to tease apart from the influence of William Morris and the Arts & Crafts movement in England, to the polemics of the Werkbund, which it influenced, to the beginnings of the Bauhaus. Giving an account of these connections is beyond the scope of this paper.
4 Droste, Magelanea, Bauhaus 1919 - 1933, Germany: Benedikt Tascdhen Verlag, 1990.
5 Malone, Dan, Guest Lecture on the "Smart Region", University of Virginia, March 6, 2000.

6 Mitchell, William. E-Topia: Urban Life Jim — But Not as We Know It, MIT Press, 1999.
7 Bentley Systems granted the interactive Web tool referred to as Model Server. The studio was co-taught by Peter Waldman and Earl Mark in collaboration with Bill Mitchell.
8 Sprint and PictureTel donated the communications equipment. and run on a Pentium computer over Internet II with video frame rates varying from 10 to 20 fps.
9 Itten, Johannes, Design and Form, The Basic Course at the Bauhaus, New York: Reinhold Publishing Co, 1964.
10 Droste., Op. Cit.
11 Droste., Ibid.
12 Droste., Ibid. This image is a three-dimensional computer reproduction of a drawing by Eugen Batch on traditional paper based media from the advertising course.
13 Naylor, Op. Cit., p. 172.

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