Investigations into the Production of Form

by
Sharon L. Roe

School of Design
Department of Archiecture
North Carolina State University
Raleigh, North Carolina.

Abstract

Computers have exploded into the world of the architect, yet architects have only begun to explore the role of computers in the creative process or the effects of particular applications on design projects. Likewise, educators are seeking methods for investigating the computer as a tool which may or may not effect the thing produced. Is it a tool for representation (copying), or a key player in the generation of ideas—a tool for the production of form? This paper describes the theoretical foundations and results of a series of exercises developed for beginning design students. In three investigations students consider:

Algorithms (the fundamental logic of a computer application) using
Building blocks (reductive entities that act as the origins of form) by
Collaging and making assemblies (techniques for experimentation and exploration).

The purpose of these exercises (called ABC exercises) is to explore the relationship between the computer as a tool and the production of form and type in architecture.

Introduction

Consider that every new tool carries with it the ideas and intentions of the inventor. This knowledge may be incidental to the creativity of the artist/ architect that decides to use the tool, or it may be incendiary. The investigations that follow will explore the potential in the relationship between ideas that develop in the design process and the computer applications developed to perform more or less specific tasks in design. When considering the play between the ideas of form and the visualization of form, it is important to remember that we are drawing on two bodies of knowledge: one is embodied in computer applications about constructing visualizations; the other is embodied in the theories of architectural form. As bodies of knowledge, each can be understood as propositional—each depends upon its definition of the fundamental or primitive elements and each requires rules or procedures for the manipulation of those elements. The first step of our inquiry, then, was to recognize type classifications of commonly used computer applications as based on the nature of their fundamental entities and rules of manipulation. Each type of application (whether painting, drawing or modeling) encourages certain types of behavior through the structure of the program: definition of primitive elements (the pixel or the pixel construction); properties assigned to those elements; and particular procedures for manipulation. For example, painting programs allow us to capture, but only for a moment, indiscriminate bits of color information set in relation to each other in the bit-map. These patterns of color, and their lightness and darkness, rely upon complex properties of perception and cognition in order to be organized into something meaningful. Things such as windows, walls or roofs show up only as recognizable patterns of color. We may duplicate, flip, rotate, or stretch these bits of color over each other, however, each time the identity of what had existed before is lost.

Object-oriented programs, on the other hand, prefer the object at the expense of the individual pixel. The object as a construction of pixels takes the place of the pixel as the primitive entity. In the operations of image manipulation, the malleability of the pixel pattern is replaced with the secure identity of the object. The lines, rectangles, polygons, circles, etc., that perform the roles of primitive elements can be magnified, rotated and layered over one another without losing their original identity. In addition, this type of program provides a hierarchical structure wherein these primitive objects can be grouped to make ever more complex assemblies—but only as defined in two dimensions. Similarly, surface modeling programs make objects such as polygons but with the addition of the third dimension. More complex constructions of polygons describe walls, blocks, cylinders or spheres in virtual space. These objects made from the primitive polygons may also act as primitive entities available for duplication, rotation, and grouping hierarchies.

In order to find good fits with the properties of these application types, we looked to theories of architecture to identify architectural entities at work in the production of form. Architects and theoreticians recognize that buildings as cultural artifacts are encoded with the knowledge of their construction and aesthetics. Rafael Moneo's survey of the literature on typology[12] leads to the conclusion that, at the most fundamental level, form may be a recognition of patterns of elements (reductive entities) understood as architectural. Those entities may be physical or metaphysical and they may carry natural, mathematical or manufactured properties. Moneo illustrates how theories on the origins of form provide a wide range of specifications for those elements capable of producing typical patterns. The problem for the architect involved in the production of form becomes one of recognizing these primary elements and their productive potential. The primitives selected for these exercises have been prescribed within theories on the origin of architectural form and also share similar specifications to the primitive entities in the computer applications used in architecture. The primary focus of these exercises, then, is to investigate the productive potential of various sorts of architectural entities within the structure of various computer applications.

METHODOLOGY

The ABC exercises were developed for students in a beginning computer methods class.[13] This is a required class usually taken concurrently with the second or third semester of the undergraduate architectural design studio. The exercises were premised on an ability to classify or typify both computer applications and buildings. Three types of computer applications were considered: painting (bit-map), drawing (2-D object), and surface modeling (3-D object). A pair of exercises was developed for each type of application. The first part is a skill-based exercise that explores the computer application as a tool that has embedded preferences and modes of production. The second part is the investigation which explores the nature of formative elements in architecture within that particular virtual environment. Students used the graphical capabilities of the computer not as a computation tool for either describing or solving problems but as a workstation for the involved activity of making constructions within a simulated universe.

The question of how the designer interprets towards significance was a driving issue in the development of a methodology for these investigations. The activity depended upon an assumption that the experience of architectural form is an ongoing perceptual gestalt. More specifically, the recognition of form—an interpretation—is primarily a visual gestalt that can be simulated in the virtual environment. Although the visual field may consist of groups of distinct elements (primitive entities), certain parts of the visual field will naturally cohere to form units.[14] Since the experience of an architectural form cannot be predicted by the manner in which the individual elements are experienced, it is appropriate for these investigations, and consistent with Moneo's findings, to regard form as an emergent property.

This investigation into the behavior of primitive elements as generated through the involved activity of making assemblies or collages, was developed to help distinguish primitives capable of producing form. In other words, if the things (the elements) act to evoke memory (the gestalt of interpretation), the involved activity of making assemblies (hermeneutical rather than operational) will produce familiar looking stuff—it will attain significance (type recognition). It will show up *as* something—*as* a window, *as* a passage, *as* a church. In doing this, students met the challenge set forth by Moneo that the recognition of form must be viewed as a recognition of patterns that we have come to understand as architectural.[15] Whether modeling, drawing or painting, the designer is allowed to work within the immediacy of both the creative and the productive reality, not to reproduce form but to set loose an activity through which form is emergent.

Investigation into the production of type-image

Introductory exercises in this pair of exercises focused on the properties of the program and the nature of the transforming image. Simple scribbles were plucked apart. Clusters of pixels were duplicated, flipped, re-selected and duplicated, folding image into image. There was a sense of discovery in the transforming image. Since the exercises had no aim other than composition, there were no problems to solve or programs to fulfill. No one interpretation could be understood as being better or more evocative than another because there was no explicit aim. The exercises resulted in formal compositions and raised the issue whether there could be either metaphoric meaning or concept without design intentions.

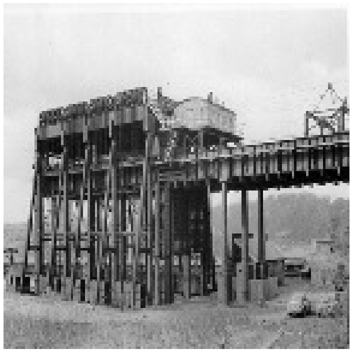
The second part of the exercise added a programmatic theme which drew more from the stuff that stimulates recognition (mnemonic). The investigation began with a photographic image of a student's favorite building. In order to represent one of Calvino's *Invisible Cities*[16], the original image was scanned as a pixel image and then manipulated through the properties inherent in the paint program (in this case *PhotoShop*). The figure/ ground relationship of the original scanned image was subverted through the process of capturing interesting clusters of pixels—pulling out a texture here, a patch of lightness or darkness there. These were manipulated through program operations of duplication, mirroring, scale-change or shape-change. The fluidity of the interpretation and the fluidity of the merging pixel patterns was facilitated by rules of production implicit in the paint program.

Primitive architectural elements were promulgated by the student's attention to significance. With the description of the city in mind, the iterative process of selecting elements and manipulating the image becomes one of interpretation rather than abstraction. Through this process of experimentation, discovery and interpretation, the students began to make visible the invisible city. William Gass in a discussion of Calvino's book noted that:

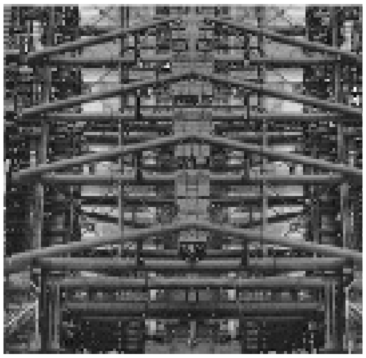
> ...there are invisibilities of at least two distinct kinds: the first is what is before us at the moment, in our mathematical mood, an unvarnished invisibility, an invisibility, in short, which does not hide itself, and which is, in that sense, not

invisible at all; and then there is the second sort, which is like the proverbial needle, the purloined letter, or the figure in the carpet, palpable, present, but unnoticed, like a floating ghetto, an invisible visibility, hidden from us like a flaw in our character, embraced without realization or recognition.[17]

This understanding shaped the design activity. It made it possible to look for significance in the emerging figure as patterns appeared *as* something relevant. Just as Calvino allows each city to appear through storytelling (trading cities, cities and eyes, thin cities, cities and signs, cities and the dead), the students allowed the invisible city to emerge through a collaging technique facilitated by the paint program.



Original Scanned Image



Interior of City

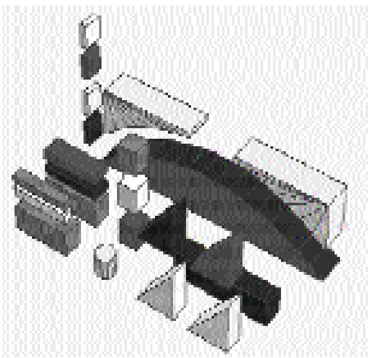
Overview of City

The screen image becomes like a game board with implied sets of relationships laid in by the programmer and the primitive elements and precise moves selected by the interpreting eye of the designer. At the root of the screen image, there is the all-prevailing grid of the pixels. Colin Rowe referred to the all-prevailing grid of the city as a “highly energetic scaffold for the fluctuating and casual event.”[18] The pixel grid also operates as a scaffold for the fluctuating event of the collage. The game of collaging is played out like the chess game with its implicit rules and implied patterns and paths. Calvino’s book, comprised of 64 sections, is also like the chess board with implied sets of paths, relationships, and subtle patterns. In the book, the king simply makes the proper moves, ponders the rules, admires the purity of each play’s endless designs, and the menace inherent in their innocent configurations.[19] The fluidity of the interpretation and the fluidity of the merging pixel patterns is facilitated by rules of production implicit in the paint program. The designer, like the king, simply makes the moves and ponders.

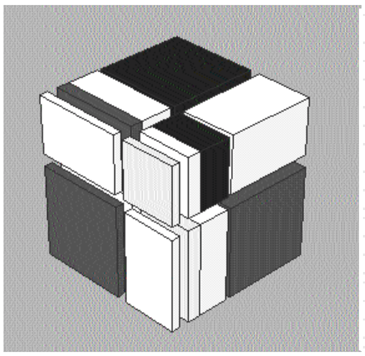
The exercises in drawing applications used the same venue for the investigations but with much less success. The initial objects seemed to resist anything but composition, shedding any metaphorical or analogical meaning. It seemed that the designer's intentions—as motivated by the program—were insufficient and that the entities themselves held the key to meaningfulness. We have some understanding of why parents are discriminate in the selection of toys for their children. The right toys hold the greatest promise that a child's play will yield insight to the world. Designers can also expect that some entities will provide better insights to the investigation of the production of form. The architect's activity of designing, as with a child's play, should proceed only once these basic elements have been identified. So rather than rely on lines and polygons—the objects specified by the application—the investigation proceeds into surface modeling only after referring again to architectural theory.

Investigation into the production of type-form

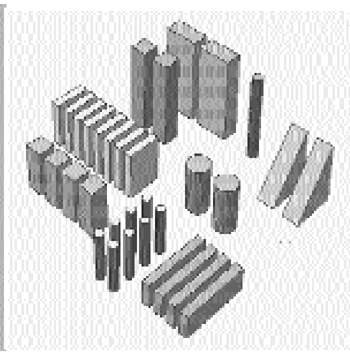
Investigations employing the 3-D surface-modeling program drew upon the primitive elements found in several sets of toy block sets. Each set of blocks chosen has a lineage to some theory on the origins of form. And each adds yet another set of clues to unravel the mystery of type and form. Three different sets of blocks were used in the exercise: the Bauspiel ein Schiff Blocks, Modulon Blocks, and the more familiar architectural Building Blocks.[9]



Bauspiel Blocks



Modular Blocks



Building Blocks

The Bauspiel Blocks are cut from a slender rectangular mass including pieces with both concave and convex curves, several small cubes and triangular pieces, an assortment of rectangular blocks, and a cylinder that was cut from a cube. The shapes look as though they were formed through an activity of construction. The blocks that carry the most information are curved pieces which look either carved, cut or bent. The activity of making leaves an imprint on the material—an appeal to memory. Although the pieces were cut from a single block like a jigsaw puzzle—ready to be rejoined as a unity—there is a familiarity in the parts so indistinguishable that it seems to work prior to deliberation.

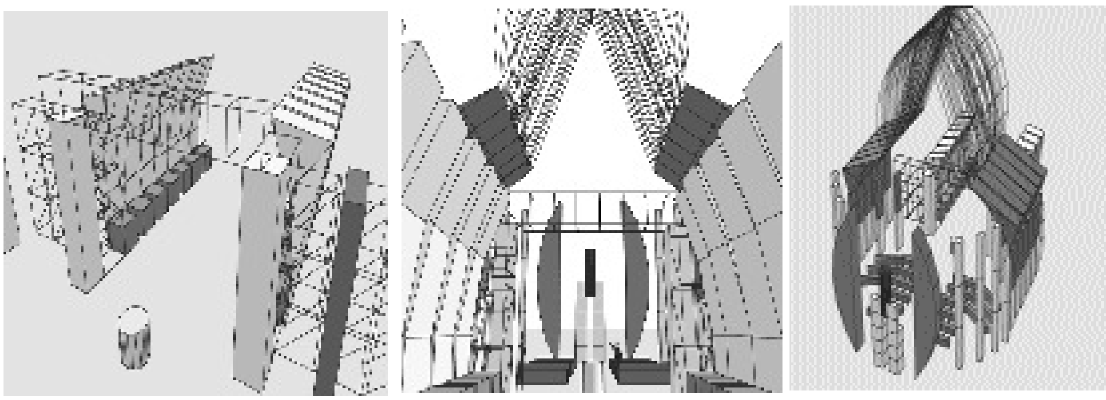
The Modulon Blocks have a similar origin as the Bauspiel. They too are cut from a single block. However, they carry a very different appeal. Theirs is a system of organization—a geometrical system that informs every width, every height, every thickness. The Modulon Blocks are made from successive cuts into a cube. Each cut is proportioned by the golden mean. All the pieces are orthogonal, no bends or curves, no shape other than rectangular mass—the first of which resulted from the first cut into the cube. The collection contains seven different masses ranging from rather blocky to very thin and planar. The pieces can be arranged to form many different proportions according to the harmonic principle.

The set of Building Blocks does not originate from a single block, nor do the blocks have a system of proportions to guide the cuts. These blocks are, however, very recognizable, although ambiguous as building components. The pieces of this set are developed from familiar shapes found in buildings: triangular pieces that might be pediments, columns of different proportions, and various block-like and wall-like masses and planes. This set is more like a collection of building parts. The other two sets are not.

The toy block sets were constructed in the 3-D virtual environment using the surface-modeling application *UpFront*.[10] Differences between the original physical blocks and the virtual blocks are worth noting. The virtual blocks could be duplicated at will, altering the purity of the original mass distinguished by a limited number of pieces. As long as the size and shape of the individual pieces were not altered, the original construction of the system was maintained. Also, the blocks held no texture, weight, or material qualities except those visual clues of shape and color. And without gravity, the designer is free to decide whether or not pieces connect or simply imply connections. It is also possible to change the color of the blocks. In either case, these manipulations were done with an understanding that either color (such as metallic or sandy) or the implication of a type of connection (such as stacked or hinged) may evoke certain non-specific material properties. Finally, in order to evoke some sympathy for scale in this scale-less environment, the designer was asked to propose an overall scale for the model by adding human figures or other entourage from a library of virtual objects. The scale of the object could change until it appeared appropriate. None of this was possible in the physical blocks.

Certain procedures given preference by the computer application such as duplicating, rotating, and mirroring of pieces or assemblies encouraged hierarchical groupings and symmetry. The models were almost always orthogonal. However, because the dimensioning systems are internal to the blocks, it was not possible to use grid coordinates furnished by the computer application if the blocks were to touch each other. Instead, the blocks themselves served as reference for the moves.
The design activity took the shape of the “Semiotics Game” developed by Juan Bonta.[22] Each student was given the sets of virtual blocks and asked to select a building type from a list of six types: supermarket, religious, bank, industrial, residential and apartment building. Different building types were tried for each different set of blocks. The blocks, as primitive elements, could not be altered in any way other than color, which included transparency—making it possible to create openings with the blocks. Students were required to establish and work from a menu of at least six views—these included interior views. Designs evolved as the students moved around various views of the model.

Once the project was initiated and the students began playing with the primitive elements, they also began to discover properties of assemblies. In the course of the evolving situation, patterns and processes were recognized or implied (things became useful). Occasionally that discovery stimulated a change in direction, even a change in the suggested building type (type recognition). Students were not required to adhere to any initial or pre-conceived ideas about which building type or block set would be best suited to each other. It was not uncommon to experiment with the block sets for some time (discovering usefulness—becoming skillful) before committing to a specific building type.



Three Views of a Bauspiel block church

After students produced three building types from the three sets of blocks, they selected the one example which they felt had been most successful. This model was then brought to the screen with its cast of saved views and no identifying label. Students and

critics then did a musical-chairs rotation through all of the computer models, viewing each through a cast of saved views, then naming each project with their thoughtful guesses about the building type. The guesses were then compared to the intentions of the designer in a class discussion of the mechanism of type recognition.
The exercise revealed that each set has an inherent capacity to behave in particular ways. In fact, each set carries with it quite different capacities to produce order. Like a messenger, each carries the origins or source of the system (the first cut, the motivation of the next cut mediated by the first). The differences lie in the nature of the blocks and how that nature informs assemblage. Design success came where there was a clear partnership between the motivation of the designer and properties of the primitive elements. Students who had an idea or concept first and then tried to get the blocks to work for them had the toughest time, the greatest frustration and the least success.

Conclusion

Whatever computer application we choose and how we choose to use it will, unarguably, raise issues for the activity for designing. One of these issues centers on the nature of the primitive elements involved in the activity—whether building blocks or patterns of pixels. Another issue concerns the recognition of form—mechanisms of perception and knowledge of precedents.

The ABC exercises were conceived to induce a profusion of ambiguities to the screen image, compelling students into metaphorical and analogical thinking as a way to see significance in the images. This gestalt condition of ambivalence—multiple values and multiple meanings—is provocative and helps to sustain interest in the design activity. The exercises were also structured to immerse the student in an activity that would simulate the activity of making and, subsequently, the recognition of the materials or systems capable of producing type-image or type-form. Through the heuristic value of this involved activity, students gained an unusual insight to the essential dynamics of the production of form by observing patterns as they showed up under a wide range of conditions and intentions. Recognition, however, depends a great deal upon the experience and knowledge of the designer, and recognizing the most promising primitive elements proved to be particularly difficult.

Students engaged in the ABC exercises discovered that not every primitive acts the same in the production of architectural form. The success of an experiment usually hinged on a working correspondence between the primitives in the application and the elements which produce form in buildings. When entities held few imbedded properties or little productive capacity, not much happened. Students asked to design with their own primitive elements often produced disappointing results—rough massing models with no particular theoretical, constructional or mathematical foundations.[23] With great consistency, the successful investigations began with a successful selection of the elements. Following that, the most compelling results were the products of partnerships between the primitive elements and the application—when the parts were properly filled and the roles properly cast. To borrow a line from Hugo Haring, "Life is not given to the work by fashioning the object, the building, according to a viewpoint alien to it, but by awakening, fostering, and cultivating the essential form enclosed within it."[24]

ENDNOTES:

1 Toffler, Alvin and Heidi. *Creating a New Civilization: The Politics of the Third Wave*. (Atlanta: Turner Publishing Inc., 1994): 29.

2 Greinacher, Udo. "The New Reality: Media Technology and Urban Fortress", *Journal of Architectural Education*. Volume 48, Number 3. (February, 1995): 176.

3 Garreau, Joel. *Edge City: Life on the New Frontier*. (New York: Anchor Books / Doubleday, 1991): 278.

4 Van der Ryn, Sim and Calthorpe, Peter. *Sustainable Communities: A New Design Synthesis for Cities, Suburbs and Towns*. (San Francisco: Sierra Club Books, 1986): xiii.

5 Crosbie, Michael J. Editorial: "Public Space Held Hostage". *Progressive Architecture*, March 1995: 9.

6 Cameron, Beverly J. (Editor). "Teaching in a Clinical Setting", *Teaching at the University of Manitoba: A Handbook*. (Winnipeg: University Teaching Services, 1993): 30-33.

7 Ibid.: 32.

8 Bloom, Benjamin S. (Editor). *Taxonomy of Educational Objectives: Handbook 1 - Cognitive Domain*. (New York: Longmans Green).

9 *Manitoba Science and Technology Advantage, 2nd Edition*. (Winnipeg: Manitoba Industry, Trade and Tourism, 1994): 30.

10 Ibid.: 30.

11 Dunham-Jones, Ellen. “Learning From the Liberal Arts”. *Proceedings: The Liberal Education of Architects*. (Lawrence: The University of Kansas School of Architecture and Urban Design, 1990): 62.

12 Rafael Moneo, “On Typology,” *Oppositions* , p. 23-45

13 These exercises and investigations are relatively pain-free ways to learn some basic computing strategies and could be employed across the curriculum—especially in beginning theory classes and design studios or as a device to integrate design and theory in later studios. The computer systems required for these exercises do not need to be high-end. The application *UpFront* was used to develop the block exercise. This is an inexpensive application (academic price is $99 at this time), the equipment requirements can be minimal (typical Macintosh or Windows installments), and it is very easy to learn.

14 The concept of holism is integral to Gestalt theory. Parts of the manifold of sensations making the experience (a field of some sort) will interact and, in doing so, lose their individuality and produce a whole-quality or configuration that is different than the sum of its parts. In this characterization of the mental process, the brain spontaneously achieves organization into objects on backgrounds and configures the components of these objects into whole qualities such as unique shape and form. For more on Gestalt theory see Frederick Perls, Ralph Hefferline, Paul Goodman, *Gestalt Therapy* (New York: Julian Press. 1951).

15 Moneo, “On Typology.”

16 Italo Calvino, *Invisible Cities*, translated by William Weaver (New York: Harcourt, Brace, Jovanovitch, 1972).

17 William H. Gass, “Invisible Cities”, in VIA *#8* (Graduate School of Fine Arts, University of Pennsylvania and MIT Press, 1986) p. 136-155.

18 Colin Rowe and Fred Koetter, *Collage City* (Cambridge, MA: The MIT Press).

19 This description of Calvino’s *Invisible Cities* is from William H. Gass, “Invisible Cities.”

20 The Bauspiel ein Schiff Blocks were designed by Alma Buscher, a furniture designer

who taught at the Bauhaus. She was well-known for her children's furniture and toys. (See Wingler: *Bauhaus*). Both the Bauspiel Blocks and the Modular blocks are manufactured by Kurt Neaf. The set, Building Blocks, was developed by Paul Tesar and his students at North Carolina State University following a workshop with Juan Pablo Bonta at an ASCA Cranbrook Teachers' Seminar.

21 Students were asked to play with these sets of virtual objects in part as a way to develop strategies for movement and assembly in virtual reality.

22 The "Semiotics Game" was developed by students at Ball State under the instruction of Juan Bonta as described in Juan Pablo Bonta, *Architecture and its Interpretation*, (New York: Rizzoli International Publications, 1979) 227-228.

23 I have considered a more involved design activity that begins with specification of primitive entities and procedures for their manipulation. In an upper-level design studio, "block" sets were developed that were more closely linked to construction tectonics.

24 Hugo Haring, "The house as an organic structure", 1932, reprinted in *Programs and Manifestoes on 20th-Century Architecture* edited by Ulrich Conrad (Cambridge, Mass: MIT Press, 1993).