An Extended Mural for a House of Mathematics

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Abstract

In a competition organized by the Utah Arts Council for the Cowles Mathematics Building, the faculty asked for art that would create the sense that this is a "house of mathematics" and convey its wide ranging influence. They also asked that it be a source of pleasure, intrigue and inspiration for future generations, a rare statement from a building committee. To document this work and its implications both for mathematics and architecture is the basis for this paper and visual presentation.

Introduction

How one experiences a work of art or architecture has always been important to my research, teaching and site specific art projects. With long corridors in the older Cowles building and limited wall space in the modern, mostly glass addition, a solo work on one of the three floors would not satisfy the spaces nor the stated goals. I began to visualize a multi faceted work that extended throughout the building. It would develop structural connections with the sciences, arts and culture while conveying the range and beauty of mathematics.

In the new addition I selected the Lobby walls on three floors that can be seen from the stairs , entering the building and through the exterior glass walls. They are approximately 12' x 12' and would be the major focus for each floor. Additional groups of plates extend into the long corridors like fingers and expand the concept. Adopting a modular scheme of 18" x 18" square plates in varied clusters helped convey a wide range of ideas while creating a strong concept. Much of the work was developed with the help of the computer and used mixed media for a more tactile experience. The natural color aluminum plates were silkscreened and in some instances hand painted. The black anodized plates are laser etched and color added by screening.

Numbers / Measure

For a complex work of this scope a strategy was needed to develop the specific art for each area. Various concepts were explored. It was not to be a history of mathematics but historical references were included. It was not a textbook, literal or pedantic. It was to be suggestive and a stimulus for the imagination. Personal viewpoints no doubt would influence portions of the art but were balanced by the criteria established. Each plate was to be a work of art related to its immediate context and part of the general intellectual, mathematical and visual concept.

Numbers were a logical point of entry and a fascinating area of historical research. The centuries long development of abstract thinking that led to concepts of quantity, sequence, numeration systems and positional rotation are inferred in the group of plates devoted to Mayan, Babylonian and Fibonacci numbers (Pl.2,4,9) culminating in emphasis on zero. (Pl.11) The last is overlaid with a random bitstream basic to the computer. Digital counting (Pl.14) continues to be used by groups today but may not include body gestures.

The census count 2000 sketched in (Pl.7) raised some interesting questions and was given the title, Who counts? Who is counting? Denis Guedj commented, "How do we add things up? By seeing each object simply and exclusively as a unit. By seeing things as entities while rejecting their specific differences". The lack of specificity in the latest count was challenged.

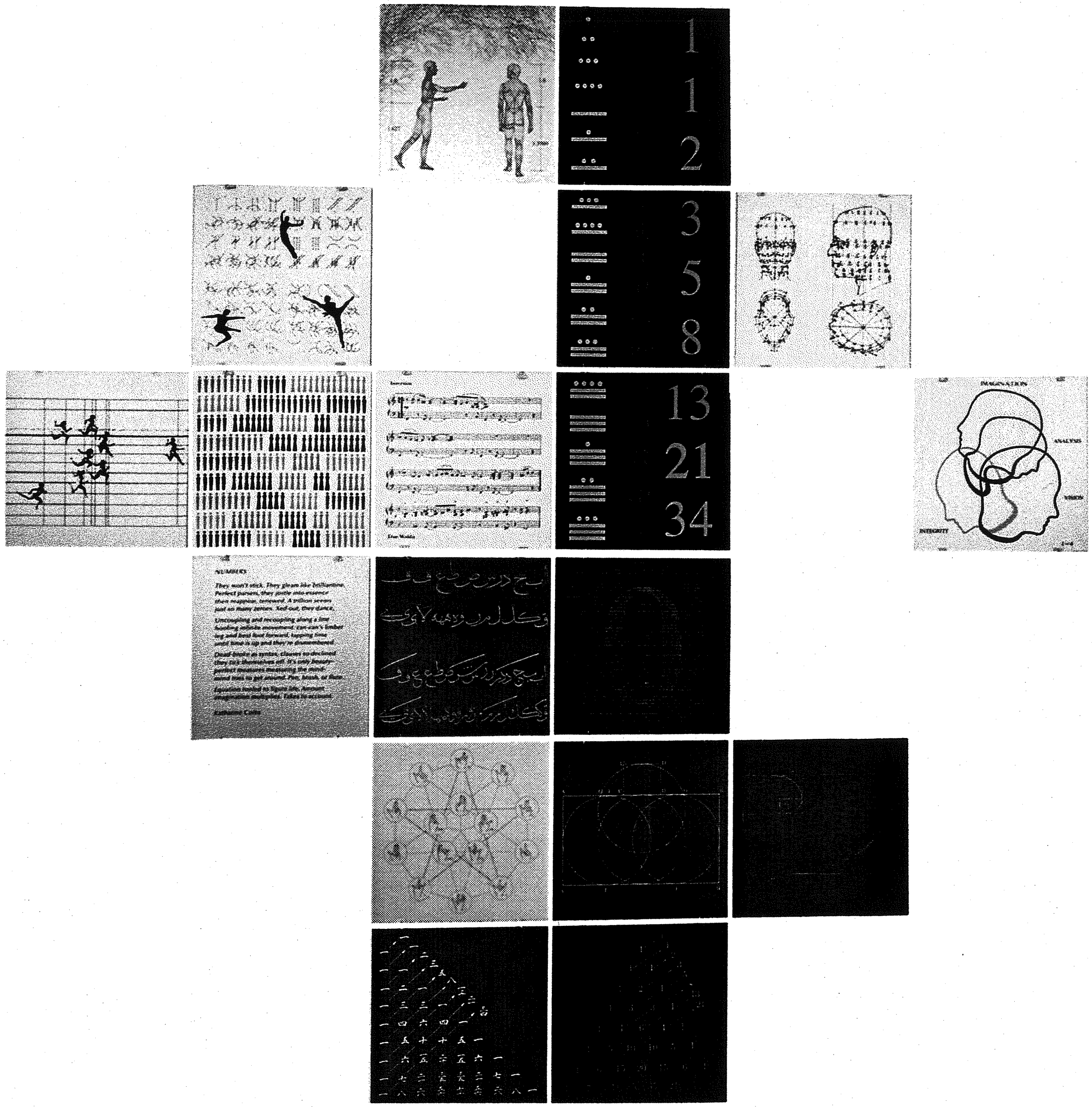
Organizing numbers in patterns and rules of notation is a fascinating study that gradually led to arithmetic. Further transformation moved the concept of number from quantity to calculating and the development of algebra. Interwoven in the pursuit of knowledge are interesting diversions such as Pascal's triangle, (Pl.18) and its Chinese equivalent, (Pl.17). The mathematician's study of probability in gaming revealed some new properties in the arithmetic triangle. Later mathematicians observed relationships with Fibonacci numbers, which are indicated on the diagonal.

The Fibonacci sequence shown in (pl 2,4,9) has many applications in organic growth patterns and in art. One thinks of the beautiful chambered nautilus shell when seeing the equiangular or logarithmic spiral in (Pl.15). Although spirals are common in nature not all exhibit Fibonacci proportions. Renaissance artists inspired by Greek art and architecture used the golden mean proportions extensively. (Pl.15) is an analysis of the famous altarpiece of Rogier van der Weyden's "Descent from the Cross". One could also cite examples by Raphael, da Vinci and more recently Cezanne and early 20th century artists. Piero della Francesca was a master mathematician as well as artistic genius. His development and skill in the use of perspective can be studied effectively in his great "Flagellation of Christ" in Urbino. Here in (Pl.5) his head studies from "De Prospectiva Pingendi" are shown. Measurement and close observation provided a balance for his mathematical principles.

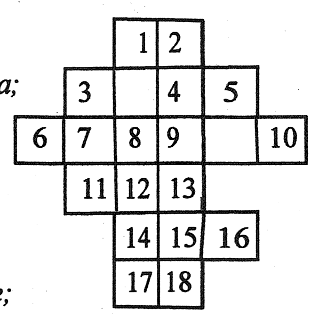
In architecture from Alberti and Brunelleschi to Le Corbusier the golden mean persisted as a design basic for proportion and expression and continues to some degree today. In painting anti formalistic directions, surrealism and other fashions temporarily dominate. However a mathematical base whether explicit or implied underlies much of today's art.

An interesting parallel to the Fibonacci sequence is the geometric progression although I have found no discussion of its visual implications in mathematical references. (1.1.2.3.5.8.13 // 1.2.4.8.16 etc.) Josef Albers in his monumental work, "The Interaction of Color" refers to the Weber-Fechner Law, "The visual perception of an arithmetical progression depends upon a physical geometric progression". He is concerned here with obtaining a graduated scale of equal intervals whether in greys or in hues. Simply mixing pigments with an equal quantity of the same color, which was a common student exercise in the past, does not produce the desired psychological effect. Much of Albers emphasis in teaching and in his art is the importance of training the eye to recognize color intervals and the context in which we see color.

By expanding the concept of numbers to include measure, many related arts and cultures could be included. I asked a very talented poet, if she would do a square poem about numbers. Her interests in science and mathematics were reflected in her poetry. The resulting sonnet is a lively, engaging piece and one could easily focus a larger work on it. Dance was an area familiar to me and a surprise to some mathematicians. The choreography of Lucinda Childs is an excellent example of geometric patterning of movement. She graciously permitted me to include it here. Movement is also recorded as time in the Swatch photo of Olympic racers, precisely caught by photography. The composer, Dan Waldis, was preparing a new work for the opening ceremony, dedicating the Cowles Mathematics building. He contributed a few bars to represent music. All of these areas could be vastly expanded and perhaps a youthful mathematician will be inspired to do so.



Numbers and Measure, 2001-2 *First Floor Lobby*



Pl 1. *Modular,* Pl 2,4,9. *Numbers: Myan, Babylonian, Fibonacci;*
Pl 3. *Choreography by Lucinda Childs;* Pl 5. *Studies by Piero Della Francesca;*
Pl 6. *Olympic racers, Swatch photo;* Pl 7. *Who Counts? Census 2000;*
Pl 8. *Jazz composition by Dan Waldis;* Pl 10. Aspects of Mind;
Pl 11. *Numbers by poet Katherine Coles;* Pl 12. *Islamic calligraphy studies;*
Pl 13. *Zero with random bitstream;* Pl 14. *Counting with hand gestures;*
Pl 15. *Rennaisance pictorial organization based on the golden number - 1.618*
Pl 16. *Logarithmic spiral using Fibonacci proportions;* Pl 17. *Chinese triangle;*
Pl 18. *Pascal's triangle showing Fibonacci numbers.*

Numbers / Measure /Geometry

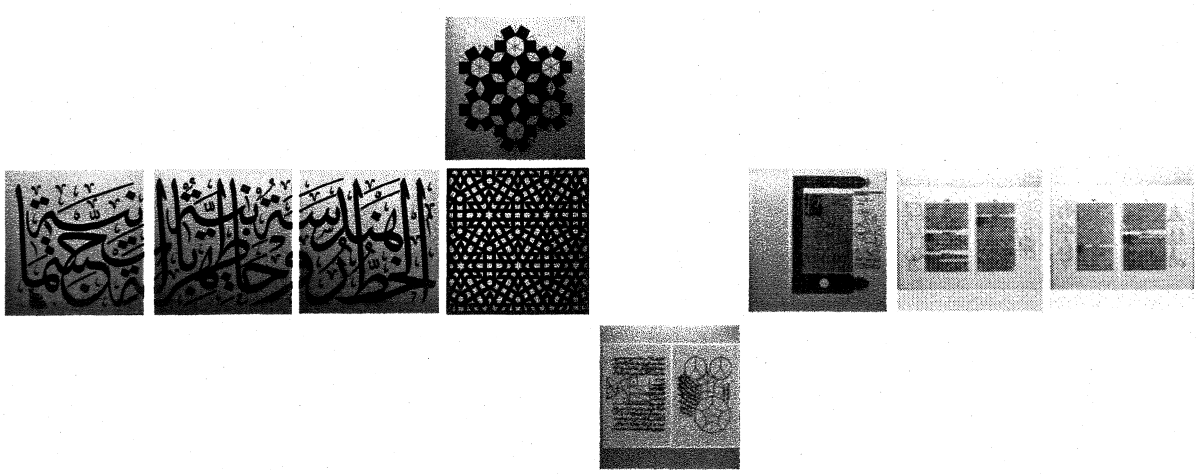
Calligraphy is beautiful writing and Islamic calligraphy is particularly beautiful. As an introduction to Islam's influence in mathematics the text draws on the great 13th century master, Yaqut al-Musta simi: "Calligraphy is a spiritual geometry, manifested by a material instrument" (Pl. 19-21). While the spiritual side of mathematics is not addressed here the work does not preclude it. The measured strokes and rhythmic beauty of the piece reveals more than words and complements the rigid geometry of (Pl. 22-23) and other panels.

Many of the early Islamic manuscripts I studied were devoted to Euclid's Geometry and it seemed more appropriate to include his original propositions in the edition of 1482 (Pl. 25-27). However the very early Paris Islamic geometric manuscript discovered by W.K. Chorbachi at the Bibliotheque Nationale seemed appropriate (Pl. 24). Entitled: "On the interlocking of similar or congruent figures" the drawing shows the design with the decagon and pentagon anticipating Penrose tiles.

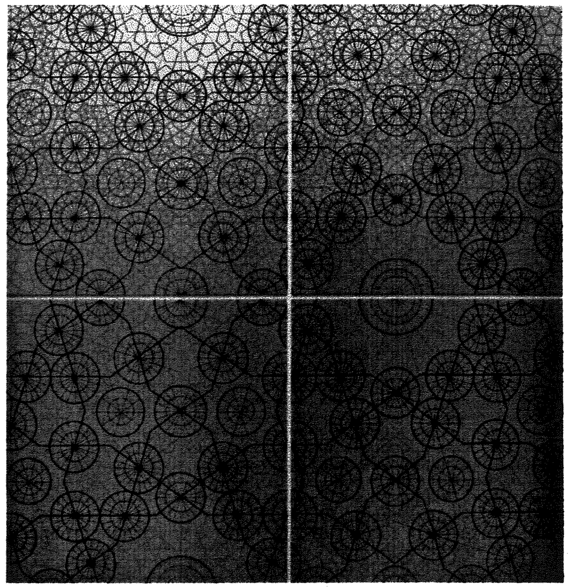
Euclid's "Elementa Geometriae" drawn from the Rare Books Collection of the J. Willard Marriott Library is a treasure to enjoy in detail as well as to study the propositions. It is also one of the most famous books published by the Gutenberg Press shortly after the Bible. Being in Latin, it is probably more accessible to students than a Greek edition would be.

Another magnificent book is "The Topkapi Scroll-Geometry and Ornament in Islamic Architecture" by Gulru Necipoglu. The scroll's 114 patterns used at various times in the building of the Topkapi Palace are discussed, their importance for Islamic geometry and details of their construction. I drew inspiration from a small pattern, expanded six times here (Plates 28-31). Separating layers for printing helped develop a healthy respect for the early artist.

The adjacent group of plates includes a range of more current geometry. (Pl.33) describes the earth's path in the warped spatial fabric and is combined with Einstein's Field Equation. A preparatory study for the geodesic dome of R. Buckminister Fuller is shown wih the icosahedron's thirty one great circles. James Carlson' spiral geometry study is a near neighbor.

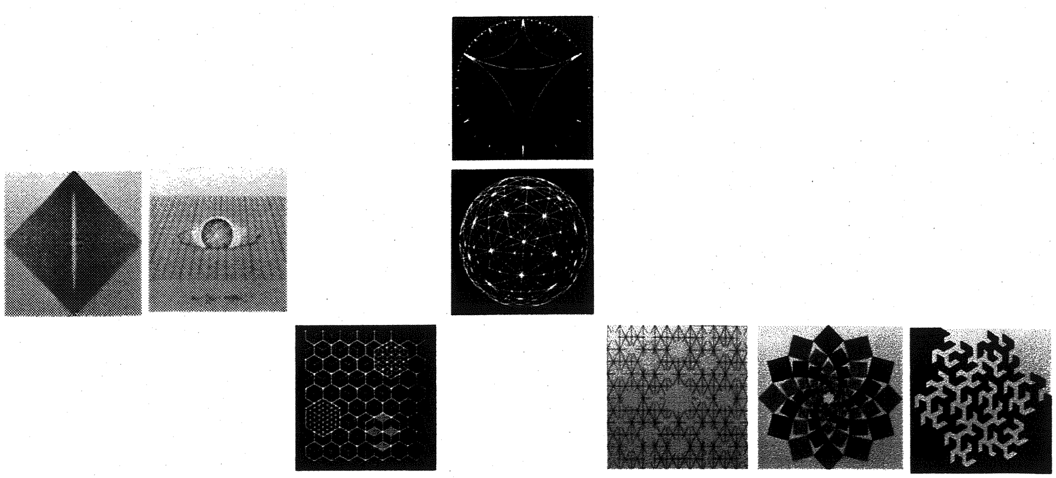


Numbers / Measure / Geometry: *First floor corridor, Plates 19 - 27*

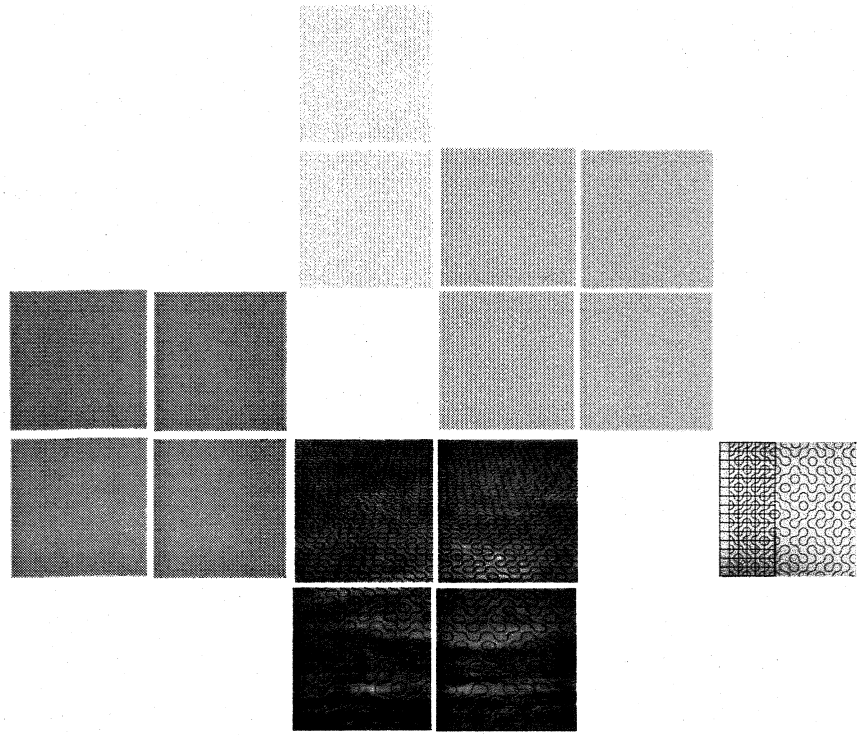


Adapted from The Topkapi Scroll 1995 by Gulru Necipoglu
First floor Corridor, Plates 28 - 31

(Pl.37) is called implied geometry and is often an intruder in my work in the area of illusion. Moire effects (Pl.32) can also be an unplanned element when working with grids but are quite beautiful to observe and can be predicted mathematically. At times using a module for developing a work can be helpful, a technique inherited from architectural training .For dynamic form my preference is for the triangle and hexagon, developed in study (Pl.34). A harmonic growth pattern of Islamic origin (Pl.38) and a FASS curve complete this cluster. FASS (an acronym for space-filling, self avoiding, simple and self-similar) is adapted here for figure ground reversal (Pl.39).



Numbers / Measure / Geometry (cont.): *First floor corridor, Plates 32 - 39*



Intersections with Nature: *Second Floor Lobby, Plates 1 - 15*
A Work in Progress

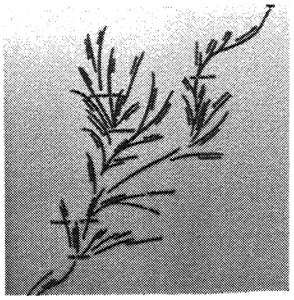
The Second Floor theme is Intersections. The Lobby focus is on the relationship of mathematics with nature. It is currently being revised to give more emphasis to mathematical structures. Clockwise panels (pl.1-4) will reveal land forms in nature. (Pl.10-13) develops plant life and trees using fractal programming.

(Pl.5-8,9) suggests water with Truchet tiling, named for the eighteenth century mathematician who described it. Randomly generated the tiling resembles patterns from the surface of the ocean often studied on Puget Sound when the salmon were not biting. (Pl.9) shows the construction for interested students.

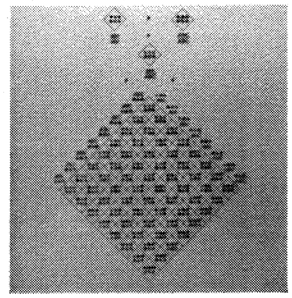
The theme of tree structures continues in the second floor corridor clusters devoted to *Intersections with Science*, particularly Biology. Initial plates are from Darwin's diaries showing his rough tree sketches and revealing his thinking prior to developing "*On The Origin of Species*". The elegant "*Evolutionary Tree*" of Sir Gavin de Beer continues the theme.

Genetic mapping is an important area of research at the University of Utah and much could be developed about it. Some limitations of plate techniques prevented using tonal images, but mapping for color inheritance in wheat is shown here. The structure of DNA is so well known that it is combined here with microarrays which suggest future individualized directions.

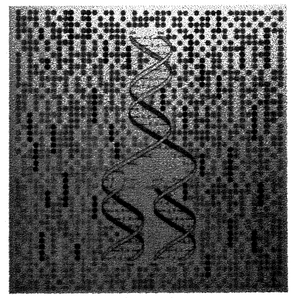
For the plates devoted to Physics, Fourier's Transform Theory provided the focus.



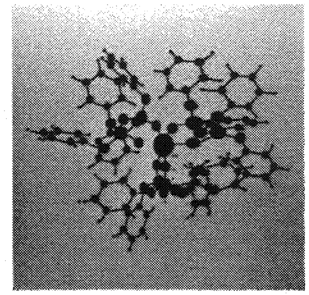
Pl .18 *Evolutionary tree of Sir Gavin De Beer*



Pl. 19 *Genetic mapping of color inheritance*

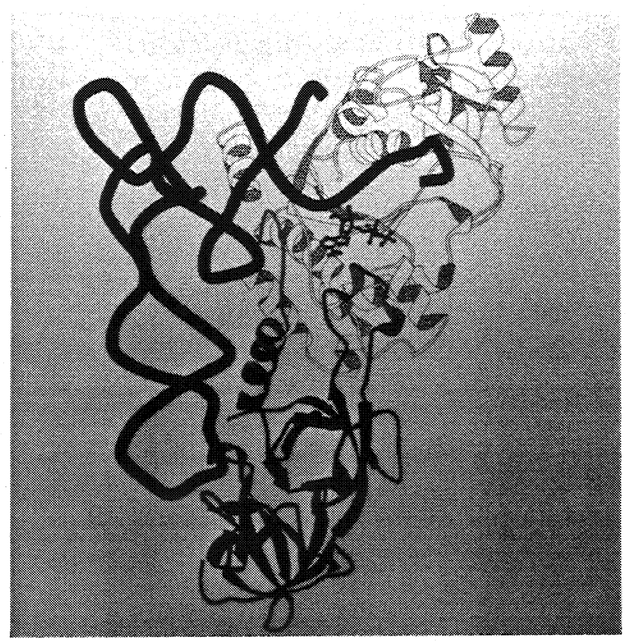


Pl.20 *DNA/Microarray*



Pl.22 *Molecular Structure of Silicon Carbide*

Intersections: Science



RNA complex form E. coli determined by Rould et al., 1989, *Second Floor corridor, Plate 21*

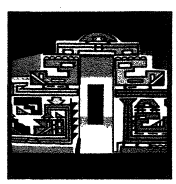
Intersections with the Arts

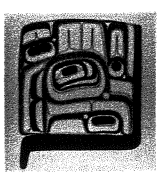
I am often confronted with prejudices about mathematics that exist in popular culture today. As a student I was never told that women could not do mathematics nor pursue technical studies. Math was never optional in a classical education. But in early college studies in art history I encountered surprising attitudes about "primitive" art and later "mathematical" art. They were considered inferior forms or irrelevant to the great history of art. As a result they became increasingly attractive to me. My experience of African, Pre-colombian and American Indian Arts developed early. Islamic art and architecture came first through Spanish literature and later in museum visits and travels in Spain and Turkey.

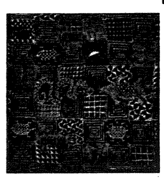
This section of *Extended Vision* posed a dilemma for me because the range of influence of mathematics in the arts is broad and deep although not always explicit. For my limited selections here I chose to emphasize so called "primitive" arts because they illustrate the very basic geometry of vision. How we see and organize forms, how the structure of weaving has influenced building structure and decoration and today the developing computer system.

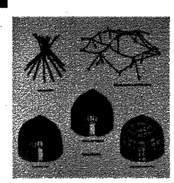
The art of the Haida of the Queen Charlotte Islands in the Pacific Northwest welds abstract forms with a sense of nature and a calligraphic hand (Pl 30) is from my own collection. The geometric forms of Navajo weaving (Pl.31) have inspired many contemporary painters and weavers just as African arts appealed to an earlier generation of cubists. When we think of modular organization it is usually in terms of precise geometric forms. In ethnic arts the boundaries are often more fluid or softer. but the structure exists. It is the deviation from a rigid structure and more spontaneous patterning that makes African designs so appealing. (Pl.32) of a resist-dyed textile from Nigeria suggests an artist with exceptional control and a wonderful sense of humor.

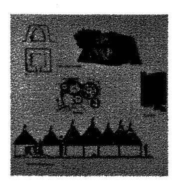
From weaving, dying, quilt making and beadwork to wall painting (pl. 33) is a natural progression for the women of the Ndebele people in South Africa. It has also been a means of preserving cultural identity in times of persecution and economic displacement. *Early Habitats,* (Pl. 34-35) seemed to be a natural link with the structures of Buckminster Fuller and the geometry of later architecture.

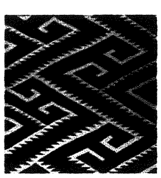




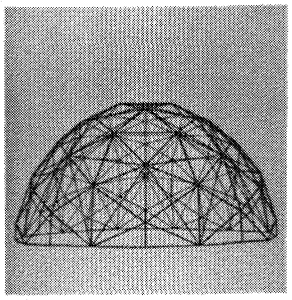




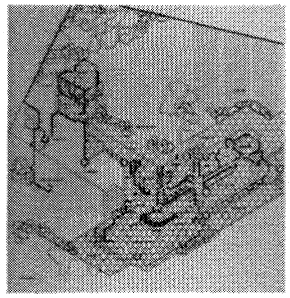




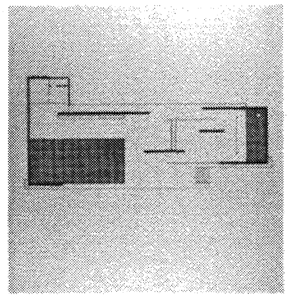
Intersections with the Arts: *Second Floor corridor, Plates 30 - 35*



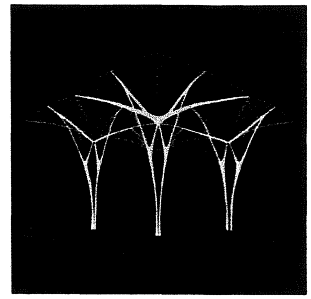
Pl.37 *Trade Fair Dome*
R. Buckminster Fuller



Pl.38 *Hanna House*
Frank LLoyd Wright



Pl.39 *Pavilion, Barcelona*
Mies van der Rohe 1929



Pl.40 *Zurich Pavilion*
Santiago Calatrava

Intersections: Architecture

To select a few masters to represent the range and influence of mathematics in architecture is naturally a subjective decision. What is important is to make the connection and to suggest a range of geometry. R. Buckminster Fuller's work reflects his intense observation of natural forms his exploration of materials in model form and relentless pursuit of ideas about shelter. In some aspects he shares these concerns with Frank Lloyd Wright, whose brilliance as a designer and engineer is part of history. Comparing the relation of the hexagonal module in the final plan for the Hanna house (Pl.38) with the square module of Mies' famous pavilion in Barcelona (Pl.39) provides some insight into the nature of architectural expression. The serenity achieved in Mies' work is also due to a conscious elimination of the unnecessary. One of the greatest living architects, Santiago Calatrava is a brilliant engineer who details his designs with the precision of a jeweler.The resulting structures rather than being sterile are elegant and daring while retaining a strong affinity for nature (Pl.40).

About the Process: Extended Vision

Traditionally the work would be defined as a collage if one could have adapted found materials. Here each panel was drawn with a specific concept in mind generally with the help of Adobe llustrator, Autocad and occasionally Photoshop. Some panels and details were programmed and others hand painted. The drawings were transferred photographically to screens or by the computer to the laser etcher.

Choosing the modular aluminum plates for the medium made the extensive development of the work possible. It was also practical for the spaces where students are walking within arms' reach. Occasionally the chosen medium presented some limitations as the work progressed. Tonal images were not suitable for primarily vector techniques.

Organizing the plates in clusters suggested the openness of ideas and the possibility of extending them. Students can visualize how they might expand the concept with their original work. It was also appealing visually as a way of activating space on the long corridors. As the chief architect for the project commented, "The art made the building come alive." Students have been very receptive and think of the mural as "cool" stuff. One frequently sees them gathered by the panels in discussion with faculty.and other students. For a University class in the History of Mathematics, a faculty member plans to involve students with the art and their individual investigations.

For the faculty, the art fulfills aspects of their mission to increase public understanding of mathematics, to attract talented students and to stimulate significant new mathematics.

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