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ABSTRACT

The concept of integrating mathematics and art course work broadens an appreciation of the connection between the two. Although calculations and getting the right answer have traditionally been the focus of mathematics at the secondary level, other topics have recently begun to be addressed, such as mathographics, or the relationship between art and mathematics, and creative constructions and shapes. Art instruction also includes considerable instruction in mathematics, as artists need to understand such concepts as parallel lines, visual distance, and perspective distortion. Moreover, many examples of mathematics in art works exist, such Albrecht Durer's use of grids in woodcuts and Salvador Dali's use of the hypercube, while there are also many examples of literature that support the mathematics/art connection. In interrelating mathematics and art at the college level, educators should keep in mind one of the essential purposes of education: to teach students how to think. Teachers must assume new roles, rather than merely telling students information. Colleges, too, are shifting from institutions that provide instruction to ones that create environments and experiences that help students discover knowledge for themselves. The combination of arts and mathematics can help students balance their education with a combination of creative imagination and logic. Contains 20 references. (HAA)

Math in Art or Art in Math

Jerry Biller

Paper presented at the Annual National Conference on Liberal Arts and Education of Artists (9th, New York, NY, October 18-21, 1995)

MATH IN ART -OR- ART IN MATH

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> Mathematics possesses not only truth, but supreme beauty.
> A beauty cold and austere, like that of a sculpture,
> without appeal to any part of our weaker nature...
> sublimely pure, and capable of a stern perfection
> such as only the greatest art can show.
>
> Bertrand Russell

The concept of integrating math and art course work broadens an appreciation of the connection between math and art. Working through mathematical eyes, one never visualizes how the artist creates. One can appreciation the poet and his poem, the artist and his painting, and the mathematician and his problem - and see all of these unfolding into a beautiful work of art.

It is not uncommon for the art student to experience high anxiety when involved in mathematical tasks. The study of art students by Judith Katz describes them as intuitively different than those at liberal arts colleges. She notes that they like short term, independent projects and enjoy assignments that allow creativity and imagination. "According to mathematics historian Dirk J. Strik (1948/1987), the first recorded concepts of number and form are represented in the work of Paleolithic artists" (Bickley, 1995, p. 7).

In investigating the idea of art in math, it was encouraging to see what appears to be a change in the focus of high school math. Calculation and getting the right answer has been the main concern. Looking through a secondary mathematics resource catalog, we see topics like: Mathographics (explore the realm where math meets art), Creative Constructions, Make Shapes, Explore Designs, mathematics that underlies architecture and design, string sculptures, complex patterns, tessellating art, the art of construction and pages on the work of M.C. Escher.

A mathematician is a maker of patterns...
His patterns, like the painter's or the poet's,
must be beautiful; the ideas, like the
colors or the words, must fit together in a
harmonious way. Beauty is the final test.
There is no permanent place in the world for
ugly mathematics.

G. H. Hardy

Geometric patterns are all around us from the fabric of our clothes to wallpaper. One class of geometric patterning is a tessellation. Tessellations interweave concepts basic to art, geometry, and design. "The study of tessellations offers students experience in the 'creative interplay between mathematics and art'. Students can express their creativity and at the same time learn art and geometry of polygons" (The National Council of Teachers of Mathematics).

Looking through an art resource catalog, we can find the reverse when they talk about perspective drawing, teaching tessellating art and the work of M.C. Escher. We look at a current college mathematics journal and see tilings of the plane on the cover. In the Chronicle of Higher Education, we see an exhibition by Helman Ferguson, "Integrating the Rational and the Romantic". The Chronicle refers to Ferguson as "a sculpture who clothes mathematics sensuously in stone and bronze." He creates unique sculptures because he sees them as "graceful reflections of pure reason" not abstractions. "As the exact sciences have the power to quantify the laws of nature, so art has the power to move the sour." The "ideas which undergird the mechanical functioning of our lives have their basis in mathematics. Beautiful and invisible, they deserve to be transmitted in order to awaken our awareness, overwhelm us with beauty and inspire a challenge to the terror we feel in the presence of higher mathematics" (Ferguson, 1995, p. B54). Millman confirms the consensus that a symbiosis exists between the artistic and mathematical views of points, lines, and planes.

When we look at what mathematics artists need to know, we immediately start with lines, parallel planes, visual distance, and perspective distortion. Most shapes found in nature can be filled comfortably in basic geometric figures as the triangle, rectangle, square, cube, pyramid, cylinder or sphere, etc. The hand can be seen as a block and a mountain could be a pyramid or a triangle. We look at drawings with one and two point perspectives and need to be aware of the optical illusion that a form becomes distorted as it recedes or comes forward in space or "foreshortening"'

When the sculptor creates; space, dimensions, center of gravity complementary sets and geometric objects are mathematical ideas which are utilized. Space is important to the sculptor. Some works occupy space with their center of gravity at a point within the sculpture. These are anchored to the ground in a manner we are accustomed. Michelangelo's David, the Discobolus and Beniamino Bufano's St. Francis on Horseback are such examples. Where as SanFrancisco's controversial Vaillancourt Fountain has a center of gravity as a point in space.

In Durer's book, published in 1528, he used a method of putting grids on faces and then distorting the grids and lines to explore what happened to faces as the proportions of various features changed. Albrecht Durer is created with the beginning of the story of morphometrics (the statistics of shape) used by Fred L. Booksteins, a Mathematician, to analyze the brains of schizophrenics.

Other examples of math in art are: 1) Theodore Cook's book, The Curves of Life. In which he states, "The line containing the figure from the top of the head to the soles of the feet is divided at the navel into exact proportions given by the golden section"; 2) The Pyramid Theme is seen in the design of an office building in Foster City, California; 3) Buckminster Fuller's Geodesic Domes; 4) The Wright's Martin County Civic Center, Marin County, California. In Frank Lloyd Wright's words, "Architecture is the scientific art of making structure express ideas"; 5) In Durer's Woodcut "Melancolia", geometric solids and the sun's rays act as lines of projection;

6) M.Ç. Escher uses tessellations to make reptiles come to life in 3 dimensional drawings; and finally, but by no means last, the unfolded hypercube was the inspiration for Salvador Dali's, "The Crucifixion".

Examples of literature that support the math/art connection include: 1) Panofsky's Perspective as Symbolic Form, In an attempt to show the difference between the two she actually shows their similarities; 2) Leonard Shlain's, "Art and Physics: Parallel Vision in Space, Time and Light" (1991), he shows an integration between art and physics; 3) Included in the 25th volume of "Leonardo" (1992), the author discusses the work of Brent Collins and the mathematical content of his topological sculptures; 4) In Henderson's, The Forth Dimension, she considers artwork from the nineteenth and twentieth century; and, 5) The Boles and Newman book, The Golden Relationship: Art, Math, Nature (Book 1: Universal Patterns), is a collaboration between a mathematician and artist. Primary focus is on the Golden Section (or Golden Ratio) as both a mathematical and visual art form. Cartesian geometry underpins the present day technology of computer graphics. The computer animation that appears on screen "exists only as a collection of mathematical equations in the computer memory" (Devlin, 1994, p. 120).

When a group of art educators were asked to find a mathematical element in the art lesson plan, their responses included remarks such as: "I failed all my math courses.", "I am an artist. I don't do math.", "There is no relation between art and math.". It was also felt to be true that "art activities that contain the exploration of possible relationships (induction) and testing those relationships (deduction) were not the same as those used in math. Bickley (1995) contends that when putting art together with math ideas, the art "constitutes an illusionary base for thinking, interpreting, knowing, and problem solving" (p. 15).

In looking for the best approach to teach and interrelate mathematics and art, we must consider what the education policies Commission considers the central purpose of American Education and that is "the ability to think" (Shane, 1981). The concept of the learner as a constructor of knowledge is essential to any curriculum. "Students who construct their own mathematical understanding transform their mathematical potential" (Office of Research, 1993, p. 5). Methods of reasoning are the same in art and math. They are intersecting and related in meaning. They are both experimental tools that facilite a transfer of learning for the art student.

Brickley, in her article, "Math and Art Curriculum Integration", hypothesizes that "congruent content between the disciplines of visual arts and mathematics exists and by attending to these congruencies, both math and art educators can provide more effective instruction through coordinated curricula" (p. 6). We need to evoke active rather than passive participation in the learning process. "The arts invite students to be active participants in their world rather than mere observers it it" (Fowler, (1994, p. 8). This means teachers must assume new roles. They can no longer teach by telling. "A paradigm shift is taking hold in American Higher Education" (Barr, 1995, p. 13). Colleges have been institutions that provide instruction and we are shifting to one that produces learning by whatever means works. Lecturing now becomes one of the possible ways to deliver instruction but not the only one. In the current learning paradigm, the colleges purpose is to create environments and experiences that help students discover knowledge for themselves, not just transfer knowledge. It "embraces the goal of promoting what Gardner calls 'education for understanding'" (p. 24). Albert Einstein summized that "We cannot solve our problem with the same level of thinking that created it." Buckminster Fuller's concept that it takes a very small force to change a large ship can be adapted to the new focus. The learning paradigm is his trim-tab (little rudder attached to the end of the rudder) of the great ship of higher education. The shift is what changes everything.

Students need to be challenged and they need to be involved in the learning process.

Tell them and they will forget

Show them and they will remember

Involve them and they will understand. . .

The combination between arts and math would balance their education with the combination of creative imagination and logic. They are developing the ability to describe, analyze and interpret skills that relate to critical thinking.

Leonardo daVinci's work reflects the predominant use of the golden rectangle and the concept of projective geometry in his masterpiece, "The Last Supper". In his words, "No human inquiry can be called science unless it pursues its path through mathematical exposition and demonstration" (Pappas, 1994, p. 86).

Todays artists are exploring a new medium in art. The computer has been associated with mathematicians, scientists, and engineers, but the computer skilled artist of today can do more in minutes that would have taken hours or days in the past. The math an artist needs to know can be taught while relating to the art they want to produce. "Efforts to increase computer use in the classroom are widespread in higher education and promising to cause major changes in the collegiate experience" (Deloughy, 1995).

The use of computers in math class can provide the student with challenges not possible until now. They will be able to understand concepts more completely by the increased availability to explore and analyze. They will have, in the words of H.E. Huntley, "The experience of creating something new or of uncovering some hidden beauty is one of the most intense joys that the human mind can experience.

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