ART SMART

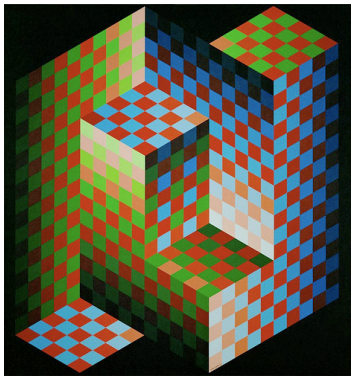
3rd Grade / February

THEME:

Art and Math

WORKS:

1. Victor Vasarely, *Gestalt-Zoeld*
2. Amish Quilt (Anonymous), *Double Nine Patch*
3. R. Buckminster Fuller, *U.S. Pavilion for 'Expo 67*
4. North Rose Window, Cathedral of Notre Dame, Paris
5. Jim McNeill, *Escher Bowl*



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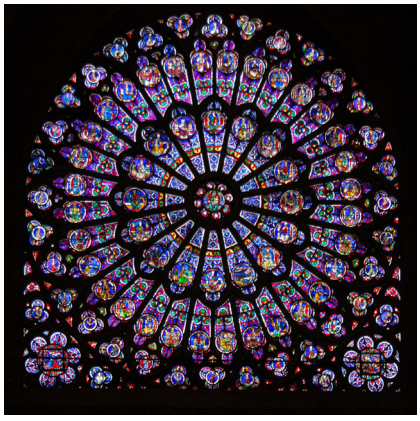

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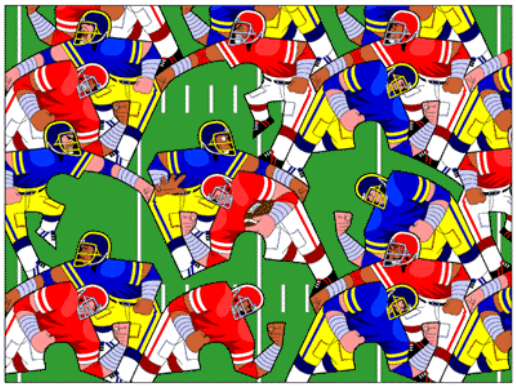

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Art Smart - 3rd Grade
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Artwork:

Victor Vasarely, *Gestalt-Zoeld*
Amish Quilt (Anonymous), *Double Nine Patch*
R. Buckminster Fuller, *U.S. Pavilion for 'Expo 67*
North Rose Window, Cathedral of Notre Dame, Paris
Jim McNeill, *Escher Bowl*

Victor Vasarely, *Gestalt-Zoeld,* 1976

Victor Vasarely is most recognized as a pioneer of Op Art, and for his paintings and prints of optical illusions.

He dropped out of medical school to paint and starting experimenting with the idea of geometric abstraction and optical illusions in paintings.

He studied how the human eye is affected by light, color and shape.

In the painting *Gestalt-Zoeld,* four large interlocking L-shaped forms are made from green red and blue squares. And done in acrylic paint, which is easy to use and easy to clean vs. traditional oil paints.

These L-shaped forms seem to alternate positions and play tricks on the viewers eyes.

Does the central cube appear to fold inward or outward? (depends on the viewer!)

Unlike implied movement found in traditional paintings, this painting attempts to trick the viewers eye into seeing movement but to also convey that actual feeling of movement to the viewer's senses.

Often Op Art appears to be made by a computer because the artist needs to be exactingly precise.

Amish Quilt (Anonymous), *Double Nine Patch,* 1920

The geometric shapes and vivid colors in Double Nine Patch are typical of the shapes and colors found in many Amish quilts.

Six characteristics pinpoint this quilt from being from Lancaster County Pennsylvania, as opposed to other Amish communities: the pattern, the use of solid color wool, the narrow inner border and wide outer border, the large corner blocks and wide bindings.

This quilt is symmetrical in design. *Does anyone know what "symmetrical" means?*

Take a look at the inner, narrow border. Does it look like the green diamonds are sewn on a blue background? (yes..) But in fact it is actually a single row of green diamonds sandwiched between two rows of blue equilateral triangles.

Double Nine patch gets its title from the patch work squares found in the focal area of the quilt. Each of these patchwork squares is made from nine smaller squares.

By using red and red-violet in a predictable order, the random use of other colors produces a dynamic pattern of movement.

Amish woman used to meet for quilting sessions knows as “quilting bees” were they could visit with one another while they produced a quilt.

They were restricted by their religion form using printed cloth in their own clothing and for patchwork quilts. Strong abstract geometric designs repeated with bright solid colors make a strong artistic statement.

R. Buckminster Fuller, *U.S. Pavilion for ‘Expo 67*

Richard Buckminster Fuller was an accomplished inventor, educator, writer, poet, and philosopher, but is most recognized for his geodesic dome designs.

Geodesic domes, patented in the mid-twentieth century by Buckminster Fuller, are lightweight but sturdy hemispherical structures.

The larger a geodesic dome is the stronger it actually becomes.

The U.S. Pavilion for Expo 67was nicknamed “Bucky’s Biggest Bubble” and was Fullers most impressive geodesic dome at approximately 19 stories tall.

The dome is made from lightweight steel pipes welded together in a series of triangles that in turn created hexagonal (6-sided) pyramids. Each of these pyramids was covered with a transparent acrylic material. That material burned in a fire in 1976 and today the frame of the dome still stands.

Would you have thought to make a circular shape out of hundreds of triangles?

North Rose Window, Cathedral of Notre Dame, Paris, 1240-50

Jehan de Chelles (Zhon duh Shell), is the recognized architect and mason, and Master of the Work of Notre Dame during the time that the North Rose Window was built and installed.

The North Rose Window is made of stained glass and lead and iron framework and is 43 feet in diameter.

Covering about 1300 square feet it is one of the largest circular frameworks from the middle ages in existence today.

The shape is that of a large wheel with concentric bands of mostly blue, violet and red glass.

The art of stained glass is often referred to as “painting with light”. Unlike canvas painting where light reflects off of a surface, stained glass allows light to pass through and “paints” the surface of whatever it touches.

Religious figures are pictured in the smaller circles These paintings were used as texts to educate a largely illiterate public.

Jim McNeill, *Escher Bowl,* 1996

Born in 1967 in New Jersey, Jim McNeil started drawing when he was three and grew up to be a graphic artist.

He loved to copy cartoon characters from animated shows, and images from movie posters and album covers.

As a graphic artist he was introduced to the computer and soon mastered electronic illustration. *Have any of you ever drawn a picture using the computer?*

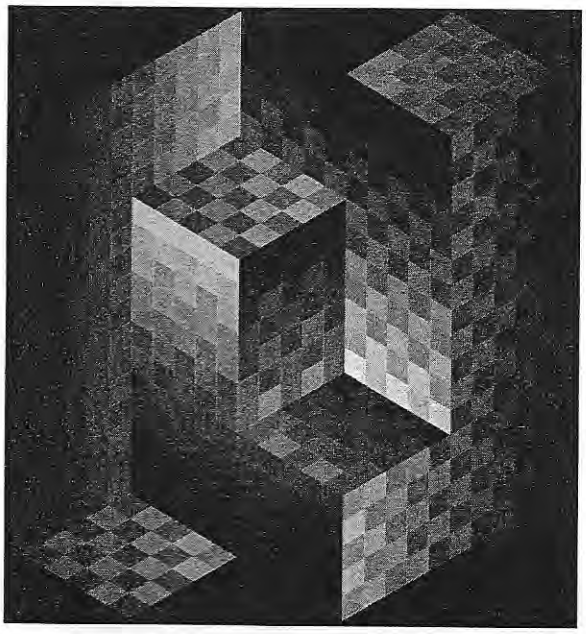
Escher Bowl was created on the computer with its ability to duplicate lines and shapes easily.

What game is being played? Are all the players exactly the same or can you see some differences? (Football, and the middle 2 players have different facial expressions as the player with the ball is punching up into the blue player who is reacting to the hit.)

The green areas help draw our focus to the action of the players…*but do you notice anything unique about the shape of the green space?* (they are the same shape as the players.)

This kind of pattern is called a **tessellation.** A tessellation is a patter made using congruent shapes – shapes that are exactly alike in size and outline. Tessellations appear to fit together like a puzzle with no overlaps and no gaps.

Victor Vasarely, *Gestalt-Zoeld*



Victor Vasarely (Vass-ah-*rel*-ee), 1908–1997, Hungarian, *Gestalt-Zoeld*, 1976, acrylic on canvas, 240 x 225-cm. (94 x 88½-in.)
Erich Lessing/Art Resource, NY. Private Collection, Paris, France

The Artist

Victor Vasarely (1908–1997), perhaps most recognized for his paintings and prints of optical illusions, was born in Pecs, Hungary. After entering the School of Medicine in Budapest, the young Vasarely discovered that he was more inclined towards the arts than the study of anatomy. Abandoning medicine, Vasarely began studies at a Budapest branch of the famous Bauhaus school. During this time, he heard lectures by fellow Hungarian abstract artist, Maholy Nagy, and became acquainted with the non-objective art of Dutch artist Piet Mondrian.

In 1930, Vasarely moved to Paris, became a French citizen, and worked as a graphic artist for about a decade. Becoming interested in the science of optics as a way to express movement in art objects, Vasarely started to experiment with the idea of geometric abstraction and optical illusions in paintings. The 1950s saw Vasarely's optical art exhibited internationally in Paris, Brussels, Copenhagen, and New York City.

Vasarely studied how the human eye is affected by light, color, shape, and form. Through experimentation, Vasarely concluded that form and color are one. In other words, Vasarely thought that all forms are defined by color so therefore all color has the same qualities of form. With this theory in mind, the artist demonstrated optical illusions as an alternative to classic representation of perspective in two-dimensional artwork (for instance, drawings, prints, or paintings). Vasarely considered his works of art to be visual stimuli.

Known as a pioneer of Op Art, Vasarely continued his work until only months before his death in his adopted hometown of Paris. Before his death, the city of Pecs paid tribute to its favorite son by converting the house where the artist was born into the Vasarely Museum. Many of the art objects in the Museum were provided and presented by the artist himself.

The Art

Four large interlocking L-shaped forms predominantly made from green, red, and blue squares twist and hover in black space and play tricks on the viewer's eye. These L-shaped forms seem to alternate positions, each dependent upon the placement of a cube located slightly off center in the image. This important cube has one red and blue surface and two red and green surfaces. How the viewer sees this cube determines which two L-shaped forms seem to be in the foreground.

Concentrating upon the outer vertical sides of the centrally located cube, the cube either appears to fold inward (away from the viewer) or outward (toward the viewer). As the cube folds inward, two upside down and interlocking L-forms, one slightly larger than the other, float from the left of the image into the foreground. Seen from this vantage, the L-shaped forms seem to be viewed from the underside.

Concentrating again upon the vertical sides of the centrally located cube, the cube folds outward while two upright and interlocking L-shaped forms, one slightly larger than the other, float from the right of the image into the foreground. Seen from this vantage point, these L-shaped forms are viewed from the side.

Focusing upon the deceptive effects created by color and shape, the visual impression of *Gestalt-Zoeld* is one of space, depth, and movement. Unlike implied movement found in traditional images, this painting attempts not only to trick the viewer's eye into *seeing* movement, but attempts to convey the actual feeling of movement to the viewer's senses. The precise geometric shapes and application of color in

Interdisciplinary Connections: Art and Mathematics

Victor Vasarely, *Gestalt-Zoeld*

this Vasarely painting defines the mid twentieth-century art movement known as Optical or Op Art. Vasarely's mastery of optical illusion is evident on the realization that the basic shape in *Gestalt-Zoeld* is simply a square created from congruent diamonds.

Guided Analysis

Cultural Context

Technology was in its infancy during the 1950s, about the same time that Vasarely began to produce Op Art. Time-saving machines, such as computers, were introduced to a society that was interested, if not somewhat skeptical, of what these machines might mean for the future. Op Art shows a similar interest in ideas about technology.

Quite often Op Art images appear to be made by computer rather than made by hand. This is because the artist must be exactingly precise with the lines, shapes, and colors of the images. With the intent of tricking the viewer's eye, it is necessary that the image be as perfect as possible. Even the smallest error (such as a misplaced color or a line drawn the wrong width) could ruin the visual effect. This artistic precision is sometimes more mechanical in appearance than human-made.

Elements of Art and Principles of Design

Scientists have discovered through logic that all matter is composed of energy and that this energy becomes particles or waves that constantly change. Vasarely discovered this same concept through his art experiments and from his own artistic intuition. Because of this discovery, Vasarely's images appear to be more like an ongoing activity than a finished artwork. *Gestalt-Zoeld* exemplifies this idea.

After looking at *Gestalt-Zoeld* for a few moments, the patterns of line, color, and shape contrasted against a black background twist and turn as the L-shaped forms perpetually alternate their relative positions as foreground and background objects. A convex cube that forms one leg of an L-shape changes into a deep, cube-like cavity. The whole picture seems to pivot about the cube. Some sections of the picture seem to emit light or have light cast upon them. In other areas, the colors seem to change their tone as they advance or recede. Similar to the constantly changing matter that science discovered, nothing is stable within Vasarely's picture plane. The sense of constant movement prevails and teases the viewer's visual perception.

Media and Techniques

The geometric abstraction utilized within Vasarely's optical images is carefully planned and exact. Vasarely's early training and career in the graphic and commercial arts no doubt assisted the artist with the technical skills necessary to achieve the complex optical illusions for which he became well-known. Vasarely planned each of his works before permanently committing them to ink or paint. The planning process included careful calculation of size, placement, and intensity of individual lines, shapes, and colors within the context of the larger image. It is easy to see that the misuse of a single line, shape, or color would hinder the desired optical effect.

Gestalt-Zoeld is an acrylic painting. First used by artists in the 1940s, acrylic paint is made from synthetic ingredients and is very versatile. Acrylics can be used on almost any surface, they dry quickly and do not yellow over time, and clean-up involves only soap and water. The use of acrylics has come to rival the use of traditional oil paints.

Comparison

Compare the congruent shapes in *Gestalt-Zoeld* to the Amish quilt, *Double Nine Patch. Each of these objects uses congruent diamond shapes and solid colors in precise, repeated patterns to create a sense of movement.*

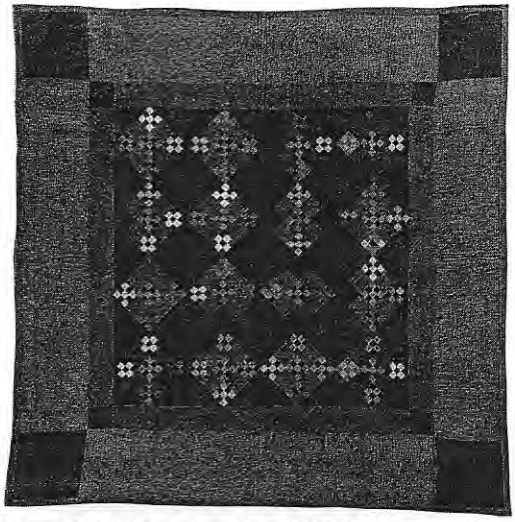
How would the planning stages of each object be similar and different? Could either the quilt or painting be created through computer imaging?

Compare the colors and congruent shapes of *Gestalt-Zoeld* to Piet Mondrian's painting *Composition: Blue, Red, Yellow* (Take 5 print Series, Nonobjective Art) *The congruent diamond shapes in the Vasarely image create a sense of depth while the congruent rectangles and black lines of the Mondrian appear to be flat.*

What clues in both works suggest that Vasarely was influenced by Mondrian's work? *The precise use of straight lines, geometric shapes, color, and optical illusion; an optical illusion of a small gray square occurs at the intersection of the black lines.*

Interdisciplinary Connections: Art and Mathematics

Double Nine Patch, Amish Quilt



Double Nine Patch, Amish quilt, c. 1920, Anonymous, American, Lancaster County, Pennsylvania, quilt, wool, 82 x 84-in.
America Hurrah Archive, NYC

The Art

The geometric shapes and vivid colors in *Double Nine Patch* are typical of the shapes and colors found in many Amish quilts. Deceptively simple in its plain facade, *Double Nine Patch* demonstrates a sophisticated, adept application of color and design concepts as well as an extremely high level of handicraft skill.

Six characteristics pinpoint this quilt as being from Lancaster County, Pennsylvania, as opposed to other Amish communities: the pattern; the use of solid color wool; the narrow inner border and wide outer border; the large corner blocks; and wide bindings. Although these characteristics can be found in quilts outside of Lancaster County, they are more typically associated with this particular community.

Symmetrical in design, the focal point of *Double Nine Patch* is a central area covering more than half the quilt surface and bound by a narrow square frame of sea blue and green. Although this narrow frame visually reads as green diamond shapes on a blue background, it is actually a single row of green diamonds sandwiched between two rows of blue equilateral triangles. Each corner of the blue and green frame is interrupted with a red square that serves as a transition between the focal area and a wide red-violet border. Inside the framed focal area are four rows and columns of patchwork diamonds juxtaposed against three rows and columns of solid red diamonds. Equilateral triangles, half the size of the diamonds, encircle the central area.

Outside of the central area and adjacent to the blue and green frame are four large red-violet rectangles that create yet another frame. Like the smaller blue frame, this red-violet border is interrupted at each corner with a red square. The red corners of each frame touch at one tip; thus leading the viewer's eye to the quilt's center of focus. The entire quilt is bound by a narrow green edge.

Double Nine Patch derives its title from the patchwork squares found in the focal area of the quilt. Each of these patchwork squares is made from nine smaller squares. Similarly, the center and corner squares within the whole-cloth (plain) squares are made from nine even smaller squares. These centers and corners use a variety of colors to create a striking contrast against the red-violet, whole-cloth squares that separate them. Selection and placement of colors help to create the pattern. By using red and red-violet in a predictable order, the random use of other colors produces a dynamic pattern of movement.

While *Double Nine Patch* exhibits many attributes that classify it as a work of art, it is doubtful that the quilt was made for only aesthetic reasons. It is equally doubtful, however, that the quilt was made strictly for the utilitarian purposes. Amish quilts are made to serve many intentions, some of which include the aesthetic and practical, but others sencompass ritual and interpersonal purposes.

It is not uncommon for Amish women to meet on a regular basis for quilting sessions known as "quilting bees." Quilting bees provide opportunities for the quilters to visit with one another while they produce a quilt for a particular person or sometimes to make a quilt for sale.

Guided Analysis

The Artist/Cultural Context

Although the specific quilter (or perhaps quilters) who created *Double Nine Patch* remains anonymous, learning about some of the traditions of the Amish people reveals much about the creator(s) of this artwork. Descended from Swiss Anabaptists, a conservative religious sect originating in Germany, the Netherlands, and Switzerland, the Amish were considered non-conformists. They were subjected to persecution in Europe because of their strict religious beliefs. In 1733, many Amish accepted William Penn's invitation to settle in America. Initial settlements were in the rich farmlands of Pennsylvania, but soon Amish communities were founded in

Ohio, Iowa, and Indiana. While today the Amish can be found in 22 American states, no Amish remain in Europe.

The Amish are a reverent and ethnically homogenous group who live by the principles of separatism, simplicity, harmony with nature, and mutual assistance. Typically living and working in rural areas, the Amish are often characterized by their steadfast commitment to traditions and beliefs. This tenacity is evidenced in their unhurried acceptance of modernization—including their dress, language, education, homes, farming methods, and modes of travel—that sets them apart from the rest of a fast-paced society.

Avoiding "worldliness," the tenets of separatism and simplicity exemplify Amish life as Amish people seek to abstain from self-exaltation and pride (thus the plain clothing and lack of printed cloth used in patchwork quilts) while embracing a strong work ethic that shuns labor-saving devices (such as sewing machines). Additionally, the Amish live within a closed, rural community that relies heavily upon mutual assistance (such as barn raisings and quilting groups) to accomplish large jobs and to provide "neighboring" or social gatherings.

The History of Quilts

Quiltmaking is not a recent process. Written records indicate that quilts were used as bedcoverings as early as the 12th century. Because quilts are made from perishable materials, few early examples survive today. The earliest example of a patchwork quilt is known as *The Levens Hall Quilt* from 17th-century England. The high quality of the design and technique used to create this quilt suggest that it was not the first of its kind to be made.

Dutch and English colonists brought the first quilts to the United States. These first quilts were made from applique. With materials being much more scarce in the frontier than in their homelands, quiltmakers, from necessity, soon turned their attention to patchwork quilts. By the mid 1800s, American quiltmakers frequently exhibited their work at local fairs and occasionally at international expositions. Prizes were awarded for craftsmanship as well as for artistic innovations in the use of color and design. During this time, many quilters began to sign and date their work. In 1883, it was estimated that quilts covered three-quarters of the beds in the United States. A decline in quilting paralleled the early twentieth-century advent of machine-made bed coverings. Interest in handmade quilts as a craft and art form was revived about mid 20th century.

Elements of Art and Principles of Design

Amish women are restricted by religious convictions from using printed cloth for their own clothing and thus for patchwork quilts. They are further discouraged from sewing together too many pieces into the designs to prevent the finished product from being too worldly. Working under these constraints, Amish quilters nonetheless have produced and continue to produce quilts of extraordinary beauty. Strong abstract geometric designs created with saturated colors are powerful in their simplicity. *Double Nine Patch* is such a quilt: minimal use of small pieces of solid color fabric and rich colors are assembled in repeated patterns that make a strong artistic statement.

The repetition and balance of color and geometric shapes within *Double Nine Patch* play significant roles in the quilt's deceptively simple design. Squares, diamonds, rectangles, and triangles in a variety of sizes repeat in predictable patterns of contrasting colors to create a visual vibrancy. Large red squares at each corner interrupt rectangular borders that frame the center of interest. Additionally, these red squares are placed in such a way as to lead the viewer's eye towards the intricate central design.

Within the central area, a variety of sizes of diamonds are placed at anticipated intervals to create a standard, repeated pattern. Patchwork squares are pieced against red squares to create an optical illusion of depth. Symmetrical balance pervades the overall design. Almost square in its outside perimeter, each shape or groups of shapes within the quilt has a mirror image.

Media and Techniques

A quilt, in simplest terms, is a utilitarian bed covering filled with some sort of padding and held together with stitching or knots. Quilts are made from three layers of cloth with the top layer being the most decorative, the middle layer being some sort of padding (usually cotton or a synthetic fiber), and the third providing a backing. The top, or decorative layer, is typically assembled from patterned, pieced blocks, solid color blocks, or blocks appliqued with small pieces of cloth to create designs or pictures. Most patchwork quilts are

pieced together from squares and triangles, shapes that have straight seams. What might be the reason for this?

The word "quilting" refers to the last stage of making a quilt, when all three of the layers of a quilt are placed together, stretched onto a frame, and sewn together with short stitches referred to as "quilting stitches." Quilting stitches artfully create a pattern in relief on the quilt's top layer.

Comparison

Interestingly, women were making quilts composed of nonobjective, colorful designs long before any artist created a nonobjective painting. Keeping this in mind, compare *Double Nine Patch* with *Gestalt-Zoeld*. Would *Double Nine Patch* be successful as a painting? Would *Gestalt-Zoeld* be successful as a quilt? Why or why not?

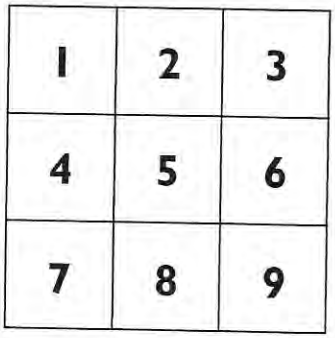
Congruent shapes (shapes that are the same size and shape) are used in both *Double Nine Patch* and Vasarely's *Gestalt-Zoeld*. Compare the use of congruent shapes in these objects. *Both objects use congruent shapes of squares, diamonds, and equilateral triangles.* Compare the use of color in both objects. *By placing certain colors next to each other, a sense of depth or an optical illusion of movement is created.*

Compare *Tar Beach* by Faith Ringgold (Take 5 Series, Urban Environments) to *Double Nine Patch. Although Ringgold uses quilts as her medium, her quilts tell stories and are not intended for functional use; a variety of printed cloth is used to create patchwork borders; a picture and text are painted onto the quilt with acrylic paint.*

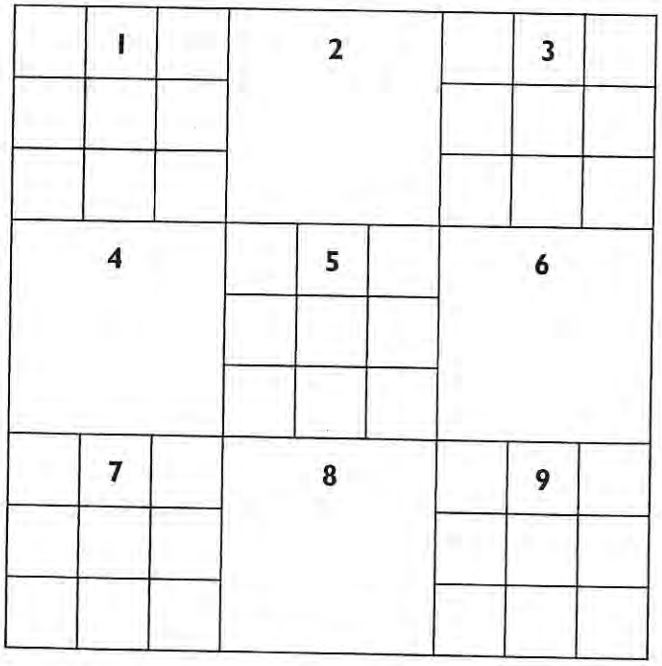
Mathematics Connections

Through an exploration of *Double Nine Patch*, students will be provided opportunities to: use problem-solving skills to investigate and understand mathematical content; relate images to mathematical ideas; draw logical conclusions about mathematics; use patterns and relationships to analyze mathematical situations; link conceptual and procedural knowledge; use mathematics in other curriculum areas; describe, model, draw, and classify shapes; investigate and predict the results of combining, subdividing, and changing shapes; relate geometric ideas to number and measurement ideas; recognize and appreciate geometry in their world; make and use measurements in problem situations; use models to explore operations on fractions and decimals; recognize, describe, extend, and create patterns.

The Double Nine Patch is so named because five blocks of nine-patch squares . . .

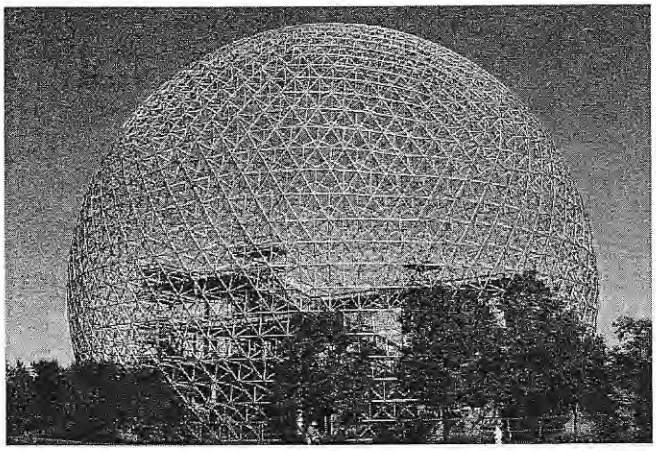


. . . are put into a larger square with four whole-cloth squares (plain fabric) to form nine blocks, or the double nine patch.



Interdisciplinary Connections: Art and Mathematics

R. Buckminster Fuller, U. S. Pavilion for 'Expo 67



R. Buckminster Fuller, 1895–1983, American, U. S. Pavilion for Expo '67, Montreal, Canada, 250 feet diameter x 200 feet high, steel pipes. Original acrylic outer surface destroyed by fire, 1976.
Lee Snider/Corbis

The Artist

Richard Buckminster Fuller (1895–1983), born in Milton, Massachusetts, is perhaps most recognized for his geodesic dome designs although he also was an accomplished inventor, educator, writer, poet, and philosopher. Well ahead of his time in history, Fuller's ideas and projects utilized technological advances to address global problems. At one time Fuller said that he invented objects and waited for humankind to need them. Though some of Fuller's futuristic designs were never widely accepted (such as a pre-assembled, portable, doughnut-shaped house and a three-wheeled, omni-directional automobile), he was highly respected for his ideas.

The geodesic dome, for which Fuller gained wider fame, was patented in 1947. Concepts from this original dome were later used in or adapted to many of Fuller's designs, both large scale and small. Among his most acclaimed spherical structures are: The Ford Rotunda Dome, 1953, Dearborn, Michigan; The Golden Dome, for the American Exchange Exhibition, 1959, Moscow; and Climatron, a climate-controlled botanical garden, 1960, St. Louis, Missouri.

From 1959 until his death, Fuller worked to develop and implement designs that contributed to the preservation of the earth. Fuller authored many influential publications including *Operating Manual for Spaceship Earth*, 1969, and *Synergetics: Explorations in the Geometry of Thinking*, 1975. Shortly before Fuller died in 1983 he was awarded the Presidential Medal of Freedom for contributing to the quality of life in the United States.

The Art

Geodesic domes, patented in the mid-twentieth century by Buckminster Fuller, are lightweight but sturdy hemispherical structures. Fuller considered geodesic designs a way to supply economical and energy-efficient buildings for a variety of applications including homes, businesses, and public exhibition spaces. Most often, as Fuller specified, geodesic domes are constructed from prefabricated triangular segments covered with some type of thin, durable material. The triangular modules create a high strength-to-weight ratio so that the larger a geodesic dome is, the stronger it actually becomes. Without need for interior load-supporting walls, geodesic domes provide functional and cost-efficient use of space. The U. S. Pavilion for Expo '67 (the 1967 World's Fair and Exposition) in Montreal, Canada, was a classic example of Fuller's construction ideals.

Nicknamed "Bucky's Biggest Bubble," the U. S. Pavilion for Expo '67 was perhaps Fuller's most impressive geodesic dome. A three-quarter sphere measuring an unprecedented 250 feet in diameter and 200 feet high (approximately 19 stories tall), the dome's interior space spanned approximately 6,700,000 cubic feet. Fuller, in conjunction with his partner Shoji Sadao, designed this huge dome to illustrate a controlled environment. This controlled atmosphere allowed people inside of the structure to feel as if they were a part of the outside world while at the same time it protected them from the elements of nature. Largely created by the use of 1,900 transparent acrylic panes that served as the dome's "skin," the surface adjusted to its surroundings. At night, or during times when natural light was minimal, the dome was translucent. During bright daytime hours, as the sun would warm the dome, sunshades would lower over each triangular module and the dome would change from being transparent to having a polished chrome appearance.

The sturdy skeleton of the U. S. Pavilion for Expo '67 was made from mass-produced clusters of lightweight steel pipes welded together in a series of triangles that in turn created hexagonal (six-sided) pyramids. Each of these pyramids were covered with a transparent acrylic material.

In 1967, United States President Lyndon B. Johnson gave the dome to the City of Montreal. Harsh extremes in Canadian weather caused excessive expansion and contraction of the steel pipes. Subsequent welding repairs resulted in a

spectacular fire in the spring of 1976. The acrylic shell completely burned in less than half an hour. Restoration of the dome began in 1992. Today the frame of the dome, without its acrylic skin, encloses a museum and environmental observation center.

Guided Analysis

Cultural Context

"One of my first days at kindergarten the teacher brought us some toothpicks and semi-dried peas and told us to make structures. With my bad sight, I was used to seeing only bulks. I had no feelings at all about structural lines. The other children, who had good eyes, were familiar with horses and barns. Because I couldn't see, I naturally had recourse to my other senses. When the teacher told us to make structures, I tried to make something that would work. Pushing and pulling, I found that the triangle held its shape when nothing else did. The other children made rectangular structures that seemed to stand up because the peas held them in shape. The teacher called all the other teachers in primary school to take a look at this triangular structure. I remember being surprised that they were surprised."

Quote from the video, *Buckminster Fuller: Thinking Out Loud*, produced and directed by Karen Goodman and Kirk Simon, New York: Zeitgeist Films, 1986.

Undoubtedly an artist with forward-looking vision, Buckminster Fuller theorized about future world problems that would demand solutions during the latter portion of the twentieth century. Fuller identified problems, such as lack of economical housing, and offered practical solutions. As early as the 1920s, Fuller was designing inexpensive waterproof and fireproof houses.

Fuller inaccurately predicted that a million geodesic domes would be built by the mid-1980s. To date, the number is probably closer to 50,000, although a precise count is difficult to calculate. Most critics of the dome cite the non-traditional shape and difficulties with furnishing a round interior as the primary reasons more domes have not been built as houses.

Elements of Art and Principles of Design

Geodesic dome construction is confined to certain foundational guidelines based on unalterable mathematical concepts. The U. S. Pavilion for Expo '67 utilized these guidelines to create a building that was aesthetically pleasing and structurally sound. Repetition of line and shape was key to the design.

The steel framework of the dome, which still stands, is a grid of triangles. These triangles, created by parallel rows of diagonal and horizontal lines, form a series of hexagons. Transparent acrylic panels in the original dome formed six-sided pyramids within each of the hexagons. The mass-produced pyramids joined to other identical pyramids to cover the dome's entire surface to give it a gem-like or honeycomb appearance.

Media and Techniques

Throughout much of history, domes have been a part of architecture. Circular mud huts in ancient Mesopotamia (about 6000 years ago) probably used domed roofs. In 14 BC, the Mycenean Greeks built tombs with domes in the shape of beehives. In about 118 AD, the Romans built the Pantheon, a temple with a domed interior. Early Christians utilized domes in small-scale construction of mausoleums and baptisteries. Byzantine (c. 532) architecture used domes in larger scale construction within churches. Islamic traditions have long embraced the dome as exemplified in palaces, baths, mosques, and tombs. Dome construction was further refined throughout the Renaissance, Baroque, and Neoclassical periods. Saint Peter's Basilica (Rome), the Church of Saint Louis de Invalides (Paris), and the Capitol Building (Washington, DC) represent domes from each of these eras.

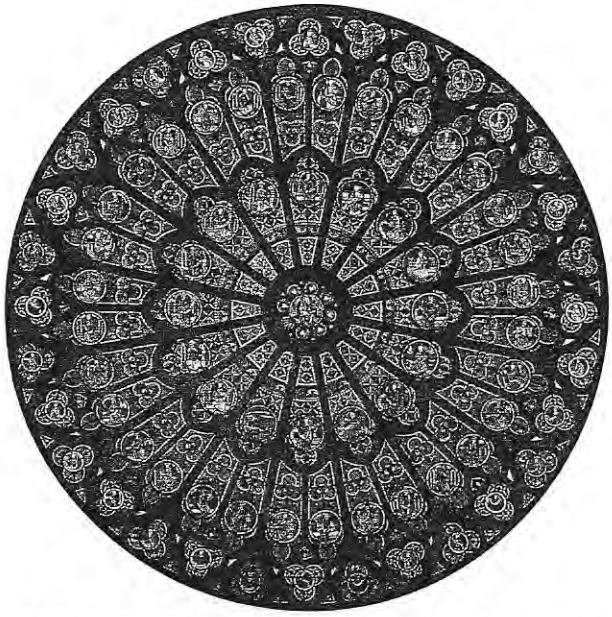
With the 20th century came technological advances that enabled the dome to change significantly from its former aesthetic and intent. Fuller's geodesic dome represents a radical departure from traditional domes. Made from lightweight materials and constructed with a filigree-like or crosshatched gridwork, geodesic domes appear less formal than their predecessors. Moreover, geodesic domes are functional and generally serve as more than ornamentation or as a portion of a larger structure.

Comparisons

Line and shape are important elements within the U. S. Pavilion for Expo '67. Compare the lines and shapes of the this dome to the lines and shapes of skyscrapers in *New York, New York* by Gene Steffen (Take 5 print series, Cityscapes). *The lines of the geodesic dome are arched or curved as they cross the round surface while the lines in the skyscrapers are straight verticals or horizontals; the shapes in the*

Interdisciplinary Connections: Art and Mathematics

North Rose Window, Cathedral of Notre Dame, Paris



Jehan de Chelles (Zhon duh Shell), unknown birth–1265, North Rose Window, Cathedral of Notre Dame, Paris, 1240–50, stained glass in lead and iron framework with stone bar tracery, 43 feet in diameter.
Giraudon/Art Resource, NY

The Artist

Inscribed across the base of the southern portal in the Cathedral of Notre Dame is the inscription (in Latin): "In the year of Our Lord 1257, on Tuesday, February 12, this work was begun in honor of the Mother of Christ, during the lifetime of Jehan de Chelles, Master Mason." Little else is known about de Chelles other than he was a recognized architect and mason, was the Master of the Work of Notre Dame during the time that the North Rose Window was built and installed, and that he died in 1265.

The title "Master Mason" implies that de Chelles was a member of a craft guild. During the thirteenth century in continental Europe and England the guild system was in favor. Groups of people with similar skills or professions banded together in associations that set standards for the industry such as the number of workers per shop, wages, hours that could be worked, and prices for manufactured goods. Additionally, the guilds were for mutual aid and protection against outside competition and provided training for unskilled workers. Typically these guilds were either for merchants (the merchant guild) or for craftspeople (craft guild or trade guild). Organization within the guilds included three levels. The first was apprentice level — composed of the unpaid workers who were learning a trade from the master in exchange for room and board. The second was journeyman level— paid workers who had become proficient in the trade. The third and highest level was master. A master was a proprietor who owned materials and tools of a particular trade, was accomplished in the trade, and trained others in his field of expertise. It is thought that de Chelles learned construction of rose windows from an uncle who had developed a method for making exceptionally large rose windows that were supported by delicate bar tracery rather than carved out heavier slabs of stone. When the exterior of Notre Dame was deemed out of proportion because of earlier reconstruction of the nave, de Chelles was given the challenge to rebuild the transept. Bravely, de Chelles approached the project that would replace the heavy walls of earlier centuries with walls of colored glass. His expertise in planning and construction provided the structure in which the great North Rose Window is set.

The Art

The North Rose Window of the Cathedral of Notre Dame in Paris characterizes the magnificence of thirteenth-century French stained glass. Covering about 1,300 square feet, this rose window is one of the largest circular frameworks from the Middle Ages in existence today. Radiating in the shape of a large wheel, concentric bands of predominately blue, violet, and red glass are held in place by a lead and iron framework. The glass is divided by dark stone bars that tend to emphasize the brilliance of the glass and lend a mystical quality. Yellow and green glass are also used in the window, colors relatively new to this time period. Only a few panels of glass and stone bar supports have been repaired or restored through the centuries. Almost all of this window consists of original materials dating from about 1250.

Architectural advancements of the 13th century allowed for the installation of large stained glass windows such as the North Rose Window. With the advent of sophisticated construction methods such as the flying buttress and with improvements in vaulted ceilings, the need for load-bearing, windowless walls was avoided. Taking advantage of this new architectural freedom, churches soon began to install not only more stained glass windows, but larger ones as well. It is typical to find entire church walls from the thirteenth century seemingly constructed of little more than glass.

Guided Analysis

Cultural Context

The building of cathedrals was almost nonstop from the 6th century through the13th. In 1250, it is estimated that Paris, a city of roughly 50,000 people, had approximately 200 churches and chapels, among these Notre Dame. Against the backdrop of a feudal society, Notre Dame played an important role in the lives of the rich and poor.

Feudalism created a society that offered many contradictions. While the feudal landowners ruled from a position of strength because of their wealth, the message that the cathedrals sent out was that everyone was equal. Daily life was cruel, or at best monotonous for the common people, yet they remained devout in their beliefs. The aristocracy held almost complete control over their subjects, but it was not unusual for a lord to participate in menial chores in order to fulfill the obligations of religious beliefs. While money and rank held people apart, the cathedrals bound them together.

Notre Dame and its stained glass construction are enduring monuments to the craftsmanship and devotion of these people to their beliefs. Church records document that funding for de Chelles' reconstruction, including the North Rose Window, was almost limitless, an indication that feudal landowners and others, such as religious leaders or merchants, contributed freely to this project.

Elements of Art and Principles of Design

The art of stained glass is often referred to as "painting with light." Unlike canvas painting where light reflects off of a surface, stained glass allows light to pass through and "paints" the surface of whatever it touches. The colors of the North Rose Window produce a brilliant blue splendor typical of French Gothic stained glass windows. Repetition of cobalt glass throughout the concentric bands and radial spokes of the large rose window achieve this rich blue. Accented with a wide range of violets, red, green, and yellow, the window paints its surroundings with sparkling color as light passes through.

Concentric bands of colored glass, the outer band having twice as many divisions (32) as the inner (16), create a radiating symmetry. Glass divisions within the same concentric circle being the same shape create a sense of unity. Additionally, the repeating lines and shapes within each division are similar in color and contribute to the unity.

A sense of variety is created between the concentric bands as each circle has its own identifying division shape. Further, every division has a different image of a religious figure. These paintings were used as texts to educate a largely illiterate public.

Movement seems to shoot from the center medallion, the spokes almost appearing to rotate or pulsate upon a hub. The dark stone bar tracery outlines the individual glass panes, with the straight spokes and scalloped edges of the stone contrasting against the colored glass.

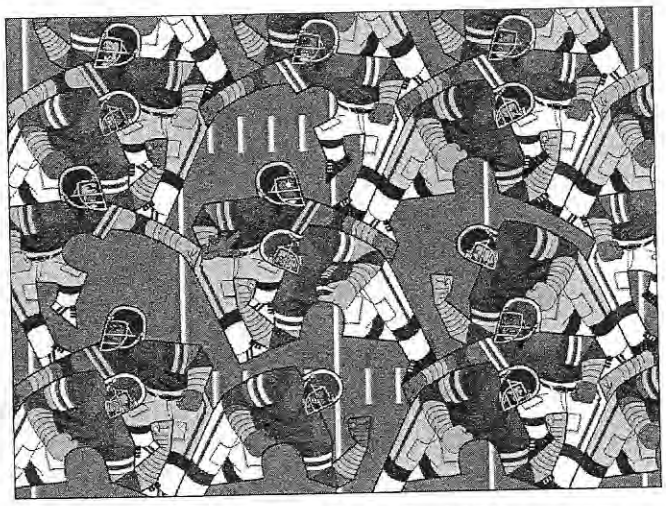
Media and Techniques

Two distinctly different types of glass were used during the time that the North Rose Window was created: pot glass and flashed glass. Pot glass is distinguished by its solid and uniform color. To make these colors, the glass maker would add to the raw materials a mixture of potash and limestone, oxides of iron (for red), copper (for green), or cobalt (for blue). Flashed glass is two sheets of glass fused together while both pieces are still hot. In this process, a sheet or layer of colored glass has a layer of clear glass fused to it. Flashed glass is used when opaque qualities are not desired.

The method for creating a stained glass window has not changed significantly throughout the centuries, although materials and tools have been refined a great deal. These are the steps that a thirteenth-century stained-glass artisan probably would have followed: (1) The artisan began by making a small sketch of the window's design. Most often these designs were not original; rather, the patron would designate that a certain other window should be copied. (2) After the design was sketched, a wooden board or large table was coated with chalk or white paint and using a lead or tin point tool, the sketch was enlarged to the actual size of the window. This full scale drawing, then as now, was called a cartoon. (3) Lines representing lead supports (the outside edge of individual pieces of glass) were drawn in black. (4) Sheets of colored glass were next placed on top of the enlarged drawing and, using a heated tool made from iron, cut to the desired shape. (5) Painted images were drawn onto the backsides of individual pieces of glass with a mixture of powdered glass, metallic salts, and other minerals. (6) The drawings were made permanent by firing the glass at a low temperature. (7) Lead H-shaped strips were then cut, shaped, and placed around the edges of each piece of glass so that the glass could be affixed to the window's frame.

Interdisciplinary Connections: Art and Mathematics

Jim McNeill, *Escher Bowl*



Jim McNeill, 1967- , American, *Escher Bowl*, 1996, computer-generated image on paper, 10 x 7-3/8-in.
Private Collection

The Artist

Born in 1967 in Rahway, New Jersey, graphic artist Jim McNeill grew up in Edison, New Jersey, and began drawing before he entered kindergarten. Using the back of his father's old business stationery, McNeill began to draw at the age of three. He has continued to draw throughout his life, although he has upgraded to better art supplies than those with which he began.

Among the first artistic influences upon McNeill were classic 1940s Warner Brothers cartoons that he watched every morning on television. After watching the animated shows, McNeill would attempt to draw the characters. He also often copied images from movie posters and album covers.

In 1990, McNeill graduated with a Bachelor of Fine Arts degree from The School of Visual Arts in New York City, majoring in illustration and concentrating on oil painting as his primary medium. After graduation, McNeill worked as a graphic artist for a small New York magazine. It was while working for the magazine that he was first introduced to the Macintosh computer and desktop publishing. Soon mastering electronic illustration, McNeill compiled a portfolio and began a career as a freelance artist.

As a freelance artist, McNeill became intrigued by the ability for computers "to treat lines and shapes as independent, free-standing objects that could be cloned and repositioned with a couple of mouse clicks." To McNeill's way of thinking, the computer's ability to duplicate lines and shapes echo the concepts found within the work of Dutch artist M.C. Escher. The conceptual similarities between his own ideas and those of Escher led McNeill to create a series of computer-generated tessellations. *Escher Bowl* is from this series.

The Art

Action abounds throughout *Escher Bowl* as players on opposing football teams block and tackle across a shallow playing field. Clusters of players push into one another, pumping arms and grimacing as they participate in this contemporary form of urban battle. In the center of the field, framed by the surrounding action, two players—one from each team—face each other in a skirmish for the football. The red player protectively bends over the football to cradle it while simultaneously his stiff right arm punches up into the blue team player. The posture and facial expression of the blue player show that he reacts to the hit with surprise. His eyes are opened wide, the palm and fingers on his right hand are fully exposed, unlike the other players whose eyes are squinted and whose hands are in fists.

As the drama unfolds at midpoint, the playing field acts as a gridded, smooth backdrop for the tumbling action. Divided into four vertical sections by white yardage markings, the shallow green field provides a sharp contrast to the colors of the players' uniforms. Encircling and offsetting the two central characters, the green areas create a focal point that highlights the most important action. Upon closer observation, four negative green shapes define the playing field. These shapes, or "field pieces" as McNeill calls them, are the same repeating silhouettes as those used to outline individual players, or "figure pieces." The field pieces serve as the background plane while the figure pieces all occupy the same foreground plane (in math, a plane is a two-dimensional, flat surface that is infinite).

Guided Analysis

Cultural Context

Tessellations have been found that date from as early as 4000 BC and are evident even today in Moorish architecture in Spain and Islamic architecture in the Middle East. The creators of these tessellations were (and still are) constrained by their religion from using representational images. No images of people, animals, or other recognizable subjects may be used, but Islamic artists developed amazingly elaborate and beautiful geometric, arabesque, floral, and calligraphic designs for tiled

mosaic floors, walls, and architecture. Many of these designs are tessellations.

The 20th-century artist most recognized for his tessellated images is Maurits Cornelius Escher (M.C. Escher). Escher, a Dutch graphic artist who lived from 1898–1972, worked primarily with woodblock and lithographic printmaking processes. His images include intricate optical illusions, impossible structures, and complex tessellations. In words that reflect his fascination with tessellations, Escher said of his work:

> *"I try in my prints to testify that we live in a beautiful and orderly world, not in a chaos without norms, even though that is how it sometimes appears. My subjects are also often playful: I cannot refrain from demonstrating the nonsensicalness of some of what we take to be irrefutable certainties. It is, for example, a pleasure to deliberately mix together objects of two and three dimensions, surface and spatial relationships, and to make fun of gravity."*

McNeill's *Escher Bowl* is titled in honor of Escher, whose intentions and tessellations provide a foundation as well as a departure point for McNeill's images. When comparing the work of these two artists, it is easy to see that the repeating shapes within the tessellations of both Escher and McNeill fall along implied horizontal, vertical, or diagonal planes and that the shapes reverse and connect in a regular pattern. Escher and McNeill each utilize the same fundamental formula for creating tessellations, but McNeill explains a basic difference between their work.

"I have always perceived Escher's work as one set of figures being the background to another set of figures. Seeing one set of figures as the negative space of the other set puts the two sets of figures on different visual planes. In *Escher Bowl*, each figure is literally 'butting heads' with the figures contiguous to it because they are all on the same plane rather than serving as backgrounds to each other."

Elements of Art and Principles of Design

Based upon the idea of repetition of shapes to create a pattern, tessellations are also called tilings or mosaics. As repeated shapes reverse and connect across, up and down, or diagonally across a picture plane, tessellations can become quite complex. Essential to most tessellations, then, is repetition of line and shape. Logically, *Escher Bowl* strongly relies upon these concepts.

The characters within *Escher Bowl* are arranged in a repeated, orderly fashion that creates a strong horizontal and diagonal format. Players with left arms bent at the elbow run across the bottom of the work. Directly above them, going in the opposite direction, run the players with right arms extended. The third row from the bottom repeats the bent arm players, but they are in reverse to the characters in the bottom row and their right arm is bent. The fourth row again finds the extended arm player, also in reverse and with the opposite arm extended. The shapes in the fifth line replicate the first, the sixth line replicates the second, and so on, into infinity.

Line also plays an important role in *Escher Bowl*. Each character is defined by a smooth, black outline that is shared by surrounding characters. This line also serves to set the characters apart from the background.

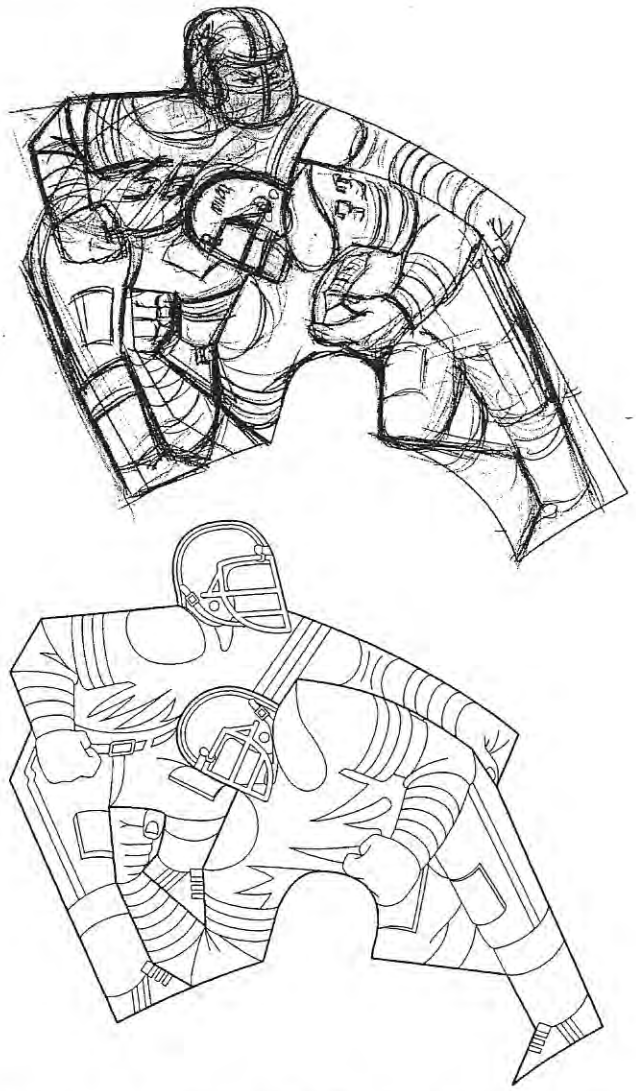
Introduction of color adds yet another layer of complexity to the image. No two teammates have full contact, creating a pattern of color placement that, in turn, causes a sense of tumbling vibrancy throughout the picture plane. The figures then become their own background when the green of the playing field is substituted for the details of uniforms within certain shapes. By placing these green shapes at specific intervals on rows three, four, and five, focus is brought upon the two players who struggle for possession of the football at center field.

Media and Techniques

A tessellation is a pattern made using congruent shapes — shapes that are exactly alike in size and outline. The simplest tessellations are made using a pattern of geometric shapes such as a square, triangle, or diamond and tracing it repeatedly, side-by-side. An example of a real-life tessellation would be a floor made from square tiles. More interesting tessellations are made by using a pattern of unusual shapes and reversing every other one in an alternating pattern. Both the original shape and the reversed shape are placed side-by-side so that both shapes share one common line. This process is repeated in a vertical or horizontal format until the desired design is achieved. Details can then be added. More complex tessellations are created by using more than one shape or details and color, but all tessellations appear to fit together like a puzzle.

Interdisciplinary Connections: Art and Mathematics

Jim McNeill, *Escher Bowl*



Escher Bowl was created on a Macintosh computer using Adobe Illustrator drawing software. Two basic, outlined shapes create the tessellated design: a human shape, knees bent in a running position and with one arm outstretched and another human shape, also in running position but with an arm bent at the elbow. True to traditional tessellated design, both shapes connect, share a common line, and reverse. Unlike traditional tessellations where shapes are manually drawn or printed, the shapes in *Escher Bowl* were created once and then duplicated by computer manipulation.

Comparisons

Both McNeill and Vasarely use congruent shapes to create their images. Compare the use of congruent shapes in *Escher Bowl* to those in *Gestalt-Zoeld* by Vasarely. *In the Vasarely image, the cubes are created by congruent diamond shapes which are each made from two equilateral triangles.*

Compare the illusion of depth created in *Reptiles* by M. C. Escher to the shallow picture plane created in *Escher Bowl*. What area of *Reptiles* is most similar to *Escher Bowl*? *The center area tessellation in* Reptiles *appears to be flat much like the entire picture plane in* Escher Bowl.

Builders, a painting by Jacob Lawrence (Take 5 print series, Interdisciplinary Connections) uses similar elements as *Escher Bowl* to show a sense of action. Compare the colors, shapes, and details of Builders to the colors, shapes, and details in *Escher Bowl*. *Both are relatively flat pictures that use a limited number of colors and details.*

Compare the action in both images. *Action in both images is represented through bent knees, elbows, and heads. In* Builders *the characters are of a variety of sizes and not repeated nor connected to one another; the characters in* Escher Bowl *are identical in size and movement and share common lines which causes a hectic sort of movement.*

Mathematics Connections

Through an exploration of *Escher Bowl*, students will be provided opportunities to: develop a hands-on understanding of geometric relationships, such as translation, transformation, rotation, reflection by creating original tessellations; use mathematics in other curriculum areas; use problem-solving skills to investigate and understand mathematical content; relate images to mathematical ideas; draw logical conclusions about mathematics; use patterns and relationships to analyze mathematical situations; link conceptual and procedural knowledge; describe, model, draw, and classify congruent shapes; develop spatial sense; investigate and predict the results of combining, subdividing, and changing shapes; recognize, describe, extend, and create a wide variety of patterns; make and use measurements in problem situations; recognize and appreciate geometry in the world around them; acquire confidence in using mathematics meaningfully.