Teaching Geometry Using Art and Architecture

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INTRODUCTION

As a classroom teacher, I am always looking for ways to teach my students with new and fresh ideas. My teaching degree includes a minor in art. I have always loved art and architecture and have been looking for ways to integrate these two forms into the classroom. I believe this unit is the answer I have been looking for. The theme of my unit will focus around geometry and its significance in art and architecture. Shapes, patterns and designs will be discussed and discovered. I will introduce the unit by teaching basic geometric concepts. The second and third sections of the unit introduce and discuss visuals of authentic art and architecture that follow the geometry concepts being taught. The linking strand of art history and architectural history will prevail. The last section of the unit will be hands-on. I would like the students to create art and structure that directly align with the content being taught.

In our society of graphic commercialization and high-tech environments, students are continually bombarded by images. Art and architecture comprise a strong presence around us, and many students don't realize or even recognize these constant visuals. It would be nice if the students could trace back modern visuals to their original sources. Although advertising agencies and graphic designers strive for originality, many times they find that the ideas they create are simply variations on designs that were created many years ago. Sometimes though, artists are deliberately using ideas from well-known art in order to have a familiarity to the audience.

Often when students see the cover of a CD or the design on a billboard, they are seeing this creation for the first time. It is only an experienced eye that can recognize the root of the design from a previous artwork. For example, the painting "The Scream" by Edvard Munch has been used in various commercials, one being a car advertisement. Also, the action of the man screaming with hands on his face is possibly the inspiration for the famous scene of Macaulay Culkin in the movie *Home Alone*. There are countless other examples in our society for which we could link current art or design with old and well-known art. As teachers, we have an obligation to our students to provide them with background knowledge and thus enhance their prior knowledge from which they can later draw for reference.

The significance for students to be exposed to famous art and architecture is a matter of building their knowledge of the world in which we live. Students should not have to wait until college before they have a chance to be exposed to art history and architectural history.

Given the constraints of time that are put upon teachers, a semester-long art and architectural history course is not possible. Also, I wanted all the art and architecture used in this unit to have a uniting theme. This would help narrow the choices for possible art and structure to be included. I have chosen the theme of geometry. Not only does it help narrow the field of choices, but geometry is a significant part of math that all students need to learn. It is my thought that introducing the subject of geometry through the use of art and architecture is a great way to grab the attention of the students and help keep that attention.

What I see students constantly do when they are bored is doodle. Sometimes I look at these doodles and it amazes me the patterns that are recurring within them. Our minds are constantly looking for patterns and links and I don't think our students understand that. If I can teach them to recognize visual patterns, then the hope is that they may soon begin to recognize relationships and patterns within other subject areas. If they can see the pattern of how a science book is laid out, then they will become more aware of how to quickly locate specific information without wasting time randomly searching or reading the entire chapter for only one piece of information. The theme of the unit will not stress this pattern usage to the extent that it becomes overwhelming or uninteresting. The main focus will be on the essence and appreciation of art, architecture and the patterns within them. The use of geometry helps focus this unit to a specific type of art and architecture.

I am a sixth grade reading teacher with five classes of various level readers. In our school we have a sixth, non-curriculum based class that all teachers teach. This is a class where the teacher's core curriculum is not taught. The purpose of this sixth class is enrichment, and so it is called. My unit will be taught to this specific class. This class changes every six weeks and within those six weeks we have approximately 10-12 classes of 45 minutes each. Therefore my unit would have to be concise enough to fit within this limited time span. This unit is designed for any teacher at any level. Math and art teachers will find it just as useful as other subject teachers, such as myself. It is also a great lesson for teaching in an ancillary, enrichment, or after-school class.

I am sectioning the unit into four parts. The first section is a basic geometry lesson. By basic, I am referring to simple shapes, simple patterns and emphasizing the learning of proper names for them. The second section is an art history and appreciation section. The third section is an architectural history and appreciation section. The fourth being a creative design section. By this, I intend for the students to create art and architecture that correlate to the patterns, designs and geometry that were previously learned. I envision this last section to really be a creative, hands-on art class. The goal of the unit is to expose students to an area of study that has likely never been experienced. I think that this unit could be something interesting and a completely new learning experience for these students.

GEOMETRY

The introduction of this unit will consist of learning basic geometric shapes and patterns. The idea is to get the students to use the proper names of shapes instead of descriptions or examples to describe the shape. For instance, the students will learn to use the word *octagon* instead of "stop sign shape." The introduction will be a brief course in shapes, patterns, and designs. Shapes to be used include: circle, square, rectangle, triangle, pentagon, hexagon, heptagon, octagon, polygon, cube, and pyramid. Patterns and design to be learned include: repeating, rotation, reflection, symmetry, tessellation, and tiling.

In addition to geometric vocabulary, I would also like to include art vocabulary. Since this unit is designed to integrate art, architecture and geometry, I think it is important for students to learn that these terminologies can have synonyms in the art world. The art vocabulary to be presented include: rhythm, balance, radial balance, and harmony.

Since time is limited, a maximum of two days will be spent on this section. A handout should be given to the students as a study tool and guide for future projects. I will not provide visual examples in this unit; however the teacher may provide these to the students when the lesson is taught.

Shapes

Circle – a closed curve or ring
Square – a plane figure having four equal sides and four right angles
Rectangle – a parallelogram having all right angles
Triangle – a plane figure formed by three straight lines
Pentagon – a polygon having five sides and five interior angles
Hexagon – a polygon having six sides and six interior angles
Heptagon – a polygon having seven sides and seven interior angles
Octagon – a polygon with eight sides and eight interior angles
Polygon – a closed plane figure with many sides and angles
Cube – a solid with six square faces, at right angles
Pyramid – a solid whose base is a polygon and whose sides are all triangles meeting at a common point

At this time, the concept of prefixes may be introduced to the students. It might be helpful for them to understand the following prefixes: *Bi = two; Tri = three; Quad = four; Penta = five; Hexa = six; Hepta = seven; Octa = eight; Poly = many.*

Geometry Patterns and Designs

Pattern – a decorative design
Repeating – to produce again

Rotation –	revolve or move around a center or axis
Reflection –	an image, as in a mirror
Symmetry –	balanced proportions
Tessellation –	a covering of an infinite geometric plane without gaps or overlaps by congruent plane figures of one type or a few types
Tiling –	to cover with tiles, with the possibility of overlaps or gaps

Art Patterns and Designs

Rhythm –	The principle of design that indicates movement by the repetition of elements. Visual rhythm is created by repeating positive shapes separated by negative spaces. The geometric equivalent would be a repeating pattern.
Balance –	The principle of design concerned with equalizing visual forces, or elements, in a work of art. The geometric equivalent would be symmetry.
Radial Balance –	Occurs when the forces or elements of a design come out (radiate) from a central point. The geometric equivalent would be rotation symmetry
Harmony –	The principle of design that creates unity by stressing the similarities of separate but related parts. The geometric equivalent would be a repeating pattern with variations.

To help students really learn these terms and visualize them, flashcards will be made. The class will be divided into three groups. Each group will be responsible for making one section of cards (shape, geometry patterns and designs, or art patterns and designs). The cards should include the vocabulary term on one side and the definition plus a visual example on the opposite side. It is important that the students become familiar and comfortable with these terminologies. Encourage students to use the correct words when referring to these shapes and patterns.

When the class set is made, use the cards for daily review throughout the unit. The first activity is a student-directed review and the second activity is a teacher-directed review. These activities are clearly presented in the lesson plans that follow.

ART HISTORY

Geometry is so much more than math. I look at it as art. When I think of geometry, I think of patterns and designs. There are so many great artists out there, but the purpose of this unit is to focus on the geometry present within art. For this reason, the unit will focus on artists that have a strong presence of geometry and pattern in their work. Artists included in this unit are: Giacomo Balla, Bronsilaw M. Bak, M.C. Escher, Donald Judd, Piet Mondrian, Miroslav Sutej, Victor Vasarely, and Andy Warhol. The emphasis will be on the elements of patterns, designs and symmetry within various works by these artists.

In addition to lessons on shapes and patterns, color will play a vital role and will be subset into the art lessons. The idea of this section is not to give a condensed art history lesson of every great artist (there would, of course, be no time for that); instead, this section will focus on artists who have emphasized geometric design in their art. Students need to be able to recognize the geometry concepts being taught through a variety of examples. A plain shape drawn on the board can make geometry very stagnate for students. The same can be said for a chalk pattern drawn on the board to illustrate geometric pattern. However, when the same terminology or concept is introduced through the life, color and excitement of art, students will find learning to be much more engaging.

Some of the artwork presented will be visually basic. The advantage to using this type of art is to relate to the students. Most likely the majority of students who will be taught this unit will not consider themselves good artists. However, if you expose the students to artwork that seems very simple, the self-esteem of a struggling artist in your class can be raised. Once a student sees that many famous pieces of art are simple arrangements of geometric figures, the intimidation of creating impossible art vanishes. The best thing for a struggling art student to realize is that it is possible for them to create beautiful art by simply arranging basic geometric shapes into appealing images. The idea is that students can see that they too can create art without the intimidation of knowing how to draw well. Approximately two to three classes will be spent on this section.

In the following passages I will be explaining the work of each artist that I use. The page numbers and references refer to the books I have used to find reprints of the artists' works. Of course, there are many places to find reproducible prints; my documentations are just a guide. You may have a source that is more efficient for you. In addition to the book references, I have also tried to provide as many Internet links as possible, so the work can be viewed online.

Most of the following artists and images may be found at *Artcyclopedia* on the Internet at <http://www.artcyclopedia.com>. Here you may find an entire encyclopedia of artists' works by simply searching under their name or the title of the image. Following are selected artists and an explanation of the chosen geometric artwork.

Bronislaw M. Bak (American, 1922-1981)

Holocaust*. 1969. Temple Emanu-El, Chicago, Illinois.*

This stained-glass window is a series of quadrangles in various colors. Although there are thick black lines and various thinner black lines running throughout this work, the colors of the various tiles really shine through. Upon further study, we can see that although the majority of the artwork is quadrangles, there are a few other shapes scattered about the work. Challenge the students to name all the shapes they can find within this piece of artwork. Be sure to encourage the students to use the correct terminology they have learned (Ragans 156).

Giacomo Balla (Italian, 1871 – 1958)

The Street Light - Study of Light. ***1909. The Museum of Modern Art, New York.***

This artwork was mostly created by using one simple V-shape formation. Although each V-shape is a slightly different form, the artwork could still be considered a repeating pattern. This piece of art is nice, in that it shows a complex picture using a simple base (Ragans 234). The Internet view of this artwork can be found at <http://www.moma.org/collection/provenance/items/7.54.html>.

M. C. Escher (Dutch, 1898-1972)

Most of Escher's works would be better suited in a unit of study on optical illusions. However, some of his works are quite clearly geometric studies that include rotation, reflection and repetition. It is one of these works that I have chosen for this unit. The official M. C. Escher website can be found at <http://www.mcescher.com/>.

Angels and Devils. ***1941.***

This artwork is created using just two images, that of a devil and that of an angel. Escher has created these two images so that they fit perfectly together like interlocking puzzle pieces. When looking at this image you can see rotation points, reflection lines, and lines of symmetry. This piece is also a good example of tessellation because there are no gaps of space within this image. This is an excellent piece to show several geometric concepts at once (Ernst 40). An online poster of this artwork may be seen at <http://www.mcescher.nl/Shopmain/Foto/Posters/e27.jpg>.

Donald Judd (American, 1928-1994)

To Define a New Spatial Order. ***1965. Also found as*** **Untitled.** ***1969. Guggenheim Museum, New York.***

This installation piece shows pattern and repetition. Each box is exactly the same size and the spaces between each box are the same length. The light spreading from this piece is geometric in itself when talking about fractals. This piece is very simple but hopefully students will see that this three-dimensional sculpture can easily lead into a discussion of architecture (Ferrier 628). This image may be found on the Internet at <http://www.guggenheimcollection.org/site/artist_work_md_70_1.html>.

Piet Mondrian (Dutch, 1872-1944)

Many of Mondrian's works may be found on the Internet at <http://cgfa.sunsite.dk/mondrian/>. Mondrian's works are a perfect match for this unit

because he is a master of geometric simplicity turned into art. The works listed below are just some examples, but any of his works would fit right into the teaching of this unit.

Color Planes in Oval (Painting III). ***1914. Stedelijk Museum, Amsterdam.***

This art shows the basic shapes of squares and rectangles of varying sizes and colors. It is simplistic in its form, yet the viewer's eye seems to move around the art. The simplicity of it is why it is chosen. Students can see what perpendicular line and varying color coming together can create (Ferrier 173). This image may be found on the Internet at <http://cgfa.floridaimaging.com/mondrian/p-mondrian5.htm>.

Composition No 10. ***1915. Kröller-Müller Museum, Otterlo.***

This art shows simple perpendicular lines crossing. There is little, but some variation of color. Here, it is the slight variation of color that really brings the art out of the canvas. The basic line and cross pattern will be something the student will feel confident in recreating (Ferrier 175). This image may be found on the Internet at <http://www.soho-art.com/cgi-bin/shop/shop.pl?fid=1044460763&cgifunction=form>.

Composition with Black, Red, Gray, Yellow, and Blue. ***1921. Museum Ludwig, Cologne.***

Here is one of the most simplistic art pieces created. Students can notice that there are only five colors and just a few lines that create the entire piece. It is bold yet simple. Representations of right angles and rectangles make this art easy to translate into geometric study. An Internet view of this work may be seen at <http://cgfa.sunsite.dk/mondrian/p-mondrian9.htm>.

Victory Boogie-Woogie. ***1943-1944. Private Collection***.

This vibrant and colorful artwork exhibits quadrilaterals in multitude. The compilation of so many varying sizes of squares and rectangles in essence seems simple, yet portrays such visual beauty (Ferrier 427). This image may be found on the Internet at <http://cgfa.sunsite.dk/mondrian/p-mondrian13.htm>.

Miroslav Sutej (Yugoslavian, 1936 - Present)

Ultra AB. ***1970. Library of Congress, Washington, D.C.***

This artwork has a distinctive pattern of red and green as well as a repetition of triangles in various rotations. The pattern is only disrupted by the impression of two round spheres at the top and bottom. But even within the spheres, there are repeating patterns of triangles and two colors of black and green (Ragans 14). The direct link to his work on line is too long to insert here. To view this work on the Internet, go to the Library of

Congress home page <http://catalog.loc.gov>. and then search the Prints and Photographs Online Catalog (PPOC). By typing in the artist's name in the search you will find his work.

Victor Vasarely (Hungarian-French, 1908-1997)

Many of Vasarely's works may be found on the web by doing a search of his name. His official website is <http://www.vasarely.org>. At his website you will find other works by Vasarely not referenced in this unit. Most of his works would be appropriate for use in this unit due to the geometric design of his style.

Boo. ***1978.***

This eye-catching artwork is a simple repetition of squares neatly aligned into rows. The illusion of the two bubbles transforms the design from plain to eye-popping. The use of simple colors of blue, black, purple and green shows students that creativity and how you use color is more important than the natural talent of artistry. The online view of this art can be found at <http://www.vasarely.org/images/mp/galerie/3-7.html>.

Graphic Study in Axonometric Perspective. ***1934. Musée Didactique Victor Vasarely, Gordes.***

This cube shows basic geometric shapes such as square, rectangle, triangle, and quadrilateral. It also shows the perspective of depth and three-dimensionality. Students can see that art truly can come from taking a basic shape and adding different dimensions of color, in this case shades of gray, and create something truly eye-catching (Ferrier 425).

Andy Warhol (American, 1931-1987)

The Twenty Marilyns. ***1962. Private Collection.***

This art shows repetition with slight variances. The pictures are the same each time with small variances in shading and color. The geometric idea to present to the students is to simply create one image, repeat the image in rows and columns, and then simply alter slight color and shading (Ferrier 657). This image can be found on the Internet at <http://www.universalcolorslide.com/ucs/slidedetail.asp?slidenum=MW06024Y>.

Self Portrait. ***1966. The Eli and Edythe L. Broad Collection.***

Like the previous artwork, Warhol has taken one image, repeated it in rows and columns, and then altered the color of each individual picture. Warhol did several self portraits in his career. The one I am referring to in this unit is the self portrait silkscreen in which the

image is repeated several times (Ferrier 658). For an Internet view of this image, go to <http://www.mfa.org/exhibitions/broad/tour.asp?p=5>.

100 Campbell's Soup Cans. *1962.*

This image is simply added to reinforce the idea of repetition. In this artwork, color, shape and size are exactly repeated. The individual differences are merely the type of soup (Willard 106-107). This image may be found on the Internet at <http://posters.seindal.dk/p272834_100_Campbells_Soup_Cans.html>.

Each of the above pieces of art has something unique to offer this unit. Almost all aspects of the geometry concepts introduced are covered by the above artwork. Since this is not an extensive list, this leaves an opening for students to search various artworks and find the geometry concepts being taught.

For a review lesson of the art history, have students do research about other artwork that displays the geometric shapes or designs being taught. Students can either bring in artwork from books and magazines or an Internet link they have found and a computer print-out of the work. The objective of the assignment is to see if the students are truly grasping the concepts being taught and if they are able to recognize these concepts within artwork.

ARCHITECTURAL HISTORY

For this section, I would like to introduce the students to a surface lesson of architectural history. Again, the main focus of the lesson is the geometric pattern within the architectural design. Architects emphasized will be Ictinus and Callicrates, Étienne-Louis Boullée, Daniel H. Burnham, Gustave Eiffel, Frank Gehry, and Frank Lloyd Wright. Since all architecture has geometry, the unit will focus on that geometry that is unusual in its design nature. Approximately two to three classes will be spent on this section.

Following will be descriptions of the different architectural structures used in the unit. As stated above, there are many places to find reproducible prints, so my documentations are just a guide. Many of these buildings can be found by searching <http://www.greatbuildings.com>.

Ictinus and Callicrates (Greek)

Parthenon. 432 BC. Athens, Greece.

This ancient structure is a standing visual of symmetry and repeating pattern. The monochromatic white marble helps to make this structure seem visually perfect in its

symmetry (Howells 22). Online photos of this structure may be found at <http://www.greatbuildings.com/buildings/The_Parthenon.html>.

Étienne-Louis Boullée (French, 1728-1799)

A collection of Boullée's works can be found on the Internet at <http://www.vitruvio.ch/arc/masters/boullee.php>. Here you can find several images of his works in one site. Since most of his works were drawings and never became actual structures, there are not a lot of images of varying angles for one structure.

Metropolitan Cathedral Project. 1781. Bibliotheque Nationale, Paris, France.

Although this structure was never built, we can use the drawing to extract many aspects of the geometry we are trying to teach. The basic shapes of triangle, rectangle and circle can be seen. The identical repeating columns show recognizable pattern. We can even find several lines of symmetry. This is a great structure for demonstrating multiple geometric concepts within one building (Trachtenberg 422). An Internet image may be found at <http://www.vitruvio.ch/arc/neoclassical/france/metropolitanchurch.php>.

Newton's Cenotaph. 1783. Bibliotheque Nationale, Paris, France.

This design seemingly puts a large sphere right in the middle of a cylindrical base. Students will be fascinated by this unusual design that has no corners. Since this work was never built, the students can use their imagination to decide how the inside would be structured (Trachtenberg 423). This image is on the Internet at <http://www.vitruvio.ch/arc/neoclassical/france/newtonscenotaph.php>.

Daniel H. Burnham (American, 1846 - 1912)

Flatiron Building. 1902. New York, New York.

The uniqueness of this building is its triangular design. Most students will think of skyscrapers as being rectangular, so this structure breaks that idea. Challenge the students to think of other shapes that could be the design floor plan of a skyscraper. In addition to the unusual shape, this building also has nice repetition and symmetry (Howells 104). An online view of this building can be found at <http://www.greatbuildings.com/buildings/Flatiron_Building.html>.

Gustave Eiffel (French 1832-1923)

Eiffel Tower*. 1887-*1889. Paris, France.

This very famous structure should be recognizable to the students. In discussion of the geometry, note the shapes of triangles, squares and right angles that collectively form this enormous structure. The students can easily see the repetition and pattern of lines crossing (Trachtenberg Colorplate 61). A more in-depth explanation of the structure may

be found at the official website at <http://www.tour-eiffel.fr/teiffel/uk/>. Here, the students can explore the structural design and learn facts about the structure as well as take a virtual tour.

Frank Gehry (Canadian, 1929 – Present)

Experience Music Project. 2000. Seattle, Washington.

This structure is quite eclectic. It seems that no two parts of the building are the same. The exterior colors consist of silver, brown, gold, red and blue. Each section of the structure seems to be its own entity. Yet somehow each of these parts come together to create one whole building that is unlike any other. Challenge the students to find shapes in the structure, introduced in this unit. Information about this structure, including images, may be found at <http://www.greatbuildings.com/buildings/Experience_Music_Project.html>.

Walt Disney Concert Hall. 2003. Los Angeles, California.

The exterior of this building has striking stainless steel curves. This structure seems to have multiple curved stainless steel blocks huddled together to form a most unique geometric structure. It is an incredible geometric structure that completely defies all the tall straight structures of downtown Los Angeles. The students will be challenged to see if they can find any right angles on the exterior of this building. The website for the Los Angeles Philharmonic and information about the Walt Disney Concert Hall can be found on the Internet at <http://wdch.laphil.com/wdch/home.html>. (The Guggenheim Museum in Bilbao, Spain is a structure by Gehry that is strikingly similar to this concert hall. Images may be found at <http://www.greatbuildings.com/buildings/Guggenheim_Bilbao.html>.)

Vitra Design Museum. 1990. Weil-am-Rhein, Germany.

This structure is another great example of an eclectic building. In contrast to the Experience Music Project, the exterior of this structure is solid white. Even with the uniform color, the structure seems to be constructed of separate geometric shapes that come together to form one building. This structure also doesn't seem to have any exact right angles, though some corners seem to come close. The rest of this structure consists of curves, sharp angles and slants. It's quite an interesting structure, visually. Information about the structure and several images may be found at <http://www.greatbuildings.com/buildings/Vitra_Design_Museum.html>.

Frank Lloyd Wright (American 1867-1959)

An excellent website for Wright's works can be found at *Wright on the Web* at <http://www.delmars.com/wright/flwright.htm>. His works are chronicled by decade. The site has numerous links to works of Wright on the web. Frank Lloyd Wright was a

brilliant architect and many of his works are so unusual that his work fits perfectly into this unit for the study of geometry.

Fallingwater House. 1937. Bear Run, Pennsylvania.

The thick concrete rectangles stacked parallel on top of one another give this structure a unique geometric look. Everything about this structure is right angles and rectangles. This structure does not seem to have a distinct pattern of repetition in the overall outside structure. This adds to the structure's uniqueness (Trachtenberg 535). One online view of the structure can be seen at <http://www.delmars.com/flwtrip/fw1.htm>.

The Solomon R. Guggenheim Museum. 1956-1959. New York City, New York.

This circular structure seems to be one continuous spiral. The majority of structures that students might be familiar with would most likely be squares. For instance, their houses, their schools and their churches are most likely buildings that have a square structural base. After exposing students to pictures of this museum structure, a discussion could be had of why the majority of structures they see are rectangular. Also, discuss other non-traditional shapes that could be used to construct a building. This discussion could be combined with the discussion mentioned in the Flatiron Building activity (Trachtenberg 536-537). An online view can be seen at <http://www.bc.edu/bc_org/avp/cas/fnart/fa267/FLW_guggenheim.html>.

Larkin Building. 1904. Buffalo, New York.

The exterior of this building seems rather plain until you notice the repetition of pattern with the exterior windows and the obvious line of symmetry down the middle. In fact it seems that every face of this building has a distinguishing line of symmetry. When we take a look at the interior of this building, the symmetry and repetition become even more pronounced. Students should be able to recognize the repetition of identical lamps, bricks, walls, and windows in this interior structure. Challenge students to count the number of possible lines of symmetry (Trachtenberg 504-505). Photos, drawings, and information on the building may be found at <http://www.pbs.org/flw/buildings/larkin/larkin.html>.

Architect Unknown

The Leaning Tower of Pisa. 1350. Pisa, Italy.

This magnificent tower is beautiful to view. The cylindrical design and curved archways make this structure visually geometric in shape alone. In addition though, this structure has obvious repeating pattern and several lines of symmetry. However, because of the lean, the line of symmetry is not directly vertical, nor directly horizontal. A discussion could be conducted among the class of whether or not this building has vertical and

horizontal symmetry. Some would argue that it does, given just the structure itself. Others would argue that it doesn't because the building is not straight vertical as it stands. An interesting discussion and subsequent debate could be conducted among the students (Howells 190). An Internet site for more information on this structure can be found at <http://torre.duomo.pisa.it/towersgallery/index_eng.html>.

Temple at Borobudur. 8th-9th Century. Java, Indonesia.

Although this structure is thought to have been build around the 8th century, it was at one time forgotten and not discovered again until the 18th century. Since its discovery, it has been hailed as one of the greatest Buddhist Temples ever created. This structure contains radial symmetry, reflection symmetry and repetition all in one. Not only does the structure as a whole contain these symmetries, but each component of the structure is also symmetrical, from each Buddha to each relief. As a challenge, the students can be asked to find how many lines of symmetry can be found in this structure (Howells 28). An online view of the Temple can be found at <http://www.buddhanet.net/boro.htm>.

All of the above structures were chosen for their unique geometric qualities. The list, of course, could go on and on. As a review, assign students to bring in a picture or website link to a structure they see as unique in its geometric qualities. Have students discuss the qualities of the structure that make it unique.

A conclusion to this lesson, if time permits, could be to take a short walking tour of the school and have students point out lines of symmetry, repeating pattern, or unique geometric qualities within the school's structure.

HANDS-ON DESIGN

The fourth element to this unit is hands-on design. The students will have the opportunity to create either an art design or architectural design using the geometric concepts introduced. The student will create one piece of art using the geometric designs learned and one drawing of model architecture also using the designs learned. Both of these projects will be small 45-minute projects. The final project will be given two or more class periods and will be a culmination of all areas learned. The student will have the opportunity to create anything he or she wants based on the art, architecture and geometry learned in the unit. Students may pair up, if desired, to create a more intense project. This will be the opportunity for the student to create a piece of art that shows what they have learned in the unit. The guidelines will only be that the student use patterns, shapes and designs that were introduced in the unit. Also, after completing the project, the student will do a short oral presentation describing what patterns, shapes, art and architecture influenced his/her design. Approximately five classes will be spent on this section.

For the art design, the idea is for the students to create art using the patterns and designs learned in the unit. Also, the students will use the influence they received from the visual images of art by artists who use strong geometric pattern in their work. This activity is designed to give students the confidence to create art. Many students do not consider themselves artists because they claim they cannot draw. The objective of this activity is to show students that anyone can be an artist if they have an open mind. Self-confidence is so important at the middle school level; any activity that raises self-esteem through self-discovery is priceless. Our school is a fine arts magnet school, so we do have many artists on campus. In fact, our school is adorned with artwork above every classroom, in the breezeway, as well as on the exterior brick walls. Our city, Houston, is also a very artistic place. We have three major art museums that are easily accessible to the students: The Museum of Fine Arts Houston, The Contemporary Arts Museum, and the Menil Collection. In addition to these major museums we also have small art museums throughout the city as well as schools for art students. Since our town is inundated with art displays, my students should be no strangers to seeing art. The challenge is getting these students to believe that they can be creative artists as well. Many students are very literal and very structured. If this activity can get them to open their eyes a little wider in their creativity, the results in schoolwork and self-esteem will no doubt rise.

The first art activity will be homework. The students will be asked to bring in pieces of manufactured textiles or objects with distinguishing geometric patterns. Have students bring in various examples such as radial balance, symmetry, repeating pattern, reflection pattern and tessellations. Assign students to bring in an example of two to three different types of patterns. The textile could be a tie, a shirt, a blanket, a dish, etc. The focus is for the students to be able to identify patterns and designs in everyday clothing and structure. When they bring the object to school they will show it to the class and explain what pattern they see in this design. The idea is for the students to use the vocabulary words that have been introduced earlier in the unit.

The second art activity will be a two-dimensional creation. The students will be asked to tile a space with a polygon other than a square. The student will choose which polygon he or she would like to use. This is where the student can discover which shapes tile easily and which shapes do not. It has everything to do with the idea of geometry and the limitations of design. Provide the students with a sheet of standard computer paper to use as the base. The student will use construction paper to create the tiles. The tiles need to be the exact same size and shape cut from a standard pattern. The teacher can provide the base pattern for the students to trace and cut. The challenge will be for the student to tile the entire paper with the one shape and not have any overlaps or spaces. The variations in color of the construction paper will turn this activity from a math project to an art project. The students will notice that when they get to the edge of the paper they will have to modify their shape by cutting the edge to make it flush with the edge of the base. A variation of this activity for older or more advanced students could be for the students to trace the shape repeatedly on the paper and then paint or color the drawn

shapes. An extension of this activity can be for the students to choose two polygons and tile the plane using both shapes. This will create more of a decorative pattern.

The third activity will also be a two-dimensional creation. The student will create a drawing of a structure that has visual balance and geometric symmetry. Depending on the class, the teacher can allow the student to use a model or photo of an actual building for help. Whether the student creates the drawing from imagination or reproduces the drawing from an actual structure is up to the teacher. Here also, the teacher has flexibility in the depth of the assignment depending on the class and age of student. An extension of this activity is for the student to create the structure in a model form. Here the activity turns from two-dimensional to three-dimensional. This is helpful for older students or advanced art students.

The final activity will be a larger project. This project will demonstrate the knowledge the students have gained from this unit. The final project will be for students to create something that demonstrates the use of all the geometry shapes, patterns and designs learned in this unit. The students can choose from the following two project choices. The student can create a piece of artwork that is geometric in design, similar to what was seen in the art history lesson. Instead, the student can choose to create a model of a building that is unique in its geometric form, similar to the structures presented in the architecture history lesson. The project should take approximately two class periods. Some work may be done at home if the project requires more attention. Also, the students can choose to work in partners to create an even greater final project.

The purpose of the project is for the students to demonstrate their knowledge of the geometry concepts presented. Requirements for the project should be that it must contain some of the shapes, patterns, and designs presented earlier in the unit. The project must also be original. It cannot be a reproduction of art or architecture presented in the history lessons. The students should have fun with this project, demonstrating their newfound geometric knowledge. If time permits, the students can do oral presentations about their project, explaining which artwork or architecture inspired them, and which geometry concepts they used in the project. If time is short, just display the art and structures around the room for all the students to enjoy.

CONCLUSION

Hopefully, this unit will cover many aspects of learning that the students will enjoy and benefit from. As teachers, we all want our students to get excited about learning. The challenge for us is to present age-old concepts to the students in ways that are understandable and interesting. Not every lesson can be fun, of course. We know that there are some things which are just less exciting to learn than others. However, if we can see an opportunity to boost the excitement about a lesson by using techniques that are fresh and interesting, then we should do our best to integrate them into our daily teachings. It is my hope that this unit is one of those teaching times.

LESSON PLANS

Lesson Plan 1: Introduction to Geometry Concepts

Objective
Students will be introduced to geometry shapes, patterns and designs.

Procedure
The teacher will introduce the geometry terminology to be used in this unit. The teacher should hand out the definition sheet with the examples. The students will look over the sheet and become familiar with the terminology of geometry. The teacher can review the terminology and get students accustomed to pronouncing the names as well as associating the correct terminology with the correct shape.

After the concepts have been introduced, divide the students into three groups. Each group will make flash cards for one section of the terminologies. Assign the first group the shapes, the second group will have the geometry patterns and designs and the third group will have the art patterns and designs. The students will use index cards. One on side of the card the vocabulary term should be written. On the opposite side, the definition and a visual example should be written. The students can use the exact definition and examples from the handout. As students are creating the cards, walk around and monitor in order to make sure the cards are being created correctly and check for accuracy. This lesson should take approximately one class period.

Lesson Plan 2: Completion and Review of Geometry Concepts

Objective
Students will review geometry concepts learned in the previous lesson.

Procedure
In the first 45-minute lesson, the students most likely did not complete all the flash cards. Begin this lesson by allowing students time to complete all cards. After all cards have been completed and checked for accuracy by the teacher, give each student one card. If there are not enough cards, two students can pair up. Alternatively, if there are not enough students, some students can carry two cards.

The activity is for students to move around the room and quiz each other with their flash card. The activity will look something like the following. Two students will come together and show the definition and example side of their card to the other student. Student 1 will read aloud the card of student 2. Student 1 will then call out the name of the vocabulary term being defined. Then, student 2 will do the same by reading the card of student 1 aloud and then calling out the correct vocabulary term. If one student says the incorrect term, the other student can help by giving clues. After each student has shared with that partner, they will move around the room and find another student and do

the activity again. This will continue for one minute. At one minute, the teacher will call time and students will switch cards with someone so they have a new card. Then the activity resumes for another minute, and so on.

This activity will be noisy and energetic. Monitor the students to make sure they are reading the card out loud and saying the correct terminology. This activity should take approximately five to seven minutes.

After the activity, collect all cards and do a teacher-directed review by holding up the card and having the whole class call out the terminology. The teacher can then reverse the cards, showing the vocabulary terminology, and have students call out the definition.

This lesson should take approximately one class period. If the activity does not take the full class period, you can start the first part of the art history lesson that follows.

Lesson Plan 3: Introduction to Art History

Objective
Students will be introduced to artwork that contains a strong geometric strand.

Procedure
The teacher will show the slides or photos of the artwork mentioned previously. It is important that the teacher show the artwork and talk about the prevalence of geometry contained within it. The images may be shown through a PowerPoint slideshow, through overheads on the projector, or through books. It is important that the student be exposed to the artwork as close to its original form as possible; this means that color is very important.

Assign the students homework to find one picture of art that demonstrates a strong geometric presence. The art can be printed from a website, cut from a magazine, or be retrieved from some other source. The student will make an oral presentation describing the artwork in the next lesson. This lesson should take approximately two class periods, allowing time for review and discussion of the art.

Lesson Plan 4: Assessment of Art History

Objective
Students will demonstrate their knowledge of lesson 3 by demonstrating ability to recognize art with geometric design.

Procedure
Students will bring in art they have found that displays one of the geometric shapes or concepts learned earlier in the unit. Students will show their art to the class and discuss the geometric presence within the artwork. This activity is designed to see how much the

students understand of the concepts learned. Allow for class comments and discussion about the artwork. This activity should take approximately one class period.

Lesson Plan 5: Introduction to Architectural History

Objective
Students will be introduced to architectural structure that is unique in its geometric design.

Procedure
The teacher will begin to show the images of the architectural structures mentioned previously. It is important that the teacher show the structures and talk about the prevalence of geometry contained within it. The images may be shown through a PowerPoint slideshow, through overheads on the projector, or through books. It is important that the student be exposed to the structures in as many angles of view as possible.

Assign the students homework to find one picture of architecture that demonstrates a unique geometric design. The structure can be printed from a website, cut from a magazine, or retrieved from some other source. The student will make an oral presentation describing the structure in the next lesson. This lesson should take approximately two class periods, allowing time for review and discussion of the structures.

Lesson Plan 6: Assessment of Architectural History

Objective
Students will demonstrate their knowledge of lesson 5 by demonstrating ability to recognize architecture with unique geometric design.

Procedure
Students will bring in pictures of structures they have found that display one of the geometric shapes or concepts learned earlier in the unit. Students will show their pictures to the class and discuss the geometric presence within the structures. This activity is designed to see how much the students understand the concepts learned. Allow for class comments and discussion about the structures. This activity should take approximately one class period.

Lesson Plan 7: Homework - Locate Manufactured Textiles and Objects

Objective
Students will demonstrate knowledge of geometry by identifying everyday objects that contain some type of geometric design or pattern.

Procedure
Students will be given the homework assignment to find an object that displays one of the design features learned. The student should locate two to three different types of pattern and design such as radial balance, symmetry, repeating pattern, reflection pattern and tiling. The objects can be anything from clothing to dishes to ordinary household items. The purpose of the activity is to get students to use their eye to see design and pattern in a different way than they have before. This activity is a homework assignment.

Lesson Plan 8: Presentation of Textiles

Objective
Students will present and discuss the objects they have brought.

Procedure
Students will present and discuss the objects they have located. Each student should show their objects to the class and describe the geometric pattern or design for which it has. Students should use the correct terminology when referring to the objects. As each object is being presented, the class can discuss what they see and if they possibly see any other pattern not mentioned. This lesson should take approximately one class period.

Lesson Plan 9: Tiling of a Space

Objective
Students will demonstrate their knowledge of tessellation.

Procedure
Students will be given a white sheet of standard computer paper. They will be asked to tessellate the plane using one tile shape introduced in the unit. The shape will be cut from construction paper and glued to the surface. When complete, the paper should show no gaps.

At this stage it is up to the teacher's discretion on how to provide the shapes. The shapes can be previously cut out by the teacher or aide and provided for the student. The shapes can also be provided in a stencil and the student can cut his or her own shapes. Remember to provide various sizes of the different shape options.

Of course some shapes will not tessellate, but provide all shapes to allow the students to do trial and error with their project. Encourage the students also to create some type of color pattern within their design.

An advanced or extension activity for this assignment is to have students use two or three various shapes to tessellate their plane. This lesson should take approximately one class period.

Lesson Plan 10: Drawing a Structure with Geometric Symmetry

Objective
Students will draw a structure that contains visual balance and geometric symmetry.

Procedure
The student will create a drawing of a structure that has visual balance and geometric symmetry. Depending on the class the teacher can allow the student to use a model or photo of an actual building for help. Ideally, though, the student will create a building that is original. The drawing can be a simple pencil drawing on standard paper. The objective is for the student to create the structure with symmetry. The student should be able to demonstrate their knowledge of what constitutes symmetry in a building. This activity should take approximately one class period.

Lesson Plan 11: Final Project

Objective
The students will demonstrate their knowledge of all concepts learned in this unit.

Procedure
The final project will be for students to create something that demonstrates the use of all the geometry shapes, patterns and designs learned in this unit. The students can choose from the following two project choices:

1. The student can create a piece of artwork that is geometric in design, similar to what was seen in the art history lesson.
2. The student can instead choose to create a model of a building that is unique in its geometric form, similar to the structures presented in the architecture history lesson.

Some work may be done at home if the project requires more attention. Also, the students can choose to work in partners to create an even greater final project.

Requirements for the project should be that it must contain some of the shapes, patterns, and designs presented earlier in the unit. The project must also be original. It cannot be a reproduction of art or architecture presented in the history lessons. The materials used for this project can be anything that students can easily find available. The students should not buy expensive materials for this project.

If time permits, the students can do oral presentations about their project, explaining which artwork or architecture inspired them, and which geometry concepts they used in the project. If time is short, just display the art and structure around the room for all the students to enjoy. This project will take approximately two class periods.

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