SCHOOLS NEXT

Design Competition Curriculum

ASSOCIATION FOR LEARNING ENVIRONMENTS
Enhancing the Educational Experience

STEM and Visual Arts Connections to Green Schools

SchoolsNEXT Design Competition

Association for Learning Environments

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Table of Contents

SchoolsNEXT Design Competition 4
Curriculum Overview 6

Unit 1: STEM and Visual Arts Connections to Green Schools
- Learning Environment Vocabulary 7
- The Architectural Style of Frank Lloyd Wright 9
- Geometric Shapes in Architecture 13
- A Stellar Survey I 23
- A Stellar Survey II 24
- Tessellation Exploration 32

Unit 2: Green Schools
- Green Schools – Networks of Benefits 37
- Meeting Community and School Needs 38
- Space Conservation 39

Unit 3: Designing the Floor Plan I
- Introduction to Scale Drawings 89
- Refining and Reasoning Behind Scale Drawings 91
- Checking Scale Drawings for Accuracy 92
- Measure Around and Within 98
- Design Your Space 112
- Best Design of a Floor Plan 117

Unit 4: Designing the Floor Plan II
- Precision Tools 122
- Ratios 124
- Proportions 130
- Energy and How It Is Measured 138
- Conversion of Measurement 141
- How to Make 3D Model 143

Lesson Plan Template 144

Resources: Please visit the SchoolsNEXT website: Design Competition Resources, Teacher/ Mentor Resources and Additional Resources for enrichment materials.

SCHOOLSNEXT DESIGN COMPETITION

SchoolsNEXT's Design Competition offers an opportunity to illustrate the kind of creativity that students bring to the planning and design process. The competition highlights the importance of well-planned, high performance, healthy, safe and sustainable schools that foster student achievement and enhance community vitality.

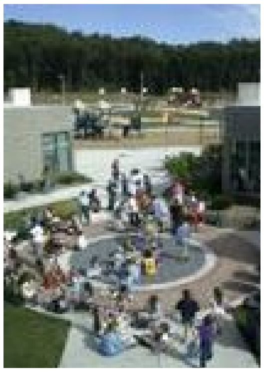
Integrating visual arts learning throughout all disciplines significantly engages all learners. The SchoolsNEXT Design Competition integrates all subject areas, provides opportunities for students to ask questions and problem solve, presents an opportunity for collaboration and community involvement, and gives experience in tactile, hands-on work while developing the eye for beauty and design. The annual competition challenges middle school students to design a sustainable school. This course enhances the learning process by encouraging the learner to consider issues such as embodied energy, conservation of resources and engaging the surrounding community in the problem at hand.

Teams are encouraged to build a project/scale model using recycled materials. However, the project must be displayed in electronic format for the final submittal and jury presentation. A video, PowerPoint and narrative documenting the planning process and rationale for the team's design are also required. Supporting materials such as plans, elevations and perspectives are encouraged. These documents are typically developed from Sketchup, Revit, or CAD.

Teachers are encouraged to fully utilize the SchoolsNEXT Design Competition curriculum and outlined lesson plans as a starting point for the participants. This is a 21st Century learning approach where students are enabled, engaged and empowered through the curriculum to develop and master skills in the visual arts, architecture, math, communication/language arts, science, technology, facility planning, leadership and teamwork. Furthermore, this multi-disciplinary curriculum is designed to address the national, math, visual arts education and environmental education standards. The curriculum is intended to cover a full semester with classes once a week, but may be accelerated or presented as an after school program. Teachers may create additional lesson plans that further address arts education and "sustainable" issues, with particular regard to their locality and environmental conditions. The students also investigate how their project will make it easier for students to learn and feel comfortable in their environment, addressing issues in the use of materials, colors, textures, lighting and how temperatures contribute to a supportive learning environment. One of the goals of this project is to motivate students to learn using a variety of tools and resources, which is intended to instill a sense of pride and ownership of their school and community. They create an environment where kids can't wait to get to school every morning!

Key to the success of the program and leading the students to paths of investigation regarding the visual arts, architecture, and history of design and use of technological tools to enhance their work, the mentor program adds an inspiring and motivational dimension to the competition. Mentors challenge and develop the students' strengths, talents and interests, providing critical connections between arts and STEM education and careers.

Through project-based learning, students explore real world problems relevant to their lives and offer solutions, bridging the gap between conceptual theory and real life skills. They learn how math, art, science and history are part of the design process. In order to design a project they need to understand what and how a school looks, feels and functions to support the teaching and learning. The competition highlights the value of arts education, STEM disciplines, design aesthetic (composition of form, color, texture and light) in concert with cooperation, teamwork and a shared vision that transcends parochial interests. To create and facilitate the structures and opportunities for these powerful connections is a significant part of working thoughtfully with education and social systems in which students are genuinely affirmed and encouraged to build self-confidence.



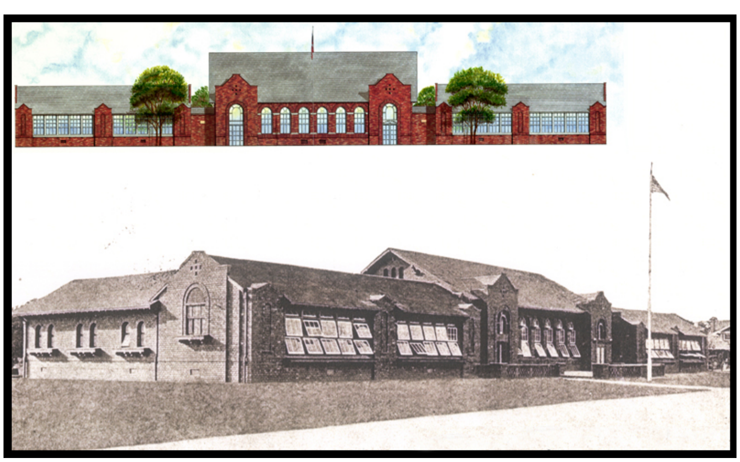
STEM and Visual Arts Connections to Green Schools

SchoolsNEXT Design Competition

The information that follows is the beginning of a pathway to a vibrant venue for integrating all disciplines through the visual arts and applying multidisciplinary elements relevant to students' lives. All too often in middle school classrooms mathematics, science, and language arts are taught from a textbook as a series of skills in isolation. While focusing on visual arts projects such as designing a school, STEM and language arts disciplines are extended and applied as students become engaged in their learning.

Each of the four units of study, *Introduction to Visual Arts, Green Buildings, Designing the Floor Plan I and Designing the Floor Plan II,* is broken down into lessons that not only emphasize visual arts, mathematics and science, but also communication, teamwork and further connections to English, social studies and health. It is assumed that the included lessons are not a student's first exposure to these middle school standards and that prior teaching has provided requisite skills for success.

The design is flexible and adaptable to the style of a teacher and needs of the participants of the SchoolsNEXT Design Competition. It is meant to be a living document, a guideline, and a starting point for creative ideas to implement a sustainable learning environment.



STEM and Visual Arts Connections To Green Schools

Grades 5-8

LESSON TITLE: Learning Environment Vocabulary

Math Standard(s) Addressed: Knows basic geometric language for describing and naming shapes (e.g., trapezoid, parallelogram, cube, and sphere).

Approximate Time Needed for Lesson: 30 – 45 min.

Students will engage in:

■ independent activities	☐ pairing	■ whole group instruction
■ cooperative learning	■ hands-on activities	☐ technology integration
☐ peer tutoring	☐ centers	☐ creating a project
☐ visuals	☐ lecture	☐ guest speakers

Class Starter: Provide a brief overview of the objectives of School Building Week and the overall goals.

Objectives: To create a working lexicon of building and architectural terms.

Materials:
- blank paper
- writing utensils
- envelopes
- 30 note cards/group
- butcher paper (optional)

Step-By-Step Procedures:
- Arrange students into small cooperative groups of approximately 3-4 students.
- Using a blank piece of paper, groups brainstorm as many math terms as possible related to the architectural planning and building of a school.
- Distribute envelopes containing vocabulary words and have students sort terms in a logical manner.
- Groups share and support reasoning for classification of terms.
- Suggestions:
  It may be difficult for some groups to sort the vocabulary words into categories. Some ideas for categories are: Inside materials, outside materials, geometric shapes, tangible items, intangible items. Not all vocabulary words will fit all categories. This is a good place to introduce geometric terminology (see lesson "Geometric Shapes in Architecture").

Guided/Independent Practice: Whole group: look at 2 or 3 vocabulary words and discuss possible classifications that could be supported.

Assessment: Informal assessment – students are able to verbally justify their reasoning for classification of terms.

Differentiation Ideas:
- Flexible grouping by learning styles
- Flexible grouping by prior knowledge
- Flexible grouping by ability level

Adaptations & Extension Ideas:
- Groups organize sorted words on butcher paper.
- Post butcher paper around the room.
- Groups share and discuss their reasoning for sorting terms as they did.

Closure: Since each group will probably have the terms sorted very differently, they will explain to teacher (or to whole class) their logic and reasoning for sorting the vocabulary terms as they did.

Connections to other Content Areas: Language Arts (writing), Science (classifying), Public Speaking

Additional Resources: http://www.healthyschools.org, http://www.epa.gov, http://energystar.gov, http://www.eere.energy.gov

Learning Environment Vocabulary

Instructions: Each group of students will sort the vocabulary words into categories. Each category must be titled. One member of each group shall report their ideas to the whole class stating the rationale for their decisions.

The words may be duplicated and cut up for distribution to the groups, or may be written or glued onto note cards for easier handling by the students.

perimeter	sidewalk	bulletin board
skylight	telephone	roofing materials
bathroom	volume	air conditioning
concrete	storage	asphalt
noise	door	natural lighting
texture	flooring materials	area
glass	hallway	awning
stairs	flag	light bulb
insulation	brick	chalk/white boards
public address system	water fountain	partition
indoor air quality	mold	temperature

STEM and Visual Arts Connections
To Green Schools

Grades 5-8

LESSON TITLE: The Architectural Style of Frank Lloyd Wright

Math Standard(s) Addressed: Understands basic properties of figures (2D, 3D, symmetry, number of faces); understands characteristics of lines (e.g., parallel, perpendicular, intersecting) and angles (e.g., right, acute).

Approximate Time Needed for Lesson: 30-45 minutes

Students will engage in:

- [x] independent activities
- [ ] cooperative learning
- [ ] peer tutoring
- [x] visuals
- [x] pairing
- [ ] hands-on activities
- [ ] centers
- [x] lecture
- [x] whole group instruction
- [x] technology integration
- [ ] creating a project
- [ ] guest speakers

Class Starter:

- Provide a brief biographical profile of Frank Lloyd Wright and his buildings.
- Introduce concepts of *tangible* and *intangible*.

Objectives: Students will recognize themes common to FLW's style of architecture and identify qualities as *tangible* or *intangible*.

Materials:

writing utensil	paper
Internet	butcher paper (optional)
List of books on next page (optional)	

Step-By-Step Procedures:

- Have students work in pairs to research Frank Lloyd's Wrights buildings (www.greatbuildings.com).
- Compare and contrast to determine omnipresent features consistent throughout his architecture.
- Individually write a descriptive paragraph explaining the overall concepts FLW had in building design.
- Include in the written paragraph examples of both tangible and intangible architectural qualities present in the buildings of Frank Lloyd Wright.

Guided/Independent Practice: Teacher presents several qualities and students indicate whether they are *tangible* or *intangible*.

Assessment: Grading of the paragraph using the six traits rubric for content.

Differentiation Ideas:

- Vary paragraph length for individual needs of students.
- Offer opportunity for students analyze a specific FLW building and present information to class.

Adaptations & Extension Ideas:

- Have students make posters on each of Frank Lloyd Wright's buildings and identify repeating themes common to each of them.
- Assign groups of students to read and report to the class on books from the list of books on next page.
- Visit an example of Frank Lloyd Wright architecture.

Closure: Students are to write one statement on a slip of paper relating to FLW or tangible vs. intangible qualities of architectural design. This will be their "ticket out the door" at the end of class.

Connections to other Content Areas: Language Arts (writing), Art History

Additional Resources: www.aia.org

Some of the states where tours of Frank Lloyd Wright architecture are available: AZ, IL, WI, AL, IA, MN. Taliesen in Spring Green, WI and Taliesen West in Scottsdale, AZ are also excellent sources of information.

Some examples of books available on Frank Lloyd Wright:

1. Frank Lloyd Wright by Robert McCarter
2. Frank Lloyd Wright**:** The Masterworks by David Larkin (Editor), Bruce Brooks Pfeiffer.
3. A Frank Lloyd Wright Companion by William Allin Storrer**.**
4. Lost Wright: Frank Lloyd Wright's Vanished Masterpieces by Carla Lind
5. Frank Lloyd Wright: Glass Art by Thomas A. Heinz
6. Frank Lloyd Wright's Usonian Houses: The Case for Organic Architecture by John Sergeant
7. Frank Lloyd Wright: Force of Nature by Eric Peter Nash
8. Frank Lloyd Wright by Iain Thomson, Frank Lloyd Wright, Maria Constantino
9. Truth Against the World: Frank Lloyd Wright Speaks for an Organic Architecture by Frank Lloyd Wright, Patrick J. Meehan (Editor)
10. 50 Favorite Rooms by Frank Lloyd Wright by Diane Maddex
11. About Wright: An Album of Recollections by Those Who Knew Frank Lloyd Wright by Edgar Tafel
12. Frank Lloyd Wright Remembered by Patrick J. Meehan (Editor)
13. Frank Lloyd Wright's Usonian Houses (Wright at a Glance Series) by Carla Lind
14. Frank Lloyd Wright's Prairie Houses (Wright at a Glance Series) by Carla Lind
15. Frank Lloyd Wright's Glass Designs (Wright at a Glance Series) by Carla Lind
16. Frank Lloyd Wright's California Houses (Wright at a Glance Series) by Carla Lind
17. Frank Lloyd Wright's Dining Rooms (Wright at a Glance Series) by Carla Lind
18. Frank Lloyd Wright's Fallingwater (Wright at a Glance Series) by Carla Lind
19. Frank Lloyd Wright's Public Buildings (Wright at a Glance Series) by Carla Lind
20. Fallingwater: A Frank Lloyd Wright Country House by Edgar Kaufmann, Jr.; Christopher Little and Thomas A. Heinz (Photographers)

The following information is extracted from "Some Mathematical Principles of Architecture" written by Fred DiTallo and posted on Yale-New Haven Teachers Institute web site. It can be found at:
http://www.yale.edu/ynhti/curriculum/units/1983/1/83.01.12.x.html

The Intangible

The two categories of architecture that I wish to discuss are the Intangible and the Tangible.

By the intangible, I mean something not immediately discernible to your reasoning powers. Something that is not quite clear in its meaning or effect. Something that causes an emotional response before you realize it.

Architecture has a story to tell. Sometimes it's a nice cheerful story, and other times it's a scary ghost story. Let's examine the differences. Starting with space, the building encloses the space, and creates an effect on the remaining space around it. How this is handled is fundamental to the profession of architecture.

Is there lots of light, wide corridors, spacious rooms inside. Is the facade of the building pleasing and inviting? Or, are the halls narrow and poorly lighted? Are the windows too small, resulting in poor lighting and stuffy overheated conditions? Is the facade drab and uninviting? How about entrances. Is it easy to get into the building, or are things forbidding?

The intangible in architecture isn't really intangible. Someone made it that way on purpose to cause the response that it causes. It was thought about, measured, and calculated. Someone decided that the door should be small or large, and if the corridors should be wide or narrow. All of this falls into mathematics also. Perhaps more on the engineering side of it. Absorption or refraction of light, noise level, sharp angles, etc.

Let's talk about the response to this as the intangible aspect. If you go into a government building to pay taxes or maybe to get a license, the halls may be narrow and dingy; the floors may be marble and echo every footstep; there may be very dim lighting; the doors in the corridors all look alike; you step into the office you think you need and no one's there or maybe lots of people are working behind desks with their backs to you. Kind of creepy? Yes, but no accident.

In his book "An Inquiry Into The Origins Of The Sublime And The Beautiful" Edmund Burke goes into quite a lot of detail as to what things cause certain reactions.

By the sublime, Burke means those things which connote danger and instill a feeling of fear and terror. By the beautiful, he means those things which connote a sense of joy.

Some things that are related to the sublime are: roughness, hardness, darkness, unpleasant smells, unpleasant tastes (bitterness), silence, vastness, uninterrupted repetitions, largeness of size, strong contrasts (such as coming into a dark building from bright daylight), loud sounds, deformity, and unpleasant proportions.

Some of the characteristics related to the beautiful are: smoothness, light, softness, color, pleasant smells and fragrances, brightness, gradual variation, gradual change, delicateness, fragility, gracefulness, elegance, and congruency in proportions. These characteristics are also related to ideals which are considered beautiful. Justice, Wisdom, Virtue, Love and Truth. Thus, the architecture itself can be used to communicate any of these things. It might be the terror of a mansion in a ghost story, or the serenity of a church.

The Intangible in architecture is the emotional impact that a building can have on a person.

As an experiment visit some buildings around New Haven. How does being in the Greyhound Bus Terminal make you feel? How about the Top of the Park Restaurant?

What are some of the differences experienced being at Teletrack or City Hall? How about a court of law or your favorite tavern?

The buildings themselves can affect you, and that is the intangible quality of architecture.

The Tangible

While the intangible is something that is aimed at an emotional response, the tangible involves the underlying laws of math and science that allows a building to be designed and constructed, things such as angles, length, width, height, arches, circles.

We will learn how the ancient Greeks designed all their structures and made all the geometric shapes and calculations using only the compass and straightedge. It is a great tribute to the Greek civilization that the average high school geometry text taught in today's high school is based on Euclid's "Elements" dating to 300 B.C.

While the total body of mathematical knowledge is vast when compared to the geometry of ancient Greece, it is still that geometry that serves as a foundation for higher math.

STEM and Visual Arts Connections To Green Schools

Grades 5-8

LESSON TITLE: Geometric Shapes in Buildings and Architecture

Math Standard(s) Addressed: Knows basic geometric language for describing and naming shapes; understands basic properties of figures; understands the characteristics of lines and angles.

Approximate Time Needed for Lesson: 30-45 minutes

Students will engage in:

☐ independent activities	■ pairing	☐ whole group instruction
☐ cooperative learning	☐ hands-on activities	■ technology integration
☐ peer tutoring	☐ centers	☐ creating a project
■ visuals	☐ lecture	☐ guest speakers

Class Starter: Review geometric shapes, both two-dimensional (such as squares, rectangles, triangles, parallelograms, rhombuses, trapezoids, and circles) and three dimensional (such as cubes, prisms, pyramids, spheres, cylinders, and cones).

Objectives: Students will identify different geometric shapes in architectural styles and buildings.

Materials: writing utensil, computer with Internet access, highlighter, printer

Step-By-Step Procedures:

- Have students work in pairs.
- Research on the Internet different historical buildings in the US and in your specific region.
- Internet sites: see additional resources section at the bottom of this page
- Identify geometric shapes in the pictures of the buildings printed by highlighting parts of the building and labeling the shapes.
- Describe tangible/intangible architectural qualities supported by the geometric shapes.

Guided/Independent Practice: Model procedure of highlighting shapes on picture of building on overhead transparency of a specific building.

Assessment: Pairs of students present one of their highlighted building pictures and describe the shapes used to create them to the class.

Differentiation Ideas:

- Flexible grouping by learning style
- Present different levels of difficulty in terms of complexity of building design (such as a castle vs. a forts vs. a typical house)

Adaptations & Extension Ideas:

- Do Geometry walk activity (see attached)
- "I Am, You Are" Vocabulary Review Game (see attached)

Closure: Have student pairs go to specific locations in the room depending on the number of different geometric shapes that they could find in their picture. For example: one corner for 1-3 different shapes, another corner for 4-6 different shapes, and stand by the door if you were able to find more than 6 different shapes.

Connections to other Content Areas: Art (analysis of pictures), Technology (Internet use)

Additional Resources: http://architecture.about.com/library/bl-buildings.htm (alpha listing of buildings and world location), www.bayillustration.com (Seattle, WA area), http://www.birkey.com/portfolio.asp?cat_id=11 (lots of buildings in Illinois), www.designcommunity.com/scrapbook/2965.html , www.butterflute.com/portfolioArchi.html

The following activity is available on the internet at
http://mathforum.org/workshops/sum98/participants/sanders/Geom3D.html.

3-D Drawing and Geometry

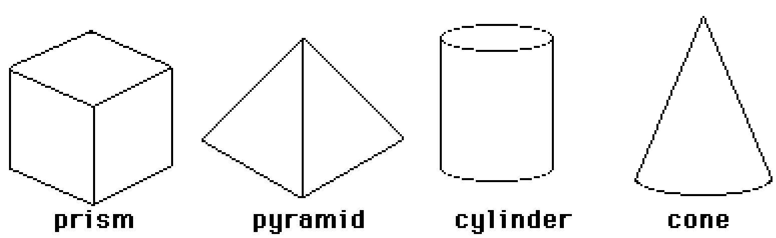
by Cathi Sanders

A Math Forum Summer Institute Project

The Geometry of 3-D drawing

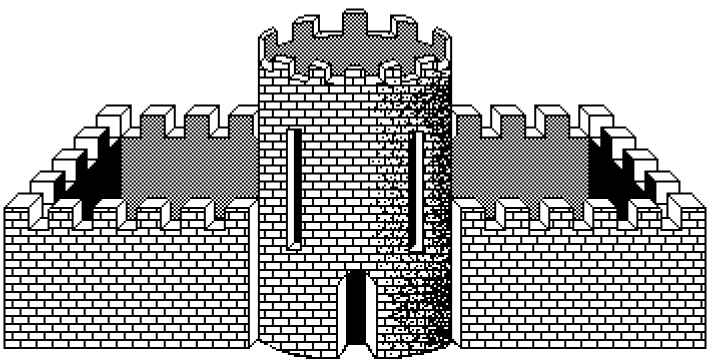
When we draw any object, we have the choice of drawing it "flat" (two-dimensionally) or as a "solid" (three-dimensionally). A floor plan is an example of a two-dimensional representation of a house. Architects often draw 3-D drawings of houses, so their clients can more clearly understand what the house will look like when it is built.

In these pages, you will be studying three-dimensional geometric objects such as cubes, cylinders and pyramids, and learning how to draw them so that they appear to be 3-D. Below are some examples of the 3-D solids you will be studying:

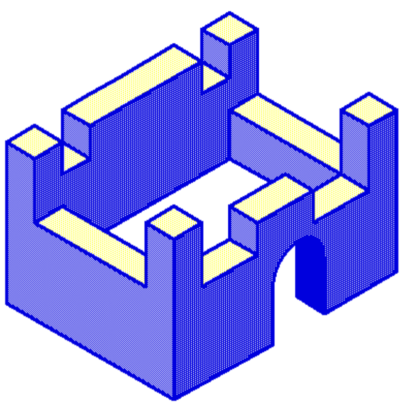


Once you know how to draw these solids, you can combine them to draw all sorts of three-dimensional objects such as furniture, houses, and even castles! The beautiful photograph below from Castles on the Web archive is of a castle called Laussel, at Marquay, in the Perigord region of France.

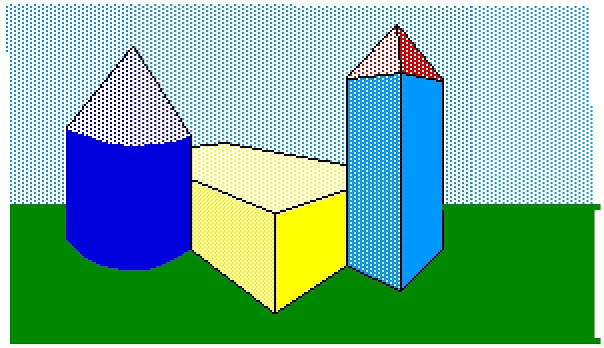
This and many other castles are made up of geometric solids. Can you find prisms, pyramids, cones and cylinders in the photograph? You can draw castles using a combination of these geometric solids. An example of a simple castle, drawn in oblique using Adobe SuperPaint computer software, is shown below:



The castle below was drawn in isometric, using the isometric grid in the Geometer's Sketchpad software:



Here's another example of a castle. This one was constructed in perspective, using the Geometer's Sketchpad:



The following activity is available on the Internet at http://wwwmath-kitecture.com/geometry.htm

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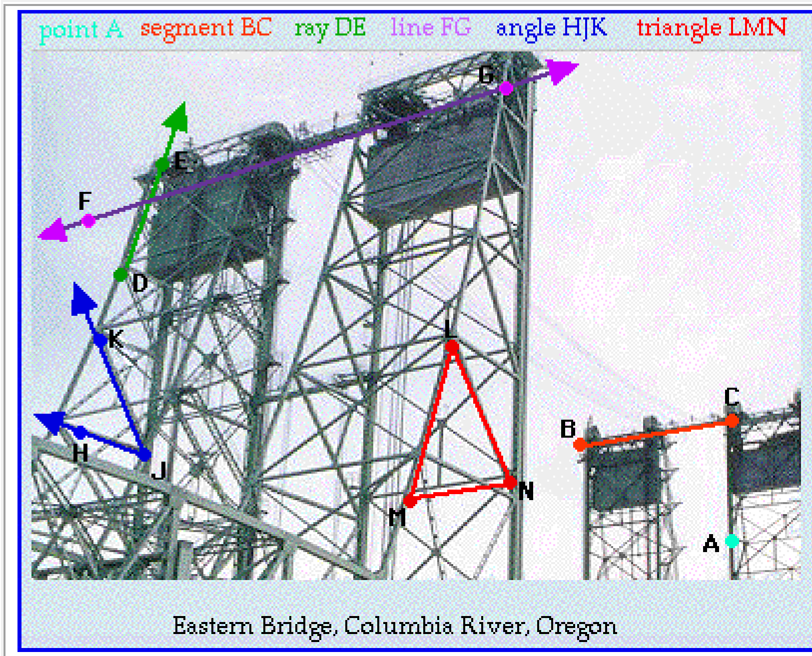
Can you find Geometric Shapes in Buildings and Structures?

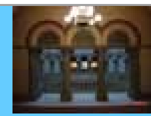


Eastern Bridge, Columbia River, Oregon

In this example, six basic elements of geometry (point, segment, ray, line, angle, and triangle) have been identified within the bridge.

From www.k12.hi.us/~csanders/ch_01 Communicate.html, ©2000

Off the Computer	**On the Computer**
Take a picture of any room, building, house, or structure in your neighborhood and use different colored markers to highlight the shapes within. You can also cut out the picture from an architectural magazine, such as *Architectural Digest* or *House and Garden*.	Scan a picture from an architectural magazine into a drawing document and use different colored lines (from the line tool) to highlight the shapes within. Please send your completed drawings to the Math-Kitecture website!
Find a picture or postcard of a famous building or skyscraper (like the Parthenon of ancient Greece) and discover the three-dimensional shapes within.	Copy an architectural picture from the Internet into a drawing document. To do this, right-click with the mouse button (Windows) or control-click with the mouse button (Macintosh) on the picture until a menu appears. Slide the mouse to the "**Copy this Picture**" option. Release the mouse button. Then start a new drawing document and go to **Edit-> Paste**.

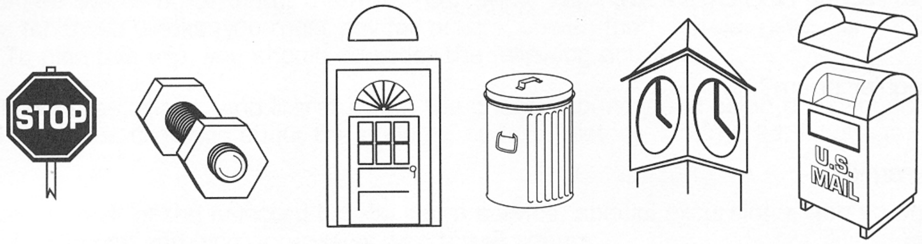
How many shapes can you find in Tweed Courthouse (NYC Department of Education)?	 Click the picture for more views
How many three-dimensional shapes (cube, tetrahedron, cylinder, etc.) can you find in this computer graphic of the Parthenon? Can you find the "Golden Rectangles" within?	 Click the picture for more views.

The above thumbnail picture is an example of architecture that has many geometric shapes within it.

The following Geometry Walk activity is copied from the National Council of Teachers of Mathematics Curriculum and Evaluation Standards for School Mathematics Addenda Series Grades 5 – 8, Geometry in the Middle Grades written by Dorothy Geddes published in 1992.

ACTIVITY 21
A GEOMETRY WALK

1. If you saw these figures on the way to school, what special geometric name would you give to each shape?



2. Now you are going for a Geometry Treasure Hunt.

	Sketch it.	Give its location.	Describe its use.

Can you find—

an angle?

a triangle?

a pentagon?

a hexagon?

an octagon?

a circle?

a semicircle?

a trapezoid?

a cylinder?

a cone?

a sphere?

a hemisphere?

ACTIVITY 21 (CONTINUED)
A GEOMETRY WALK

	Sketch it.	Give its location.	Describe its use.
Can you find—			
a nonrectangular prism?			
a square pyramid?			
parallel lines?			
perpendicular lines?			
two nonparallel lines that do not intersect?			
tessellations?			
a line of symmetry?			
congruent figures?			
similar figures?			
an unusual shape?			

3. Discuss the following questions in your group:
   a. Why are bike wheels or skateboard wheels shaped like circles instead of squares?
   b. Why are openings in a bike rack in the shape of long narrow rectangles?
   c. Why are manhole covers circular and not square?
   d. Why are traffic signs of different shapes?
   e. What shape are the smokestacks on most factory buildings? Why do you think they are built in that shape?
   f. Why are there different shapes for buildings? Which shape building do you like best? Why?
   g. What shape rectangle is most pleasing to your eye? Sketch one. Why are index cards made in sizes 3 x 5, 4 x 6, and 6 x 8? Are these shapes pleasing to your eye? (Do some research on the Golden Rectangle.)

4. Do a "journal write": Describe your Geometric Treasure Hunt in a note to a friend.

"I Am, You Are"

Vocabulary Review Game

angle	triangle	hexagon
pentagon	octagon	circle
semicircle	trapezoid	cylinder
cone	sphere	hemisphere
prism	pyramid	parallel lines
perpendicular lines	tessellation	congruent figures
similar figures	equilateral triangle	isosceles triangle
scalene triangle	parallelogram	obtuse angle
right angle	right triangle	acute angle

Using the vocabulary words in the box above and 27 note cards, do the following:

1. On the front of each card, write the words "I Am"
2. On the back of each card, write the words "You Are"
3. On the "I Am" sides of each card, write a definition of one of the words above.
4. On the "You Are" sides of each card, write the vocabulary words, MAKING SURE that no card contains a matching word/definition pair. (Each card should have a definition on the front with a vocabulary word on the back that does NOT match the definition.
5. TO PLAY: distribute a card to each student (if there are fewer than 27 students, some students may get more than one card – if there are more than 27 students, create additional cards using other geometry terms of your choice).
6. Select a student to stand and read the "I Am" side of their card.
7. Other students listen to the definition that was read. Whoever has the vocabulary word that matches the definition that was just read stands and says "You Are…"
8. That same student now reads the "I Am" side of their card, and whoever has the card matching ***that*** definition stands and reads the "You Are…" side… etc.

Teacher can time how long it takes the class to go through the complete cycle of cards. After one round, collect and redistribute the cards and begin again, timing each round to see if the class can improve their time for each round.

STEM and Visual Arts Connections To Green Schools

Grades 5-8

LESSON TITLE: A Stellar Survey I

Math Standard(s) Addressed: Understands the basic concept of a sample; organizes and displays data using graphs; understands basic characteristics of measures of central tendency.

Approximate Time Needed for Lesson: 30 – 45 min.

Students will engage in:

☒ independent activities	☒ pairing	☒ whole group instruction
☐ cooperative learning	☐ hands-on activities	☒ technology integration
☐ peer tutoring	☐ centers	☒ creating a project
☒ visuals	☐ lecture	☐ guest speakers

Class Starter: Review components of a survey, the purpose of a survey, and appropriate data organization.

Objectives: To have students create, interpret, and utilize a survey in creating their school building.

Materials:
- paper
- writing utensil
- colored pencils
- white board (or chalk board)
- dry erase markers (or chalk)

Step-By-Step Procedures:
- Brainstorm as a whole group what the important features are that we want our new school to have.
- Create a standardized survey form containing 10 questions that incorporate the key features.
- Each student in the class completes the form selecting their choice for each of the 10 questions.
- Tally (on the board) the number of specific responses to each of the 10 questions.
- Use a Stem and Leaf plot (Lesson II) to organize the data.
- Group students and assign each group one question to display results in bar graph form.
- Interpret bar graph criteria for building the school with the entire class.

Guided/Independent Practice: Teacher may want to initially teach Stem and Leaf Plots and lead the brainstorming phase for key features of school. Vocabulary for the lesson is also included in activity

Assessment: Have students write the most important criteria of a school and why it is important to them.

Differentiation Ideas:
- Create a shortened survey for individual student needs.
- Use pictures in survey for students who may be limited English proficient.

Adaptations & Extension Ideas:
- Extend the activity by surveying other classes, family and friends.
- Use Stem and Leaf plots to tally the above results.
- Create bar graphs of the results.
- Display graphs in cafeteria so that entire student body may view the survey results in visual form.

Closure: Teacher-led discussion about the key features that will need to be included in the design phase of the new school.

Connections to other Content Areas: Public Speaking, language arts (writing questions)

Additional Resources:

STEM and Visual Arts Connections
To Green Schools
Grades 5-8

LESSON TITLE: A Stellar Survey II: Stem and Leaf Plots

Math Standard(s) Addressed: Display data as lists, tables, matrices, and plots.

Approximate Time Needed for Lesson: 30 – 45 min.

Students will engage in:

- [ ] independent activities
- [ ] cooperative learning
- [ ] peer tutoring
- [x] visuals
- [ ] pairing
- [x] hands-on activities
- [ ] centers
- [ ] lecture
- [x] whole group instruction
- [ ] technology integration
- [ ] creating a project
- [ ] guest speakers

Class Starter: Review vocabulary for measures of central tendency. Ask students for examples of data with very large or very small numbers (i.e. census results), which would cause difficulties in writing tallies. Talk about why it is more appropriate to use one measure of central tendency over another depending on the situation.

Objectives: To have students tally results of a survey in creating their school building.

Materials: paper, writing utensil, white board (or chalk board), dry erase markers (or chalk)

Step-By-Step Procedures:

- Have students work in groups with data from each survey (each group has one question results).
- Have one student from each group go to board to write data from survey results.
- Talk about need for organization in tallying results of survey.
- Define a Stem and Leaf Plot for tallying responses and finding measures of central tendency (mean, median, mode).
- Organize data by letting the stem represent the greatest place value and the leaf representing the next place value.
- After writing the numbers you may want to write them in ascending or descending order.
- Explain why a key at the end is necessary to show place values and how this allows very large or small numbers to be included in the table.
- Have students in each group do plots using different sets of data.

Example of data: 23; 17; 19; 3; 17; 14; 21; 5; 1; 17

Stem	Leaf
2	**3 1**
1	**7 9 7 4 7**
0	**3 5 1**

Key: 2/3 = 23

May be rewritten:

Stem	Leaf
0	**1 3 5**
1	**4 7 7 7 9**
2	**1 3**

Key: 1/4 = 14

Guided/Independent Practice: Teacher may want to initially teach Stem and Leaf Plots before leading the brainstorming phase of the survey.

Assessment: Have students write situations where one measure of central tendency is more appropriate than another to use. Have students practice finding mean, median and mode from stem and leaf plots.

Differentiation Ideas:

- Create a shortened survey for individual student needs and then a shortened plot.

Adaptations & Extension Ideas:

- Collect data from class, make a stem & leaf plot, find measures of central tendency.
- Survey other classes and plot results.
- Introduce statistical plots like box & whiskers and find measures of central tendency from the plot.

Closure: Discuss situations where one measure of central tendency may be more indicative of results than another. Have students discuss when mean, median or mode is most useful for survey. Which measure of central tendency do you think will be best indicator of survey results?

The following information and activities are copied from the National Council of Teachers of Mathematics Curriculum and Evaluation Standards for School Mathematics Addenda Series Grades 5 – 8, <u>Dealing with Data and Chance</u> written by Judith S. Zawojewski published in 1992.

CHAPTER 1
DATA GATHERING BY STUDENTS

When students gather their own data, they become intimately familiar with the information. They are then able to move from individual experiences with vast amounts of detail to an experience in which they tally, represent, and combine those individual pieces of information. During the process, they develop an understanding of what it really means to organize and summarize data. The implications of grouping and combining data for the sake of gaining a larger, more generalized picture take on meaning. When students draw conclusions based on their experience, they develop the skills needed to become critical consumers of someone else's data summaries and analyses. All citizens are bombarded daily with results from studies, surveys, and polls that someone else has done. Only through personal experiences with the whole process can students develop the critical thinking skills to question, analyze, and interpret data from outside sources.

Large data collection projects readily embed all four themes of the *Curriculum and Evaluation Standards*. Communication plays a major role in formulating questions and verbally analyzing data. Further, the charts and graphs that organize and represent data are forms of communication for users of information. Problem solving permeates the whole process as students decide on interesting topics, formulate questions, plan the collection of data, implement plans, analyze results, make conjectures about their original questions, and decide how to formulate answers. Statistical and probabilistic reasoning are used as students conjecture about cause-and-effect relationships, search for alternative explanations for data trends, and make decisions under uncertain conditions. Finally, large data collection projects are inherently connected to a variety of academic disciplines, since the context of the question is independent of the process of gathering, organizing, summarizing, and analyzing data. Research projects provide students with active experiences in dealing with information and data firsthand. Such projects are easily implemented with all students at the classroom level and nationwide statistics competitions have become popular. Hawkins (1987) reported that nine- to nineteen-year-old students in the United Kingdom regularly address social, commercial, and scientific questions in the Annual Applied Statistics Competition. Recently, an American Statistical Prize Competition, modeled on the British version, was started in the United States (Cameron 1987).

Students can become involved in gathering and processing their own data through surveys, experiments, and simulations. Surveys are a nice way to begin the process with middle school students. The information is usually descriptive, requiring only that students find valid means of obtaining the desired data. Experiments are somewhat more sophisticated because students not only use descriptive techniques but also must design experiments using the scientific method. Simulations are similar to experiments but can be more sophisticated, since they use random number devices—number cubes, spinners, random number tables, and computer programs—to represent, or model, real-world situations.

SURVEYS

The spirit of the *Curriculum and Evaluation Standards* is captured by having students conduct their own surveys. Children's natural curiosity is piqued when they have information about topics of interest to them. Students enjoy the whole process of developing, conducting, and analyzing surveys. The following survey project was developed by a fifth-grade teacher as a long-term investigation implemented over six weeks.

ILLUSTRATION 1: SURVEYS, STATISTICS, AND STUDENTS: AN INTERDISCIPLINARY UNIT

Sandy Paull

CONNECTIONS: ***Surveys are inherently interdisciplinary. The questions usually deal with nonmathematics topics, and the information is usually quantified for ease in organizing, summarizing, and analyzing.***

This unit introduces students to the concept of average by looking for a profile of the "average" student in their school. During this project, students also see statistics used in the real world, standard curriculum skills used in application, and quantitative ideas used in other disciplines.

Materials

computer word-processing or survey-creating capabilities
centimeter grid paper
long lengths of string for each group of students
poems: "In the Middle" (McCord 1975, p. 7)
"Who's Who" (Viorst 1981, p. 14)

Preparation

TECHNOLOGY: ***Software has been designed for classroom use in developing survey questions, collecting data, and representing data.***

Set up a word-processing file in which students can easily enter their survey question. Cut one seven-meter-long string for each group of students. Obtain the poems to read to the class.

Activity 1: Introducing "Average"

1. Poems that give a delightful introduction to the concept of "average" are "In the Middle" by David McCord and "Who's Who" by Judith Viorst. Each poem refers to the idea of being average. Read the poems to the class. Ask the students to classify themselves as average or not. Lively discussions involving some value judgments are likely to occur as students share their ideas and explanations. Follow the discussion by assigning students to write a short essay, poem, or story about being average or describing the "average student" in their school.

2. *Evaluation.* Long-term projects furnish an opportunity for students to keep in a notebook a daily log describing what they have learned, the questions they still have, and their feelings about the activities and the assignments. Weekly reading of the students' logs can provide information to teachers for making decisions about further instruction. For example, some students in this illustration used *average* to reflect a social value: it is "good" or "not good" to be average. Because in mathematics the term is purely descriptive, it was helpful for the teacher to know that students were using the term for different purposes. The teacher was able to explore explicitly and purposely the subtle differences between the uses of *average*. Teachers should expose students to the idea that the meaning of terms can change subtly in different settings.

Activity 2: What Is a Survey?

1. Ask students to share their knowledge of polls and surveys. Topics commonly mentioned are TV ratings, predictions for presidential elections, and marketing surveys conducted in shopping malls. Ask students to share their personal, informal use of polls or surveys. For example, in deciding what kind of pizza to order for a recent birthday party, they may have asked all their friends which ingredients they liked or did not like.

2. Summarize by asking students to answer the following questions in writing:

What is a poll or a survey?

Why would someone want to conduct a survey?

What kind of questions do you think they ask?

What kind of information is obtained from the poll or the survey?

How do you think the information is used?

Activity 3: Developing the Project Goal

1. Share the project goal with the students: The class as a whole is to determine the profile of an "average student" in their school. Suggest that an effective way to obtain an honest, accurate picture is to do a survey. The survey is to be prepared and administered by students in the class. The first task is to figure out what information is needed.

2. Split the class into small groups to brainstorm the types of information needed. Groups should report their ideas, and the class as a whole should develop a master list of characteristics to investigate—height, favorite food, number of hours of TV watched per day, and so on.

Activity 4: Developing Class Survey Questions

PROBLEM SOLVING: As students develop their own questions for use in the surveys, they are involved in "problem formulation."

1. Ask the class as a whole to choose five characteristics from the list developed in Activity 3. Use student-suggested questions to form a five-question survey that all students should answer individually. Share the responses as a class and look for ways to tally and organize the responses. Note when responses are easy to tally (e.g., yes/no responses) and when they are difficult to combine or organize (e.g., open-ended responses). Decide why difficulties were encountered, and discuss ways to rewrite the items to make combining and tallying the data easier.

2. Administer the "new" five-question survey, but this time students should imagine answering the questions as though they were someone else. "Perspective-taking" can help students identify when questions may mean different things to different groups of respondents. For example, given the item "Do you like to read?," pose the following questions for discussion:

COMMUNICATION: The same question may communicate different ideas to different people. For example, "How many people are in your family?" may mean aunts and grandparents to one person and only parents and siblings to another.

Will all students in grades K–8 understand this question?
[They probably will.]

Will all students understand each question in the same way?
[Probably not, since kindergartners generally do not know how to read. The question is likely to mean something different to kindergartners than to fifth graders.]

How can the question be refined to mean the same thing to everyone?
[One possibility is to ask, "Do you like to read or be read to?"]

Will the question get the data you are looking for?
[It looks like it will.]

3. Continue to involve students in activities for writing effective questions. See Illustration 5 for further ideas.

Activity 5: Developing the Individual Survey Question

1. Each student should select a topic and write a first draft of a survey item. Pairs of students should then read and critique each other's questions. Discussing some of the questions with the whole class will

make it clear that every question needs to be carefully evaluated to ensure that it will get the information desired.

2. *Evaluation.* Evaluating students' progress in reviewing and refining their own survey items is important. One way to assess this progress is to have students write their initial question on the top of a page, have their partners write a critique in the middle of the page in a different color ink, and then have the students write the final question below the critique in the original color ink. In figure 1, the teacher first checked whether the partner gave a valid critique of the item. The student did, and therefore received one point. The item-writer was given one point for apparently understanding the critique and another one to two points for appropriately refining the survey item.

Adam

Item

How many people are in your family, including yourself?

Circle One: 1 2 3 4 5 6 7 8 more

Critique

When I read your question I wasn't sure if I should include my step brother who lives with us. Maybe you could list the types of relatives you mean.

Lara

Rewrite Item

Including yourself, your parents and your full brothers and sisters, how many people are in your family?

Circle One: 1 2 3 4 5 6 7 8 more

Fig. 1

3. Make plans to pilot each question with two or three students in other classes. Discuss the advantages of trying out the questions on a diversity of students (i.e., varied ages or gender). Students should prepare copies of their items, ask potential survey respondents to write their answers, and then ask the respondents what they thought the question meant, why they answered as they did, and whether they thought the question was clear.

COMMUNICATION: Survey items may benefit by first piloting them in interview form. The direct verbal interactions allow students to hear responses directly and to immediately confront issues of miscommunication.

4. After the pilot, students should rewrite their questions in final draft form and have them approved by the teacher. Each student then can enter his or her question on the master survey, which has been set up in a word-processing program on the computer.

USING TECHNOLOGY: One way to randomly select students from a whole school is to assign each student a number, program the computer to generate a finite set of random numbers, and interview students with those numbers.

Activity 6: Whom Should We Interview?

Pose the following questions for discussion:

Whom should we interview?

What would happen if students surveyed only their friends?

What would happen if the survey were conducted in the lunch room when only first- through third-grade students were at lunch?

The students should realize that the above situations would probably result in data that represent only certain subsets of the student body. For example, if they gathered information about height or age during the first- through third-grade lunch, the "average" height or age would be much too low to represent the entire student body. Concepts of bias, sampling, and randomness can be explored in a meaningful context. The best way to avoid sample bias is to use a random sample, which is achieved by striving for a selection process in which all people in the intended population have an equally likely chance of being selected. Often, a random sample is not possible or is too difficult to implement; students need to think seriously about avoiding situations that can result in biased samples and improving the representativeness of a sample. Only after students have encountered these questions in their own collections of data are they able to critique and question information based on other people's sampling and data collection techniques.

Activity 7: Planning the Implementation

Students should plan as a class how the survey will be distributed and collected. Many questions need to be addressed:

Who should administer the surveys?

Has permission been secured from the teachers whose classes would be involved?

When can we take selected students from the teacher's class? Have we developed a schedule?

What if someone does not want to respond to the survey questions?

Brainstorm other possible implementation questions and discuss alternatives for each one. Encourage students to plan for unexpected circumstances. To prepare for the unexpected, students should review the purpose of the survey and be ready to make decisions on the basis of good judgment, sensitivity to respondents' and teachers' needs, and the goal of the survey.

Activity 8: Organizing and Representing the Data

Remind students that they will need to share their outcomes for the class members to develop a "profile" of the "average" student; they will need to put their data in a form that can readily communicate the results to their classmates.

1. Introduce alternative ways to represent data using the information from the five-question class survey developed in Activity 4. Use a variety of plots and graphs on each set of data, discuss the impressions given by each, and decide which ones would be useful in developing a profile of the "average" student. Specific ideas for comparing graphs can be found in Illustration 6: Comparing Plots and Graphs.

2. Writers of the survey items should be given the raw data for their own question. The teacher can cut up the questionnaires and give each

♦ ♦ ♦ ♦ ♦ ♦ ♦ ♦

student the part with his or her item. (If a survey-making software program was used, students can readily obtain an individual printout of their data for their own question.) Students should tally and organize the data.

3. Ask students to prepare at least two different plots or graphs appropriate to their data. They should share their representations of the data with the class and discuss the different impressions communicated by the different forms.

Activity 9: Summarizing the Data

It is natural to use concepts of central tendency and distribution when describing and summarizing information to solve a problem or make a decision. Using data gathered by the class furnishes rich opportunities for students to learn about summary statistics in a meaningful context.

1. Use the five survey items developed by the class in Activity 4 to introduce and discuss measures of center and spread appropriate to the data. For example, to develop the concept of the arithmetic mean, divide the students into groups of three or four and ask them to measure their heights. Have each group cut one continuous length of string to represent the sum of their individual heights. Then fold the string into three or four equal parts (depending on the number of students in the group). The resulting length is that of the mean, or arithmetic average. Although this activity uses no numbers, the procedure for finding the mean (i.e., finding the total height and then dividing by the number of people) is clearly evident in the physical actions. Students can compare their own heights to that of the folded string to develop an understanding of why the mean does not necessarily have to be equivalent to any one value in the data set.

REASONING: Using concrete materials rather than numbers to demonstrate procedures can help students develop reasoning skills. Numbers tend to trigger memorized computational responses, whereas the use of concrete materials promotes reasoning procedures.

2. Students should engage in further activities with measures of central tendency and measures of spread. Illustration 7: A Look at the Average Wage compares the roles of the mean, the median, and the mode in a realistic problem setting. Illustration 8: Exploring Standard Deviation is technology-based and requires that students use the statistics functions on a scientific calculator to investigate a real-world problem.

3. Students should summarize their own data and write a brief description of their results to share with their classmates.

Activity 10: Drawing Conclusions and Making Decisions

Finally, the students must use all available data to decide on the general characteristics of the "average" student. Small groups of students can propose prototypes to the class, and students can then discuss how well the prototype represents the student body as a whole. Clearly, there will not be one specific profile that is correct, but there will be many areas of agreement and many discussions about "ranges." After the small-group work and the class discussion, students should be individually assigned the task of writing a poem or a limerick about the "average" student in the school. These poems can be printed in the school newspaper or presented at an all-school show. This task cycles the project back to its interdisciplinary roots.

STEM and Visual Arts Connections To Green Schools

Grades 5-8

LESSON TITLE: Tessellation Exploration

Math Standard(s) Addressed: Understands geometric transformations of figures (e.g., rotations, translations, dilations).

Approximate Time Needed for Lesson: 30-45 minutes

Students will engage in:

- [ ] independent activities
- [x] cooperative learning
- [ ] peer tutoring
- [x] visuals
- [x] pairing
- [ ] hands-on activities
- [ ] centers
- [x] lecture
- [x] whole group instruction
- [x] technology integration
- [x] creating a project
- [ ] guest speakers

Class Starter: Review the meaning of the term "tessellation" and discuss how the concept of a tessellating pattern could be utilized in a school building project.

Objectives: Students will be able to identify tessellating patterns in buildings.

Materials:

plain paper
colored pencils
computer
printer
cardstock (optional)
scissors (optional)
tape (optional)
poster board (optional)

Step-By-Step Procedures:

- Lecture: definition, examples, and historical connections of tessellations (see additional resources) transparency. Discuss different types of tessellations (rotations, reflections, translations).
- Students work in pairs and go online to: http://mathforum.org/sum95/suzanne/whattess.html.
- Students navigate through the Math Forum @ Drexel site and explore links to view examples of tessellations in architecture throughout history.
- Students generalize knowledge gained to buildings in their community that contain a tessellating pattern.

Guided/Independent Practice: Teacher demonstrates step-by-step procedures for cutting and taping tessellating tile (to complete the extension activity).

Assessment: Students print a picture of an historical building and write a brief description of the time period of the building and type of tessellation it demonstrates.

Differentiation Ideas:

- Offer options of varying difficulty for the extension activity (easiest: translation, medium: reflection, difficult: rotation).

Adaptations & Extension Ideas:

- Students create a handmade tessellation by cutting and taping a square tile made from cardstock, designed appropriately, and traced repeatedly to fill a poster board.
- Students create a computer-generated tessellation using the software "Tesllation Exploration"

Closure: In pairs, students explain to their partner one thing that they learned about tessellations during today's lesson.

Connections to other Content Areas: Art (architecture), History

Additional Resources:

Definition & examples of tessellations (attached) - http://mathforum.org/sum95/suzanne/whattess.html

The following activity is available on the Internet at
<u>http://mathforum.org/sum95/suzanne/whattess.html</u>

TESSELLATIONS

Definition

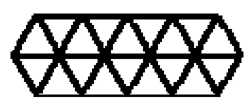
A tessellation is created when a shape is repeated over and over again covering a plane without any gaps or overlaps.

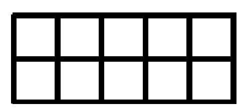
Another word for a tessellation is a **tiling**.

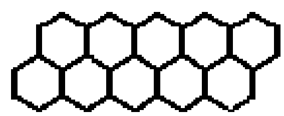
A dictionary***** will tell you that the word "tessellate" means to form or arrange small squares in a checkered or mosaic pattern. The word "tessellate" is derived from the Ionic version of the Greek word "tesseres," which in English means "four." The first tilings were made from square tiles.

A regular polygon has 3 or 4 or 5 or more sides and angles, all equal. A **regular tessellation** means a tessellation made up of congruent regular polygons. [Remember: *Regular* means that the sides of the polygon are all the same length. *Congruent* means that the polygons that you put together are all the same size and shape.]

Only three regular polygons tessellate in the Euclidean plane: triangles, squares or hexagons.We can't show the entire plane, but imagine that these are pieces taken from planes that have been tiled. Here are examples of

a tessellation of triangles


a tessellation of squares


a tessellation of hexagons


When you look at these three samples you can easily notice that the squares are lined up with each other while the triangles and hexagons are not. Also, if you look at 6 triangles at a time, they form a hexagon, so the tiling of triangles and the tiling of hexagons are similar and they cannot be formed by directly lining shapes up under each other - a slide (or a glide!) is involved.

You can work out the interior measure of the angles for each of these polygons:

Shape	Angle measure in degrees
triangle	60
square	90
pentagon	108
hexagon	120
more than six sides	more than 120 degrees

Since the regular polygons in a tessellation must fill the plane at each vertex, the interior angle must be an exact divisor of 360 degrees. This works for the triangle, square, and hexagon, and you can show working tessellations for these figures. For all the others, the interior angles are not exact divisors of 360 degrees, and therefore those figures cannot tile the plane.

Historical and Geographical Connections

for Tessellations and Tilings

Moorish architecture in Spain and Islamic architecture in the Middle East offer excellent examples of tessellations or tilings.

> Because of the strict injunctions against such depictions of humans or animals which might result in idol-worship, Islamic art developed a unique character, utilizing a number of primary forms: geometric, arabesque, floral, and calligraphic, which are often interwoven. From early times, Muslim art has reflected this balanced, harmonious world-view.

- Elisabeth Siddiqui, *Islamic Art*

Tilings from Historical Sources

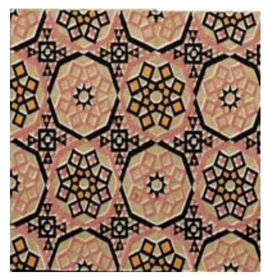
The images on these pages are taken from the CD-Rom edition of The Grammar of Ornament, by Owen Jones, originally published in 1856. The images here are reproduced by kind permission of the publishers. This site is maintained by Steve Edwards

Egyptian

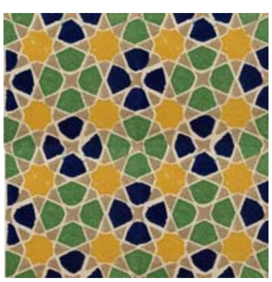
Persian

Byzantine

Arabian

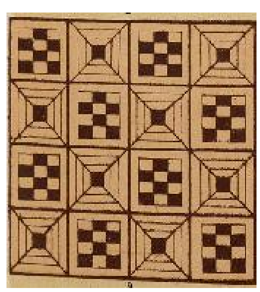


Moresque



Indian

Hindu



Chinese

Basic Geometric Transformations

Translation (slide) – A translation transformation occurs when a figure slides around on a plane to fit together with other figures congruent to it.

Rotation (turn) – A rotation transformation occurs when a figure rotates, or turns, in order to fit together with other figures congruent to it.

Reflection (flip) – A reflection transformation occurs when a figure has to flip over in order to fit together with other figures congruent to it.

What is a tessellation?

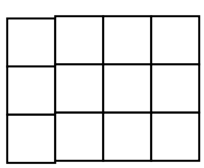
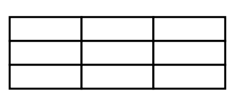
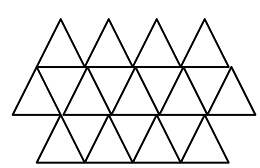
When you fit individual tiles together with ***no gaps or overlaps*** to ***fill a flat space*** (plane), you've made a tessellation.

Where do tessellations exist?

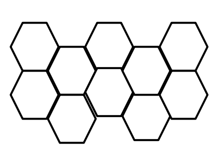
...not just in your math classroom!

In your home and other buildings:

Ceramic tile floors, brick walls, and wallpaper patterns

In nature: bee's honeycombs



*only 3 regular polygons will tessellate: equilateral triangles, squares, and hexagons.

Where's the Math?

As you explore activities such as drawing tessellating patterns, there are several mathematical concepts that are emphasized and enriched:

- knowledge of the basic geometric transformations
- symmetry
- visual-spatial relationships
- reinforcement of vocabulary words

Historical and Geographical Connections

Moorish architecture in Spain and Islamic architecture in the Middle East offer excellent examples of tessellation tilings.

Association for Learning Environments
Enhancing the Educational Experience

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