Diamonds: A Girl's Best Friend? Gems to Geometry

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BEAUTY IN THE EYE OF THE BEHOLDER

The phrase, "Diamonds are a girl's best friend," has been overly exploited to sell jewelry, movies, and images of women around the world. It is okay to set a price for pieces of jewelry and movies, but the images of women are priceless.

In the eyes of the general public, diamonds represent love, beauty and wealth. The media has used these gemstones to influence women to believe that the size of the "rock" on their finger determines their status in society. In this unit we will explore the untapped world of math and science hidden behind the wealth and beauty of diamonds.

Some women may never stop to think where diamonds come from, how diamonds are formed, and how diamonds are used in other professions. Therefore, it is my intention as a science teacher to expose and open young middle school girls' eyes to the wonders and excitement of gemstones, crystals and geometry. The students will study the seven crystalline structures, the classifications of polygons, polyhedrons and search out many math and science careers.

Media Image

In our society, the media plays a critical role in career choices for women. Media images of female scientists and female engineers are rare. According to the report of the Congressional Commission on the Advancement of Women and Minorities in Science, Engineering, and Technology Development in 2000, "Women make up 19% of the science, engineering, and technology workforce."

> Given the current improved status of females in mathematics, we would expect a corresponding increase in the percentage of women obtaining master's degrees and doctorates in related fields, such as science, engineering, and technology. Unfortunately, there has been little improvement in the numbers of females completing advanced degrees in these fields. The National Science Foundation (1998) reports disturbing statistics:
>
> - In 1995, a mere 17 % of engineering master's degrees and only 31% of all science and engineering degrees were awarded to women.
> - Also in 1995, there was a 4% decrease in the number of women receiving computer science degrees.
> - While they make up 46% of the overall labor force, women are only 16 % of the science and engineering workforce.

- Women receive over half of all bachelor's degrees awarded, but only one-fourth of those are in natural science and engineering.
- In chemistry, despite gains at lower levels, women are not making inroads into management and the higher academic ranks. (Sanders & Peterson)

Priceless

As a female science teacher, I will try to increase the interest level of middle school females in math and science by presenting "Gems to Geometry." Precious gems are very beautiful. Gemstones take a long time to form and they are rare. This lengthy process has made the worth and value of these precious gems "priceless."

When a female in middle school embraces a math concept her educational choices are improved and her career choices can become priceless. "Children's science shows feature three times as many males as female characters and twice as many adult male scientists as female scientists. Of the female characters, most have secondary roles such as lab assistants or students" (*Did You Know?*).

Gap

Is there a gap among males and females in math and science courses at the middle school level? In my middle school science classes, I have fewer of my female students participate in the local school science fair than their male counterparts. The female students are at the same age and grade level. However, I believe the female students do not participate in the school science fair because they are under the belief that "science" is for boys or that they are not good students in science. "The great preponderance of evidence indicates there is no math gene" (Campbell)!

How can the social and cultural factors change? When will our expectations increase for females to pursue science and math as careers? When the expectation increases for females to excel in math or science then self-esteem and confidence levels of young females will increase. Our educational system and the way we educate female students must change. We need to encourage young females to continue taking upper levels math and science classes in high school and college. "For women to have opportunities for higher-level achievement in science and mathematics, they need to take demanding courses in high school. If they do not; they will find themselves out of the pool of potential talent" (Sanders & Peterson).

We must educate teachers to practice gender equality in the math and science classroom. Parents must compel their daughters to pursue science and math courses. As females enroll in math, science and technology courses they could choose to enter the math and science professional world. Parents and teachers cannot close the gender gap without the help of the media. The media must present opportunities and examples of women in math and science roles. Media coverage and exposure will provide the public

with the wide range of career opportunities of women in math, science and technology fields. If all of the above things are met, the gender gap will close in both math and science related careers.

> In elementary school, roughly the same number of girls and boys are interested in science and math. But beginning in about sixth grade, more girls than boys begin to drift away from these subjects. One consequence of this leaking pipeline is that women remain underrepresented in most technical professions – while our nation's need for scientists and engineers remains unmet. (*Did You Know?*)

The gender gap will narrow as young women are encouraged to enter science and math classes with confidence in their ability to become successful scientists and mathematicians alongside their male counterparts.

The Fear

Science and math are foundational courses for doctors, engineers, architects, inventors, and scientists. Two days ago a young female student at my school realized that she wanted to become a doctor, but expressed her fear of facing the required math and science classes. I believe this fear permeates the school's female population in our education system. The gender gap increases when fear is allowed to run rampant in the minds of our female students.

This fear can be eliminated from the lives of female middle school students if educators would mentor them and provide examples/models of female scientists and mathematicians. A safe haven that encourages the female student to learn and practice math and science concepts will guarantee an environment that produces confident females to enter the professional world of math and science careers.

Exposure and Overlap

One of the objectives of this unit is to close the gender gap in math and science at the middle school level by exposing young girls to the exciting concepts and ideas about science and mathematics. However, educators must take the fear out of math and science courses by showing the similarities found in both science and math. Even though science and math are two very separate systems, they overlap in several areas. Some of those areas are simple and common; therefore, the fear factor should be eliminated when the female students are exposed to these two curricula.

Some similarities are simple and easily understood. There are overlapping areas in science and math when it comes to process skills such as observation, classification and terminology. These areas are used to explain various math strategies and science concepts. If female students realize that math and science are closely related, less energy will be expended to fear and more energy will be spent on using the common skills that

are in both subjects. Math and science use manipulatives to reinforce concepts and strategies learned in class. When manipulatives are used, they provide hands-on learning for the female student. Math and science manipulatives allow the female learner to practice math and science strategies. Practicing with manipulatives builds math and science confidence in the female learner. This occurs because many concepts in math are similar to the concepts in science even though the language is different. Polyhedrons are math concepts and gemstones are science concepts, nevertheless, they are one and the same. A polyhedron is a three-dimensional polygon and a gemstone is a solid with a crystalline structure that can be represented by a polyhedron. This unit will help the female learner explore how basic polygons are the steppingstones for the intricate work of gemologists as they work with the crystalline structures of gemstones and minerals.

Gems to Geometry

This unit's initiative is to inspire young girls at the middle school level to explore math and science concepts in order to build confidence in themselves so that maybe they will pursue a math or science career. "Gems to Geometry" will provide interactive math or science activities to assist, to inspire and to provide self-assurance in math and science. At the completion of this unit the female student will be able to:

- Identify and classify polygons;
- Compare and contrast crystals and polyhedron shapes;
- Grow crystals using household substances; and
- Face math and science concepts without fear.

Science and Math

What is math? What is science? Do the two ever meet? Do they have anything in common? These are questions that educators should help female learners answer. "Mathematics is the science dealing with the measurement, properties and relationships of quantities as expressed in numbers or symbols. Mathematics includes arithmetic, algebra, geometry, and calculus" (Barnhart).

Some people believe that math is not a science; they think of mathematics as the study of patterns and relationship. In this unit we will not debate the age old question, "is math a science." We will try to introduce the two disciplines to middle school girls to demonstrate that math and science are closely related. Math is used to solve scientific problems. The learner needs to know that common concepts and similar language bring science and math together.

Crystallography

Crystallography is one of the branches of science that shares common concepts with geometry, a branch of mathematics. The study of crystals and the laws that govern their growth, external shape, and internal structure is called crystallography. The female learner will take a closer look at crystals and geometry when they identify the seven

crystalline structures and compare and contrast polygons to polyhedrons. Geometric terms are also used when the seven crystalline structures are described. The learner can research the form of crystals, the atomic arrangement of crystals; the physical properties of crystals and of course the symmetry of crystals. In the gemstone research lesson the learner will find examples of the seven crystalline structures.

Breaking it Down

"Polygons are the two-dimensional version of a three-dimensional polyhedron." Does this statement attract females to listen? Will this statement be so ominous that it will intimidate instead? Could the educator re-word the statement? Perhaps one could say, "The diamond that you have drawn on your paper is flat and is only two-dimensional: this is called a polygon. When you have a hand-held solid object that is in shape of a diamond, you have added an extra dimension. Now it is called three-dimensional, or a polyhedron."

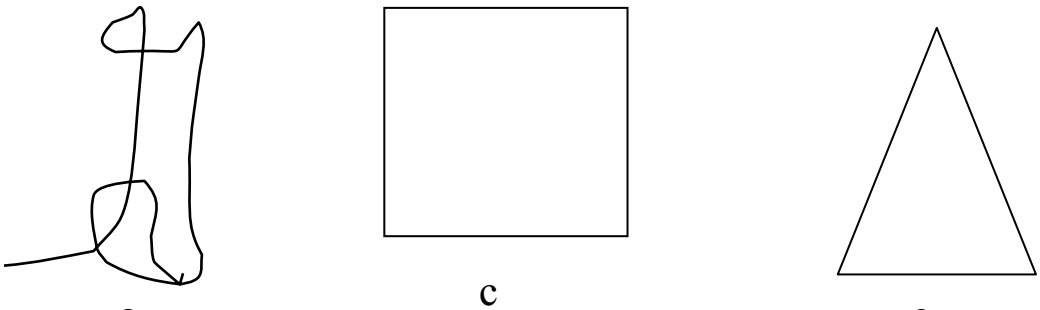
The educator should point out what a polygon is and that the learner has observed polygons since pre-school, but may not have known the formal definition. Educators must educate and increase the knowledge of all students. Further, educators must breakdown stiff, stale vocabulary words to help the learner embrace the concept instead of the definition.

The term polygon is used to describe a planar figure or two-dimensional figure. A polygon is a closed figure consisting of a set of edges, or sides, each of which is a straight-line segment. If all the edges have the same length and all angles are equal, the polygon is called regular.

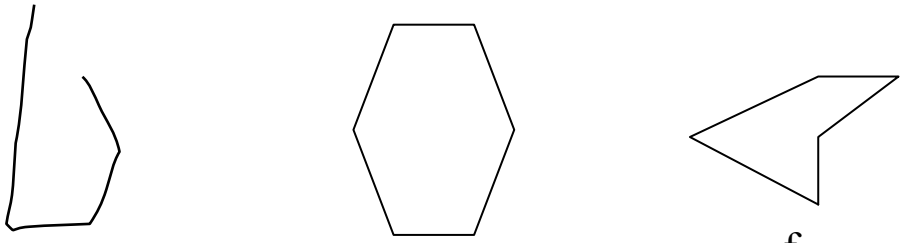
Polygons

Math and science educators teach concepts and they should use different strategies to help the female learner understand and apply the concept to learning situations. Science and math educators can use a combination of phrases and pictures to convey the definitions of math and science terms.

Worksheets like the one below can assist with terms and phrases:



a c e

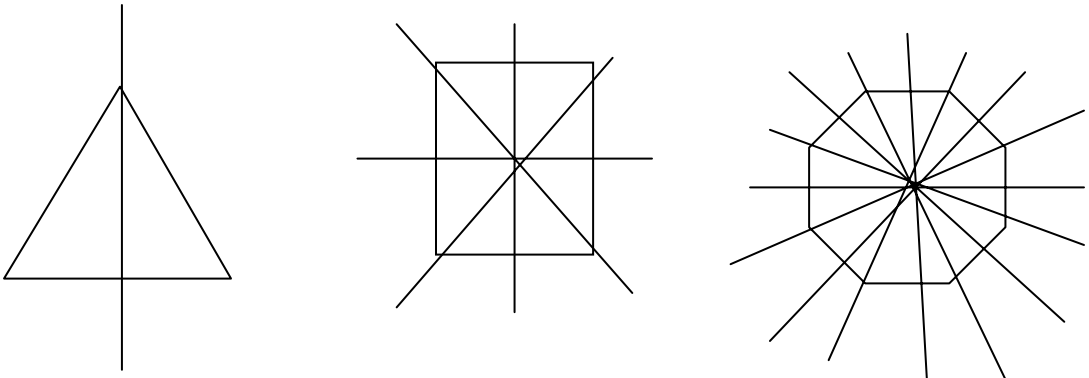


Of the figures above, **Figure a** and **Figure b** are not polygons. Why? **Figure a** does not have straight edges. **Figure b** is not closed. **Figure c** and **Figure d** are both polygons. **Figure c** is a rectangle, a closed figure with straight edges. **Figure d** is also a closed figure with straight edges: it is a hexagon. **Figure e** and **Figure d** and are regular polygons. **Figure c** and **Figure f** are not regular polygons because they do not have congruent angles and edges. Finally **Figure e** and **Figure f** are examples of polygons. **Figure d** is a hexagon and **Figure e** is an equilateral triangle. They are regular polygons because they are closed and have straight edges and all angles are congruent. **Figure f** is a polygon but it is not a regular polygon.

With the above example and simplified definition the female learner can move to the next level of classifying polygons by the number of sides or angles the polygons have. Rectangles, triangles and pentagons are common polygons. The learner can observe these common polygons in road signs, traffic signs and billboards. When educators make the connection of everyday life to math and science the female learner will be able to embrace the concepts in the science and math classroom with confidence.

Symmetry

Symmetry is another term, which encompasses math and science concepts. Symmetry is a word used in geometry classes, used in science classes and it is used in designing jewelry. Many science and math professionals use symmetry when designing and constructing buildings, rockets, jets, clothing and jewelry. Concepts are images that come with different meanings and explanations within a specific topic. Symmetry means that a figure or an object can be divided into two congruent halves. This definition can be taught in the classroom by using a common mirror to middle school girls. The two congruent halves are mirror images of it. They are two equal halves that are identical in every way. The female learner can find the symmetry of a gemstone or a crystal by using the imaginary line of symmetry to divide the gemstone or crystal. When the two halves match each other, the gemstone or crystal is said to have one line of symmetry. The figures below have one or more lines of symmetry. The imaginary lines must divide the object into two mirror images in order to be considered a line of symmetry.



a b c

In **Figure a**, the isosceles triangle has one line of symmetry. The imaginary line created two identical or congruent halves. In **Figure b** the rectangle shows four lines of symmetry that create congruent halves each time an imaginary line is drawn. The octagon in **Figure c** has eight lines of symmetry. Symmetry is not just for polygons in math; science uses symmetry when talking about crystalline structures. The educator can point out to the female learner that she can find symmetry in art, in numbers, in photographs, in letters of the alphabet and the list goes on and on. "Geometry is everywhere: in architecture, the symmetries of crystals, car wheels, textile design, painting and sculpture. Although we all respond at least unconsciously to this structure most of us cannot see the geometry that surrounds us. Part of the problem is the language" (Field).

Crystals

The word "crystal" comes from the Greek word *krustallos* meaning "clear ice." All crystals grow in an orderly arrangement. They can grow from gas, molten lava, or a solution. The most common growth occurs when a liquid evaporates leaving a chemical behind that separates itself through crystallization. All crystals are solids and as we all know all solids are not crystalline. One example of a non-crystalline solid is obsidian, a volcanic rock that cools so quickly that there is no time for crystals to form. Obsidian is like glass. Crystals grow until a barrier gets in their way. In order to grow a large crystal it needs room or freedom to grow and a lot of time to grow. The female learner will experiment with growing crystals in this unit. Crystals can be compared to polyhedrons because of their three-dimensional shape. Crystals have symmetry. This symmetry can be rotational symmetry, reflective symmetry, translation symmetry, or glide reflective symmetry.

The Barrier

Language barriers occur in classrooms daily. They occur in every state in this country. The barrier is not just the problem of a non-English speaking child, but the problem of female learners in science and math classes. Understanding science and math concepts hinge on the ability of the learner to comprehend what is being said. The technical language of science and math causes the average learner to misunderstand concepts and

strategies. The female learner becomes reluctant to ask questions and communicate her discoveries. Math and science are closely related in concepts, but the vocabulary is different. As educators we must show the similarities of these two core curriculums. This will help the female learner to make the transition from math to science.

In math the learner will study symmetry of polygons and polyhedrons. The symmetry concept used in math can be transferred to a lesson on the symmetry of the seven crystalline structures in science. Understanding symmetry is the same skill in math as well as in science. If this is pointed out in similar areas in math and science, the female learner will begin to be successful in both. Their confidence level will increase because they have made an association between math and science.

Differences in our society have always caused some barrier. The gender gap in math and science can be closed when the educator points out language differences and similarities. The female learner will begin to assimilate math and science concepts with confidence. This newfound confidence will motivate female learners to enroll in higher-level math and science classes in high school and college. This could even lead to an increase of females pursuing careers in math and science.

The Reality

In most schools separate gender classes are not an option. My middle school has given me special permission to teach a separate gender class. Nevertheless, the "Gems to Geometry" unit can be used in a dual gender classroom and help close the gender gap in science and math classrooms.

The educator plays the most important part in closing the gender gap. Encouraging the reluctant female learner to participate in math and science classes is one of the biggest challenge educators has. The female learner lacks confidence and motivation in math and science classes. In order to prevent this, the educator must ensure that the female learner understands the concepts and can communicate her understanding of them.

With this encouragement, the educator must also provide examples of successful females in math and science fields. These examples can motivate the female learner to pursue higher-level math and science courses. The educator must acknowledge the gender gap in the classroom and in math and science careers. The inequalities in math and science careers are based upon the lack of young females enrolling in higher-level math and science once they graduate middle school.

Even though separate gender classes are not a reality, closing the gender gap in math and science should become a reality for the math and science educator. Closing the gender gap is a problem that all educators must face. I hope "Gems to Geometry" will motivate math and science educators to create a bias-free learning environment that allows female learners to excel in math and science classes. I believe this will provide a firm foundation for the female learner to pursue math and science careers of their choice.

"It is easy to discriminate unknowingly in the questions we ask, the praise we offer, the task we assign, the attention we give. Largely unaware of the implications and consequences of our actions, we act on ingrained attitudes and behaviors. With actions that speak louder than words we are telling some children that they are not as capable as others are simply because of their gender" (Shalaway).

Barriers, discrimination, and gaps are only obstacles; every obstacle can be hurdled. As parents, educators and society we must teach our children to overcome and not give up. Our young females learners must knock down the barriers, overcome the prejudice, and close the gap in the math and science course in high school and college.

LESSON PLANS

All of the following lesson plans have been designed for students in grades six and seven.

Lesson Plan One: "Diamonds: More than a Girl's Best Friend" (3-4 class periods)

Objectives

- The learner will take notes from teacher lecture and the video on gemstones and diamonds.
- The learner will be able to explain facts about diamonds and their physical properties.
- The learner will define minerals and gemstones. They will research the physical properties of minerals.
- The learner will research an assigned gemstone.
- The learner will create a poster to illustrate their gemstone appearance.

Materials

Computers
Internet access
Printer
Poster Board
Colored Markers
Colored Pencils
Folder
Notebook Paper
Pen/Pencils

Procedure

1. The learner will listen to the teacher lecture on diamonds and take notes. The teacher will give the students questions to answer that cover the lecture on diamonds.
2. The learner will watch a video on minerals and answer a worksheet that covers the mineral video.
3. The teacher will give the learner a list of gemstones.
4. The learner will choose a gemstone to research.
5. The learner will use a computer with Internet access to do the research paper.

The research paper must include:

- 3 typed pages
- Title
- The name of the gemstone
- What it is made of?
- How does it form?
- Where is it found?
- Define mineral.
- Is it a mineral or not?
- List 3 chemical properties of the gemstone.
- List 3 physical properties of the gemstone.
- List 2-3 things that the gemstone could be used for.
- Explain the color, streak, luster, and hardness of the gemstone

6. The learner will create a gemstone poster and give a five-minute presentation on her gemstone. The poster must include:
   - Two images of the gemstone.
   - A picture of the gemstone.
   - A crystal diagram of the gemstone.
   - The images must be colored.
   - The title must be in three-inch letters.
   - The hardness of the gemstone.
   - The luster of the gemstone.

Lesson Plan Two: Polygons (One Class Period)

Objectives

- The students will define polygons.
- The students will classify the polygon and tell if it is regular.
- The students will count the sides of each polygon and decide if the angles and sides are congruent.

Materials

Polygon Worksheet
Pencil
Polygon vocabulary worksheet

Procedure

1. Give students a copy of the Polygon Vocabulary (Appendix B)
2. Students complete the Polygon Worksheet (Appendix A)
3. Draw and Label Five Polygons
4. Draw and label Five Regular Polygons

Lesson Plan Three: Alpha-Symmetry (One class period)

Objectives
- The learner will identify lines of symmetry of the English alphabet.
- The learner will define rotational symmetry, translation symmetry, reflection symmetry, and glide reflection symmetry

Materials
Stencils of the English alphabet
Colored pencils
Metric ruler
Xerox paper
Notebook paper
Scissors
Glue
Construction paper

Procedures
1. Using a stencil the learner will trace the twenty-six letters of the English alphabet.
2. The learner will cut out their letters of the English alphabet.
3. The learner will fold, rotate and examine each letter to find the line(s) of symmetry, if they are there.
4. Once the learner has established the line(s) of symmetry the learner will draw the correct line of symmetry on each letter.
5. The learner will classify the letters into groups of 1, 2, 3 or more lines of symmetry.
6. The learner will glue each group on a page.

Evaluation
1. Which letter(s) have no lines of symmetry?
2. Which letter(s) have one line of symmetry?
3. Which letter(s) have two lines of symmetry?
4. Did any letters have more than two lines of symmetry? If so what were the letters.
5. Draw an equilateral triangle. How many lines of symmetry does it have?
6. Draw an isosceles triangle. How many lines of symmetry does it have?
7. Draw a rectangle. How many lines of symmetry does it have?
8. Draw a regular octagon. How many lines of symmetry does it have?
9. What is symmetry?
10. Define the following words: rotational symmetry, translation symmetry, reflection symmetry, and glide reflection symmetry.

Lesson Plan Four: Polyhedrons/Crystal Mobile (Two class periods)

Objectives
- The learner will be able to identify the seven crystalline structures.

- The learner will be able to create the seven crystalline structures.
- The learner will be able to define faces on a crystal.
- The learner will be able to identify each face on a crystal.

Materials

Transparent tape
Descriptions of the 7 crystalline structures from the Internet:
Chemistry: Types of Crystals by Anne Marie Helmenstine
System nets of the 7 crystalline structures from the Internet:
Nets of Crystals by Suzanne Alejandre
Scissors
String
Metal hangers
Labels

Procedure

1. The learner will write the name of each of the seven crystalline structures and a physical description of each crystalline structure.
2. The learner will define faces.
3. The materials managers will hand out the materials needed.
4. The learner will cut out the polyhedrons or the net of each crystalline structure.
5. The learner will fold and tape the polyhedra or the crystalline structure systems.
6. The learner will correctly label each polyhedron or the crystalline structure systems.
7. The learner will use a wire hanger to create a mobile by using string to connect each polyhedron to the wire hanger in any order.

Evaluation

1. How many faces does each of the 7 crystalline structures have? List each one and write the number of faces next to the crystalline structure.
2. Which crystalline structure has the shape of a diamond?
3. Which crystalline structure has all square faces?
4. Which crystalline structure has a hexagon cross-section shape?
5. What is another name for the isometric crystalline structure?

Formal Assessment

The teacher will present each table with seven unlabeled crystalline structures. The students must correctly label each crystalline structure.

Lesson Plan Five: "Crystals: How Does Your Crystal Grow?" (7-14 days)

Objectives

- The learners will be broken into 5 groups
- Each group will grow crystals using one of the five household substances: sugar, salt, Epsom salts, borax and alum.
- The groups will compare the grown crystals with the seven crystalline structures.

- The groups will classify the grown crystals using a magnifying glass.
- The groups will measure the grown crystals using a metric ruler.

Materials

Sugar
Salt
Epsom Salt
Borax
Alum
String
Hot Plate
Magnifying Glass
Five beakers

Procedure

1. Boil 800 ml of water on a hot plate
2. Pour 500ml of the boiling water into a beaker or beaker
3. Pour 3 ml of sugar or what ever your household substance into the beaker. Make sure you only add 3 ml of your substance. You want it to dissolve in your beaker or water until no more will dissolve. Do not add to much substance. Be patient and stop adding the substance when the substance will not dissolve any more and collects at the bottom of the beaker.
4. Tie a paper clip to one end of the string and a pencil to the other end.
5. Place the paper clip end of the string into your solution and place pencil end across the top of the beaker so that the string will not drop down into the solution.
6. Place the beaker in a place where it will not be disturbed. Observe your solution and crystals daily. The solution will evaporate as the crystals grow.
7. Examine your crystals with a magnifying glass.
8. On the 7^{th} or 10^{th} day, take your crystals out and measure the growth.
9. Classify your crystals.
10. Which group grew the largest crystals?

Evaluation

1. Draw a picture of what your crystal looks like.
2. Draw a picture of crystals the other groups grew.
3. Classify the crystals into one of the seven crystalline structures.
4. Research the following questions on the Internet.
    - What 3 things do crystals need to grow?
    - What 2 things will stop crystals from growing?
    - What crystalline structure does a diamond have?
    - What can you do to grow the largest crystal?
    - Does the rate of evaporation affect the size of crystals?
    - Does the temperature of the water affect the size of crystals?

APPENDIX A

Polygon Worksheet

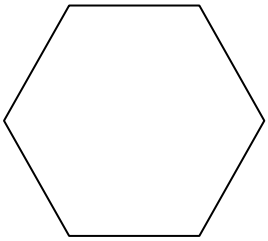
I. What is a polygon?

II. What is a regular polygon?

III. Draw a triangle, a quadrilateral, a pentagon, a hexagon and an octagonal shape.

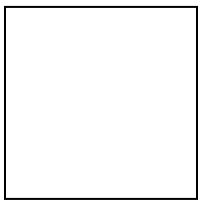
IV. Draw a regular triangle a regular quadrilateral, a regular pentagon, a regular hexagon and a regular octagon shape.

V. Classify the polygon below.

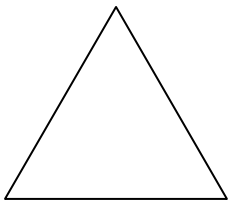


A. How many sides does this polygon have? _____
B. What is the name of this polygon? _____
C. Are the sides congruent? _____
D. Are the angles congruent? _____
E. Is this a regular polygon? _____
Explain your answer _____

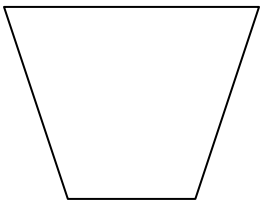
VI. Classify each polygon by the number of sides it has.



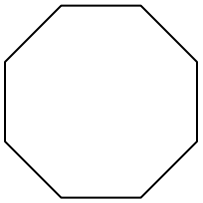
a. _____



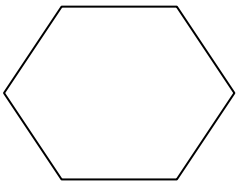
b. _____



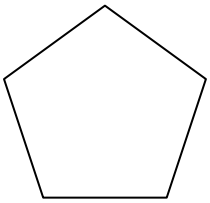
c. _____



d. _____



e. _____



f. _____

APPENDIX B

Polygon Vocabulary

1. Polygons are closed plane figures with sides that are line segments.
2. Vertex is the point where two sides of the polygon meet.
3. Edge is a line segment where two faces of a space figure meet.
4. Face is a flat surface or plane region of a space figure.
5. Plane is a flat surface that goes on in all directions.
6. Equilateral triangle is a triangle that has three equal sides and angles.
7. Trapezoid is a quadrilateral that has one pair of parallel lines.
8. Quadrilateral is a four-sided figure formed by four line segments.
9. Parallelogram is a quadrilateral that has two pairs of parallel lines.
10. Rectangle is a parallelogram that has four right angles.
11. Square is a special type of rectangle with four congruent sides.
12. Angle is the figure formed when two rays that have the same end point or straight lines meet.
13. An acute angle is an angle measuring less than 90 degrees.
14. Obtuse angle is an angle that measures greater than 90 degrees.
15. Right angle is an angle that measures 90 degrees.
16. Congruent: figures that are the same shape and same size.
17. Similar: Figures that have the same shape but different size.
18. Line of Symmetry is a line that divides a figure into two identical parts that are mirror images of each other.
19. Rhombus is a parallelogram with all sides the same length.

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