



INDIGENOUS WISDOM: CENTURIES OF PUEBLO IMPACT IN NEW MEXICO

A Pueblo-Based Educational Curriculum • IndianPuebloEducation.org

MIDDLE SCHOOL CURRICULUM

2nd Edition

Title of Unit: Re-creating Pueblo Bonita with Pythagoras

Content Area: Mathematics

Grade Level: 8

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Section A: Introductory Materials

Name: Regina Jojola Lucero

Title of Unit: Re-creating Pueblo Bonita with Pythagoras

Content Area: Mathematics

Grade Levels: Grade 8

Rationale:

As Native American People, each time we set foot into a Kiva, it is with positive, loving emotions. In this unit, the core value of love is brought to life through the recreation of a sacred site, flowing with prayers filled with love from the Pueblo people.

The Pueblo People also give great respect to the universe in aligning Pueblo Bonito to it. The value that Pueblo People place on the Earth's natural resources is priceless, and the core value of respect is deeply rooted in each structure at this sacred site.

The construction of this sacred site was with compassion for the Pueblo People. It is a place that provides shelter and a spiritual place to pray, essential to the culture of the Pueblo People.

Balance, another core value that is evident in this unit, is about using limited resources well and maintaining a healthy equilibrium with the ecosystem. While the Pueblo People lacked in the knowledge of textbook math, their utilization of resources was far beyond the imagination.

Lastly, it took Service, the most important core value, for the Pueblo People to work together to build this sacred site of such geometrically detailed dwellings. As students apply modern day mathematics to the reconstruction of Pueblo Bonito, the entire class will work together to strategize and build a sense of community among them.

Pueblo Bonito was constructed and occupied sometime between 850 and 1150 BC. This unit is connected to the 100-year timeline in that the fight for preservation of sacred sites needs to be acknowledged. The preservation of sacred sites is very important to Pueblo People because it gives them a connection to their roots as well as a spiritual connection to their ancestors.

Unit Goals:

1. Students will be able to explain a proof of the Pythagorean Theorem and its converse.
2. Students will be able to solve the right triangle by applying the Pythagorean Theorem.
3. Students will be able to apply the Pythagorean Theorem to real life problems and explain their problem-solving strategies.

The main focus of this unit is to prove the Pythagorean Theorem and apply it to real-world and mathematical problems connecting to the Indigenous People. The lesson will begin with proving the Pythagorean Theorem and understanding its converse: if the sum of the squares of the lengths of the two sides of a triangle is equal to the sum of the third side, then the triangle is a right triangle. The first lesson offers a hands-on activity to explore the attributes of a right triangle and the Pythagorean Theorem. The next lesson creates opportunities for students to work in small groups to apply the theorem to solve a right triangle. The final lesson enables students to connect with their culture as they recreate Pueblo Bonito by locating the centers of the Kivas within the Pueblo. An extension of the unit can be a project in which students build a model of this unique and powerful site, and appreciate the mathematics behind their creative work.

Standards:

| Common Core Standards | Common Core Standards for Mathematical Practice |
|--|--|
| CCSS 8.G.B.6 CCSS 8.G.B.7 CCSS.8.G.B.8 | CCSS.MATH.PRACTICE.MP1 CCSS.MATH.PRACTICE.MP4 CCSS.MATH.PRACTICE.MP5 CCSS.MATH.PRACTICE.MP6 |

Section B: Lesson Plan One

Title: Proving the Pythagorean Theorem and its Converse

Duration: 60 minutes

Grade Level: 8

Learning Objectives:

1. Students will be able to explain a proof of Pythagorean Theorem and its converse.
2. Students will be able to use the Pythagorean Theorem to understand the relationship between the sum of the squares of the legs and the square of the hypotenuse of the right triangle.

Prerequisite Skills and Knowledge:

1. Squaring integers
2. Writing and solving equations with one variable
3. Simplifying radicals

Materials and Resources

1. Graph paper, crayons, scissors, black marker, ruler, glue,
2. Calculator

Guiding Questions

1. What are the properties of a right triangle?
2. How is the Pythagorean Theorem used to solve the side lengths in a right triangle?

Core Values: Service, Compassion and Respect

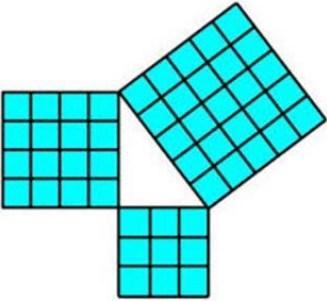
Procedure:

- Bell ringer (3 minutes):
 - $5^2 = 3^2 =$
 - $5^2 + 3^2 =$

- Introduction (5 minutes)
 - Teacher writes the formula $a^2 + b^2 = c^2$ on the board and asks the following:
 - Can someone tell me what this formula is?
 - If I have a number squared what does that mean?
 - What shape is an example of a number squared?
 - Teacher shares a brief history on Pythagoras
 - www.mathopenref.com/pythagoras.html or
 - www.famousscientists.org/pythagoras

- Activity to prove the Theorem (30 minutes)
 - Each student needs two pieces of graph paper, crayons, 1 pair of scissors, a ruler, a black marker, and glue.

| Instructions to students | Teacher questions |
|---|---|
| 1. On your graph paper, use a straight edge to draw a right triangle ABC where AB is 5 units, BC is 3 units and AC is 4 units. Make sure to label each side a, b, and c so that each letter (lower case) corresponds to the opposite vertex (upper case). | * What could be a unit to measure each side? * How did you decide to connect one side with another to make a right triangle? * Which side is the longest? How does it look in the triangle? (make sure the 5 is the hypotenuse) |
| 2. Construct a square (label it A) that has dimensions of 3 units by 3 Units. Color it another color. | <i>Students should be counting squares and drawing their squares.</i> * How many sides does a square have? |
| 3. Construct another square (label it B) that has dimensions of 4 units by 4 units. Color it another color. | * How many unit squares are in each square you drew? How do you know this? * What is a measure of the area of each square? How do you know this? |
| 4. Construct another square (label it C) with the dimensions 5 units by 5 units. Color it another color. | |
| 5. Cut out all four shapes | <i>All squares should be labeled except the triangle</i> |

| | |
|--|---|
| <p>6. Place the squares to the corresponding sides of the triangle. (Teacher may have to sketch an example on the board.) Example:</p>  | <p>* According to Pythagoras, A squared plus B squared is equal to C squared. What do you think he meant by such a statement? * How can you prove Pythagoras' thinking using the figures in front of you?</p> |
| <p>7. Prove that the area of square C is a sum of the area of squares B and C by cutting and pasting the square figures.</p> | <p><i>Students cut and paste squares A and B to fit into square C.</i></p> |
| <p>8. Teacher presents students with Pythagorean Triples and encourages them to try the activity on their own using various right triangles.</p> | <p>Pythagorean Triples: (5, 12, 13), (6, 8, 10), (12, 9, 15)</p> |
| <p>9. Teacher can pose questions to promote student understanding on the converse of the Pythagorean Theorem.</p> | <p>* If the two smaller squares didn't fit into the largest square, what can we conclude? * When you know the measures of three sides of a triangle, how do you know if the triangle is a right triangle?</p> |

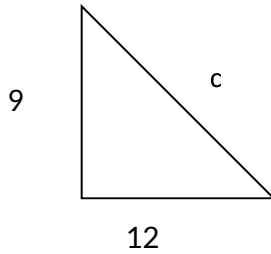
- Worksheet #1 (20 minutes)
 - Consider small group work to complete in class.

Name: Period:

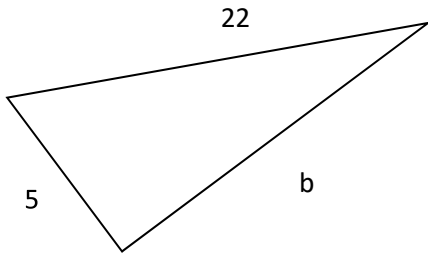
Worksheet #1: Solving the Right Triangle

Solve for the unknown measures of the right triangles provided below. Show your work and round your answer to the nearest tenth.

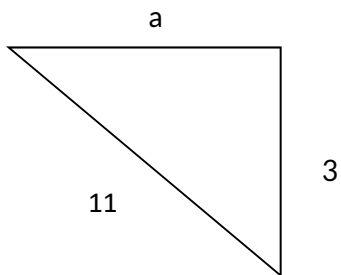
1.



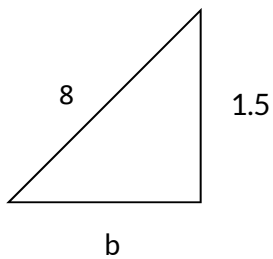
2.



3.



4.



5. If a rectangle has the dimensions 12 ft x 16 ft, what is the measure of its diagonal length?

Lesson Plan Two

Title: Applying the Pythagorean Theorem to Real World Problems

Duration: 60-90 minutes

Grade Level: 8

Lesson Objectives:

1. Students will be able to apply the Pythagorean Theorem to a real-world scenario.
2. Students will be able to solve the right triangle.
3. Students will be able to approximate the distance between two points on a coordinate plane by using the Pythagorean Theorem.

Prerequisite Skills and Knowledge:

1. Recalling the Pythagorean Theorem
2. Writing and solving one-variable equations
3. Using the inverse operation of squares and rounding to the nearest tenth

Materials and Resources:

1. Graph paper, ruler, colored pencils
2. Calculators

Guiding Questions:

1. How is the Pythagorean Theorem applied to solve real life problems?
2. How is the Pythagorean Theorem connected to finding the distance between two points on a coordinate plane?

Core Values: Service, Compassion, and Respect

Procedure:

- ❓ Bell ringer/discussion (3 minutes)
 - What is the formula to find the unknown measure of the sides of a right triangle?
 - Which part of the triangle does the letter a, b, and c in the Pythagorean Theorem represent?
 - Draw a triangle with the measures $a= 3$ units, $b= 4$ units, $c= 5$ units. How do you prove it is a right triangle?

- ❓ Activity (40 minutes): Applying the Pythagorean Theorem on the x-y coordinate plane
 - Divide the class in groups of three.
 - Each person gets a different colored pencil to complete a worksheet. (This will ensure that everyone participates.)
 - Hand out a worksheet (attached) for each group.
 - Teacher reads a scenario and gives instructions to the students.
 - Teacher facilitates small group work and walks around to make sure questions are answered.

Name: _____ Period: _____

Worksheet (Lesson 2)

Instruction: On your graph paper, draw the x-axis and y-axis and label the origin to represent a coordinate plane. Each square represents a mile. Your Pueblo is located at the origin of the coordinate plane (0,0). Another Pueblo is located at (6, 8). The farming land where berries are plentiful for harvesting is located at (-2, 13). The forest that has quite a bit of large game to hunt is located at (-4, -7). The primary source of the water for your Pueblos, the Rio Grande River, is located at (4, -3).

Locate these areas on the coordinate plane, illustrate the surroundings, and name your Pueblo and the other Pueblo. Once you finish your drawing, answer the following questions on a separate piece of paper. You should use the Pythagorean Theorem to support your answers and show all your work. (Round your answers to the nearest tenth with appropriate units.)

1. What is the distance from your Pueblo (0,0) to:
 - a. The Farming land where you gather berries
 - b. The other Pueblo?
 - c. The Forest Hunting site?
 - d. The Rio Grande?
- e. What is the distance from the Forest Hunting site to the Rio Grande?
- f. How far do the people from the other Pueblo have to travel to get to the Rio Grande?
- g. What is the distance from the Farming land of berries to the Forest Hunting site?
- h. Would it be better for the villages to trade food? Why or why not? Justify your answer with math.

Rubric:

| Category | 4 | 3 | 2 | 1 |
|-----------------------|---|---|---|---|
| Creativity | Illustrations are creative and well thought out with appropriate labels. | Good effort, use of some colors | Some work in illustration; labels missing | Little effort and poor quality of illustrations |
| Mathematics/precision | 90-100%% accurate with plotting the coordinates and determining the distances | At Least 75% accurate with minor errors | Less than 50% accurate with major errors but effort shown | Little/no attempt |

Score:

Comments:

Lesson Plan Three

Title: Re-creating Pueblo Bonito with Pythagoras

Duration: 60-90minutes

Grade Level: 8

Lesson Objectives:

- ❑ Students will be able to apply the Pythagorean Theorem by measuring the distance between two landmarks in their own communities.

Prerequisite Skills and Knowledge:

1. Recalling the Pythagorean Theorem
2. Writing and solving one-variable equations
3. Using the inverse operation of squares and rounding to the nearest tenth

Materials and Resources:

1. Calculators, pencils, colored pencils
2. Ground plan of Pueblo Bonito (attached)

Guiding Questions:

1. Does the distance of the hypotenuse have to be a perfect square?
2. Is there a bottom half of the coordinate plane in the picture of Pueblo Bonito?
3. How is the Pythagorean Theorem connected to finding the distance between two points on a coordinate plane?

Core Values: Respect, Balance, Service, Love, Respect, and Community

Procedure:

- ☐ Bell ringer
 - Solve a right triangle ABC: if $a = 54$ units and $c = 85$ units, find the measure of b . Use a calculator and round the answer to the nearest whole number.
- ☐ Teacher pairs students to collaborate on this task.
- ☐ If student need more practice, continue to give more examples (will need more time)
- ☐ Each pair gets a ground plan of Pueblo Bonito (attached) and a worksheet with instructions and the data of known measurements.
- ☐ Teacher shows the photos of Pueblo Bonito or a brief video (5 minutes) on Chaco Canyon: <https://www.youtube.com/watch?v=TIVErSKLzkw&noh>
- ☐ Teacher reviews the instructions with the students. (Be sure to clearly indicate where the main wall, the x-axis, y-axis, and the origin is located.)

Name: _____ Period: _____

Worksheet Activity 3: Re-creating Pueblo Bonito with Pythagoras

- Your objective is to first find the vertical distance from the main wall to the center of ten Kivas that are located within the Pueblo.
- Six of the Kivas (#1, 3, 4, 5, 9, and 10) are located to the right of the main wall and four (#2, 6, 7, and 8) are located to the left.
- The only information you are given is the distance from the origin up the main wall (**a**) and the distance from the origin to the center of the Kiva (**c**); find the distance from the main wall to the right or the left (**b**) by applying the Pythagorean Theorem.
- Make sure to label your Kivas with its numbers.
- Each person's work should be shown in a different color.
- Each person is responsible for working on 5 Kivas and locating the centers in the blank Pueblo.
- When calculating, make sure to round to the nearest whole number.

Kivas to the Right of the main wall

#1 a=22mm, c=24mm **#3** a=55mm, c=64mm **#4** a=5mm, c=8mm **#5** a=69mm, c=69.35mm

#9 a=17mm, c=67mm **#10** a=74mm, c=77mm

Kivas to the Left of the main wall

#2 a=59mm, c=59.3mm **#6** a=48mm, c=56mm **#7** a=4mm, c=37mm **#8** a=66mm, c=68mm

Answer Key:

#1 b=10mm #2 b=6mm #3 b=33mm #4 b=6mm #5 b=7mm #6 b=29mm

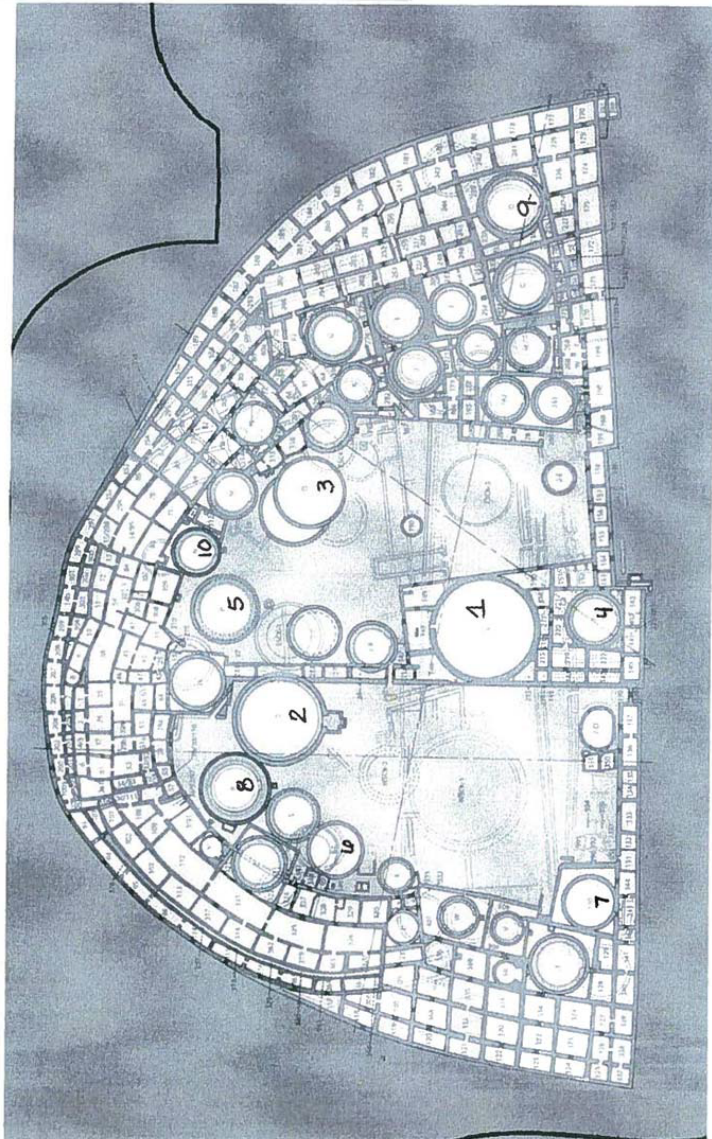
#7 b=37mm #8 b=16mm #9 b=65mm #10 b=21

Modifications:

1. Peer coaching
2. Providing multiplication tables
3. Providing assistance for measuring distance by the ruler and using calculator
4. Providing pre-printed notes on reading the x-y coordinates
5. Timing accommodations: Take more time to complete a task; Have extra time to process oral information and directions
6. Organization skills accommodations: Mark texts with a highlighter
7. Give directions in small steps using as few words as possible
8. Provide visual aids; Use pictures or graphics
9. Show a model of the end product (such as a completed math problem or finished quiz)
10. Allow the student to use a calculator without penalty

Section C: Culminating Activity:

If your school is located in New Mexico, you can take students on a field trip to Chaco Canyon. Students may also respond positively to an activity in which students print out a plan of an important cultural site and illustrate ways to approximate distances between two points by applying the Pythagorean Theorem.



Pueblo Bonito with Coordinate Plane

