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| **Title** | **Discovering Pythagoras in the Real World** |
| **Introduction** | Eighth grade students will be discussing and discovering the Pythagorean Theorem. Students will view a video of a real world situation that involves right triangles and the Pythagorean Theorem. They will work collaboratively to discover the theorem and formula to solve Pythagorean Theorem problems. |
| **Curriculum Alignment** | Expressions and Equations 8.EE.2 Evaluate square roots of small perfect squares and cube roots of small perfect cubes Geometry 8.G.7 Apply the Pythagorean Theorem to determine unknown side lengths in right triangles in real-world and mathematical problems in two and three dimensions. |
| **Learning Outcomes** | After this unit, the students will have an understanding of how to apply the Pythagorean Theorem.  By completing the activities, the students will be able to calculate the missing length of a right triangle in two dimensions in real world situations.  At the conclusion of this unit, the students will be able to evaluate perfect square roots to determine the missing side length in a right triangle. |
| **Time Required and Location** | This lesson is intended to last for five consecutive days with periods from 60 to 75 minutes each. |
| **Materials Needed** | For this lesson, the teacher and student will need the following:   * copy of the salt pile drawing * pencil and paper to record data * a pile of sand or dirt proportional to the toy truck for each group (use whichever material you have available) * toy dump truck that actually dumps for each group * 24 inch piece of string for each group * 12 inch ruler for each group * dot paper   **Technology resources**  The teacher will need to access the video interview with Chad Bandy of the North Carolina Department of Transportation attached to the lesson. The teacher will need a computer, a projector, and speakers to show the video. The teacher will need a digital camera and video camera to record students working in the Exploration phase. The students will need a graphing calculator to perform calculations. |
| **Participant Prior Knowledge** | The teacher prerequisites are:   * copy the salt pile illustration. * set-up scenario with toy dump truck, pile of sand or dirt, and measuring tools.   The student prerequisites are:   * understand how to calculate the square root of a number. * know how to solve one and two step equations. |
| **Facilitator Preparations** | The teacher will need to copy the illustration of the salt pile to distribute to the students. The teacher can also provide a digital copy of the diagram to the students. The teacher will also need to set-up the scenario of the dump truck, sand pile, and measuring tools. The teacher will need to create a pile of sand proportionate to the size of the dump truck being used. The dump truck should be place at least six inches from the pile of sand. |
| **Activities** | **Exploration**  The following question will be written on the board and stated verbally before the lesson begins: Given a pile of sand, a dump truck, and measuring instruments, how many ways can you explain to find the diagonal distance from the truck to the top of the sand pile in order to load or unload the truck?  ASK students to get into their assigned groups of 4 – 5 students. ASK one member of the group to get the dump truck, string, and ruler. Show the students where the truck should be parked each time, in reference to the pile. Use the measurements of 6”, 12”, 18” and 24” from the end of the pile. Explain to the students that the distance they will be finding doesn’t include going to the ground. Show the students how to use the string and ruler to stretch and measure between the dump truck and the pile of sand or dirt.    SAY: *You will have 20 minutes to find the diagonal distance as many different ways as you can. Use only the tools provided to you to find the distance.* (24” piece of string and ruler) After 20 minutes, ASK: What was the easiest way to find the distance? Did you incur any problems during this lab? Some possible problems could include the tools that the students had available were not large enough to measure the distance from the truck to the pile.  SAY: *You will have 20 – 25 minutes to find the diagonal distance as many different ways as you can. This time, you may use any tool to find the distance.* Students may use tools that they find around the room. (For example a student might use a t-shirt from Physical Education class to stretch out and then use the ruler to measure the shirt. Other examples that a student might choose are objects that are available in the classroom: straws, pencils, markers, paper, eraser, etc.) Note: The object chosen may not be long enough if it is shorter that both the height of the pile and the distance from the pile. After 20 – 25 minutes, ASK: What was the easiest way to find the distance this time? Did you incur any problems during this lab? Are there any possible solutions to these problems? SAY: *Return the dump truck, string, and ruler to the area designated for materials.*    **Model System**  After the exploration activity, ASK: What ways did you come up with to measure the diagonal distance? SAY: *How can you measure the distance if the tool you are using is not big enough?* This will lead to a class discussion with the end goal being that we need a formula to determine the distance. SAY: *Cut out a triangle that is less than a quarter of the size of your paper. Now trace the triangle on the dot paper. Draw a square off each of the sides of your triangle.* This will lead to another class discussion about the relationship between the squares. The teacher will guide the students to figure out that the two smaller squares will fit inside the biggest square. The end goal of this discussion will be to formulate a theorem about the relationship between the squares.  **Content Wrap-Up**  The teacher will use a Power Point presentation to explain the vocabulary involved in the problem (hypotenuse, legs, Pythagorean Theorem, etc.). Within this same presentation, the teacher will do practice problems with the students. The teacher will guide the students through how to calculate the missing side of the triangle. The students will come to the board to work out the problems. The other students will be checking the work to make sure it was done correctly.  **Guided Practice**  The teacher will give the students 4 – 5 examples of right triangles Pythagorean Theorem problems. The students will work independently to complete the problems, showing all work. The students will be able to ask for guidance if needed. |
| **Assessment** | This unit will consist of two assessments, one formative and one summative. The teacher will have the students complete a 3-2-1 paper, on a piece of loose leaf paper. On this paper, the student will write down 3 real world situations or scenarios where Pythagorean Theorem can be applied in the real world, 2 ways to solve a right triangle problem, and 1 item that the student is still confused or has a question about. The teacher will use the second part of this assessment to see if the students understood how to find the missing side of a right triangle. The last part of this assessment will be used to guide further discussion and/or re-teaching of the Pythagorean Theorem. The second assessment will be a test which consists of eleven problems. The purpose of both of these assessments is to find out where the student’s thinking is about the Pythagorean Theorem. |
| **Critical Vocabulary** | **Pythagorean Theorem**: in a right triangle, the sum of the squares of the two legs is equal to the square of the hypotenuse  **hypotenuse:** the side opposite the right angle in a right triangle  **legs:** the two sides of a triangle that make up the right angle  **right triangle:** a triangle that contains one right angle |
| **Modifications** | Students with learning disabilities will work with the EC teacher aide to complete the task. The teacher aide will lead the students though the activity asking appropriate questions for the students. If a teacher aide is not available, this lesson should not be used for this topic. |
| **Alternative Assessments** | The students will illustrate the scenario of the activity they just completed. They will need to label and explain the illustration. The students will need to use proper Math vocabulary that was covered in this unit. This alternative assessment will be meant for the students that need to explain their thoughts rather than answer word problems. |
| **References** | Pythagorean Theorem vocabulary <http://connectedmath.msu.edu/parents/help/8/looking_concept.pdf>  This website shows concepts and examples of vocabulary in the Looking for Pythagoras book. This would be a good resource for both the teacher and the student.  Proof of Pythagorean Theorem <http://www.mathwarehouse.com/geometry/triangles/pythagorean_theorem.html>  This site allows the students to manipulate the squares on the legs of the right triangle to fit inside the largest square off of the hypotenuse. |
| **Supplemental Information** | One supplemental resource that a teacher could use as an extension of this activity is a web quest on Pythagoras.<http://questgarden.com/40/35/0/061104085820/index.htm>  The students can use the web quest by themselves or with a partner. |
| **Comments** | This plan was developed after I made a video of the local NCDOT supervisor. He had mentioned in the video that the DOT was working on a conveyor system to load and unload salt trucks in the winter for treating the roads. I thought about how this could tie into my curriculum. The conveyor, the ground, and the height of the pile make a right triangle. This meets the standards about Pythagorean Theorem. |
| **Author Info** | My name is Mark Jankowski and I teach 8th grade Pre-Algebra and Algebra at Asheville Middle School in Asheville, NC. This is my tenth year of teaching. I have taught all across the country. I started teaching in Las Vegas before moving to southern California to teach. The last five years have been spent on the east coast in the Carolinas. I currently hold a license to teach in 4 states. In my ten years, I have taught Math and /or Science. I have worked with North Carolina Department of Public Instruction to develop documents related to the new Common Core State Standards. I have served as math chair at two of the four schools that I worked. I currently am working on two fellowships.  This project was developed after recording a video of a DOT engineer. After watching the video, I discovered that I could make a right triangle out of the height of the pile of salt and the distance that the truck was form the pile. The last side would be formed by the conveyor that will be built to load and unload the trucks. Many of my students ask when and where they will use the Math they learn. Using the DOT example of salt piles and loading and unloading into the truck, will help my students to see the relevance of using the Pythagorean Theorem.  My mentor Jan King is a professional development consultant for the North Carolina Department of Public Instruction. She assists districts and charters in the western part of the state as they implement Race to the Top (RttT) initiatives. Jan works under the “Great Teachers and Leaders” pillar of the state’s RttT plan. She is a former teacher, instructional coach and administrator. She was named the 2010 Wachovia/Wells Fargo “Principal of the Year” for North Carolina. |