DOINGWHATWORKS

SAMPLE MATERIAL

Algebra Investigation

University Park Campus School, Massachusetts

Topic: Helping Students Navigate the Path to College

Practice: Prepare Students Academically

At University Park Campus School (UPCS), teachers focus on helping students learn facts through deductive reasoning. In this assignment plan, middle school math students learn the Pythagorean Theorem by applying their own problem-solving and logic skills to assigned problems using various triangle cutouts. The assignment is conducted in small groups, and students are encouraged to discuss their thinking as they work through the assignment. The end result of the task is that students have determined the Pythagorean Theorem through their own practical application of its ideas, making it more relevant and useful to them.

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Clark University's Jacob Hiatt Center for Urban Education
Learning Activity Plan

Uncovering the Pythagorean Theorem

*I. Describe **what** it is you will teach. What is the content?*

- Students will discover the Pythagorean Theorem. In other words, they will discern that the sum of the squares of the legs of a right triangle equal the square of the hypotenuse.

*II. Describe **why** the content is important for your students to know.*

- The Pythagorean Theorem is applicable in many situations including those involving construction, navigation, and distance. The Pythagorean Theorem is the foundation for the distance formula they'll need to learn in 10^{th} grade. It also gives purpose for learning about squares, square roots, and different types of triangles.
- It is important for students to discover, to play like mathematicians, to realize that if they can think, talk, and listen, they can DO mathematics like real historic mathematicians.

*III. Describe what specifically students will **know** and **be able to do** after the experience of this class.*

- Students will review that area is simply the number of squares that cover a 2-dimensional surface.
- Students will be able to uncover the Pythagorean Theorem.
- Students will utilize new vocabulary including leg, hypotenuse, and square roots.
- Students will see a purpose for learning the Pythagorean Theorem as they review application problems that require knowledge of the relationship among the sides of right triangles. After this lesson, they will go back and solve those problems.

*IV. Describe **how** you and your students will know they understand what it is you want them to know and be able to do.*

- Listening, Discussion, Individual and group questioning, Posters
- On the posters, I will look for understanding of the relationship written in words, shown with numbers, and described in a formula. Students may not all represent the relationship in the form $a^2 + b^2 = c^2$, but they should have something equivalent.

V. Describe how you will provide for individual student strengths and weaknesses. How will you and your lesson consider the needs of each student?
Beginning of lesson (The starter problem is the problem of the day which begins each class.)

- "Individual think time" during the starter problem will be enforced to allow each person to think about his/her word problem, decipher it, and explain it to their group.
- The application problems involved in the starter problem vary in difficulty, and students who often struggle will be given the pack of problems to distribute among their group-mates so they can choose whatever level of problem they desire. The earlier problems will include a corresponding diagram.
- Group members will hopefully support one another through the starter. I will encourage this by circulating and prompting discussion as necessary after "silent thinking time". Students won't be able to show the others their problem, but they can explain it. This rule is given to make sure all

students talk and participate, and that one person is not left with all the problems determining the commonalities.

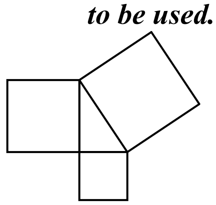
Discovery Activity

- Individual students will be given different triangles. Some will use basic numbers so the computation doesn't get in their way of a discovery. Others will use decimal and irrational values.
- Posters will be individual to ensure that each student is thinking, writing, and formulating their own ideas.
- The approach here is a visual one. Students, when solving Pythagorean Theorem problems in the future, will be allowed and encouraged to draw today's visual if they prefer it to the algebraic approach of the formula. By providing this visual and the hands-on activity, different learning styles will be addressed.

VI. Describe the activities that will help your students understand the content of your class lesson by creating an agenda with time frames for your class. Be prepared to explain why you think each activity will help students on the path toward understanding.

Today's Activities:

Time	***Teacher Activity***	***Student Activity***
	-Board in front of room assigns groups of 3. -Starter problem is described on board. -Poster materials (construction paper, scissors, glue sticks, rulers, centimeter graph paper, markers) are available on the back table. -Various right triangles have been cut and assigned to each individual student.	
8:05-8:08	***Handout problems; starter board is posted with groups and directions for problem handouts. When passing out the problem slips, I'll pass them to a "dealer". The dealer can determine who gets what. I'll number each problem and the higher values will be trickier. The dealer will be the student in the group of 3 who would prefer to take questions 1 & 2. That way they have some control and won't be overwhelmed. I have a feeling the kids who need a challenge will get the tougher problems. Keep students aware of time limits. Circulate to make sure students who have trouble reading can understand the question enough to explain it to their group.***	***Individual thinking time- Read problem and figure out what it's asking.***
8:08-8:13	***Tell students it's talk time. "See what the problems have in common. Don't show anyone your problem, but you can tell them about it." The last command is to ensure that all kids talk and that one student does not end up with all the problems and does the work alone.***	***Kids share the gist of their problems within their group, trying to find commonalities.***

8:13- 8:20	Facilitate class discussion- "What do the problems have in common?" "OK- by the end of this lesson, you will be able to solve these problems. Today you will discover a relationship that involves the sides of a right triangle." "Funny how Brianna remarked yesterday that even though we were working with triangles, square numbers were involved." (Students discovered that when you scale the sides of a triangle, the area of the triangles increase by <u>the square</u> of the scale factor.) Explain that we'll use squares again with triangles today- Show visual to be used.  I'll use a 12-16-20 triangle to demonstrate the activity's directions. The 12x12, 16x16, and 20x20 squares should be cut prior to class, and shown as part of the instructions. This modeling should be enough to explain what to do.	Volunteers share what their group noticed. They should notice that each of the application problems involves a right triangle and to solve the problem, one must find a missing side of the right triangle.
8:20- 8:30	Pass out the directions for the activity and the triangles, previously assigned to students according to ability & comfort level. Triangles are in envelopes so that each group gets one envelope of 3 triangles with student names written upon them. Triangles have any of the following dimensions in centimeters: 3-4-5, 6-8-10, 9-12-15, 6-6-6$\sqrt{2}$, 5-12-13, 2.5-6-6.5 Each group member gets a different triangle, assigned to make sure each student is challenged at their own level.	One person from each group collects and passes in problem sets. Another goes to the back table to get a set of markers and a glue stick. Another gets a graph paper and a pair of scissors for each group member. They begin the activity, by first reading the directions given.
8:30- 8:40 Kids cut squares and find areas.	Circulate. Express time limits.	Students should have squares cut and labeled with the area by 8:40. Students will continue to follow the tasks described on the handout.

8:40-8:50 Kids record what notice in notes	***Circulate.*** ***Make sure students are not writing a+b=c (common error). Use questioning to avoid/correct this.***	***Students should be recording what they notice about the areas in words and formulae as a rough draft in their notebooks (acting as mathematicians recording in notebooks what they notice).***
8:50-9 Create posters	***Circulate.*** ***Express time limits.*** ***"When we discuss your discoveries at 9:00, I should be able to call on any group member to explain their group's findings. Be sure each of your teammates, including you, is prepared to explain your findings."***	***Students will be told to aim for 9:00 to finish their poster.*** ***Extensions (for those who finish poster quickly):*** ***1. Within directions- Does the discovered relationship work for non-right triangles? Show proof.*** ***2. Puzzle 1,2,3 handouts showing the two smaller squares off the sides of a right triangle fit in the larger square.*** ***3. Go back and answer the application questions from the beginning of class.***
9-9:15	***Facilitate discussion.*** ***Ask students who worked with non-right triangles to show findings.*** ***Show GSP document, which has the above visual, the areas of the squares, and calculates the sum of the 2 smaller squares. This shows a numerous amount of right triangles in one drag of the mouse, and for each triangle, the sum is the same as the hypotenuse^2. "Can we assume this relationship is true for ALL right triangles?"*** ***"Congrats! You discovered the Pythagorean Theorem like mathematicians did way back in the day."*** ***Share history if time.***	***Answer as I pose the question of "What did you notice?" or volunteer to supplement, question, or disagree with the ideas of their peers.*** ***Hopefully, students agree that we can assume this relationship is true for all right triangles.***

VII. Reflection:

Overall the class was very successful, as each student discovered the Pythagorean Theorem by the end of the period. Each group produced a poster; most of which displayed $a^2 + b^2 = c^2$*. Other formulas included* $c^2 - a^2 = b^2$ *,* $c^2 - b^2 = a^2$*. At least two notebooks featured a * a= A, b*b=B, c*c= C, and A+B=C. Students were able to communicate the relationship among the sides of a right triangle using words, numbers, and algebraic equations.*

All students were active in their group. This was surprising to me as I neglected to tell them in the directions that each student was to make a poster. I usually have students produce individual products so that I know each student is able to communicate their understanding and to make sure each student is working. However, working on one poster, created more conversation among the students in this particular class. Students benefited from the dialogue. In my next class, I made sure to tell students to produce individual posters, as I suspected that a handful of students in that class would not participate, and therefore think, as much as others if only one product per group was required.

The starter problem provided a purpose to the activity and I would do this again. Although students did not solve the problems, they are now able to, and will in future classes. I did not get to share any history with students pertaining to Pythagorus or the Pythagorean Theorem as we ran out of time, but I will do this next class.