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GEOMETRY LESSON
Flying Kites: Raising Students Sky High

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Overview

Concepts: Geometry, Measurement, Number Sense, Mathematical Reasoning, Critical Thinking, Number and Operations, Communication

Skills: Identify the properties of a kite and a rhombus, create a kite or a rhombus blueprint aligned with the geometric properties of each individual geometric shape, construct the kite or the rhombus to scale using the previously designed blueprint.

Vocabulary: *rhombus* (a quadrilateral with all sides equal in length; a square is a special case of rhombus); *kite* (a quadrilateral with two distinct pairs of adjacent sides; a rhombus is a special case of kite); *midpoint, vertex, vertices.*

Properties: *rhombus:* Any side can be a base; the altitude of a rhombus is the perpendicular distance from the base to the opposite side (or, when needed, its extension); the area of a rhombus can be found in several ways (see bonus activities, below). *kite:* At least one pair of opposite angles have equal measure; angles between unequal sides have equal measure; no angle is greater than 180° (a kite becomes a *dart* when one of the unpaired angles is greater than 180°).

Grade Level(s): 6, 7, 8.

Duration/Length: Three (3) 50 minute periods.

Prior Knowledge: measuring using a ruler, scaling measurement with ratio or proportion, right angles, and attributes of line segments and shapes (e.g., diagonals, midpoint, vertex).

California Common Core State Standards: Grade 6: 6.RP.1, 6.RP.3.d, 6.NS.3; Grade 7: 7.RP.2.b, 7.NS.2.a, 7.NS.3, 7.G.1, 7.G.2; Grade 8: 8.G.1.3, 8.G.1.4. California website for the state standards: `www.cde.ca.gov/be/st/ss/documents/ccssmathstandardaug2013.pdf`.

Materials: 8.5"× 11" white copier or grid line paper, markers, color crayons, color pencils, rulers, protractor, markers, light colored (e.g., white) 13-gallon plastic trash bags, electrical tape, dowels 1/8" × 36" (two for each group), super twine string, permanent markers, and scissors.

Background: What makes a kite fly? What are the mathematical concepts addressed in the construction of a kite? The goal of this project is to have students develop, construct, and fly a handmade kite. By the end of the project, not only will students recognize that the three main

forces that affect the flight of a kite (lift, gravity, and drag) are crucial but also that a kite's geometry is integral to its balance and flight capabilities. Through this engaging, hands-on project, students will apply critical thinking skills and spatial reasoning and deepen their understanding of measurement, geometric constructions, scale, and proportion. This lesson can be used to review geometry content or to introduce new material, including academic language.

Day 1

Description: The lesson begins with a teacher-led discussion that will ultimately lead to a student introductory activity on the development of a flying kite.

Materials: 8.5" × 11" plain paper or grid paper, ruler, and colored pencils or crayons.

Teacher Activities	**Student Activities**
Step 1 (15 minutes) Launch. Teacher starts with class in a discussion exploring the properties of kites and rhombuses. While displaying illustrations of each quadrilateral, the teacher asks students to identify some visible attributes of each quadrilateral. The teacher guides class discussion toward discovery of the properties unique to a kite and a rhombus. The classroom discourse goal is to simultaneously construct curriculum knowledge and develop academic language associated with the mathematical concepts. To support language development, vocabulary terms are introduced or reviewed in tandem with notation symbols (e.g., tick marks symbolizing congruent segments). Ensure discussion addresses line segments in polygons (i.e., perpendicular and intersecting lines). On the word wall, whiteboard, or poster board teacher gathers the identified characteristics and academic language throughout the discussion for students to refer back to as needed.	The students participate in a class discussion, pinpointing some of the distinguishable attributes of the two quadrilaterals. This will allow them to discover attributes that are specific to each shape. Furthermore, they will be able to see any similarities that both shapes may have. As the students are identifying characteristics of the shapes, they are asked to use the academic terminology associated with them. This allows students to become familiar with the terminology that they will be using for the subsequent lessons. By the end of the class discussion, students will be familiar with the properties of kites and rhombuses.
Step 2 (30 minutes) Hands-on student activity. The teacher strategically puts students in groups of 2 to 4 members. Each group's task is to create scaled drawings of two distinct flying shape designs (kite and rhombus) on 8.5" × 11" paper, highlighting the properties of each quadrilateral. Depending on the grade level, the scale could be provided by the teacher, or it can be created by the students. Once scale drawings are completed, within the group students compare and contrast the two designs and form a hypothesis and justification about whether one design will fly better or that both will perform equally well. Students enter the conjecture and rationale into their individual notebooks.	Once the students have become familiar with the properties related to each figure, they work in assigned groups of 2 to 4 members. Each group creates a scale drawing for each of the two designs: a true rhombus and a true kite. Each group will need to discuss which of the two designs they predict will function the best when flying and why. Each student will enter this hypothesis into her or his notebook, along with deductive rationale, based on the properties of each quadrilateral. At the end of their group discussion, the members must agree on one design to test, which will they will create the following day.
Step 3 (5 minutes) Whole class discussion. The teacher poses questions with the intent of reinforcing what the students have learned. Select students to purposefully scaffold discussion (e.g., see Stein, Engle, Smith, & Hughes, 2008). Closure Questions: • What is at least one academic or mathematical word you learned today? • What mathematics did we do today? Explain as if you were describing the lesson to someone who was absent. • What was the most challenging concept? Explain.	Students participate in the closure discussion. As the students are responding, they will be reinforcing the material that they just learned and clarifying misconceptions that were left unaddressed in the beginning of the lesson.

Day 2

Description: The lesson will begin with a teacher-led discussion that will review and reflect on content from the previous lesson. After the class discussion, each individual group will engage in the construction of their pre-decided flying shape design.

Materials: light colored/white plastic trash bags, electrical tape, dowels, string, different colors of permanent markers (e.g., *Sharpies*), scissors, and rulers.

Teacher Activities	Student Activities
Step 1 (5 minutes) Launch. Begin the lesson by reviewing the properties of a kite and a rhombus in the form of a teacher-guided class discussion in which every student has the opportunity to share information and ideas. Throughout the discussion, the teacher assesses student content knowledge and determines if further review is needed. The teacher answers questions and addresses any related student concerns before starting the group activity.	The lesson begins with students participating in a class discussion. Students have the opportunity to review the material from the previous day: properties of kites and rhombuses. They also have the opportunity to ask questions about the content or the instructions for the group activity that will follow.
Step 2 (25 minutes) Construct the flying shape. Students get in their pre-assigned groups and appoint a "runner" to collect materials. *Note: Post the materials list in an area that is visible to all students.* As student groups create and decorate their flying shapes, the teacher walks the classroom, making sure students are on task and following the directions correctly (see Instruction Sheet, page 15). If it seems many groups are struggling, the teacher can bring the class together and review necessary steps with the entire class. Student groups follow their scale drawing "blueprint" to construct a flying shape, in the form of a kite or rhombus. Keep in mind that the student activity sheet has them use the doubled thickness of the bag and one-half of the outline to mark and cut a mirrored half-shape that will be unfolded to create the full shape. *Suggestion: Have groups personalize their kites using colored markers.*	Students return to Day 1 groups and select a "runner" who gathers necessary materials to construct one flying shape. Students draw an outline on the garbage bag, cut the bag along the outline, unfold, and verify the scaled measurements of the diagonals. The lengths of the diagonals are used to measure and cut the dowel sticks to the needed sizes. Students tie the dowel sticks together with string and firmly attach the four dowel ends to the four corners of the cut plastic bag using electrical tape. Lastly, they attach a long piece of string to their kites at the intersection of the dowel sticks.
Step 3 (12 minutes). Flying! The class goes to an open space where they can easily attempt to fly their shapes. The teacher makes sure that each group member gets a chance to fly the group's shape. Additionally, the teacher ensures groups jot down key observations about trying to fly the shape. The teacher also encourages groups to trade with trade with at least one other group, preferably with a group that chose the alternate quadrilateral, and repeat the flying attempt and making of observations and notes.	Each group member has the opportunity to get the shape flying. Once they have tried their own shape, students trade with at least one other group, preferably with a group that chose the alternate geometric shape. Students record observations in their notebooks (e.g., challenges that arose while flying each shape; comparing and contrasting the experience of flying different shapes).
Step 4 (8 minutes) Debrief. All return to the classroom for a short discussion. The teacher asks questions regarding student observations and challenges. The teacher also asks students for a discussion that compares and contrasts the two types of shapes when flown. The teacher leaves the discussion open-ended in order to promote an authentic reflection from the students in the reflection assignment (see below).	Students discuss their individual experiences, sharing similarities and differences identified between flying the two different kinds of shape. The students share and compare results with the entire class, making notes for use in the homework reflection and for the next class meeting.

Assignment/Reflection Paper (homework): The students are instructed to write a reflection paper describing whether or not the empirical results of the experiment support their theoretically-grounded hypotheses. They must analyze data collected during Step 3 but may also

include other experience. The purpose of the reflection is for the students to analyze their data, draw conclusion, and support their claim through cited evidence.

Reflection Question: Did the shapes fly the same? If not, which type of shape flew the best (kite or rhombus)? Why?

Day 3

Description: The lesson begins with a teacher-led discussion that reviews and reflects on content from the previous lesson. After the class discussion, each student group creates a presentation on the flying shapes experience and mathematical concepts.

Materials: Notes from previous days, access to presentation materials or software (e.g., poster board or Google Doc presentation), flying shapes from Day 2 (optional).

Teacher Activities	**Student Activities**
Step 1 (5 minutes) Launch. The teacher begins the lesson with a guided discussion regarding student individual reflection papers and their final conjectures on whether the shapes flew the same or if one flew more effectively. The teacher scaffolds discussion by seeking purposefully chosen volunteers to start with commonly noted ideas and increase complexity to more subtle aspects of the similarities and differences in the shapes and their flying performance.	The students engage in the class discussion regarding their conjectures. They share key ideas supporting their claims.
Step 2 (30 minutes) Presentation preparation. The teacher directs students to assemble into their pre-assigned groups and to (1) give each person up to 2 minutes to state the hypothesis and support from their reflection paper and (2) after all ideas are presented, discuss their reflections within the group. Then, (3) students must come to a consensus, from their discussion, on whether the shapes flew with the same qualities or if one was more effective than the other. Once the students come to a consensus, they (4) brainstorm an outline for their presentation and (5) as a group create a short Google Docs presentation on their final findings. As the students work, the teacher circulates the room, assessing progress and assisting students as needed.	The students get into their groups. Each group member is required to share their conjectures with supporting information. Once each group member has shared, the group as a whole reviews ideas and comes to a consensual hypothesis that either one quadrilateral design performs better as a flying shape or the two are equivalent. Next, they develop an outline for their presentation, which includes their hypothesis and supporting evidence (e.g., personal experience, specific mechanics of the flying shape, data from class discussions, and photos or illustrations).
Step 3 (10 minutes) Share presentation. As groups finish, pair them to share their presentation with another group. As the students work, the teacher circulates the room, assessing progress and assisting students as needed. *Note: The lesson could be extended for one more day in order to allow all the groups to present their findings to the entire class instead of just one other group.*	Once students complete their presentation (e.g., in Google Docs), they share the presentation with another group and are audience to the other group's presentation.
Step 4 (5 minutes) Closure. The teacher brings the class together as a whole for one last class discussion revealing that the rhombus design was a challenge to fly due to the highly regular geometric properties of a rhombus being inferior in flight.	The students join the class discussion and offer ongoing commentary during the discussion.

Instruction Sheet for Creating the Flying Shape

(1) Unfold or unroll the garbage bag so it lies flat, but DO NOT OPEN the bag. To ensure a large, even, shape, identify a folded edge of the bag (no seam) and consider how to draw the shape to use as much of the bag surface as possible. Keep in mind that after the outer edges are cut through both layers of the bag, it unfolds into the desired shape.
(2) Using your scale drawing for reference, align the longest diagonal along the folded edge of the bag then measure and draw an outline of HALF of the chosen shape (kite or rhombus) onto the garbage bag.
(3) Cut the outer edges of the shape through both layers of the bag.
(4) After the shape has been cut, unfold the garbage bag. At this point, the shape will unfold in its entirety.
(5) Measure the diagonals of the shape in order to accurately measure and cut two dowel sticks, one for each diagonal. Once the sticks have been cut to the appropriate lengths, tie the two dowel sticks together (for a rhombus, at their midpoints; for a kite the dowels cross at a ninety degree angle and are tied at the midpoint of the short diagonal and wherever is needed on the long diagonal to make the ends of the sticks line up with the vertices). After tying the sticks together, place the sticks on top of the shape, making sure that the ends of the sticks are at the vertices. Once the sticks have been placed, securely tape the ends to the plastic bag vertices using the electrical tape.
(6) Cut a piece of string about 4 yards long. Tie one end of this long string around the intersection between the sticks. This will help secure the sticks together and also serve as the tether for flying the shape.
(7) At this point, the shape is complete and ready to fly. Personalize the flying shape by drawing on the plastic with permanent markers.

Bonus Extension Questions

Bonus 1. There are several ways to find the area of a rhombus. Two correct formulas are given below. Based on what you know about finding the area of rectangles and of triangles, explain why each formula works. Include drawings to illustrate how the two formulas are geometrically equivalent.

Area of a rhombus $= b \times a$, where b is the length of the base and a is the length of the altitude (height).

Area of a rhombus $= \dfrac{d \times D}{2}$, where d is the length of one diagonal and D is the length of the other diagonal.

Bonus 2. A rhombus is a special kind of kite. Do the same formulas work for finding the area of a kite? Why/why not?

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References

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