GEOMETRIC BUILDING DESIGN

TGR FOUNDATION

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LESSON OVERVIEW

In this lesson, students will use Google Maps to visualize the relationship between two-dimensional and three-dimensional shapes. They will then continue to investigate how 2D shapes are connected to 3D shapes, particularly when related to surface area and volume. To demonstrate their understanding, students will create a 2D scale drawing and a 3D scale model of a building that fits within the constraints of a certain city area, with the ultimate goal of having the "[Your Community Name]" City Council select their building to be constructed. Taking on the role of a career related to city planning, students will then get to work as they consider the space that is available, as well as how to represent the building using a variety of 2D and 3D figures. Students will ultimately present their building, during which they will explain their design, justify their decisions and do their best to convince the city council to choose their proposal!

The accompanying presentation was created with PowerPoint so that it can be used in a variety of classrooms. If you are using a laptop with an LCD projector, simply progress through the PowerPoint by clicking to advance. All of the interactive aspects of the presentation are set to occur on click. This includes images, text boxes, equations, answers and links to outside webpages, which will appear in your web browser. If you are using an interactive whiteboard, tap on each slide with your finger or stylus to activate the interactive aspects of the presentation. It does not matter where you tap, but you can make it appear as if you are making certain things happen by tapping them. In the notes for each slide, there will be information on how to proceed.

THIS LESSON FOCUSES ON

ENGINEERING DESIGN CYCLE	21ST CENTURY SKILLS
• **Defining the Problem**	• **Collaboration**
• **Designing Solutions**	• **Communication**
• **Creating or Prototyping**	• **Critical Thinking**
• Refine or Improve	• **Creativity**
• **Communicating Results**	

SUGGESTED TIME

3-4 class sessions (45 minutes each)

GRADE LEVEL

6-8

CONTENT AREAS

- Spatial Reasoning
- Geometry
- Algebra

ESSENTIAL QUESTIONS

1. How do maps provide 2D representations of 3D shapes and structures?
2. What 3D shapes exist in the world around us?
3. How can perimeter, surface area and volume be used in city planning?
4. How do we apply the concept of ratios to design models to scale?

GEOMETRIC BUILDING DESIGN

HAVE YOU EVER WONDERED...

How long does it take to build a building?
While designing a building is one part of the process, actually building your design is another large step! While it's hard to say exactly how long builds take, statistics do exist on regular apartment buildings. A large building with between two and four units normally takes about 11 months. Larger developments with 20 or more units can take between 13-14 months. Remember, though, these are averages…and many projects take much shorter and much longer!1

What are some of the world's most visited buildings?
Every year, the vision and work of architects prompts a tremendous amount of travel around the globe. Though the differences between the stone remains in Machu Picchu, the Acropolis in Greece, the Great Pyramid of Giza and France's Eiffel Tower are certainly dramatic, they all share one thing in common: They stand among the world's most visited sights![2]

MAKE CONNECTIONS!

This section captures how this activity connects to different parts of our lives and frames the reason for learning.

HOW DOES THIS CONNECT TO STUDENTS?	HOW DOES THIS CONNECT TO CAREERS?	HOW DOES THIS CONNECT TO OUR WORLD?
Did you know that many of the classes you take in middle school and high school will help prepare you for a career in architecture and building-design? Your history courses help you understand design from a historical perspective. Your math and science courses help you strengthen your problem-solving skills, in addition to gaining specific career-related skill sets. Physics, for example, will help you understand what buildings need to stay standing tall, whereas trigonometry is needed to calculate arches, beams, bridges and more.	**Architects** create the actual design for new and renovated buildings. They must take design requests and measurements into consideration as they develop concepts for both the interior and exterior of buildings. **Civil Engineers** design and oversee construction of public works. Their projects usually involve large infrastructure like dams, bridges, buildings, tunnels, roads and railways. **Building Inspectors** review projects to make sure the plans and structures are up to code and meet the requirements of local laws and zoning regulations.	Architecture around the world tells a story. For instance, did you know buildings in the Netherlands were built slanting forward so furniture could be pulled up on a pulley outside the building and not scrape the exterior paint? Historical buildings help us understand a community's past, and planning for new architecture has the power to influence people's quality of life in the future.

GEOMETRIC BUILDING DESIGN

MATERIALS

- Computer and projector
- Chart paper or white board
- Scrap paper, at least one per student
- Teacher Resource: Rectangular Prism Net, at least one teacher copy
- Geometry Nets student capture sheet, one per 3-4 students
- 3D Hunt student capture sheet, one per 2 students
- Career Cards student capture sheet, one card per student
- Blueprint Design student capture sheet, one per 3-4 students
- 3D Construction student capture sheet, one per 3-4 students
- City Council Presentation Prep student capture sheet, one per 3-4 students

For the class to share:

- Graph paper
- Cardstock or poster board
- Crayons, markers or colored pencils
- Glue
- Scissors
- Tape
- Rulers
- Measuring tape

OBJECTIVES

Students will be able to:

- **Analyze** the similarities and differences between two-dimensional and three-dimensional shapes.
- **Consider** perimeter, surface area and volume* as they design a blueprint of their proposed building.
- **Draw** a blueprint and construct a three-dimensional model of their building to scale.
- **Collaborate** with their peers to present a convincing proposal that justifies and explains their design choices.

  *Volume can be integrated as a challenge.

BACKGROUND INFO

Spatial reasoning is defined as the ability to mentally visualize and manipulate two-and-three-dimensional objects. Though it's often not a subject that is explicitly taught, its importance is undeniable. One's spatial ability can be a predictor of success in STEM-related subjects and fields3. The study of engineering, mathematics, arts, natural sciences, etc. all relate to spatial reasoning, and careers that involve everything from computer graphics, drafting and imaging to surgery, meteorology and molecular studies benefit from an aptitude in spatial skills. One's spatial ability even affects the ease with which everyday tasks are accomplished, such as reading a map, packing or merging into traffic[4].

This guide strives to give educators a resource to promote spatial awareness and reasoning in their classroom in order to help students develop this skill set. It provides slide-by-slide details to help educators be prepared to explain, discuss and facilitate the hands-on content in the presentation. The presentation is designed to cover four 45-minute class sessions, but it is flexible depending on the students' needs and the time available. Additional extensions and challenges are included both throughout the lesson and at the end of this manuscript.

This lesson plan follows an inquiry-driven 5E instructional model: Engage, Explore, Explain, Elaborate and Evaluate. The lesson begins by an investigation of Google Maps as students consider the various relationships between two dimensional and three-dimensional shapes. During this investigation, students will learn about the concept of surface area, and how they can use their knowledge of 2D shapes to figure out the surface area of 3D shapes. In order to do this, students will be introduced to the concept of a geometry net: a flattened version of a 3D shape that can be folded back together to make its original shape. By creating a net of a 3D shape, students can easily see the 2D shapes that comprise it. This enables them to find the area of these 2D shapes, which – when added together – amount to the 3D shape's surface area. As a challenge, students may also explore the concept of volume.

Sources:

1. Madigan, Kathleen. "Vital Signs How long to build an apartment building?" The Wall Street Journal. blogs.wsj.com/economics/2013/11/19/vital-signs-how-long-to-build-an-apartment-building/
2. Frias, Stephanie. "9 of the Most Visited Tourist Attractions in the World." Skyscanner. skyscanner.com/tips-and-inspiration/inspiration/9-of-the-most-visited-tourist-attractions-in-the-world
3. Cimons, Marlene. "Science of Spatial Learning." U.S. News and World Report. https://www.usnews.com/science/articles/2012/05/17/science-of-spatial-learning
4. What is Spatial Ability? Johns Hopkins Center for Talented Youth. http://cty.jhu.edu/talent/docs/SpatialMore.pdf

PROCEDURE

DAY 1

ENGAGE (Slides 0-2)

Overview: Students will be guided through a series of views on Google Maps and will describe the similarities and differences between the 3D and 2D projections.

Slide 1

Teacher Preparation Note: Before class begins, paste an image of a popular location in your students' community into the image placeholder spot on this slide. Your goal is to select a building or location that students will be excited to see on the board. You may get this image from Google Maps by taking a screenshot of it, or you could search for a photograph using Google Image Search.

1. As class begins, click on the Google Maps button. The hyperlink will open your web browser and bring you to Google Maps. Type in the address or name of the image that you previously inserted on this slide.
2. Tell students that they are about to look at this community location in three different ways. Instruct them to observe the maps carefully, as they will be asked to compare and contrast the views.
3. First, click on the small satellite map square at the bottom and ask students to observe the map as you zoom in and out.
4. Then click and drag the yellow Google person onto the map to see the streets from "his/her perspective." Use your mouse or the arrows to look around and move up and down the street.
5. Finally, click the back arrow in the top left corner of your screen and then click on the small map square to switch back to the regular map view. Once on this view, give students a few moments to observe the screen.
6. Toggle back to the slide presentation, and click once to make the "Map Statements" header appear.
7. Click the screen once more to reveal the first bullet: The map(s) contain shapes.
8. Instruct the class to think about the three map images they observed (regular map, satellite and street view) and hold up fingers to show how many maps the statement applies to (one, two or three fingers).
9. Once there is a consensus among the class that this statement refers to all three maps, click the screen another time to review a blank bullet. At this point, ask for a student volunteer to make a statement that applies to one, two or all three of the maps. Upon hearing the statement, students should hold up their fingers to demonstrate how many of the maps the statement applies to.
10. If there seems to be confusion, break the question down and review the answer. Feel free at any point to toggle back to your web browser and review the different map views.
11. Allow three or four students to share statements before progressing to the next slide.
12. Note: Creating a triple Venn Diagram on a piece of chart paper is an alternative way to compare and contrast the map views.

Slide 2

1. Lead students to a discussion of shapes. Mention your original statement: All three maps contained shapes. Acknowledge that while this is certainly true, the way in which each map view uses shapes to represent objects was very different.

2. Click the slide once to make the two questions below appear. Read them aloud and allow students a moment to discuss with a partner before sharing their answers.
   - Which map(s) contained two-dimensional or 2D shapes? (If needed, define 2D as a flat shape. It only has two dimensions, such as length and width.)
     - Answer: The regular map view
   - Which map(s) contained three-dimensional or 3D shapes? (If needed, define 3D as a shape with three dimensions: length, width and height. Objects in the real world are 3D!)
     - Answer: The street view and satellite view

3. Click the slide again to bring up two images, side by side. These images are of the same building, but one is a 3D image and one is a 2D image.

4. Ask student pairs to discuss and consider: How are the shapes within the two images related?

EXPLORE (Slides 3-6)
Overview: Students will investigate the relationships between 2D and 3D shapes, as well as area and surface area. They will be presented with a rectangular prism and will work together to net the shape and calculate its total surface area. They will then go on a scavenger hunt for 3D shapes in their school or surrounding area and will be tasked with calculating the surface area of at least one of their findings.

Slide 3

1. Project a rectangular prism and ask students to consider the buildings they saw in street view on Google Maps. How is this prism similar and different to the buildings they saw?

2. Then click the slide and pose: How is this rectangular prism related to the flat, 2D map view?

3. Click the slide again and the prism's six faces will appear. Explain that the 2D map showed one face of this prism. Guide students in recognizing how the six 2D shapes come together to make the 3D prism.

Slide 4

1. Explain that understanding the relationship between 2D and 3D shapes is important because it can help you better understand both shapes.

2. Quickly review the equation for Area: Area = Length x Width. Reiterate that area is used to figure out the amount of space inside a 2D shape.

3. Explain that the outside area of a 3D shape is a little different. For starters, it's called "Surface Area." The definition of surface area is: the total area of the surface of a 3D object. In other words, if someone was going to paint a 3D shape, how much area would they have to paint?

4. Instruct students to think/pair/share in order to answer: How could we use area to figure out the surface area of this rectangular prism?

5. Allow student pairs to share their thoughts and then guide them towards the idea that they can begin by breaking the rectangular prism into its six 2D shapes, like they did on the slide before. The process of breaking down a 3D shape into its 2D shapes is called creating a geometry net (or, more simply, a net). When you create a net, the 3D shape is entirely flattened into a 2D shape. These new 2D shapes could then be glued back together again to make its original shape.

6. Task student pairs to use scrap paper to create a net of the rectangular prism in order to develop an equation for the prism's surface area.

7. When students are ready, click the slide to reveal the second net image, as well as the surface area equation (SA = 2wl + 2lh + 2hw). If you think students would benefit from a 3D manipulative of a net, use the Rectangular Prism Net handout to further model a geometry net. Answer questions as need be.
8. Once students seem comfortable with this concept, click the slide one more time to reveal numerical dimensions for the prism. Students should once again work in pairs to calculate the actual surface area of the prism. Discuss the answer (1,120 square units) as a group before moving forward.

Slide 5

1. Pose the question: How could you use a net to figure out the surface area of other 3D shapes?
2. Divide the class into groups of three or four students. Distribute a Geometry Net student capture sheet to every group and assign half of the groups to examine cylinders and the other half to examine triangular prisms. Instruct students to follow the step-by-step directions on the student capture sheet. (Student groups who finish early can create a net for both shapes.)
3. When the groups are ready, ask them to explain their findings. The class should arrive at an understanding that:
   - Surface area of a cylinder is: A = 2πrh + 2πr2 (click to reveal on slide)
   - Surface area of a triangular prism is: SA = bh + (s1 + s2 + s3) l (click again to reveal on slide)

Slide 6
Note: If students need a more thorough explanation of how to figure out the surface area of a cylinder using a net, walk through this slide more slowly. If not, it may be used as a review.

1. Instruct students to observe the cylinder image and identify the 2D shapes that they see.
2. Click once to reveal the two circles and review their area equation:
   - Area of 2 circles: πr2 + πr2 = 2πr2
3. Click a second time to reveal the rectangle and review its area equation:
   - Area of a rectangle: length (which is the circumference of the circle or 2πr) x height
4. Click a third time to reveal the total surface area equation:
   - SA = 2πrh + 2πr2

Slide 7
Note: If students need a more thorough explanation of how to figure out the surface area of a triangular prism using a net, walk through this slide more slowly. If not, it may be used as a review.

1. Ask students to observe the triangular prism image. Call on a student volunteer who, with help from the class, can label the prism using the variables provided on the slide.
2. Give students a moment to work with a partner to net the prism, keeping the edges labeled correctly.
3. Click once to reveal the net image and ask students to compare their work.
4. Explain that now all students need to do is add up the area of each of these 2D shapes to find the surface area of the 3D shape!
5. Click a second time to reveal the area equation for the two triangles:
   - 1/2bh + 1/2bh = bh
6. Click a third time to reveal the area equation for the three rectangles:
   - s1 x l + s2 x l + s3 x l = (s1 + s2 + s3) l
7. Finally, explain that these two equations just need to be added together so we can get the surface area of the entire shape.

8. Click a final time and reveal that Surface Area = bh + (s1 + s2 + s3) l

Slide 8

Note: Use this slide for students and/or classes who could use an additional challenge! If calculating surface area is enough of a challenge for the time being, proceed to Slide 10.

1. Ask students: How might area be useful in finding the volume of a rectangular prism, triangular prism or cylinder?
2. Before arriving at an answer, make sure students understand the definition of volume as the measure of the amount of space inside a 3D figure. In other words, if the shape was hollow, how much water or sand could it hold?
3. Divide students into the same groups as before and allow groups to choose a shape on the board to investigate. After giving them several minutes to brainstorm the volume equation using scrap paper, review the equations below:
   - First click: Volume of a rectangular prism = area of the base x height
   - Second click: Volume of a triangular prism = area of the base x height
   - Click a third time: Volume of a cylinder = area of the base x height
4. For an additional challenge, click a fourth time to reveal the question: If you know the volume of a cylinder, what is the volume of a cone?
   - Encourage students to observe the relationship between the cone image and the cylinder image. Click a final time to reveal the answer:
     - Volume of a Cone = 1/3 (area of the base x height)

Slide 9

1. For the time remaining in class, send students on a one-mission scavenger hunt to find a 3D structure in your school or surrounding community.
2. Divide students into pairs and distribute the 3D Hunt student capture sheet to each pair, as well as a ruler or measuring tape.
3. Review the instructions on the student capture sheet and set a time for when students must return to class. Tip: This will be a good time for differentiation. For students who may benefit from simpler or more complicated structures, you may want to suggest a few starting points.

DAY 2

EXPLAIN (Slides 10-16)

Overview: Students will apply what they have learned to a problem scenario in which they have to create a proposal for a new building design. Using their knowledge of perimeter, surface area and volume, they will begin to create a building that fits into the space provided. Students must create a scaled 2D blueprint of their design that explains their intentions for the building.

Slide 10

1. Begin class by telling your students that their help is needed in a fictional situation: The old building down the block is being torn down next month. In its place will be an empty lot, and the city is taking proposals on what should go there. Your job will be to design and propose a new building that could go in its place. To do this, [Insert your community name] City Council is asking that all proposals include a 2D and 3D representation of the design that demonstrates to scale what your proposed building would look like and how it would fit in the available space.
2. Divide the class into groups of 3-4 students. Each group will work together to complete a proposal for city council.
3. Explain that there are a variety of professions that collaborate to plan for, design and construct community buildings. Pass out one Career Card to each student and explain that for the rest of the lesson, they will pretend

that they actually have this profession. While all students in the group will have to work together and split every task, students should keep their "career" in the back of their mind and consider how a person in this job would approach the task at hand.

Slide 11

1. Now that student groups have their careers and a job to complete, it's time to get to work! To kick off, encourage groups to work together to brainstorm: What basic information would they need from the city in order to develop a building proposal?
2. After students have a chance to share their ideas, explain that the city council provided the following information (Click once to project the design specifications):
   - Size of lot: 200,000 square feet
   - Shape of lot: rectangle
   - Perimeter of lot: 1800 feet
   - Dimensions: The city hasn't been able to measure this yet, but we have been told the length is 100 feet longer than the width.
   - Height requirements/restrictions: None
   - Additional considerations: Buildings that consider the environment and the surrounding community will be given priority review.

Slide 12

1. Pose to the class: How can we use algebra and our knowledge of perimeter to figure out the dimensions of the lot without waiting for the city to measure it?
2. Direct student groups to use the information provided to determine the dimensions of the lot.
3. After students have had a chance to work through the problem, click once to reveal the rectangle with algebraic dimensions based on the information provided.
4. Click a second time to reveal the perimeter equation using these variables:
   - $1800 = 2 [x + (x + 100)]$
   - $1800 = 2 (x + x + 100)$
   - $1800 = 2 (2x + 100)$
   - $1800 = 4x + 200$
   - $1600 = 4x$
5. Click a third time to reveal the answer: $x = 400$. Once x is known, we know that the lot's width = 400 feet and the lot's length = 500 feet.

Slide 13

1. Reread the students' job, as presented on the slide. Explain that now that the lot's dimensions are known, the first important task is to develop a blueprint (or drawing) to scale.
2. Ask: What does "to scale" mean? Click once to reveal the following definition:
   - In a to-scale drawing, every part of the drawing is smaller or larger than the original by a certain ratio.
3. Ask students if they know what "ratio" is. Click a second time to load the ratio definition, and explain ratio as a way to compare two numbers of the same kind or two things of the same type. Work with your class to fill out the following two ratio examples:
   - The class ratio of girls to boys is: ___: ___
   - The ratio of the teacher's height (in inches) to one student's height is ___:___

4. Explain that you always simplify the ratio as much as possible, just as you simplify fractions. Simplify the ratios above if needed.

Slide 14

1. Bring the discussion back to the original task, which asks for the blueprint to be "to scale." Ask: How do you think ratios are connected to scale drawings?

2. Click the slide once, and lead students toward the following explanation:
   - Ratios are used to tell us how much smaller or larger the drawing is as related to the object in real life.
   - A drawing with a scale of 1:10 means that anything drawn at 1 unit actually has a size of 10 units in the real world. This means that the drawing is 10x smaller than the actual object.
   - Use the graph paper on the screen to visually explain that an object that is 1 square long in the drawing would actually be 10 squares long in real life.
   - A drawing with a scale of 10:1 would mean the reverse. In other words, the image is 10x larger than the actual object. If it was being drawn on the graph paper on the screen, it would be the size of 10 squares but would actually only be 1 square in real life.

3. Ask students:
   - What scale might we use to enlarge a picture of an ant so we can label its parts?
     - Click the slide to show a visual.
     - Answer: 10:1 or larger
   - What scale might we use to create a model of your bedroom? Use this question as a time to explain that ratios do not have to be in increments of 10. Ratios could be 100:1 or 1:40 or 1:16. However, the ratio should always have "1" on one side of it, to show how one real-life unit is represented.
     - Bedroom answer: 1:30 or smaller

4. Wrap up this slide by asking student groups to consider: Why are scale drawings important? Why should they consider scale when drawing a model or creating a building design?

Slide 15

1. Distribute one Blueprint Design student capture sheet to each group, review the instructions, and let students get to work. As students are working, provide help and assistance as needed. Instruct groups who finish to share their design with you for review.

   Note: This handout includes a volume challenge in the very last step. It may be helpful to designate which groups, if any, should try to complete this challenge.

Slide 16

1. When the blueprints are complete, pair each group with another group, and instruct students to share their blueprints and ideas with each other in preparation for moving towards the building process.

2. Encourage groups to ask each other questions that their "careers" would be concerned with, such as:
   - Are you able to read and fully understand the blueprint?
   - Are any dimensions missing or has anything been overlooked that needs to be addressed before the building begins?

3. Rotate throughout the classroom as the groups are sharing. Before students move on to the building process, make sure you have reviewed and approved each group's design.

DAY 3

ELABORATE, (Slides 17-19)

Overview: Once their 2D blueprint has been approved, students will brainstorm how to create a 3D model of their design. They will ultimately construct a 3D model of their building that remains to scale, and they must prove that it fits within the space constraints. For an additional challenge, students may incorporate other design characteristics (building design elements, landscaping, etc.) as long as the model continues to be to scale.

Slide 17

1. Now that the blueprint is complete, it's time to create the 3D to-scale model. Ask students: Based on the work they have completed so far, what would be the best way to create a 3D model that is to scale?
2. Help lead them to the answer of creating a net that illustrates all sides of their building to scale on graph paper. From there, they can attach the graph paper to cardstock or poster board and construct their building. Remind students that a building usually consists of more than one 3D shape!
3. Distribute the 3D Construction student capture sheet to each group. Review the directions and show students where they can find the graph paper, cardstock or poster board, crayons or markers, glue, scissors and tape.

Slide 18

1. Project the image and reminders on this slide as students work together to build their model. Rotate throughout the classroom and help as needed as students build.

Slide 19

Note: You may flip forward to this slide if there are students who are moving through the build process quickly, or if there are groups you wish to provide with an additional challenge. As is described on this slide, you may encourage these groups to:

1. Create more of the building's internal facilities (structures, building features, etc.) within the space constraints.
2. Design a communal green space outside the building that the community could use. Students could research elements to include in this outdoor space, including native plants and animals, while continuing to take the space constraints into consideration.

DAY 4

EVALUATE, (Slides 20-22)

Overview: If time allows, students can be led through mock city council presentations in which they present their models to the "council" (their class members). If time does not allow for this step, you will be able to evaluate student work based on the blueprints and 3D models that they have already created.

Slide 20

1. Once students have completed both their blueprint and their 3D model, it's time to present their ideas and try to convince the city council that their proposal should be selected to fill the empty lot!
2. Pass out the City Council Presentation Prep student capture sheet to each group and review the instructions. Answer any questions and then allow groups time to prepare their presentations.

Note: For an added challenge, you may require cost analysis as an additional presentation criterion for some or all students.

Slide 21

1. This slide provides a professional backdrop for students to use during their presentations. Once students have finished putting their proposals together, it's time to present!
2. Remind students who are presenting to act as if they are addressing the [Insert your city/town name] City Council. Ask them to do their best to make eye contact and speak clearly.
3. Tell students that if they are not presenting, they should pretend they are city council members who are determining the fate of an important city development. As such, they should behave respectfully and listen fully and they may ask relevant questions at the end of each presentation as needed.
4. Remember to end with a round of applause for all presentations!

Slide 22

Note: This slide gives you the option of if, and or how you declare a winner. If you would not like to select a winning team, then you may end this activity with the round of applause for all presentations on Slide 21. If you would like to select a class winner, below are a few options on how to do so:

1. Have your class (as they continue to pretend to be city council members) vote anonymously on a winner.
2. Display the projects in your school and encourage the student body and/or teachers to vote on their favorite design.
3. Assume the role of head city council member and select the winner yourself.

Optional Extension Activities

To continue to build on the concept of spatial awareness with your class, consider the following extension activities:

1. Extension #1: Vertices
   - Using their 3D model, students can examine the concept of vertices, faces and edges. In particular, students can explore Euler's Formula, which states that F (Faces) + V (Vertices) – E (Edges) = 2.
2. Extension #2: Cross Sections
   - To study cross sections (which is the view you get when you cut through an object), students can begin by looking at cross sections of basic 3D shapes. They can then move on to create cross sections of their building for the construction crew to use during the building process.

COMMON CORE MATH STANDARDS ADDRESSED

Sixth Grade:

- CCSS.MATH.CONTENT.6.RP.A.1
  Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities.
- CCSS.MATH.CONTENT.6.G.A.4
  Represent three-dimensional figures using nets made up of rectangles and triangles, and use the nets to find the surface area of these figures. Apply these techniques in the context of solving real-world and mathematical problems.
- CCSS.MATH.CONTENT.6.EE.A.2.C
  Evaluate expressions at specific values of their variables. Include expressions that arise from formulas used in real-world problems. Perform arithmetic operations, including those involving whole-number exponents, in the conventional order when there are no parentheses to specify a particular order (Order of Operations).
- CCSS.MATH.CONTENT.6.EE.A.3
  Apply the properties of operations to generate equivalent expressions.

Seventh Grade:

- CCSS.MATH.CONTENT.7.RP.A.2
  Recognize and represent proportional relationships between quantities.

- CCSS.MATH.CONTENT.7.G.A.1
  Solve problems involving scale drawings of geometric figures, including computing actual lengths and areas from a scale drawing and reproducing a scale drawing at a different scale.

- CCSS.MATH.CONTENT.7.G.B.
  Solve real-world and mathematical problems involving area, volume and surface area of two- and three-dimensional objects composed of triangles, quadrilaterals, polygons, cubes, and right prisms

- CCSS.MATH.CONTENT.7.EE.B.4
  Use variables to represent quantities in a real-world or mathematical problem, and construct simple equations and inequalities to solve problems by reasoning about the quantities.

Eighth Grade:

- CCSS.MATH.CONTENT.8.G.C.9
  Know the formulas for the volumes of cones, cylinders, and spheres and use them to solve real-world and mathematical problems.

COMMON CORE ELA STANDARDS ADDRESSED

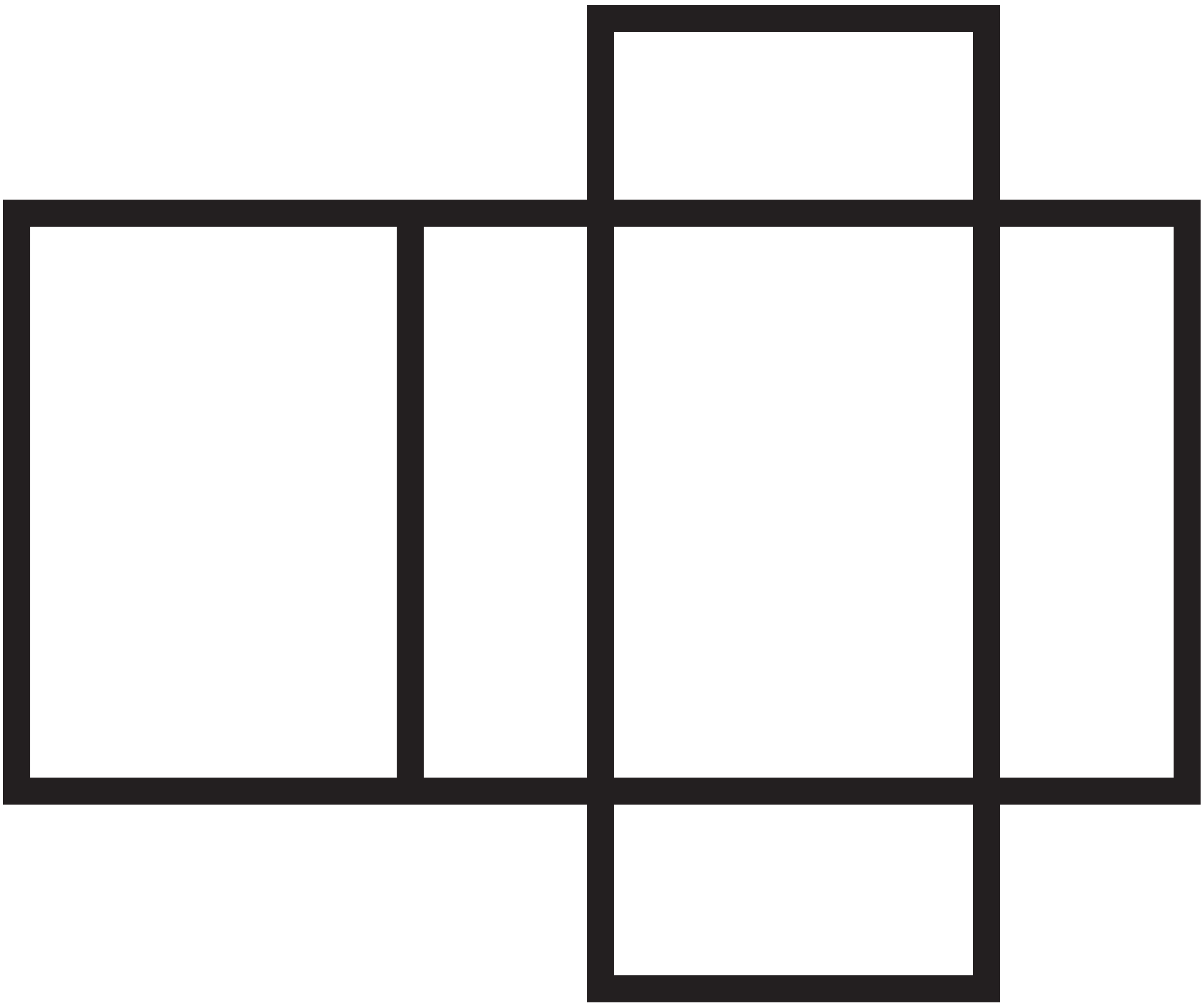
- CCSS.ELA-LITERACY.CCRA.SL.4
  Present information, findings, and supporting evidence such that listeners can follow the line of reasoning and the organization, development, and style are appropriate to task, purpose, and audience.

- CCSS.ELA-LITERACY.CCRA.SL.5
  Make strategic use of digital media and visual displays of data to express information and enhance understanding of presentations.

- CCSS.ELA-LITERACY.CCRA.SL.6
  Adapt speech to a variety of contexts and communicative tasks, demonstrating command of formal English when indicated or appropriate.

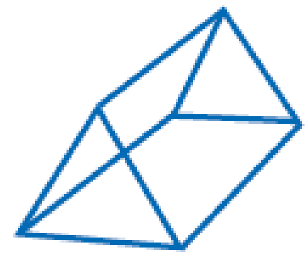
TEACHER HANDOUT: RECTANGULAR PRISM NET

Directions: Cut out the net below so students can visualize and manipulate a geometry net. If you think your students would benefit from manipulating this themselves, make several copies of this handout.v



GEOMETRY NETS STUDENT CAPTURE SHEET

Triangular Prism



Step 1: Use the variables below to label the triangular prism:

b = base

h = height of the triangle

s1, s2, and s3 = the length of each side of the triangle

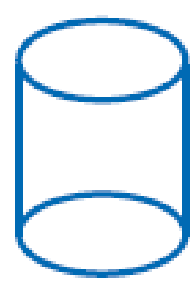
l = the length of the rectangles

Note: One side of the triangle will be labeled both "b" and "s3"!

Step 2: Net the triangular prism in the space provided below. (In other words, flatten this 3D shape into its 2D shapes!) When you net it, be sure to keep each of 2D shapes labeled with the variables above.

Step 3: Using what you know about the area of triangles and rectangles, create a formula that you could use to calculate the triangular prism's total surface area. Try to make the formula as simple as possible.

Cylinder



Step 1: Use the variables below to label the cylinder:

h = height of the cylinder

r = radius of the circle

Step 2: Net the cylinder in the space provided below. (In other words, flatten this 3D shape into its 2D shapes!) When you net it, be sure to keep each of 2D shapes labeled with the variables above.

Step 3: Create a formula that you could use to calculate the cylinder's total surface area. Try to make the formula as simple as possible.

3D HUNT STUDENT CAPTURE SHEET

Mission Details: Find one 3D structure in your school/community. It can be ANYTHING: a piece of furniture, a pillar or column, a garbage bin. The possibilities are endless! Following the directions below, you'll then work with your partner to calculate this object's surface area.

Step 1: Search for a 3D object. Once you've found one, sketch it below.

Step 2: Think about what dimensions you'll need to calculate the surface area of this object. When in doubt, it's better to measure too much than not enough! Use your ruler or measuring tape to complete these measurements and label them on your sketch.

Step 3: Use the space below to create a net of your object. After you break down your 3D object into its flat 2D shapes, be sure to label its dimensions.

Step 4: Find the area of each 2D shape in order to calculate your object's total surface area. Record all work below and then circle the total surface area.

Challenge: What is the volume of your object?

CAREER CARDS STUDENT CAPTURE SHEET

Directions: Cut out the cards below and distribute one to each student.

Civil Engineer

You help with building design and also serve as the manager in the construction of public works, such as roads, buildings, bridges, tunnels, etc.

Architect

You take the lead role in designing the building, including interior and exterior details as well as design specifications and measurements.

Architectural Drafter

You turn the architect's designs into a detailed technical drawing of the building that construction workers will refer to as they build.

Planning Surveyor

You help to oversee the development of building projects in towns and cities, including determining whether building plans are doable and considering the economic and environmental effects of a project idea.

Building Inspector

You will review plans and completed builds to make sure the structure meets building codes, local laws, zoning regulations, etc.

Urban Planner

You create plans for land use as you consider how to best develop positive, functioning communities.

BLUEPRINT DESIGN STUDENT CAPTURE SHEET

Lot Specifications

Size of lot: 200,000 square feet

Shape of lot: Rectangle

Perimeter of lot: 1800 feet

Width = 400 feet

Length = 500 feet

Directions: All construction projects begin with a blueprint, which is a scaled drawing of the building's design. Your building design group will be creating a 2D blueprint of your building on the grid paper below.

Step 1: Review the size of the lot and examine the graph paper below. What scale will you use for your design?

Scale: ______________________________

Step 2: Using this scale, create a 2D sketch of your proposed building on the grid below. The grid represents the entire empty lot, so you will want to consider how much outdoor space is around your building. You may include landscaping and other outdoor elements as long as they are drawn to scale!

<u>Remember:</u> Special consideration will be given to buildings that consider the environment and surrounding community, so keep this in mind as you design.

Step 3: Use the space below to calculate your building's surface area. Make sure that any dimensions needed to calculate surface area are also labeled on your blueprint.

Tip: It will be helpful to separate your building into its various 3D shapes, create nets to calculate each shape's surface area and then add them together to calculate your building's total surface area!

Total Surface Area: ______________________

****Challenge:** In order for the city to estimate your building's heating and cooling costs, calculate the volume of your building below:

Volume: _________________________

3D CONSTRUCTION STUDENT CAPTURE SHEET

Instructions: Work with your group to follow the steps below and create a to-scale 3D model of your blueprint design.

1. Carefully create a to-scale net of your building on graph paper. Use your Blueprint Design student capture sheet as your guide!
2. Once you have the scaled net complete, consider what you want your building to actually look like! Work with your team to discuss and draw the design elements that will make your building unique, such as doors, windows, signs, colors, etc.
3. When you are done with your design, cut out the outline of each two-dimensional shape. Glue it to the cardstock/ poster board and cut it out again.
4. Now use tape and/or glue to attach your pieces together and construct your 3D model!

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CITY COUNCIL PRESENTATION PREP STUDENT CAPTURE SHEET

Directions:

Your planning is complete, but you still have one more important step: You must now convince the city council that they should choose YOUR design to fill the empty lot! Work with your group to follow the steps below to put together your presentation.

Step 1:
How would you introduce your building in a way that captures the attention of the city council? Write a one or two sentence introduction below:

Step 2:
How will the building fit into the space constraints of the lot? Explain in a few sentences. Remember to refer directly to your blueprint and/or model during your explanation!

Step 3:
What is unique and/or special about the design of your building? Again, remember to refer directly to your model to help prove your point!

Step 4:
How will your building benefit the community?

Step 5:
How can you wrap up your presentation in a persuasive way? End with a few sentences to convince the city council why they should select your building over all other proposals.

Step 6
Finally, compile Steps 1 – 5 into a two-to-three minute presentation. Decide who will say each section and make sure each group member has a part to say. Then practice your presentation, making sure to speak clearly, loudly and persuasively!