Mathematics: The Language of STEM

Geometrocity: Building A City With Math

Could You Be An Architect?

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CONTENT AND TASK DECISIONS

Grade Level(s): Fifth/Sixth

Time Frame: 3-4 Hours

Description of the Task:
Students will be given the challenge of designing their own city using three dimensional shapes (prisms and cylinders) made from two dimensional objects (nets). Students will find the surface area and volume of the three dimensional shapes used to build their city.

Indiana Mathematics Content Standards:

- 5.M.4: Find the volume of a right rectangular prism with whole-number side lengths by packing it with unit cubes, and show that the volume is the same as would be found by multiplying the edge lengths or multiplying the height by the area of the base.
- 5.M.5: Apply the formulas $V = l \times w \times h$ and $V = B \times h$ for right rectangular prisms to find volumes of right rectangular prisms with whole number edge lengths to solve real-world problems and other mathematical problems.
- 5.M.6: Find volumes of solid figures composed of two non-overlapping right rectangular prisms by adding the volumes of the non-overlapping parts, applying this technique to solve real-world problems and other mathematical problems.
- 6.GM.6: Construct right rectangular prisms from nets and use the nets to compute the surface area of prisms; apply this technique to solve real-world and other mathematical problems

Indiana Mathematics Process Standards:
PS.1: Make sense of problems and preserve in solving them
PS.4: Model with mathematics
PS.5: Use appropriate tools strategically
PS.6: Attend to precision

Mathematics Content Goals:

- Create a three dimensional city made from two dimensional nets
- Find the surface area of three dimensional shapes using nets
- Find the volume of three dimensional shapes
- Apply the formula to find the volume of three dimensional shapes
- Find the volume of two non-overlapping right rectangular prisms by adding the volumes of the parts
- Solve real world problems involving surface area and volume of three dimensional shapes

Language Objectives:

- **Listening and Reading:** Students will be able to follow the instructions that were read aloud, provided on the board and provided on paper.
- **Speaking:** Students will be able to describe the task in their own words to another student. Students will be able to use academic language to share their design, thoughts, struggles, and successes with their classmates.

Materials:
Geometrocity: Building A City With Math Information, graph paper, scissors, tape, colored pencils or crayons, unifix cubes, Youtube video
https://www.youtube.com/watch?v=F7hIF-2lMTs: **Introduction of surface area and volume**
https://www.youtube.com/watch?v=2Hw12xW5ZZ8: Do you want to be an Architect?
http://www.senteacher.org/worksheet/12/NetsPolyhedra.html: 3-D Net Models for building of city

THE LESSON
Before:
Activate prior knowledge:

- Show YouTube video introducing surface area and volume:

https://www.youtube.com/watch?v=F7hIF-2lMTs

- What is a two dimensional shape?
- What is a three dimensional shape?
- What is a net?
- What is surface area?
- Can a net be used to find surface area?
- What is a real life example of why we would need to find the surface area of a shape?
- What is a right rectangular prism?
- What is volume?
- How do we find volume of a three dimensional shape?
- Have the students cut out the rectangular prism net. While they are cutting, explain, "This graph is called a net. This net is an unfolded rectangular prism. When it is refolded, we can fill it up to show volume. The rectangular prisms and nets in this lesson are measured in centimeters." Have the students fold the figures into a rectangular prism.
- Say: "Looking at your rectangular prism, what can you tell me about it?" (It has 6 faces (sides). It is constructed of rectangles. The opposite faces are the same size.)
- Have students discover the surface area of the shape by using the net. Have students open their prism and find the volume using unifix cubes.
- Can you combine two shapes to make a larger shape?
- How would you find the surface area and volume of that shape?

Be sure the problem is understood:
Pass out: Geometrocity: Building A City With Math

- Ask them to share with a partner and answer this question: Explain the task in your own words.
- Why would we need to know the surface area of buildings within a city?
- Can you think of a reason we would need to know volume of buildings within a city?
- Show YouTube video about being an architect:

https://www.youtube.com/watch?v=2Hw12xW5ZZ8

Establish clear expectations:

- Explain that students will be working with a partner.
- A planning guide must be approved before building of city begins.
- Your city must be named.
- A scale model must accompany each city.
- Each group must have twelve buildings with different dimensions.
- Each group must have a thirteenth building designed together that has two shapes connected.
- Each person in the group is responsible for six buildings and calculation sheets for each building.
- Each group will find the cost of building materials for their buildings. (Exterior paint or brick, and roofing.)
- Each group will prepare a 5-10 minute presentation to share with another group.

During:

Let go: While students are beginning their design, the teacher is moving around the room encouraging productive struggle and monitoring students/groups who are struggling.

Listen actively: provide appropriate support

- Observe that each child/group understands the challenge.
- Monitor students to be sure they are able to begin the challenge

Provide appropriate support:

Ask guiding questions to listen for content understanding. Questions could include:

- What are you trying to do?
- What information do you need here?
- What three dimensional shapes are you including in your city?

Provide worthwhile extensions: If students finish their exterior design early they can choose the following challenge options (If you have high ability students in your classroom, I would require other three dimensional shapes to be used also.) :

- Add a shape not required originally to their city and give the volume and surface area of that shape. Students would need to justify how they know the volume of the chosen shape is correct.

After:

Promote a mathematical community of learners:

- In groups of four students will share their city design.
- Ask: What did you notice that was different about what your peers did with their design?
- What did you notice was the same?
- How did other groups meet the challenge differently than you?

Listen actively without evaluation:

- How did you come up with your city design?
- What did you learn from your discussion with your partner?
- What would you change if you designed another city?

Make connections:

- What math have you worked on before that helped you make sense of this task?

- Did beginning with simple shape help you with this task? Why or why not?
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Summarize main ideas:

- Review vocabulary: net, polyhedron, face, edge, vertex, surface area, net, volume, right rectangular prism
- Ask the question: Would you like to be an architect?

ASSESSMENT

Observe:

- Students will present their city to other groups.
- Students will complete a fact sheet for each building.
- Each group will have an attractive city sample that is aesthetically pleasing and includes the name of the city. Each person will explain the six cities they created.

Ask:

- What did you learn by completing this task?
- Do you think you could find the volume and surface area of all rectangular prisms?
- Could you teach someone who does not know how to find the surface area of a rectangular prism? Could you teach volume?
- Could you give a real world example of why you might need to be able to find surface area and volume of rectangular prisms?

Geometrocity: Building A City With Math

You are now hired as an architect to be on a team that will be designing a new city. The city needs to be attractive to visitors, but also cost effective. Over the next few days, you will work with 1 other person to build a city. It can be completely fictional or modeled after a real city. The buildings in this city will be comprised of three-dimensional objects (prisms) made from two-dimensional objects (nets). In the process, you will use the formulas we learned for finding surface area and volume of these figures to determine how much it will cost to build your city. With your partner, you will decide which buildings you want to include in your city. You will then choose a scale to use for your model and start drawing up a design for your city. You will construct your buildings by drawing nets and cutting them out to fold into geometric solids. Each building can be comprised of a single geometric solid or multiple solids put together.
Throughout your construction process, you will be designing, measuring, and collecting data about your buildings so that you can eventually calculate the final cost of each building and ultimately the cost to build your city. You will also be researching the cost of materials and making decisions about what materials should be used for which buildings for quality and cost efficiency.
Once you have built your city and completed your calculation sheets to determine cost, you will be presenting the your final product to the class.

1. Complete the Planning Guide Worksheet)
    - With your partner, decide what type of city you would like to design, which buildings you would like to include, and what you want your buildings to look like. Your final project must have a minimum of 12 buildings with different dimensions. Each person in your group is responsible for 6 buildings. Your building must be comprised of prisms and cylinders. All buildings MUST be school appropriate.
    - Each group must have a thirteenth building designed together that has two shapes connected.
    - Choose a name for your city - be creative!
    - Determine what materials you will need/want to build your city. Construction paper, tape, glue, scissors, markers, rulers, and cardboard for the base of your city will be provided. If you need/want other supplies, see the teacher or bring them with you to class.
    - Determine how many calculation sheets you will need, you will need one sheet for each solid you plan to use in your city.
    - When you have completed this sheet, have it approved by the teacher. Then you may move to step 2.
2. Begin Construction
    - Obviously, you cannot construct life size buildings, so choose a scale that would be <u>reasonable</u> for the city/buildings you have chosen to design. Example: 1 inch = 8 feet. Please note that each group will (and should) use a different scale based on the buildings they choose to design. The scale should be consistent throughout the project and should be included somewhere on the base of your city (like you would see on a map).
    - Draw nets and cut them out of construction paper - keep in mind your scale. I would recommend drawing and measuring your net on graph paper first (like we did in class) or

using a ruler/protractor/compass to measure and draw directly on the construction paper. See the following link: http://www.senteacher.org/worksheet/12/NetsPolyhedra.html. DO NOT print or trace the samples in the links. Use them to help you draw a net that will fit your scale.
- IMPORTANT: Fill in the "Measurement" section of your calculation sheet for each solid as you create it. It is much easier to measure/record the dimensions as you go than to try to measure them after they have been attached to the final project.
- Fold your nets into buildings and glue or tape them together. Start decorating your solids so they look like buildings. If your building consists of more than one solid, attach these pieces together.
- When all group members have completed their buildings, you should begin decorating your base and attaching your buildings. Don't forget to label and decorate all of your buildings. You also must include your scale and the name of your city somewhere on your final project.

3. Calculation Sheets (click below for link if you have lost your paper copy)
    - You should have completed the top part of the calculation sheet for each building you made during the construction phase. You should now use those measurements to complete the remainder of the calculations on the sheet.
    - Please note that you will not necessarily cover the entire surface area with paint/siding/brick or roofing material. For example, you will not put bricks on the bottom of the building that is sitting on the ground nor will you roof and paint the same side.
    - Calculate the costs for each building and record in the corresponding spot on each sheet.
4. Building Materials Cost
    - You will need to find the cost of paint or brick and roofing materials.
    - Go to Menards or Lowes website to find materials cost or do your own research to determine the cost per square foot.
    - Turn in calculation sheets when finished.
5. Final Presentation

    - Group Members should prepare a 5-10 minute presentation to share with another group. Presentation should include the name of the city and an explanation of each building and why it was chosen, obviously using your final project as a prop. The presentation should explain the scale and why it was chosen. It should touch on what materials were used, the cost per material, and the final cost of the city.
    - Each group member is responsible for speaking about the 6 buildings that they were responsible for designing.
    - You may use other visuals, such as PowerPoint or the document camera.

Prism – (Please specify what TYPE of prism this is!!)

Type of Prism: _____

Name of Building:_____

Measurements

length of base = _____ width of base = _____

height = _____

Surface Area of Prism

Formula = _____

Plug - In = _____

Answer = _____

Surface Area of Prism to be roofed (circle one) shingles metal

Formula = _____

Plug - In = _____

Answer = _____

Volume of Prism

Formula = _____

Plug - In = _____

Answer = _____

Cost for Building

Cost of paint:

Cost of roofing material: