**Subject area/course**: Mathematics/Pre-Calculus

**Grade level/band**: 10-12

**Task source**: Summit Public Schools

**Cube It - Patterns, Polynomials, and Modeling**

**TEACHER'S GUIDE**

1. **Task overview**:

Students will design and analyze an object made of regular shapes of their choosing. They will specifically analyze how changing the object's dimensions based on a set of self-created equations affects the properties of that object. They will then produce a poster to display their model and the justification for their object's growth.

1. **Aligned standards:**
2. **Primary Common Core State Standards**

#### [CCSS.MATH.PRACTICE.MP1](http://www.corestandards.org/Math/Practice/MP1/) Make sense of problems and persevere in solving them.

#### [CCSS.MATH.PRACTICE.MP2](http://www.corestandards.org/Math/Practice/MP2/) Reason abstractly and quantitatively.

#### [CCSS.MATH.PRACTICE.MP4](http://www.corestandards.org/Math/Practice/MP4/) Model with mathematics.

[CCSS.MATH.CONTENT.HSA.CED.A.2](http://www.corestandards.org/Math/Content/HSA/CED/A/2/) Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales.

[CCSS.MATH.CONTENT.HSF.BF.A.1](http://www.corestandards.org/Math/Content/HSF/BF/A/1/) Write a function that describes a relationship between two quantities.

[CCSS.MATH.CONTENT.HSG.GMD.A.3](http://www.corestandards.org/Math/Content/HSG/GMD/A/3/) Use volume formulas for cylinders, pyramids, cones, and spheres to solve problems

[CCSS.MATH.CONTENT.HSG.MG.A.1](http://www.corestandards.org/Math/Content/HSG/MG/A/1/) Use geometric shapes, their measures, and their properties to describe objects (e.g., modeling a tree trunk or a human torso as a cylinder).

1. **Secondary Common Core State Standards**

#### [CCSS.MATH.PRACTICE.MP6](http://www.corestandards.org/Math/Practice/MP6/)Attend to precision.

#### [CCSS.MATH.PRACTICE.MP7](http://www.corestandards.org/Math/Practice/MP7/)Look for and make use of structure.

[CCSS.MATH.CONTENT.HSF.IF.A.2](http://www.corestandards.org/Math/Content/HSF/IF/A/2/) Use function notation, evaluate functions for inputs in their domains, and interpret statements that use function notation in terms of a context.

1. **Critical abilities**

Experimentation and Evaluation**:** Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text. Evaluate hypotheses, data, analysis, and conclusions, verifying the data when possible and corroborating or challenging conclusions with other sources of information.

Communication in Many Forms**:** Use oral and written communication skills to learn, evaluate, and express ideas for a range of tasks, purposes, and audiences. Develop and strengthen writing as needed by planning, revising, editing, and rewriting while considering the audience.

Modeling, Design, and Problem Solving:Use quantitative reasoning to solve problems arising in everyday life, society, and the workplace, e.g., to plan a school event or analyze a problem in the community, to solve a design problem or to examine relationships among quantities of interest. Plan solution pathways, monitoring and evaluating progress and changing course if necessary, and find relevant external resources, such as experimental and modeling tools, to solve problems. Interpret and evaluate results in the context of the situation and improve the model or design as needed.

1. **Time/schedule requirements:**

This task will take approximately 2 weeks, depending on your school schedule and other activities.

1. **Materials/resources:**

* Item A. Cube It: Student Directions
* Item B. Intro: Design Worksheet
* Item C. Intro: Painted Shape Worksheet
* Item D. Phase 1 Design Worksheet
* Item E. Phase 2 Analyze Worksheet
* Item F. Phase 3 Reflection Worksheet

1. **Prior knowledge:**

* Geometric formulas
* Functions

1. **Connection to curriculum:**

None listed.

1. **Teacher instructions:**

**Introduction**

1. Cube-It Entry Event - Identifying Patterns and Relationships (1)

**Objective -** To introduce students to the idea of patterns and relationships between growth and set some standard understandings of how to represent the information.

**Activity -** Students will complete the 2 worksheets included in the Entry Event (Design Worksheet and Painted Shape Worksheet).

**Assessment -** Students will have both worksheets filled out correctly.

**PHASE 1: Design**

1. Decide on an object

**Objective -** To let students have the freedom of choosing an object of their own. The decision also requires students to think of what types of objects exist where their dimensions and properties are important to us.

**Activity -** Class will go over the “Intro- Picking an object” PowerPoint, then individually choose an object.

**Assessment -** Students will have an object chosen where analyzing its growth is important. (If a student chooses something simple, like a rectangular prism, make them think of an object in real life that matches the shape and is important, such as a packing box.)

1. Break your object into regular shapes

**Objective -** To see how complex shapes can be broken into multiple smaller regular shapes.

**Activity -** Students will take their object and break it into regular shapes. Make a list of the different regular shapes that make up their object.

**Assessment -** Students will have a list of regular shapes that make up their object.

1. Decide on properties to observe

**Objective -** To have students think about what properties might be important for their object.

**Activity -** Students will choose 2 or more properties to focus on for their object in addition to Volume and Surface area. For example, a student looking at a packing box might want to specifically look at the ratio between surface area and volume. A student looking at a human being might want to specifically look at the surface area from above to analyze exposure to the sun.

**Assessment -** Students will have their 4 properties listed. Volume, Surface Area, and two others of their choice.

1. Decide on starting dimensions for the individual regular shapes

**Objective -** To have students think about what are realistic dimensions of an object.

**Activity -** Students will figure out the required dimensions for each of their regular shapes. Then determine starting dimensions for each shape. Remember to remind them about the importance of units.

**Assessment -** Students will have a list of their regular shapes’ dimensions and a starting dimension for each that gives their object a normal starting size and shape.

**PHASE 2: Analyze**

1. Write growth formulas for each individual dimension

**Objective -** To analyze the formation of formulas and how different formulas will produce different outputs.

**Activity -** Students will look at different formulas and determine which ones to use for each of their dimensions. This will be important because it will determine the dimension and shape of the object as they grow. Obviously, something like an animal will grow faster in some directions than in others.

**Assessment -** Students will have formulas for all of their dimensions.

1. Calculate dimensions for individual regular shapes at each of the other 3 sizes

**Objective -** To practice the use of formulas.

**Activity -** Students will plug numbers into their formulas and figure out the dimensions for each of the different growth stages of their object.

**Assessment -** Students will have tables to organize the Dimensions of each shape for each growth stage.

1. Calculate the properties for the entire object at each size

**Objective -** To practice the use of formulas.

**Activity -** Students will determine the properties of the objects using either direct formulas that already exist (i.e.: volume for a sphere). For the property of the whole object, it will require them to find the properties of each individual shape and then add them together.

**Assessment -** Students will have tables organizing each property at each growth stage.

1. Draw and label your object at the 4 different dimensions

**Objective -** To practice modeling and precision.

**Activity -** Students will draw out their object at all 4 growth stages. This will require them to pay close attention to the units they used, and make sure that their object is drawn correctly according to the proportions. They may need to be shown how to properly draw to scale.

**Assessment -** Students will have 4 drawings, each with the correct proportions (scale and units) and labeled.

1. Write formulas for properties

**Objective -** To build skills on identifying formulas from a data set.

**Activity -** Students will analyze their properties’ data and create formulas for each individual property.

**Assessment -** A formula for each of the four properties.

**PHASE 3: Reflect**

1. Answer reflection questions

**Objective -** To provide a space to make note and understand how the different formulas affected the object’s growth.

**Activity -** Students will answer the questions on the Phase 3: Reflection worksheet.

**Assessment -** Questions properly answered.

1. Create a poster to present knowledge and skills learned and practiced

**Objective -** To practice modeling and show the connection between each of the different parts of the object, its shapes and the formulas that govern them.

**Activity -** Students will take their object, its dimensions, and its properties and display them on a poster for the rest of the class to see.

**Assessment -** A poster with the following.

* Title and Objective
* 4 Drawings: One for each of the different stages of growth with all important parts labeled
* Tables: tables to organize the data for dimensions and properties
* Written Descriptions: Written explanations to describe the growth of your object
* Analysis of the Objects properties

1. **Student support:**

None listed.

1. **Extensions or variations:**

None listed.

1. **Scoring:**

Student work can be scored using the Summit Public Schools Cube It rubric.