**Unit 6: Investigation 7 (2-3 Days)**

**Size and Shape in the Real World**

***Common Core State Standards:***

G-MG.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).★

G-MG.2. Apply concepts of density based on area and volume in modeling situations (e.g., persons per square mile, BTUs per cubic foot).★

G-MG.3. Apply geometric methods to solve design problems (e.g., designing an object or structure to satisfy physical constraints or minimize cost; working with typographic grid systems based on ratios)

**Overview**

Surface area/volume relationships in biology, modeling problems, etc. This investigation poses a problem for mathematical modeling. It introduces the complexity of working in scale, making decisions about appropriate units, measuring, designing a model built from the solids described earlier in Unit 6, preparing sketches, making calculations of surface area and volume. Students must analyze sketches and prepare sketches of three-dimensional objects. Students must plan their own problem-solving steps and having worked through a scaffolded problem carry out their own well-documented project from beginning to at least a plan for action, if not a completed 3-D printed object. It is suggested that teachers offer the possibility that the most effectively designed object will be printed. 3-D printing is available in many school libraries or technology centers as well as public libraries, office stores such as Staples, and through online resources such as Shapeways.

**Assessment Activities**

**Evidence of Success: What Will Students Be Able to Do?**

* Students will be able to state a problem clearly and plan a step-by-step approach to solving the problem.
* They will be able to document and support their computations.
* They will be able to test their solutions against the original problem and evaluate their solutions.

**Assessment Strategies: How Will They Show What They Know?**

* **Journal Entry 1** asks students to evaluate the pros and cons of different systems of measurement.
* **Exit Slip 6.7** requires students to use metric and convention units in computations involving volume, weight and density.
* **Journal Entry 2** has students evaluate the modeling process.

**Launch Notes**

Rapidly developing changes in the accessibility of 3-D printers is providing opportunities for people to use CAD (computer aided design) programs to design prototype solutions to their own problems and then print them directly to usable objects. This technology has many applications in medicine and industry and other areas. Replacement parts for household appliances can be printed instead of ordered. Parts that are no longer made can be made on site. Currently dentists use office based 3-D grinders to prepare porcelain dental crowns on site while patients wait instead of sending molds to a lab which used to take 2-3 weeks. College students have developed ways to make prosthetic devices that are inexpensive and readily replaceable for growing children. See the two videos below that illustrate the process and outcomes. The first features a middle school student whose father is able to build a hand for his son through information on the Internet. The second features a college student who builds a hand for a much younger child:

<http://www.huffingtonpost.com/2013/11/04/dad-prints-prosthetic-hand-leon-mccarthy_n_4214217.html>

<http://www.cbsnews.com/news/student-makes-3d-printed-prosthetic-hand-for-boy/>

**Teaching Strategies**

In **Activity 6.7.1 Three-Dimensional Modeling: Understanding the Problem** students read the statement of the problem aloud. Working in groups they determine what they will need to do to reach a successful conclusion. They will also discuss how they will evaluate their solution at the end of the problem.

**Group Activity** Have students work in groups throughout this investigation.

**Differentiated Instruction (For Learners Needing More Help)**

Some students may need help extracting the information they need from the story.

**Differentiated Instruction (Enrichment)**

Activity 6.7.4 is open ended and provides students with an opportunity to be as creative as possible.

**Activity 6.7.2 Three-Dimensional Modeling: Working with Scale** addresses the fact that thetechnology will require measurements made in both inches and centimeters. Students will need to decide when and how to make the appropriate conversions. Students will first make their own measurements. These measurements will be adjusted using proportions to close approximations of the real life measurements. The measurements will be used to design a couch in **Activity 6.7.3.**

**Journal Entry 1**

In the United States we typically use the conventional American measuring units of inches and feet, while almost all of the rest of the world uses the metric system of meters and centimeters. Discuss advantages and disadvantages of the two systems. Look for students to describe the differences in computational complexity between decimals and common fractions and the question of which type of ruler is easier to read.

**Activity 6.7.3 Three-Dimensional Modeling: Designing a Model** follows Eleanor’s problem and uncovers a project. The activity then asks students to work in groups to create a design and then implement it on a 3-D printer. If a printer is not available, students may print their net on cards stock and assemble the model or craft one using modeling clay. A number of calculations involving volume, surface area, and density are required along the way.

You may give **Exit Slip 6.7** following **Activity 6.7.3.**

**Journal Entry 2**

Discuss with your classmates what you have done, where you ran into problems and how you overcame the obstacles. Then write a summary of your discussion in your journal. Look for students to point to specific instances where they ran into problems.

**Activity 6.7.4 Creating Individual Models from Start to Finish** is an optional, open ended activity, which may be treated as a performance task. (If this activity is selected, allow for an extra day for this investigation.) Students are aksed to identify another piece of furniture for the doll house – perhaps a bed, a table, a chair, a cabinet. Each student makes a plan to design the object to scale, uses technology to assist in the design and construction of the object, then evaluates the success of the plan. Students document their work at each stage and students present their design process through poster presentations.

**Closure Notes**

Student solutions to this problem (these problems) will be highly individualized. Ideally students will have an opportunity to share their posters through poster talks in the classroom.

**Vocabulary**

CAD computer aided design

density

**Resources and Materials**

Use a 3-D printer if your school has one

Graph paper

Rulers with inches and centimeters