BUILDING A BOAT: GUIDED AND OPEN INQUIRY

Preparing for the 2014 GED® Science Module

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Aluminum Foil Boats

This activity allows students of all levels to participate in a science experimental process, and teaches them the basics of design. Given a set amount of aluminum foil, each student must design and build a boat to hold a minimum of 100 pennies before sinking. Students are then challenged to improve their design to hold as many pennies as possible (two more times minimum).

Standards: SC.912.N1.1, 1.4, 1.6, 1.7. SC.912.P.8, 8.6

Learning Objectives: What will students know and be able to do as a result of this lesson?

- Students will be exposed to the Scientific Method as a result of this hands-on investigation.
- Students will determine how different boat hull configurations provide the best results.
- Students will use physical properties of known materials to deduce via calculations the weight of a penny, and the importance of surface tension.
- Students will conduct independent literature search.
- Students will have a better understanding of Archimedes Principle.

Prior Knowledge: What prior knowledge should students have for this lesson?

Students should know:

- how to use a balance (triple beam or electronic).
- how many significant digits to record for the mass reading from the balance.
- how to calculate average mass.
- how many significant figures to round their average mass answer.
- how to calculate area.
- how to calculate volume.

Materials Needed:

- Aluminum foil
- Ruler
- Pennies
- Scissors
- Triple Beam Balance or Electronic Balance
- Container with freshwater capable of holding 3” deep

Safety Considerations: None

Guiding Questions: What are the guiding questions for this lesson?

Begin the lesson by asking the class to brainstorm the way a boat or ship is able to stay afloat – even with passengers. It is helpful to have each student holding a penny at this point.

Teachers can opt to have the students discuss in small groups or with their "shoulder partner" before having the class discussion/brainstorming session.

Examples of questions to guide the discussion: What factors would affect the buoyancy of a boat? What are some of the physical changes? What are some chemical changes if any?

The teacher will record all given answers where all students can see them (chalkboard, whiteboard, computer projection, etc.).

Ask students to now classify the ideas given into 3 categories. Ideally the students will see there are at least 2 main categories (boat will float because... Or the boat will sink because...). The third category is that the surface area ratio changes. Sometimes the teacher will need to help guide them to this category.

Ask the students to choose which prediction they want to use in their hypothesis (float, sinks, or stay the same) and record it in their Boat Building Journal.

Instructions:

1. If this activity involves many students, you may want to decide on a particular dimension. A good size boat is anything between 4 cm x 4 cm to 15cm x 15 cm.
2. Have the students use as many sheets of aluminum foil as possible to try different designs. Remember, this is their design, and your job is to facilitate.
3. Students must form their boats by hand; no tape or other aids.
4. Once the boats are created, have each student collect the data needed to complete the data table in their “Boat Journal.”
5. Based on pretesting information, such as weight of the boat, surface area of the boat, and volume of the boat, have students predict how many pennies their boat can hold before it sinks.
6. Test the boats in a container with fresh water.
7. Have students predict the outcome if using salt water.

Encourage students to visit a few of the links below for additional information on making aluminum foil boats. Some sites may provide different ideas for creating the best design. Students may decide to surf the web for more information. Beginning sites to show students would be:

eHow - http://www.ehow.com/how_5895045_make-shapes-aluminum-foil-boats.html

PBS Kids: Science Rocks - http://pbskids.org/zoom/activities/sci/boatsafloat.html

Lesson Plan Overview

Introduction: How will the teacher inform students of the intent of the lesson? How will students understand or develop an investigable question?

- After the brainstorming session and having each student make/record a personal hypothesis, the teacher will ask, "how could we test the hypothesis?"
- Students will give various answers and again may need facilitation to get to "We need to get the needed materials and start building the aluminum foil boats.
- The teacher should also talk about the size of the boat-- being that some may be more difficult to build than others.

Investigate: What will the teacher do to give students an opportunity to develop, try, revise, and implement their own methods to gather data?

- The teacher will direct students to collect the data they need as discussed in the introduction. (Try to have different designs as possible, so there is an opportunity for each student to improve his/her the design. I asked the students to build a minimum of three boats. The first goal would be to have the first boat hold 100, then to improve the design.
- Depending on the sample size the class has to work with the teacher can decide how best to gather the data. (I had the student work independently then share the data on a class data sheet.)
- Students will record the mass of a penny, the mass of the boat built, the area of the boat, the volume of the boat, number of pennies it took to sink the boar, in their journal. The data will be display using a table and a graph using Excel. Teacher should point out the use of significant figures and guide students in using them for the data collection.
- Students should be instructed how to use a spread sheet program such as Excel prior to this exercise.

Analyze: How will the teacher help students determine a way to represent, analyze, and interpret the data they collect?

- After the data is collected into a table into their notebook, the teacher leads a discussion about how learning about Archimedes Principle is vital in boat hull construction. Have students talk through the 'rules' for graphing (what variables on what axis, scientific title, taking up the entire graph grid given, connecting the data points, etc.) then instruct them to graph their data and discuss whether or not the data support the hypothesis they made.

Side note: After class the teacher can compile their individual data and enter the data into an excel spreadsheet, and use it to make a graph to project so they can compare results

Closure: What will the teacher do to bring the lesson to a close? How will the students make sense of the investigation?

- There is a big difference in hull manufacturing processes. Teachers should have a class discussion to ensure students realize this, and facilitate them through the reason why this might be. (price of materials, density of materials). Many times a student will research on the internet for a 'right' answer as they are not confident on how to complete the assignment. Reinforce that this was not a reproduction assignment but an engineer assignment.
- Teachers may select different metals, as they have different masses based on their properties.
- Students will complete the assignment by writing a complete laboratory report. Instructions for this report are included in a different hand out.

Lab Report Instructions

Part 1. Abstract. This is for you to summarize your findings, as well as to introduce what you are learning about. You need to write this last after you make sense of your results. This is 100 to 200 words. Example: you went to a movie, and now you are telling someone about the movie. This means you just give the plot and the ending.

Part 2. Introduction. This is not the same as the abstract. This is for you to introduce the project and what you will be learning about. You will also provide prior knowledge that is the foundation of your investigation. It will take a paragraph or so.

Part 3. Hypothesis. This is where you put your prediction.

Part 4. Procedure. This is where you write a step by step (in a paragraph) format of what you did. Someone reading this should be able to reproduce your procedure.

Part 5. Results. This is where you place your results in a table, graph or chart format. Do not attempt to explain your results here. Just your data.

Part 6. Analysis. This is where you explain your findings and talk about the data. You must thoroughly explain your findings. This is where you make sense of the data and show that you know what you are talking about.

Part 7. Conclusion. This is where you determine if your hypothesis is correct and that the data supports your hypothesis. You need to be able to come up with a conclusion. 1 paragraph minimum.

Part 8. A cover page with title, name, class.

Part 9. Your boat journal must accompany your report.

Sample Lab Report

Boat Building (Title of Report)

Bailey Sayers (Name of Student)

GED® Prep Science Class (Name of Class)

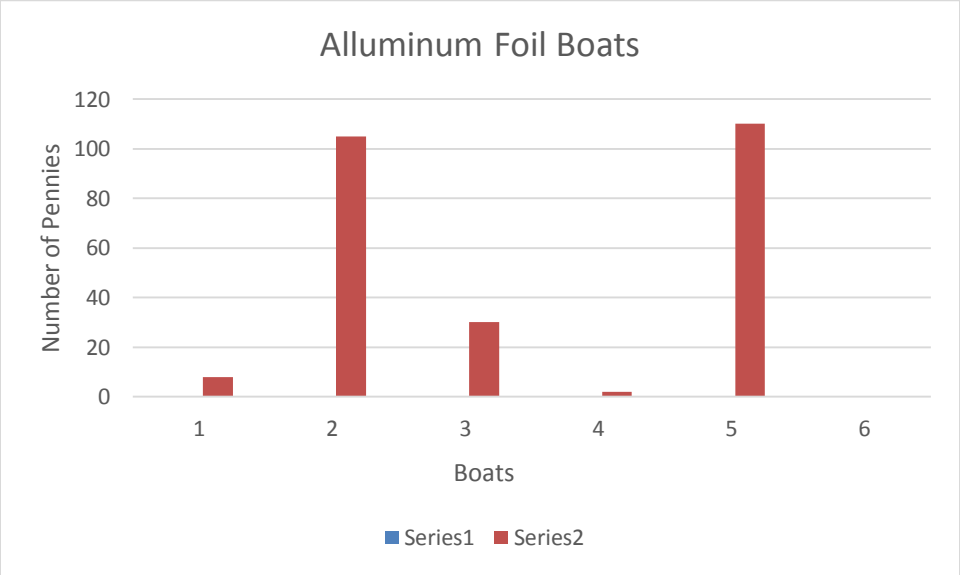
Abstract: The purpose of this experiment was to see which aluminum foil boat design would hold the most pennies without sinking in a bucket of fresh water. In this experiment there were 5 boats tested. Out of those 5 the last one was the best boat. The results showed that boat #1 could hold up to 8 pennies. Boat #2 could hold up to 105 pennies without sinking. Boat #3 started sinking with 30 pennies in it. Boat #4 only held 2. Boat #5 held up to 110 pennies because there were pontoons on the bottom of it. Overall a boat build with pontoons is going to be more efficient that a boat without.

Introduction: In this experiment different boats were built out of aluminum foil to figure out which design would hold the most pennies without sinking in a bucket of fresh water.

Hypothesis: Due to research, the best boat design is shaped like a sphere and will hold the most pennies without sinking.

Procedure: First get aluminum foil and at least a $1.00 in pennies. Second fill a bucket with fresh water. After that is done, cut a piece of aluminum foil that is a minimum of 6 by 6. Do research to find out which boat is going to hold the most pennies. Start building the boat. After the boat is built weigh how much it is. Then put the boat in the bucket of water and see how many pennies it will hold without sinking. After that is all done, find the area, volume, and density of the boat that was built.

Results:



Analysis: During this experiment five boats were tested. The first boat was done without any research and could only hold 8 pennies until it took in water. For the second boat, research told that the boat would hold more pennies if the boat had straight edges. So this boat had four straight

edges and it started sinking with 105 pennies. Boat three's research said the best way was to build it small and make it shaped like a sphere. After testing the boat in fresh water, it could on hold 30 pennies. When boat four was built, there were pontoons taped to the bottom to make it stay floating. When aluminum foil was being put over the pontoon they got demolished and as soon as it was put in the fresh water it started sinking without any pennies in it. For boat five, boat four was rebuild. It had four pontoons instead of two and it was made bigger. This boat ended up being the best one and held 110 pennies before it started to sink.

Conclusion: The hypothesis was incorrect. After performing and analyzing the experiment it was proven that the best boat was made like a pontoon boat. The aluminum foil pontoon boat held up to 110 pennies without sinking.

Aluminum Boat Building Journal

Name _____