**Activity - How to Think Like an Engineer**

**Learning Outcomes**

Students will be able to:

● Determine how to specify a characteristic of a product

● Test ideas for where to set a specification

● Evaluate the result of tests to set a specification

**Common Core State Standards:**

**Vocabulary:** Engineer, engineering, specifications, temperature

**Materials:** Bagel, color chart, pencil and paper, access to a kitchen oven

**Procedure:**

The following exercise is based on a true story...

Obtain a plain bagel, any plain bagel will do. Look at the color of the bagel. Did you know that there is a specification for that color? It's true. A commercial bagel has to be baked until it reaches a specific color. Did you know that one of the colors used to judge a bagel comes from the french fry standard color chart? It does. See <http://www.potatopro-shop.com/product_info.php/usda-french-fry-color-card-p-53>

Knowing that all products require a specification is a key part of this exercise to show young learners how an engineer thinks while performing his or her job.

**Step 1:** Quiz the students to see if any of them know what an engineer does on the job. Then explain to them that the primary role of an engineer is to think. They have to solve problems, think of new products, think of ways to make existing systems better, and design new things.

When they draw up the design for something, they have to create something called "specifications." A specification is a precise way of describing one characteristic of a product that tells you whether the product was produced successfully.

<https://en.wikipedia.org/wiki/Design_specification>

http:// www.dictionary.com

What does that mean? Hold up the bagel and ask the students what color is the bagel. When they say "brown," reply by asking "Did you know that there are specifications for the color of foods?"

Ask the students if they eat french fries. Then show them the french fry color chart. The scale of brown for french fries goes from #1 for barely brown up to #4, which is dark brown but not completely burnt. A bagel is usually specified by an engineer to be #2 french fry brown when it comes out of the oven.

#2 brown is usually selected by the food engineer after asking bakers, product sales people, and customers which color they prefer their bagels to be. The color chart helps people to select their favorite level of brown. The engineer will average the results and make the winning answer the specification for the product.

**Step 2:** An engineer will also use the specification to develop instructions on how to bake the bagel. A standard baking oven will bake bread at 425 degree Fahrenheit. But, how long should the bagel dough be in the oven? An engineer carries out tests to determine how long to bake the bagel so they will always come out of the oven with a #2 french fry brown color.

The engineer must test some ideas to determine the proper baking instructions. You can simulate this will an oven at home, or one in the school. Previous knowledge of baking bread (or looking over some bagel recipes) will give you a rough idea where to start your test. Ask the students what happens to the color of bread the longer it stays in an oven? (It gets darker).

<http://www.kingarthurflour.com/recipes/bagels-recipe>

Most recipes will call for 20 to 25 minutes of baking. But which one of these is correct? An engineer finds out by conducting tests. In this case, we can simulate the process with just four ready to bake bagels.

All four bagels go into a 425 degree oven. Engineers are precise, so they would use a good oven thermometer to make sure the oven is 425 degrees.

The first bagel comes out of the oven and onto the cooling rack after 15 minutes.

The second bagel comes out at 20 minutes.

The third bagel comes out at 25 minutes.

The fourth bagel comes out at 30 minutes.

*Note:This range of times and temperature can be adjusted to match the baking instructions that come with your bagels. The test is based on testing over, under, and recommended cooking times, each equally spaced from the other.*

After the bagels come out of the oven, have the students observe their colors (you can also bake them at home and bring them into class). They do get darker over time. Which time is closest to #2 french fry brown?

**Step 3:** Drawon the whiteboard a chart with the four equally spaced times on the X-axis. On the Y-axis, draw four equal marks for French Fry Brown #1, #2, #3, and #4. Have the students rate each bagel for color. Mark the consensus on the chart. Connect the data points with a color pen other than red.

An engineer does the following using mathematics, but we can do it with a red marking pen. Draw a red, horizontal line from French Fry #2 to it meets you data curve. Turn and make a vertical line down to the X-axis. Where it meets the X-axis tells us how much time it takes in a 425 degree oven to reach #2 brown.

The answer become the instructions for baking the bagels. The instructions where possible by setting a specification and then testing the product. This is the same method used by engineers to determine more complex specifications, such as the strength of a parachute needed to land a spacecraft on Mars.

**Answers should include:**

● Actual data with chart

● The student's ability to describe the temperature and time your test determined to bake a bagel.

**Further Questions to Ask:**

1. Could a bread baker also use this method to improve the quality of bread? (Yes)

2. Could a person baking bread at their own home benefit from measuring the actual temperature of the oven? (Yes)

3. Can you think of another specification used for food? (amount of sugar, size of product, number of food bits in a bag, etc.)

**Further Discussion with Students:**

As you can see, an engineer has to come up with a specific set of instructions that anyone can follow to get a successful results. Ask them if they want to see how important this is. Explain that the engineer won't be there to help you bake, only the instructions. Let's draw up a set of instructions for putting on a coat.

Take a coat and hold it in your hands. Ask, "What do I do first to put this coat on?" If they something like "put your arm in the sleeve," put your left arm in the right sleeve. Continue to do the wrong thing based on what they suggest for about a minute. Now ask them if being very specific would make this work better. "How about put your right arm in the right sleeve?"

Don't frustrate them, but make it clear that "engineering" clear instructions is how you get most things in the world to work correctly.

**How the Students Can Demonstrate What they Learned:**

There are many ways to show they have learned the lesson. Write up an idea to test for making a food they enjoy (i.e. how many pickles are the right number of pickles on a hamburger). Have the students write up the steps for sharpening a pencil. Did they remember to note which end of the pencil gets sharpened?

There are four grams of sugar in a sugar cube. Have the students draw out this specification in common foods as a stack of the right number of cubes. For example, a cereal box many say it contains 16 grams of sugar per serving. That is a specification. What does it look like? Draw four cubes of sugar, or better still, have students stack the actual cubes for a food product they eat (have them bring in the empty container). Make sure someone brings soda pop so they can see how much sugar that has. Now ask how many servings they eat a day. If they drink 3 bottles of soda a day, then make three piles of sugar cubes, one for each serving. Now they can see the specification in the real world and also be shocked by the amount of sugar they eat in a day.