# JAY BRANNON

# Taming a River to Become a Great Engineer

## STEM Lesson Plan for Grades 6-8

Helping all students, especially women, to be interested in engineering as a possible future can be challenging. Research suggests that role models are important for helping students to see themselves in a jobs where they have been underrepresented. In addition, having challenging and fun engineering experiences help students to want to become engineers.

Many engineering projects though are focused on competitions, but that isn't the essence of engineering. The cycle of determining a problem, identifying what's needed to solve the problem, trying and testing possible solutions, and optimizing and iterating to find an adequate solution is what makes an engineering project.

In this lesson plan, students will watch a video where Jay Brannon explains how she became a successful engineer. After figuring out what she says are some key factors to being a great engineer,the students will look at how water flow changes the banks of a channel. After trying to figure out some keys to the change in flow, students will iteratively make changes to protect the area around the channel. At the end, they will examine what behaviors they used to be successful.

**NGSS Standards**
CCC: Structure and Function
ETS1.A: Defining and Delimiting Engineering Problems
ETS1.B: Developing Possible Solutions
ETS1.C: Optimizing the Design

# Part I: Watching the Jay Brannon Video

Before the students watch the video, the teacher should explain that in this video an engineer will explain what makes her a successful engineer. The teacher should ask students to record what personality traits, desires, and behaviors are important to becoming an engineer.

For younger students, you may need to use sentence starters like

Jay Brannon said that she had to overcome the obstacles of _________

Jay Brannon said that she wants to _______

The video has on-screen icons that will help students when she is saying key components of her success. For some students, pausing the video at those moments will help them better record what is going on.

In small groups have the students summarize what they saw and then make sure that the entire class has all of the points. While they may have more than these, they should at least note:

- Jay Brannon went into engineering because she wanted to help others.
- Jay Brannon went into engineering because she wanted to be creative.
- Jay Brannon’s career path helped her succeed as an engineer.

## Making a Great Engineer Checklist

Students now should now make a checklist of things for themselves to do if they want to be a good engineer. Then when they do something on the checklist, they should mark it off. For example

| *Activity* | |
|---|---|
| *I helped someone* | 卌 \| |
| *I didn’t give up when something didn’t go the way I planned* | 卌 \|\|\| |

Students will use this checklist several times in the following projects. Don't assign points or give too much praise, otherwise students will just game the system. We just want them noting when they are doing something a good engineer does, helping them to internalize that they can be an engineer. Alternatively, you can make it the task of one of the members of the group to note when their groupmates are being good engineers.

# Part II: Engineering Cycle

Clean and abundant water is so important to humanity that most people live near rivers and streams. Running water, though, comes with a price, since it can erode, flood, and undermine. Civil engineers work hard to tame the power of moving water. In this engineering challenge, students will make stream tables using baking soda and observe how water can change its surroundings. Students will then try to come up with ways to control water's destructive force.

**Materials**

- Plastic tray approximately 6 in x 18 in x 3 in or similar
- 5 lbs. baking soda (inexpensive bulk baking soda can be found in pool supply stores)
- 3 16-ounce cups
- 1/16, 3/32, ⅛ inch, and ¼  inch drill bits
- Books or blocks to raise the tray
- Dried beans or other markers
- Pitchers
- Bucket
- Food coloring
- Small 1-ounce cups
- Wide straws cut into 1 inch pieces
- Small stones

## Construction and Investigation

Drill a 1/4 hole in the bottom of the tray near one end. Drill or poke holes in the bottom of the cups approximately 1/16, 3/32, ⅛ inch wide. Fill the pitchers with water and add a few drops of food coloring.

Have the students mound baking soda sloping up in the tray so that it is approximately 1 inch thick through most of the tray and then sloping to the hole in the last inch or so. Place the block under the tray to give the tray a slope. Place a bucket under the hole at the end of the tray. Use a pencil to make a gently wavy channel in the baking soda. Place beans along the banks of the channel.

Note: while baking soda is more expensive than sand, it has several virtues. Patterns in baking soda are easier to see, and since the baking soda is finer than the sand, they develop faster. Also baking soda won't clog up pipes if it goes down the drain.


Explain to the students that in a few minutes they will place the cup with the largest hole at the top of the channel and allow water to flow out and down. Ask students to individually predict using words and pictures  what will happen to the channel over time as water flows into the channel. After they have completed their individual predictions, have them discuss in their groups what they think will happen.

Have the students fill the cup with colored water from the pitcher and allow water to drip into the channel. The students should record how the channel moves as time goes on. They will want to make several drawings or take pictures of the development of the channel.




Some things that the students are likely to notice

- The channel gets wider with time.
- The channel changes position.
- Curves tend to get curvier.
- Sometimes the channel will cut off a very curvy portion to create a shorter path.
- The beans or markers move coming to rest in new positions.

You may wish to help students explain what they are seeing by giving them additional vocabulary words like erosion, current, flow, levee, and oxbow.

Have students scoop away the dyed baking soda and smooth the surface. Create a new channel, approximately the same as the last one. Have students place the cup with the smallest hole over the channel.

Ask students to predict in words and pictures what will be different if less water per second flows into the channel. After they predict individually, have them consult with their group and try to make a consensus prediction. Summarize the groups' predictions on the board.

Allow the students to do the experiment again with the smaller volume of water. They are likely to notice that the channel changes much more slowly, if at all.

### Stopping Floods and Erosion

Ask students to imagine that the beans along the channel are houses or businesses. Give students the task of acting like civil engineers, trying to reduce the damage to the people and businesses represented by the beans.

Have the students reset the streamtable again by scooping away the dyed baking soda and smoothing the surface. They should create a new channel, approximately the same as the last one and again add beans along the banks.

Explain that civil engineers use many methods to try to control the movement of rivers, including making lakes or retaining ponds, adding culverts, strengthening levees, and adding additional channels.

| **Flood control feature** | **Possible simulation** |
|---|---|
| Lake or retaining ponds | Scooping out a depression and/or adding a small cup |
| Additional channels | Cut additional channels with a pencil |
| Culvert | Straws |
| Levee strengthening | Small rocks |

Have groups use the above materials to decrease the effects of the flow. Encourage students to keep careful notes about what they are doing. Photographs can often be helpful. When the groups are ready have them let the water flow.

  

Most groups are likely to have some success. Have the groups report to the class what worked. Real civil engineers often have constraints on what technology that they can use. For example, a solution that would protect many beans would be to completely divert all the water away from the channel into a new that is farther away from people. In addition to the great financial cost that would be borne by this solution, many of the people who live near the channel want some water to flow down it. So solutions that completely divert flow are nonstarters. In other situations, people would like to collect some of the flow to be used as irrigation later. Other projects have the problem that people often live away from the river and diversions cause flooding for them.

Have the students set up the channel again. For each group place some number of additional constraints. For example, you might add a subdivision (represented by beans) some distance away from the channel. You might show a port along the channel that needs water to flow into it. You might install a farm that needs water. The number of new constraints should be great enough that the solution is difficult and will take several trials to figure out. Make the challenges different for each group. By making the challenges vary by group, the groups are more likely to work together and pass on useful information to figure out solutions.

The students should iterate their design over several runs, trying to protect their beans from disruption. As they succeed, you can add even more constraints, like limiting the distance of new channels or the number of culverts as “cost saving requirements.” Have students report out to their classmates as time goes on, creating a textbook for protection against water flow.

## Part III: Evaluation

While many kinds of assessment work, the students and the teacher should assess how well they improved their rocket launch. You could write an assessment that offers possible changes and asks students to predict how that would control flooding and erosion.

In addition, each group should report out on how well they worked together. Having the students briefly present their work to their classmates tends to give the best opportunity to figure out what happened in their group. They should explain

- What their challenge was
- What they tried
- Whether or not it was successful
- How they could tell if it was working
- What they did if they didn't all agree on what to do
- How often did they get to put a mark on their checklists