

## **Engineering and Design Notebook**

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Endeavor STEM Teaching Certificate Project

CURR 676: The E in STEM: Meaningful Content for Engineering

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## **Identify the problem**

For the sailboat challenge, this section included the mission or purpose for the challenge, the constraints, and the goal. The problem presented says that students have been stranded on an island and must use the resources on the island to build a sailboat in order to escape. The student and I identified the problem that decided that we need to build a sailboat that could carry us (hold weight) and use wind power to move. There is a suggested list of materials to use for this project. I used most of the materials suggested but replaced the styrofoam cups with cork. I felt that it was a more natural material for students to use since they are using resources from an island. Next time I would replace the craft sticks with real sticks and include string.

For the constraints we discussed how big the boat could be and where we would be sailing them. Since the project was at home we decided to sail them in the bathtub. It was decided that the boat could be no larger than 8 inches by 5 inches. There was not a constraint on the height of the sail.

The criteria in this project is labeled as the goals. Looking at the washers we decided that the boat needs to hold at least 5 washers without sinking or tipping and needs to be able to sail across the bathtub. In retrospect I should have added a minimum time criteria. I was not sure how fast one of the boats could travel the length of the bathtub so it was not included. If implementing in school I will use the best design I have and set a minimum time that is appropriate for the container that students will be using to test their designs.

## SAILBOAT CHALLENGE

## Identify the Problem

**Mission**

In your own words, describe the overall mission of this challenge.

Our mission is to make a sailboat that will float and be powered by the wind. It also needs to hold at least 5 washers.

**Constraints**

What are the constraints for your design? I.e. What are the rules for this challenge?

- The surface area of the boat cannot be larger than 5" x 8"
- The keel cannot be longer than 3" - Must hold at least 5 weights.

**Goal**

How will you determine a successful design?

The boat will hold at least 5 weights and will travel across the bathtub without tipping over or sinking.

**Key Topics**

Answer the following in your own words.

1. How does a sailboat float?

A boat floats by displacing the same amount of water as its own weight.

2. How does a sailboat move?

A sailboat moves by using the energy from the wind.

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## **Brainstorming**

Evaluating materials and their properties is an important step in the ED process. It can help prevent students from trying to use all the materials presented to them simply because they are there. I feel I often struggle with this step because with younger students only so many types of properties have been introduced. For example if a material is strong or weak, will it rip easily? Is the material rigid or flexible? Is the material absorbent? It seems that the same properties are often repeated for most of the materials.

For this challenge the brainstorming portion was incorporated with evaluating the materials. First we made diagrams of sailboats and labeled their parts (boat, mast, sail, and keel) and learned about buoyancy and displacement. We then used the brainstorming sheet as we looked at our material choices. The brainstorming was broken down into three categories: float, move, and waterproof. These are three important components to building a sailboat that will meet the criteria and gave more purpose to the evaluation of the materials. We were able to brainstorm together as we looked at the properties of each material and its usefulness.

## SAILBOAT CHALLENGE

## Brainstorm



Carefully review the materials provided. Can you think of different ways to use the materials to build a sailboat? Think about how you will use each material to either make your boat float or to help it move through the water. Think about if the material is waterproof and how this will affect where you will use it.

| Material    | Float  | Move  | Waterproof  |
|-------------|--|---|---|
| Straws      | Glue together to create a base for the boat.       | Use as a mast to hold up the sail.              | Yes! Can use this material anywhere, but remember to close the openings to prevent sinking. |
| Tinfoil     | Use it around a structure for the base.            | Could be used as the sail.                      | yes it can be used for any part of the boat.  |
| Paper       | No, it will get too wet and possibly fall apart    | Could be used as a sail.                        | No, it would not be a good material.  |
| Wax paper   | could be used as a boat base, may not hold weight. | could be used as a sail. It is flexible.        | It looks like it will hold up to rain.  |
| Craft stick | could be used as a frame for the boat.             | could be used as a mast or a keel.              | yes   |
| Cork        | a few corks could help it float.                   | could be used for the keel                      | yes, cork will repel the water.   |
| Cups        | They will float but may not be good for the base.  | Maybe good for the keel? Too small of the sail. | yes/no it will start to fall apart.   |

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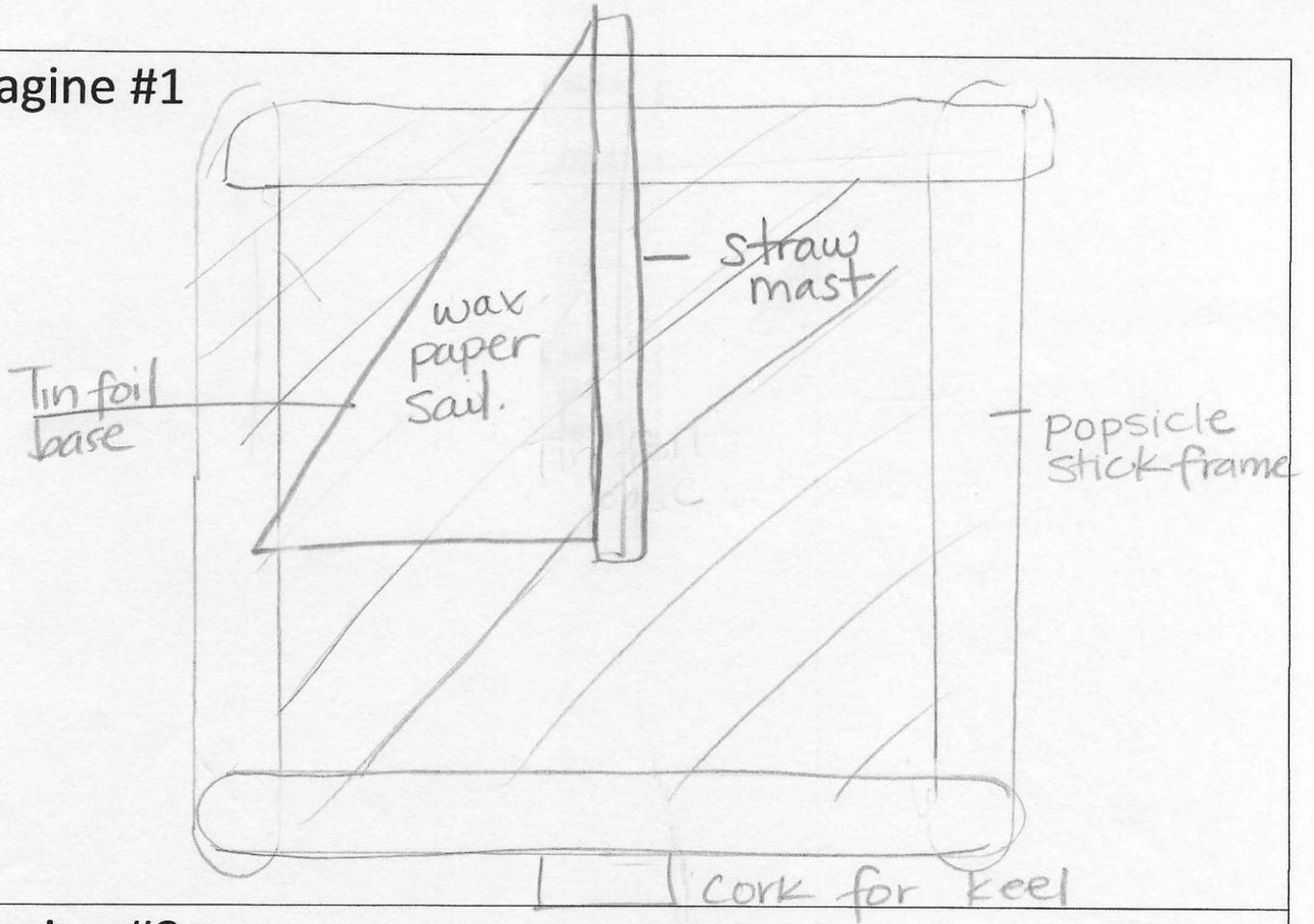
## Design

In this stage of the process the student and I each imagined four different ideas for a possible sail boat that would meet the criteria and constraints. I used a labeled diagram of a sailboat to again discuss the parts of a sailboat. This also served as a reference for the student to label when drawing their ideas.

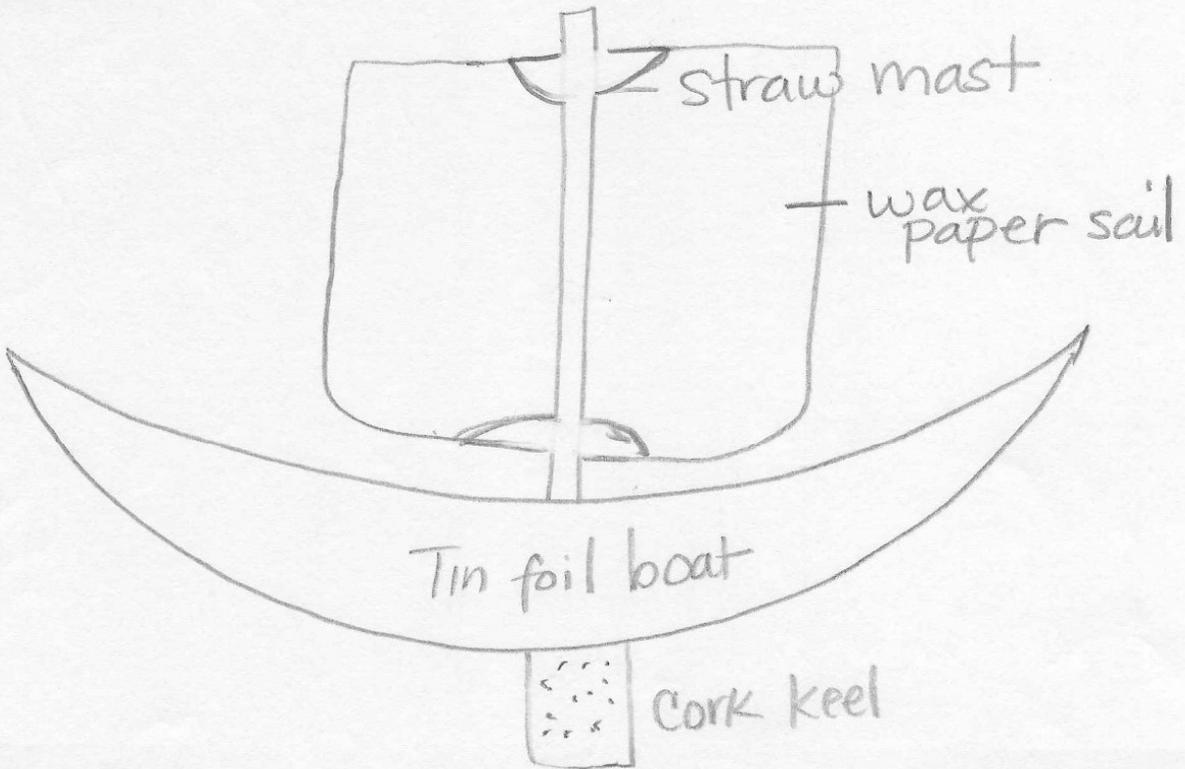
This was the most difficult step for the student but one that I enjoyed. They found it difficult to think of “that many” ideas. We talked through this process and I suggested that the ideas do not need to be radically different from one another. If you like a particular idea then on the next idea you can change one element, either the shape of one the parts (boat or sail) or change the material.

The original packet for this challenge did not include a page for drawing multiple ideas. I decided to add in a page of my own for the Imagine step of the ED process.

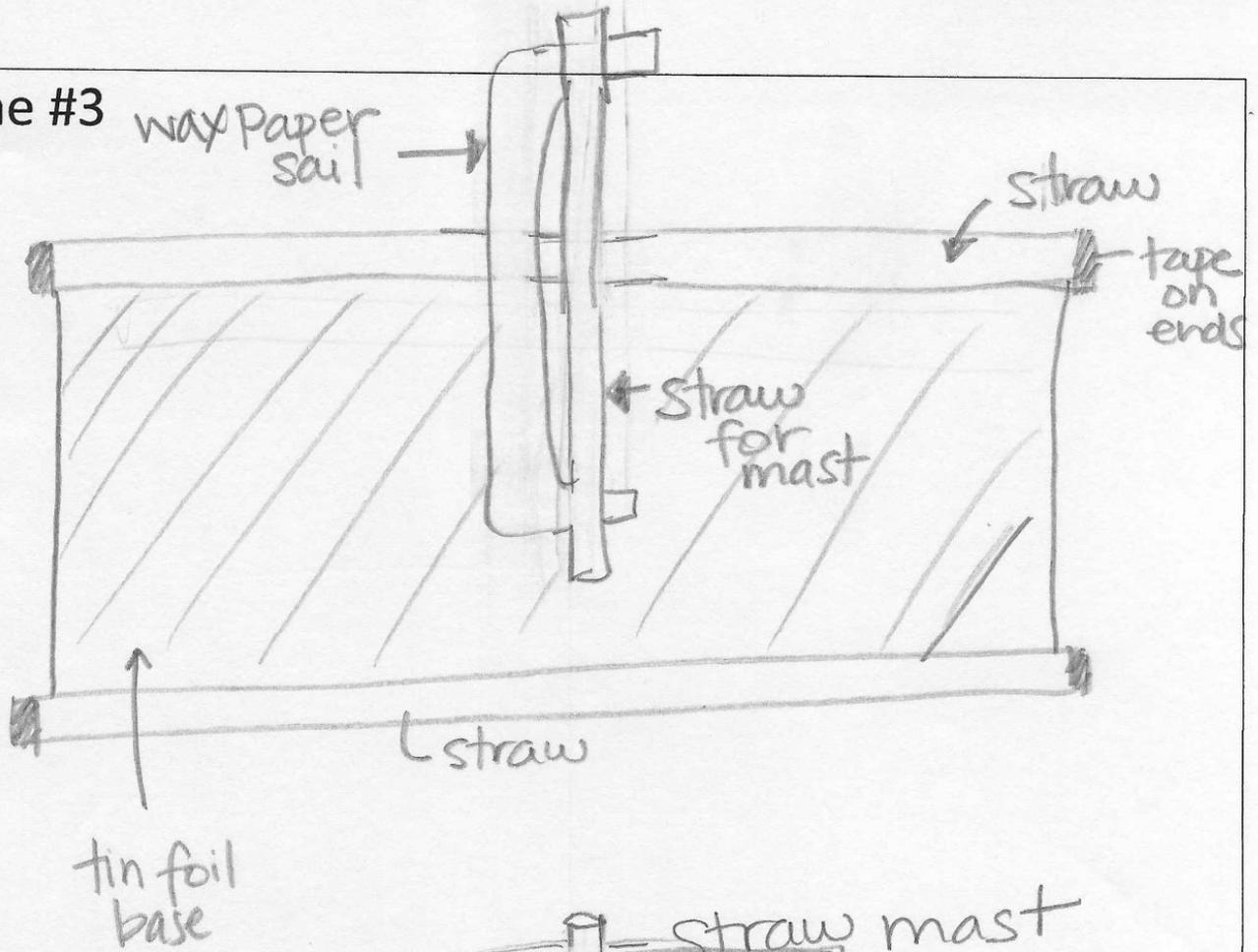
### Imagine #1



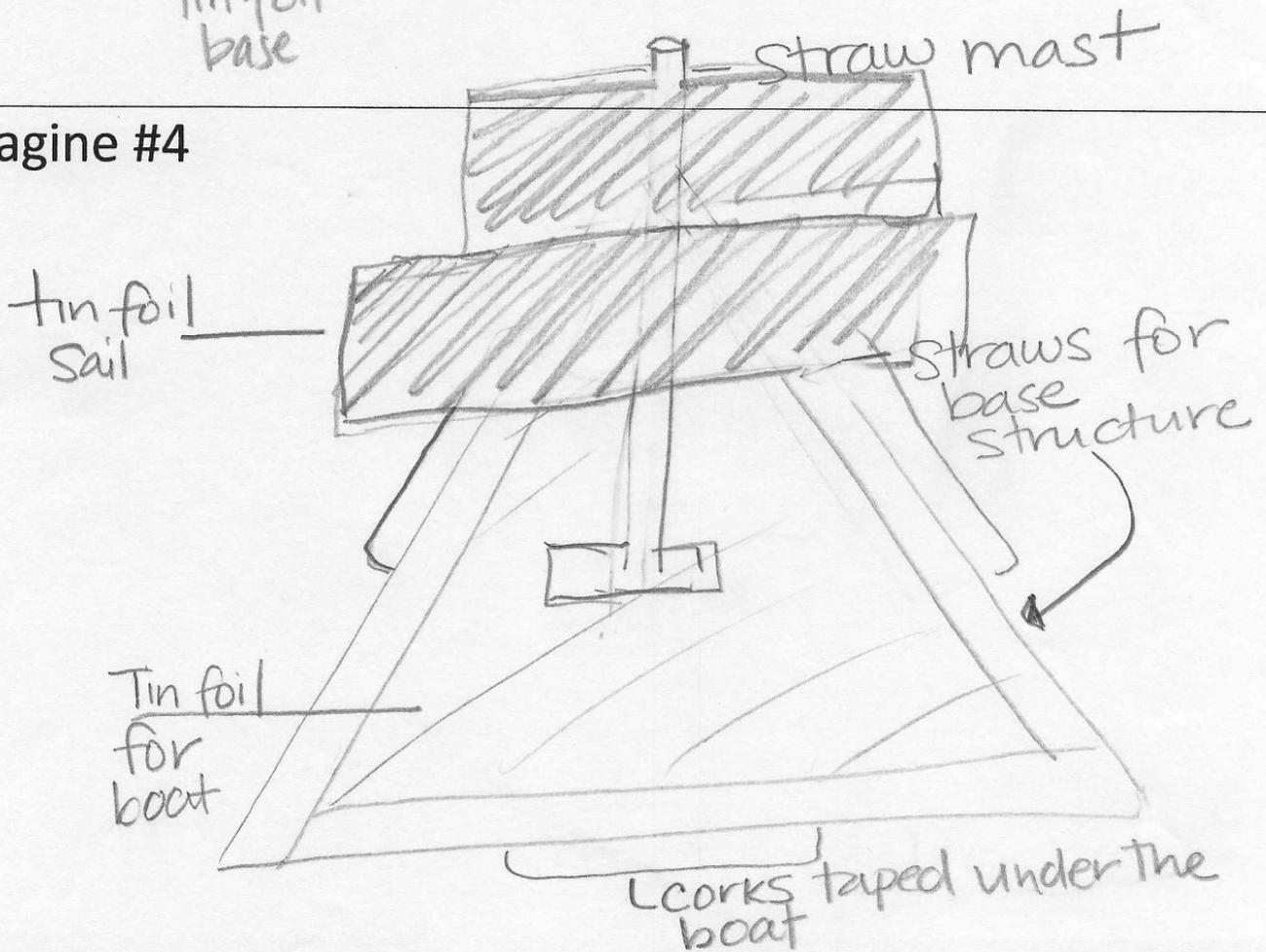
### Imagine #2



Imagine #3



Imagine #4



## **Build**

In this step the student and I each chose the design we thought would work the best. I decided to go with the triangle shape for the base of my boat and use corks at the bottom. I used tin foil to make the sail. As I was building the sail I quickly realized that it was going to be difficult to attach the mast. The student also had the same issue. We worked together to hold up the mast while the other one taped it to the bottom of the boat.

I also saw that I would have a problem with my sail. I was going to add a crossbar to keep it from flopping over too much but since it was not in my original drawing I kept it the way it was and tested it as is. The student also began to question whether her boat would be too heavy since it was made entirely of popsicle sticks. Again she stuck with the plan and agreed to readjust after testing.

# Plan #1

I will build a prototype of Imagine # 4.

|  |  |
|--|--|
| Size (how many cm or inches is it?)          | 5" x 5" x 5"  <sup>1/2 inches</sup><br>inches |
| Shape (is there more than one shape?)        | The base is a triangle<br>The sail is two rectangles   |
| Materials (list all materials that you used) | - straws (4)      - tape<br>- tin foil<br>- corks (3)  |
| Other details....                            |  |

# Plan # 3

After thinking about what worked and what did not work with Plan #1 do you want to use another idea from your imagine? YES or NO

(If you are going to draw a new idea use the next plan sheet)

If yes: Which Imagine idea will you use? IMAGINE # \_\_\_\_\_

|          |   |
|----------|---|
| Size     | The length is 7 1/2" inches<br>The width is 3"          |
| Shape    | The base is a rectangle<br>The sail is also a rectangle |
| Material | straws (3)      wax paper (1)<br>tin foil (2)           |

### **Test and Evaluate for Plan #1**

There were two testing stages for this project. The first was to test the criteria of holding at least 5 washers. The student's first plan sank after one washer. She concluded that the boat was too heavy and she should use a different material for the base of her boat. She noted that popsicle sticks could be used as a frame but probably should not be used for the whole thing.

My first plan held 12 washers before it sank. Unfortunately, after it sank the mast completely came off. Even though it held 12 washers I did not move on to the second stage of testing. When the boat sank the mast came completely off. This was a total design failure with the tape. We evaluated together how we could continue to use tape by trying to secure it in a different way that would keep it from possibly getting wet and coming unglued.

### **Redesign**

For my Redesign/Improve I decided to go with a different size and shape. I used one of the ideas I had drawn in the Imagine step. The student also used a different design. She chose to go with a lighter but strong boat design. She also made the boat larger but still within the limits of the constraints. Again we used the tape for the mast but added tinfoil around the bottom to protect the tape in case water go into the boat.

### **Test and Evaluate for Plan #2**

We successfully completed the first test of holding at least 5 washers on the boat. The student was excited to see that her new plan worked and the boat did not tip over after one washer. Now it was time to test the second criteria: will the boat sail? There were two sets of trials. The first was to time and record the boat without washer and the second was to test and record with the weight of 5 washers.

The testing went as expected, a little chaotic at first. To test we used the bathtub and a mini fan for the wind. We decided the boat would need to make it to one end of the tub to the other. Here again I was faced with another challenge that often happens in the classroom no matter how often we practice. The challenge of how to use a stopwatch. When we are timing something that is so short, 5 seconds, 6 seconds, every second counts. The student timing must be quick enough to stop the timer without adding 1 or 2 seconds onto the clock. Because I wanted to be consistent with how the fan was blowing on the sailboats I released the boat and held the fan while the student controlled the timer.

One of the questions that is part of the reflection is whether or not the boat sailed straight. We both had issues with this. It was a simple readjustment of taping the sail so that it would not spin with the force of the wind. This spinning caused the boats to spin sometimes as it moved across the water increasing its travel time.





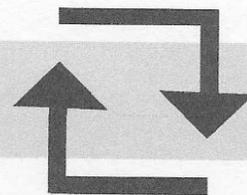
**Student design #1**



**Student design #2**

## SAILBOAT CHALLENGE

## Test &amp; Evaluate I



Time to test your sailboat! First, your sailboat must be able to hold the required amount of weight without sinking. Follow these steps and record results in the table below:

1. Place your sailboat in the water.
2. Place the first weight on the boat. Count to 3.
3. If the boat is not collecting any water, add another weight and count to 3.
4. Repeat steps 2-3 until you have added all the required weight. If your boat sinks, record how much weight it held before sinking and then modify your design.
5. Continue testing until you successfully hold all the required weight without sinking.
6. You can not proceed to the Sailing Test until you successfully hold all the weight!

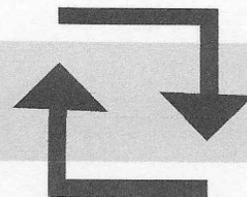
Required number of weights to pass test: 5

| Trial       | # of weights before sinking | Pass weight test?                         | Design Notes   |
|-------------|-----------------------------|---|--|
| Plan<br># 1 | 12                          | <input checked="" type="radio"/> Yes / No | tape came off the mask after it sank.<br>*will not do sail test. |
| Plan<br># 2 | 16                          | <input checked="" type="radio"/> Yes / No | Able to more evenly distribute the weight.                       |
| 3           |                             | Yes / No                                  |  |

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## SAILBOAT CHALLENGE

## Test & Evaluate II



Now let's see how fast your sailboat can go. Follow these steps and record results in the table below:

1. Place the front edge of your sailboat on the starting line in the container.
2. When the timer says "Go!", release your sailboat!
3. Stop the timer when the front edge touches the other end of the container.
4. Record the time.
5. Place the weight into the sailboat. Repeat steps 1-4 to measure the speed of the weighted boat.
6. Complete 3 trials of the sailboat test.

Testing of Plan #2 only

| Trial | Time without weight (sec) | Time with weight (sec) | Design Notes  |
|-------|---------------------------|------------------------|---|
| 1     | 7.5                       | 8.5                    | Sail is moving around too much. was not secured to mast.            |
| 2     | 8.27                      | 10.5                   | Water is getting into the straws lowering the boat.                 |
| 3     | 13.6                      | 8.5                    | Too much variation in time due to movement of sail around the mast. |

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### **Share the solution**

This challenge provided a reflection section that both student and I completed. After answering the questions on our own we shared what we learned. We both decided that a boat with a larger surface area that was made of lighter material worked the best. We also agreed that the material of the sail is important because when the student used paper it began to fall apart when it got wet. Being able to harness the energy of the wind was also an important criteria of this challenge and we both agreed again the securing the mast and the sail were important to a successful design.

## SAILBOAT CHALLENGE

# Reflection

Think back to the engineering design process that you used to complete the sailboat. Note any challenges you faced and answer the questions below. Your teacher may ask for you to present your results to the class.



## 1. Compare your design to the other team designs.

### a) What are some similarities?

We both used the same material for the base of the boat which was tin foil. We also both used straws for the mast.

### b) What are some differences?

My boat was longer and I also used straws to hold my boat structure on the sides. I also use wax paper instead of paper for the sail.

## 2. How did you make your boat float?

My boat was able to float because it was large enough to displace enough water and light enough to allow the force of buoyancy to make it float.

## 3. How did you make your boat use the wind to propel forward?

The boat used the wind to move it forward because the sail was large enough and light enough to capture the wind and the force to push it.

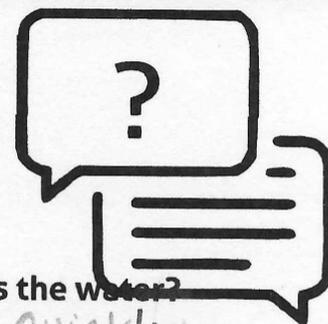
## 4. Did your sailboat move in a straight line? Why or why not?

No it did not. The sail was not secured enough to the mast and was allowing the wind from the fan to change its direction.

## 5. Did it matter how you placed the weights on the sailboat?

Yes!

# Reflection



6. What factors affected making the sailboat move quickly across the water?

The large sail helped the boat move quickly.

7. Which material did you use the most in your final design? Why?

I used tin foil the most because it is both light and waterproof. It is also strong enough to hold the washers.

8. What material did not work well in your design? Why?

The tape started to come off as the boat got water inside. I could use hot glue so that it is more water resistant.

9. If you had more time, what would you change about your design?

I would add more height to the boat by taping corks to the bottom sides like a pontoon boat.

10. What was the most enjoyable part of the engineering challenge? Why?

I enjoy the building part the most. I like to see my idea become an actual object.

11. What was most frustrating in the design challenge? Why?

The most frustrating part of the challenge was that I did not secure the sail to the mast and it caused my boat to not sail straight.

12. What are some challenges you faced in working as a team?

N/A

## References

STEM Sailboat Challenge Math & Engineering Activity. (n.d.). Retrieved July 5, 2020, from <https://www.vivifystem.com/new-products/stem-sailboat-challenge-math-engineering-activity>