Pavan Raj Gowda
June, 2013

Title: Rove Beetle + Fire Ants Inspired Floatation Device

Question:

How to design a raft that is light weight, foldable, easy to use as a transport, and is small enough to be put into an emergency kit that is also sustainable, and eco-friendly?

Hypothesis:

I predict that spreading the spacing of the raft out, like a mesh, would be better, because it would be slimmer and more effective. I also predict that putting salt and soap in the water would make the raft move since it changes the surface tension, making a “natural motor”.

Materials Required:

1. Wooden Mat
2. Bamboo mat
3. Two or three dolls to symbolize human weight
4. Large bowl
5. Water
6. Soap to symbolize the Rove beetles slime
7. Salt
8. Bending Straws
9. Straw connectors
10. Coins to test Surface tension
11. Organic Liquid Laundry soap
12. Teaspoon
13. String
14. Dropper
15. Funnel
16. Small piece of Cloth
17. Weights for measurement
18. Balance for weight measurement
19. School Ruler for measuring distance

Procedure:

1. Fill a large bowl with water
2. Place the wooden mat in water
3. Place the doll on mat and add coins on wooden mat until it sinks
4. Record the number of coins and dolls when it starts to sink.
5. Weigh the coins and the doll using the balance, and record the total weight

Picture shows the wooden raft starting to sink

6. Repeat 2 to 5 with the bamboo mat

Picture shows the bamboo raft starting to sink

7. Let the mats to dry
8. Place the bamboo mat in water
9. Slowly add salt using the teaspoon close to one side of the bamboo mat, and see if it moves and record your observation

Picture shows adding salt to one side of the raft

10. Pour out everything in the bowl and clean the bowl, then refill with fresh water
11. Dry the mat
12. Place the mat in water and now using the dropper slowly add the detergent at one side of the mat. Count the number of droplets as you do this and note down the number of droplets at which the mat starts to move by itself. Measure the distance moved using the school ruler.

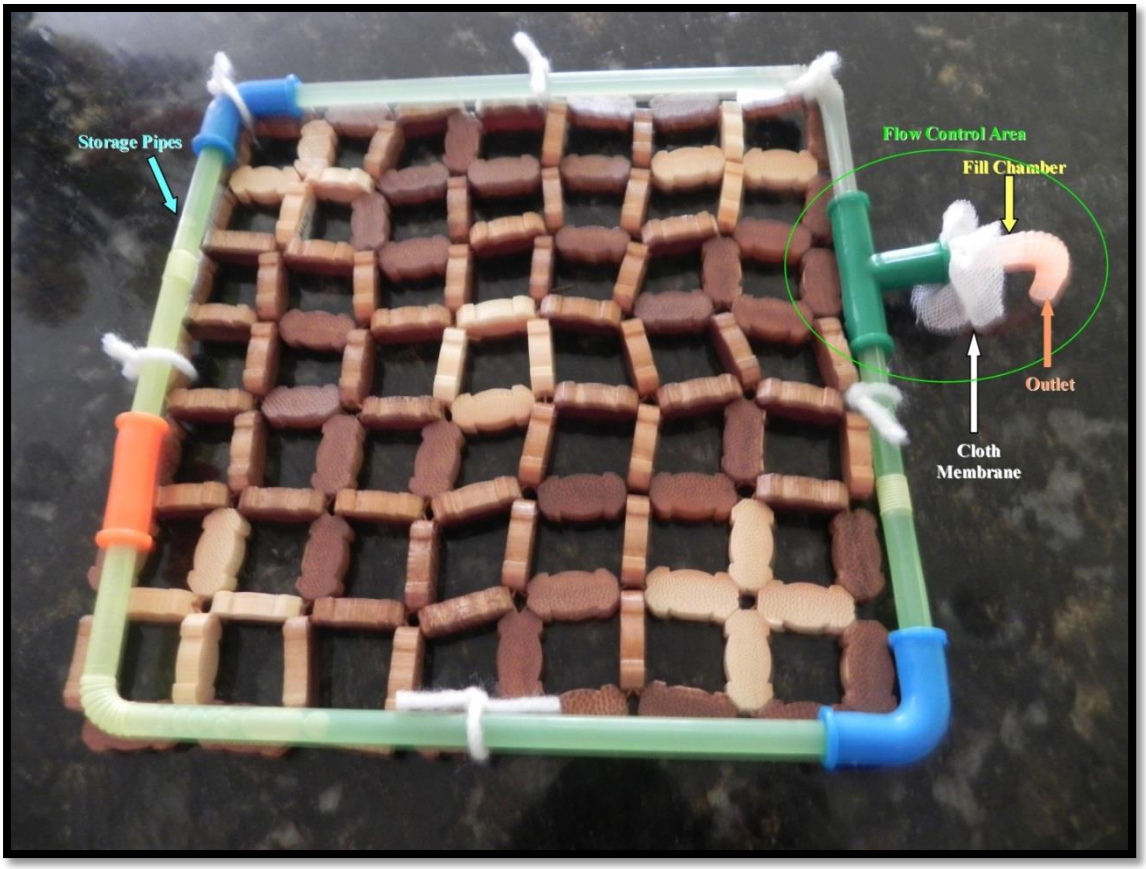
Picture shows adding laundry liquid to one side of the raft

13. Pour out everything in the bowl and clean the bowl, then refill with fresh water
14. Repeat steps 8 to 13 with the wooden mat

Picture shows adding salt to one side of the raft

Picture shows adding laundry liquid to one side of the raft

15. Based on observations decide which mat is better to proceed further.
16. **Now for the product prototype** -Tie the straws around the mat using strings as shown in the picture, to form the storage pipes
17. Add a T-connector to the straw pipes on one side of the mat as shown in the picture to form the "Flow Control Area"
18. At the T-connector, using a funnel, fill the storage pipes fully with the laundry liquid.
19. To the edge of the T-connector, place the piece of cloth, and then attach another small piece of bendable straw to build the Fill Chamber and outlet as shown in the picture.



Picture shows the design and construction of the storage pipes and Flow Control Area

20. Ensure the liquid soap drips slowly at the outlet when placed outside the water bowl.
    Note: the outlet needs a proper cap/lid to briefly open and let the liquid from the tube go out and the outlet must be closed immediately. When placed in water without the cap/lid properly closed, the water will diffuse into the tube in the reverse direction, instead of the soap coming out and filling the Fill Chamber.

Picture shows slow liquid soap drips at the outlet

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Observations, Analysis, and Results:

Part 1: Choosing the best mat:

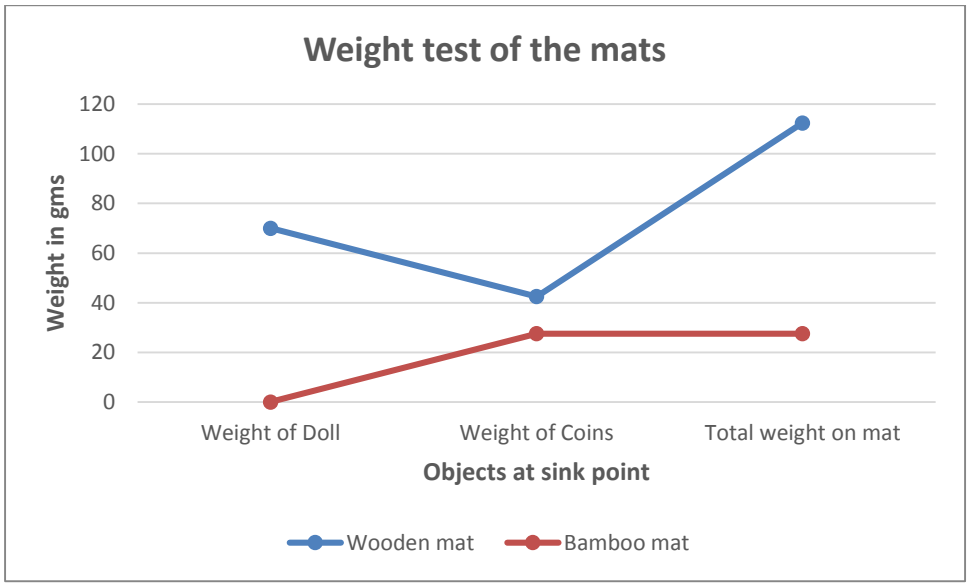
I used two types of mats, one is the wooden mat woven in square shapes, and the other was a bamboo mat woven in straight lines.

These two mats were chosen for testing because it was foldable and had spaces in-between, which was a requirement for my testing to mimic the fire ants colony floatation.

Observation:

Weight test of the mats: (Data recorded at the point when the mat starts to sink)

	Wooden mat	Bamboo mat
Doll (70 gms per doll)	1 doll	0 doll
Coins (2.5 gms per coin)	17 coins	11 coins
Total weight at sink point	112.5 gms	27.5 gms



Analysis:

1. Wooden Mat holds more weight and was foldable too.
2. It also has square shaped mesh pattern

Result:

The wooden mat met most of the criteria of the fire ants mesh structure; hence I chose the wooden mat to proceed to part two of my experiment.

Part 2: Choosing the best material to create movement in water:

The Rove Beetle's slime that is released in water for movement reduces the surface tension of the water at that spot. This causes a natural force from high surface energy to low surface energy. This force pushes the mat forward.

(**Note:** Surface tension has the dimension of force per unit length, or of energy per unit area. The two are equivalent—but when referring to energy per unit of area, it is normally referred as surface energy.)

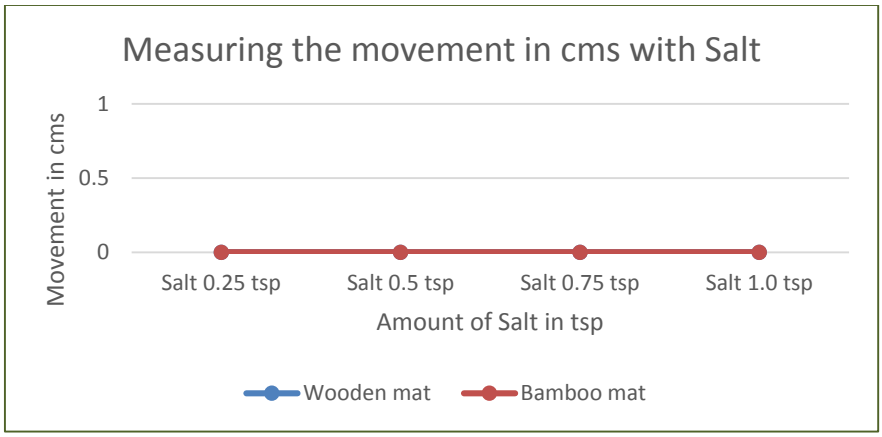
So, I looked at materials that would reduce surface tension. I choose "Salt" and "Liquid soap". For my test, I wanted to use these materials and drop it on one side of the mat in a controlled manner, so that the surface tension is reduced only in a spot.

Observation:

Movement test of mat: (Data recorded at the point when the mat started to move by itself)

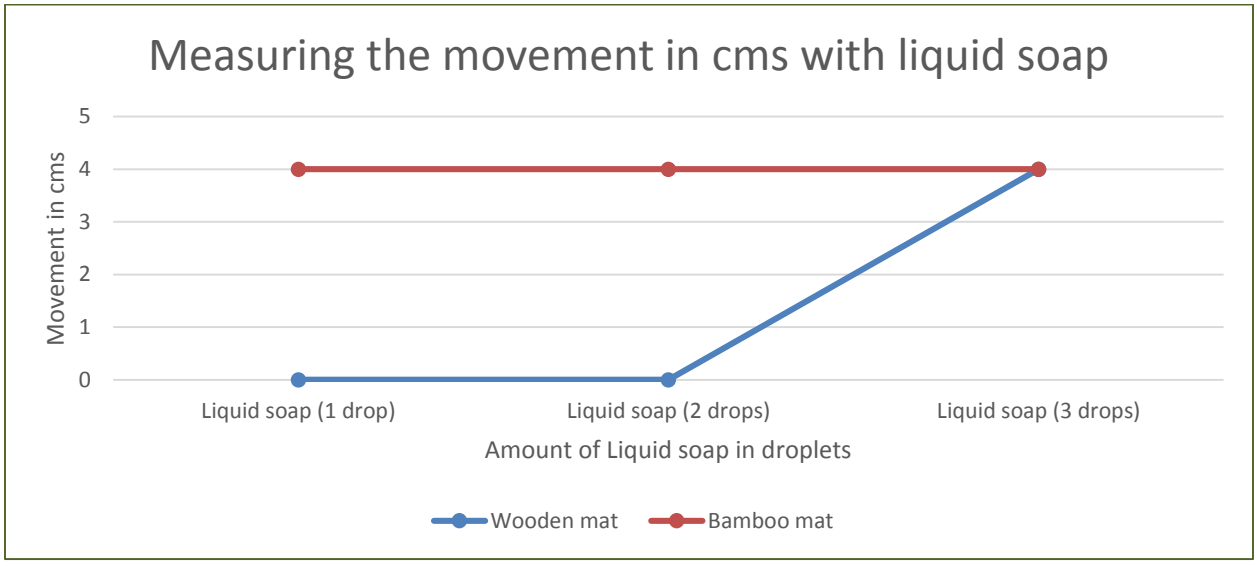
a) **Measuring the movement in cms with Salt**

	Wooden mat	Bamboo mat
Salt 0.25 tsp	0 cms	0 cms
Salt 0.5 tsp	0 cms	0 cms
Salt 0.75 tsp	0 cms	0 cms
Salt 1.0 tsp	0 cms	0 cms



b) Measuring movement in cms with liquid soap (Maximum distance available for movement is 4 cms in the bowl – Stop test when mat moves to this maximum distance)

	Wooden mat	Bamboo mat
Liquid soap (1 drop)	0 cms	4 cms
Liquid soap (2 drops)	0 cms	n/a
Liquid soap (3 drops)	4 cms	n/a



Analysis:

1. There was no movement at all with salt with both wooden and bamboo mats
2. Bamboo mat moved faster with less liquid soap

3. Wooden mat required comparatively more liquid soap, but when it moved, it moved fast

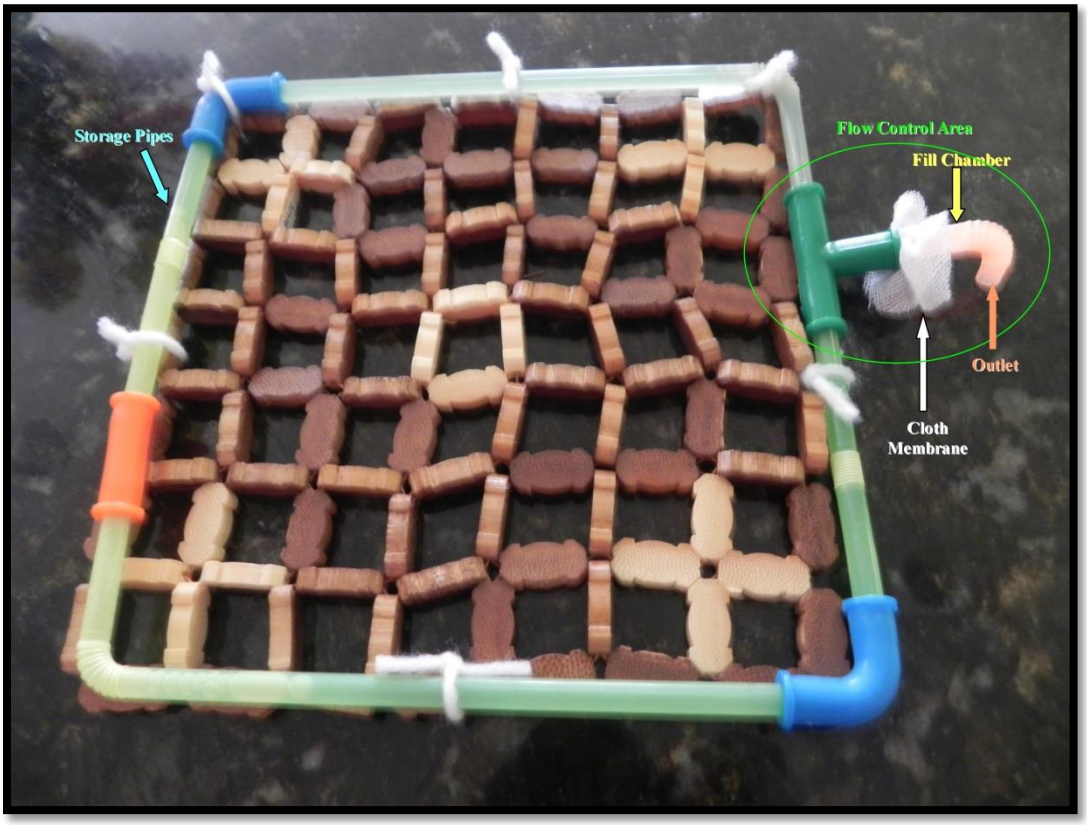
Result:
Liquid soap was a better option where controlled reduction in surface tension is required to cause the natural force of movement.

Prototype: Designing the solution:

I choose the following materials to proceed with the prototype:

1. Wooden Mat
2. Liquid Laundry soap

Here is my first design of the Rove Beetle + Fire Ants Inspired Floatation Device:



Ideas for further research and development:

- Add flow control areas to all four sides of raft
- Add a cap/lid to the outlet pipe to be operated like a switch
- Design a smaller compact flow control area so it doesn't protrude away from the raft.
- Instead of just wooden raft, use a combination of wood and coconut fibers to create a mesh like layer to make the mat even more efficient and durable
- Try other thin membranes, for better control of liquid in the Fill Chamber
- Study the actual composition of the slime secreted by Rove Beetle, and use a solution to mimic this composition.

Conclusion:

I can conclude that the fire ants structure is the strongest, and best to float on water. The mesh like structure uses less material, and helps with the mat being light and foldable too. Also, I learned that by mimicking the Rove Beetle's movement on water technique, which is by slowly releasing a liquid that reduces the surface tension of water at one side of the mat in a particular area, causes a natural movement of force from high surface energy to low surface energy. This force pushes the mat forward. By controlling the drips of liquid to reduce the surface tension, the mat can be used for transportation too in the desired direction, which would be a very useful feature in emergency situations.

Application for this device:

Due to global warming there are longer periods of dry weather and flash floods occurring quite frequently at the end of long dry season, so we need to be prepared in case of a flash flood emergency. We need something that is light, thin, and can be stored in cupboards or backpacks. Regular rafts are good, but it is too bulky and is hard to store in our homes. Along with the raft you would also need a motor in the raft or oars to transport in the raft. In emergency situations, having the floatation plus transporting feature in one device would be very handy and helpful.

This particular floatation device is not only light and foldable; it is also capable of propelling itself forward. This device would be great in a flash flood emergency kit, and help people to survive until a rescue team arrives.

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Supporting research work:

Website used for research: AskNature.org

In order to create this floatation device, I looked at many living creatures to find solutions that exists in the natural world. The group formation of the fire ants when water floods their nest was very fascinating to me. During flood, if each ant tried to float by itself, it would drown. Also if all the ants clumped together without any gaps, they would still drown. The fire ants actually created a mesh structure by holding on to each other with gaps in between each ant. Through this formation a very light and super hydrophobic raft is created that helps almost the whole colony survive the flood. So, I chose to create my floatation device that mimics the ants mesh raft structure.

In order to make the device move, I looked at many natural solutions that use the following principles:

1. Create movement without using additional energy
2. Use only eco-friendly solution

While doing my research, I was particularly inspired by the way Rove Beetle moves on water. This beetle can walk on water slowly using the hairs on its legs, and the slime like solution from its abdomen reduces surface tension allowing it to glide on water. Since I could not find the composition of the slime secreted by the Rove Beetle, I looked at other ways to change surface tension.