Clean Up in Zero-G:

An Experiment in Absorbency

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ABSTRACT

As nearly every surface in the International Space Station is covered in equipment, cleaning spills in space becomes a very important endeavor. Since liquids do not behave the same way on Earth as they do in a microgravity environment, it is important to capture floating liquids and dispose of it before equipment is damaged. Which type of cloth would best clean up a spill in space? Assuming water and blood are two liquids most likely to be spilled in space, what type of fibers would best absorb them? If 30 cm squares of fabric (linen, wool, microfiber, and cotton) are injected with 10 mL of distilled water, then the linen should absorb the best as linen is known for its absorbent properties. If 30 cm squares of fabric (linen, wool, microfiber, and cotton) are injected with 10 mL of simulated blood, then the linen should absorb the best as linen is known for its absorbent properties. Each square of fabric was massed, placed in an experiment glove box, injected with 10 mL of either distilled water or simulated blood from a 20 mL syringe with the tip of the syringe touching the fabric, placed in a Ziploc bag, removed from the experiment glove box, and the mass of the fabric in bag measured. (The mass of the bag had previously been measured.) The mass of the distilled water or simulated blood absorbed was then calculated. Student and teacher data showed that microfiber absorbed the distilled water the best. Cotton absorbed the simulated blood the best, but there was not a statistical difference between the cotton and microfiber. Due to the smaller volume and mass of microfiber, it would make an excellent choice for cleaning up spills on the International Space Station and long duration space flights.

INTRODUCTION

Purpose:

The purpose of the experiment is to find the best absorbing fabric in order to clean up spills of water or blood in microgravity.

Problem:

We rarely think twice when cleaning up a spill at home or school. We grab some paper towels, wipe up the liquid, and sometimes leave a little behind. However, when you spill a liquid in space, the phenomenon of microgravity makes it even more important to clean up a spill as well as the fact that the majority of interior surfaces are covered in vital equipment. So, what fabric is the most absorbent in order to clean up a spill in space? And, what liquids are most likely to be spilled? For this experiment, water and simulated blood are being testing with various fabrics to see what absorbs the best. The size, volume, and mass of the fabric samples are also a factor since space is of a premium on the International Space Station and future long duration flight vehicles.

Question:

What type of fabric (linen, wool, microfiber, or cotton) will be most effective absorbing distilled water and simulated blood?

Hypothesis:

If 30 cm squares of fabric (linen, wool, microfiber, and cotton) are injected with 10 mL of distilled water, then the linen should absorb the best as linen is known for its absorbent properties.

If 30 cm squares of fabric (linen, wool, microfiber, and cotton) are injected with 10 mL of simulated blood, then the linen should absorb the best as linen is known for its absorbent properties.

METHODS

Variables:

Manipulated/Independent: The manipulated/independent variable is the type of fabric (linen, wool, microfiber, cotton).

Responding/Dependent: The responding/dependent variable is the amount of liquid (distilled water or simulated blood) absorbed.

Controls:

- Size of fabric samples (30 cm squares)
- Amount of liquid injected (10 mL)

Materials:

- Distilled Water
- Simulated Blood
- 2 - 30 x 30 cm squares of linen
- 2 - 30 x 30 cm squares of cotton
- 2 - 30 x 30 cm squares of microfiber
- 1 - 30 x 30 square of wool
- 2 – 20 mL syringes
- Electronic balance
- 7 Gallon size Ziploc bags
- Experiment Glove Box

Procedure:

1. Measure mass of linen square and record.
2. Measure mass of Ziploc bag and record.
3. Place linen square inside experiment glove box.
4. Fill syringe with 10-mL of distilled water.
5. Touch tip of syringe to fabric.
6. Steadily inject water onto fabric.
7. Remove fabric, place in Ziploc bag, and seal.
8. Remove from experiment glove box.
9. Measure mass of linen square and Ziploc bag. Record
10. Repeat steps 1-9 with cotton, microfiber, and wool.
11. Measure mass of linen square and record.
12. Measure mass of Ziploc bag and record.
13. Place linen square inside experiment glove box.

14. Fill syringe with 10-mL of simulated blood.
15. Touch tip of syringe to fabric.
16. Steadily inject simulated blood onto fabric.
17. Remove fabric, place in Ziploc bag, and seal.
18. Remove from experiment glove box.
19. Measure mass of linen square and Ziploc bag. Record
20. Repeat steps 11-19 with cotton and microfiber.
21. Calculate mass of wet fabric for each sample and record.
22. Calculate mass of liquid absorbed for each sample and record.

Alternate Procedure (used with one class):

1. Measure mass of linen square and record.
2. Fill syringe with 10-mL of distilled water.
3. Touch tip of syringe to fabric.
4. Steadily inject water onto fabric.
5. Measure mass of wet linen square. Record
6. Repeat steps 1-5 with cotton and microfiber.
7. Measure mass of second linen square and record.
8. Fill syringe with 10-mL of simulated blood.
9. Touch tip of syringe to fabric.
10. Steadily inject simulated blood onto fabric.
11. Measure mass of wet linen square. Record
12. Repeat steps 7-11 with cotton and microfiber.
13. Calculate mass of liquid absorbed for each sample and record.

RESULTS

Raw Data:

Raw Data: Distilled Water, Linen				
Initial Mass (g)	Mass of Ziploc & Fabric (g)	Mass of Ziploc Bag (g)	Final Mass (g)	Water Absorbed (g)
17.70	19.60	5.50	14.10	0.00
16.70	20.50	4.40	16.10	0.00
17.97	27.72	4.31	23.41	5.44
22.76	24.90	8.32	16.58	0.00
17.39	26.60	8.80	17.80	0.41
16.60	19.44	3.66	15.78	0.00
18.60	27.30	4.90	22.40	3.80
16.48	25.33	8.65	16.68	0.20
17.80	26.10	8.30	17.80	0.00
15.20	26.10	8.03	18.07	2.87
12.99	17.85	4.85	13.00	0.01
16.48	25.33	8.75	16.58	0.10
16.52	21.63	8.03	13.60	0.00
18.10	27.10	8.70	18.40	0.30
16.00	28.70	8.70	20.00	4.00
12.88	21.88	4.25	17.63	4.75
13.96	24.20	8.75	15.45	1.49
15.90	23.40	8.20	15.20	0.00
17.30	26.60	8.80	17.80	0.50
9.14	27.79	8.80	18.99	9.85
15.00	20.00	8.00	12.00	0.00
15.10	23.40	5.70	17.70	2.60
16.52	28.10	8.03	20.07	3.55
17.80	36.10	7.90	28.20	10.40
15.10	26.10	8.20	17.90	2.80
16.00	28.70	8.70	20.00	4.00
15.60	N/A	N/A	20.70	5.10
17.00	N/A	N/A	22.70	5.70
16.20	N/A	N/A	22.90	6.70
17.30	N/A	N/A	22.30	5.00
26.60	N/A	N/A	33.30	6.70
16.60	N/A	N/A	22.00	5.40
15.40	N/A	N/A	23.30	7.90

Raw Data: Distilled Water, Cotton				
Initial Mass (g)	Mass of Ziploc & Fabric (g)	Mass of Ziploc Bag (g)	Final Mass (g)	Water Absorbed (g)
27.20	39.90	5.50	34.40	7.20
25.50	38.80	4.40	34.40	8.90
24.64	45.31	4.31	41.00	16.36
26.00	43.70	8.80	34.90	8.90
24.02	42.00	8.32	33.68	9.66
26.00	43.70	8.80	34.90	8.90
22.60	33.15	8.77	24.38	1.78
22.00	31.14	4.53	26.61	4.61
24.80	33.00	4.90	28.10	3.30
24.23	41.25	8.75	32.50	8.27
25.40	41.80	8.40	33.40	8.00
25.08	40.68	8.03	32.65	7.57
23.69	40.85	4.85	36.00	12.31
25.10	43.20	8.70	34.50	9.40
21.00	27.64	4.25	23.39	2.39
23.00	39.90	8.50	31.40	8.40
24.89	45.50	5.00	40.50	15.61
26.60	40.50	8.20	32.30	5.70
26.00	43.70	8.80	34.90	8.90
33.64	50.93	8.80	42.13	8.49
25.00	43.00	8.00	35.00	10.00
20.30	38.80	5.70	33.10	12.80
27.30	45.40	8.20	37.20	9.90
23.00	39.90	8.60	31.30	8.30
25.70	34.50	7.20	27.30	1.60
24.60	N/A	N/A	33.10	8.50
24.60	N/A	N/A	33.40	8.80
24.80	N/A	N/A	32.00	7.20
24.20	N/A	N/A	37.60	13.40
17.80	N/A	N/A	19.50	1.70
24.80	N/A	N/A	33.00	8.20
25.80	N/A	N/A	33.40	7.60

Raw Data: Distilled Water, Microfiber				
Initial Mass (g)	**Mass of Ziploc & Fabric (g)**	**Mass of Ziploc Bag (g)**	**Final Mass (g)**	**Water Absorbed (g)**
16.40	34.80	4.40	30.40	14.00
14.42	35.25	4.31	30.94	16.52
16.50	34.70	8.80	25.90	9.40
14.75	32.80	8.32	24.48	9.73
16.50	34.70	8.80	25.90	9.40
15.50	33.77	6.64	27.13	11.63
17.90	34.70	4.90	29.80	11.90
16.61	33.03	8.75	24.28	7.67
17.70	36.10	7.90	28.20	10.50
15.64	32.49	8.03	24.46	8.82
18.69	36.29	4.85	31.44	12.75
16.61	33.03	8.75	24.28	7.67
15.64	32.49	8.03	24.46	8.82
17.10	36.50	8.70	27.80	10.70
18.08	23.65	4.25	19.40	1.32
17.60	36.30	8.90	27.40	9.80
17.23	38.10	8.80	29.30	12.07
13.90	32.00	8.20	23.80	9.90
16.50	34.70	8.80	25.90	9.40
18.77	35.32	8.80	26.52	7.75
15.00	33.00	8.00	25.00	10.00
16.30	29.90	5.70	24.20	7.90
15.64	32.49	8.03	24.46	8.82
17.70	36.10	7.90	28.20	10.50
18.60	32.50	8.20	24.30	5.70
19.60	N/A	N/A	27.00	7.40
18.90	N/A	N/A	30.90	12.00
17.30	N/A	N/A	28.50	11.20
16.70	N/A	N/A	26.10	9.40
19.60	N/A	N/A	27.00	7.40
17.30	N/A	N/A	35.70	18.40
18.60	N/A	N/A	24.60	6.00

Raw Data: Distilled Water, Wool				
Initial Mass (g)	Mass of Ziploc & Fabric (g)	Mass of Ziploc Bag (g)	Final Mass (g)	Water Absorbed (g)
20.6	30.5	4.9	25.6	5.00
16.9	25.68	4.25	21.43	4.53
19.4	30.7	8.5	22.2	2.80
20.11	35.79	8.8	26.99	6.88
19.4	30.7	8.5	22.2	2.80

Raw Data: Simulated Blood, Linen				
Initial Mass (g)	Mass of Ziploc & Fabric (g)	Mass of Ziploc Bag (g)	Final Mass (g)	Water Absorbed (g)
17.97	22.28	4.31	17.97	0.00
16.70	20.50	4.40	16.10	0.00
14.64	23.24	4.31	18.93	4.29
17.30	26.30	8.80	17.50	0.20
17.43	34.02	8.75	25.27	7.84
15.88	24.38	8.03	16.35	0.47
12.99	21.29	4.85	16.44	3.45
15.88	24.38	8.03	16.35	0.47
17.50	27.00	8.50	18.50	1.00
14.04	32.61	8.23	24.38	10.34
15.40	22.40	8.20	14.20	0.00
15.10	21.80	5.70	16.10	1.00
15.88	24.38	8.03	16.35	0.47
15.10	26.60	8.20	18.40	3.30
17.50	27.00	8.50	18.50	1.00
18.30	N/A	N/A	20.60	2.30
18.00	N/A	N/A	22.10	4.10
16.30	N/A	N/A	22.70	6.40
16.00	N/A	N/A	21.60	5.60
16.20	N/A	N/A	22.70	6.50
18.00	N/A	N/A	20.40	2.40

Raw Data: Simulated Blood, Cotton				
Initial Mass (g)	Mass of Ziploc & Fabric (g)	Mass of Ziploc Bag (g)	Final Mass (g)	Water Absorbed (g)
24.52	43.70	5.30	38.40	13.88
25.50	38.80	4.40	34.40	8.90
26.00	40.90	8.80	32.10	6.10
24.90	34.02	8.75	25.27	0.37
23.50	41.97	8.03	33.94	10.44
12.39	40.36	8.42	31.94	19.55
26.80	39.90	8.20	31.70	4.90
26.00	40.90	8.80	32.10	6.10
20.30	40.60	5.70	34.90	14.60
27.30	43.30	8.20	35.10	7.80
26.90	N/A	N/A	38.50	11.60
24.60	N/A	N/A	37.30	12.70
24.80	N/A	N/A	33.20	8.40
27.90	N/A	N/A	37.20	9.30
26.90	N/A	N/A	35.50	8.60
25.80	N/A	N/A	35.10	9.30

Raw Data: Simulated Blood, Microfiber				
Initial Mass (g)	Mass of Ziploc & Fabric (g)	Mass of Ziploc Bag (g)	Final Mass (g)	Water Absorbed (g)
14.92	18.73	4.31	14.42	0.00
16.40	34.80	4.40	30.40	14.00
24.42	33.31	4.34	28.97	4.55
16.90	35.20	8.80	26.40	9.50
16.50	35.20	8.80	26.40	9.90
19.70	35.90	7.89	28.01	8.31
15.71	31.95	8.03	23.92	8.21
18.69	36.85	4.85	32.00	13.31
19.70	35.90	7.89	28.01	8.31
17.50	36.09	8.83	27.26	9.76
13.90	32.40	8.20	24.20	10.30
16.30	38.80	5.70	33.10	16.80
18.60	37.90	8.20	29.70	11.10
18.20	N/A	N/A	27.20	9.00
18.50	N/A	N/A	28.50	10.00
17.30	N/A	N/A	27.50	10.20
18.20	N/A	N/A	27.20	9.00
17.30	N/A	N/A	27.50	10.20
18.60	N/A	N/A	26.50	7.90

Raw Data: Teacher Experiment, Distilled Water					
Fabric	**Initial Mass (g)**	**Mass of Ziploc & Fabric (g)**	**Mass of Ziploc Bag (g)**	**Final Mass (g)**	**Water Absorbed (g)**
Linen	18.40	27.50	8.90	18.60	0.20
Cotton	25.10	43.20	8.80	34.40	9.30
Microfiber	18.40	37.50	8.70	28.80	10.40
Wool	20.60	29.60	8.80	20.80	0.20

Raw Data: Teacher Experiment, Simulated Blood					
Fabric	**Initial Mass (g)**	**Mass of Ziploc & Fabric (g)**	**Mass of Ziploc Bag (g)**	**Final Mass (g)**	**Water Absorbed (g)**
Linen	18.20	27.20	8.80	18.40	0.20
Cotton	25.50	45.10	8.70	36.40	10.90
Microfiber	17.50	37.00	8.70	28.30	10.80

Statistical Analysis of Data:

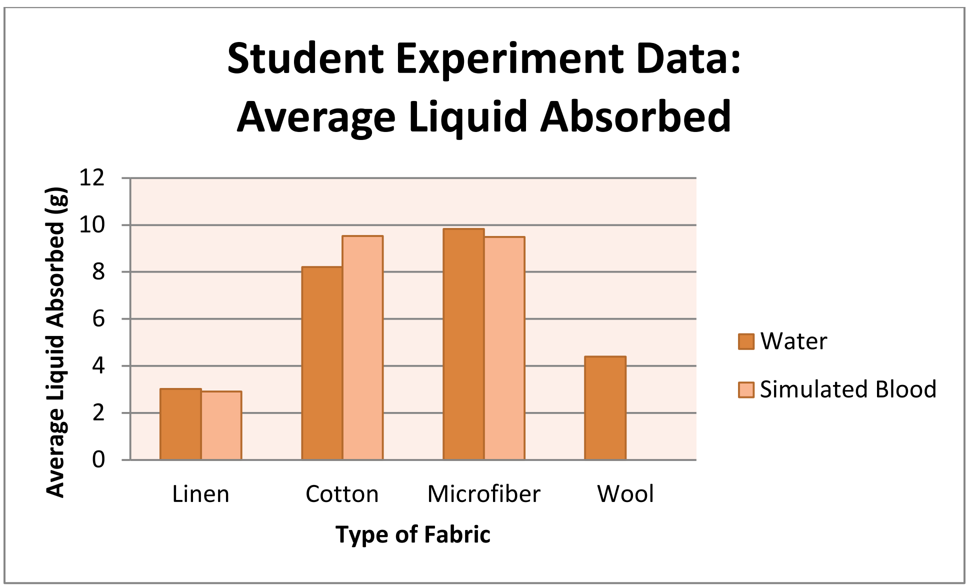
Student Experiment Data: Water Absorbed (g)				
Cloth	**Average**	**Standard Deviation**	**Median**	**Mode**
Linen	3.02	3.05	2.80	0.00
Cotton	8.21	3.56	8.45	8.90
Microfiber	9.83	3.07	9.57	9.40
Wool	4.40	1.53	4.53	2.80

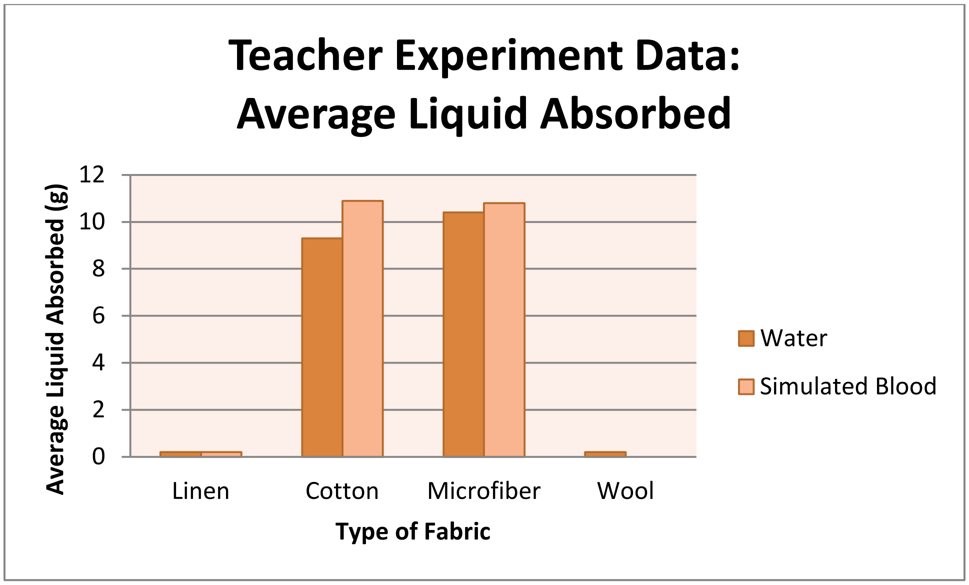
Student Experiment Data: Simulated Blood Absorbed (g)				
Cloth	**Average**	**Standard Deviation**	**Median**	**Mode**
Linen	2.91	2.91	2.30	0.00
Cotton	9.53	4.29	9.10	6.10
Microfiber	9.49	3.36	9.76	8.31

Student Experiment Data: Average Liquid Absorbed (g)				
	Linen	Cotton	Microfiber	Wool
Water	3.02	8.21	9.83	4.4
Simulated Blood	2.91	9.53	9.49	N/A

Teacher Experiment Data: Average Liquid Absorbed (g)				
	Linen	Cotton	Microfiber	Wool
Water	0.2	9.3	10.4	0.2
Simulated Blood	0.2	10.9	10.8	

Graphical Data:





Analysis:

The experiment was performed by four different classes of students. Each class had eight or nine groups of three or four students each. Students performed the experiment as described in the procedures section. One class conducted the experiment using the alternative procedure. Additionally, the teacher performed the experiment one time as a control to compare against student collected data.

While completing the experiment, not all students had time to perform all steps in the procedure. This is reflected in the raw data tables. Additionally, only one class had access to the wool, and there was only enough to perform the experiment using distilled water. Some students measured a negative amount of fluids absorbed by the linen and wool. In the data tables, this was converted to an absorption of 0 grams.

Based on the experimental results, microfiber and cotton are both very good at absorbing both distilled water and simulated blood. Linen and wool, though known for being absorbent of sweat against skin, do not appear to be a good choice for cleaning up spills in space. The average distilled water absorbed by the cotton was 8.21 grams with a standard deviation of 3.56. The average distilled water absorbed by the microfiber was 9.83 grams with a standard deviation of 3.07. The microfiber absorbed an average of 1.62 grams more distilled water than the cotton with a smaller standard deviation. The average simulated blood absorbed by the cotton was 9.53 grams with a standard deviation of 4.29. The average simulated blood absorbed by the microfiber was 9.49 grams with a standard deviation of 3.36. Although the cotton absorbed 0.04 grams more simulated blood than the microfiber, this is not statistically significant. Additionally, the standard deviation for the microfiber is smaller.

The teacher collected data aligns with these results with the microfiber absorbing 1.1 grams more distilled water than the cotton. The cotton absorbed 0.10 more grams of simulated blood than the microfiber. However, the teacher data shows a much lower rate of absorption for the linen and wool samples.

DISCUSSION

Conclusion:

As represented in the data collected, microfiber would make an excellent choice for cleaning up spills and/or absorbing water and blood on the ground. This does not support the hypothesis that linen would be the best choice for absorbing the liquids. This may be due to the fact that linen is good for absorbing bodily fluids like sweat away from the body in order to maintain a constant body temperature. This would be a slow rate of absorption where the experiment investigated a quicker rate of absorption. Microfiber is often used for absorbing water from cars after a car wash, and the results support this use.

There are several sources of error in the experiment. Although students were instructed to touch the tip of the syringe to the fabric, it was observed that not all students were touching the syringe to the fabric. This could affect the amount of liquid absorbed. There were seven different balances of two different models used during the experiment. Although each group of students used the same balance throughout the experiment, it appears the balances were not all calibrated correctly. The size of each Ziploc bag was identical, but some students measured the mass around 4 grams and others around 8 grams. This would also affect the mass of the fabrics measured. Additionally, air in the Ziploc bag could affect the accuracy of the measurement. With the linen, many students found a negative amount of liquid absorbed. Since this is not the case, it appears the balances were not sensitive enough to accurately measure the changes. Finally, there are more trials with the distilled water than with the simulated blood as many student groups were not able to perform the simulated blood experiment due to time constraints.

Application:

Microfiber and cotton are both good choices for cleaning up spills of water and blood. Since microfiber has a smaller mass and volume than the cotton, it would appear to be a good choice for cleaning up spills in microgravity. More microfiber cloths could be placed in the same amount of space as cotton cloths enabling the ability to clean up more spills if necessary. Conversely, the same number of microfiber cloths than cotton cloths could be stored in a much smaller space; this would open up valuable space in the space station and other space faring vehicles.

Recommendations for Further Research in Microgravity:

The ground based experiment seems to confirm that microfiber would be a good choice for cleaning up spills in microgravity. However, in order to validate the results, the experiment needs to be conducted in microgravity. It will be important to make sure the tip of the syringe is touching the fabric. This will aid in the absorption of the fluid by the fabric. Additionally, it will be important to expel as much air as possible from the storage Ziploc bags in order to eliminate that source of error. Finally, it will be imperative that the same balance is used throughout the experiment in order to eliminate additional sources of error.

Microfiber is a synthetic fabric usually made of polyester. Combining polyester microfibers and cotton together may create an even more absorbent fabric. A further experiment could test the absorbency of oils. Microfiber reportedly does well absorbing oils, and this would be a worthwhile experiment to conduct both on the ground and in microgravity.

LESSON PLAN

Duration: Two 70-minute class periods

Engage:

1. Ask students: How do we clean up a spill in space?
2. Conduct a short discussion of answers.
3. Show students Commander Hadfield's video about cleaning up spills in space. http://www.youtube.com/watch?v=8Hj3GnPRsJ4&list=PLUaartJaon3LV-ZQ4J3bNQj4VNVG2ByIG&index=40
4. Discuss student reactions. Pose questions like, "What materials might be the best choice for cleaning up a spill in space based on the information for Commander Hadfield?

Explore:

1. Ask students to predict how water and other liquids behave in microgravity.
2. Ask students what happens when you wring out a wash cloth on Earth. What would be different in space?
3. Show Commander Hadfield's video about wringing out a washcloth in space. http://www.youtube.com/watch?v=o8TssbmY-GM&list=PLUaartJaon3LV-ZQ4J3bNQj4VNVG2ByIG&index=21
4. Review special properties of water as it relates to the phenomenon witnessed in the video clip (adhesion, cohesion, surface tension, and capillarity).
5. Pass out Gore fabrics, cups of water, and pipettes. Have students investigate what happens when water is placed on the fabric.
6. Discuss: Why would these fabrics not work well for cleaning up a spill? What would be a good use for them?
7. Introduce terms of hydrophobic and hydrophilic. Discuss how it relates to the experiment.

Explain:

1. Pass out experiment lab paper (see page ___).
2. Have students complete background research notes, question, hypothesis, materials, procedure, and variables.
3. Approve student procedures, and allow students to conduct the investigation.
4. Students should then complete the data collection, data analysis, and conclusion sections.
5. If time, conduct class discussion about findings.

Notes:

This lesson was conducted with students in the afternoons of our state testing week. Due to unforeseen circumstances, there were last minute schedule changes to two of the classes resulting in less time to complete the activities. This is reflected in the experiment data. If more time was made available, an extend and evaluate section would also have been incorporated into this lesson plan. Video of student involvement can be found here: https://vimeo.com/67426263

Name: ____ Class Period: ____________

Group Members: ____

Fabrics and Absorbency

BACKGROUND RESEARCH NOTES

QUESTION (5 points)

What are you investigating? What is the question you want to answer?

HYPOTHESIS (5 points)

Which fabric do you think will absorb the most? Write in an "if, then, because" statement. *(If* I let go of the egg, *then* it will fall *because* of gravity.)

MATERIALS (5 points)

List everything you will use; make sure you use a bulleted list.

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PROCEDURE (10 points)

What are the steps to complete the experiment? Use as much space as you need and be DETAILED!

1.

VARIABLES (5 points)

Manipulated/Independent Variable (Cause) – What will you change or manipulate in your investigation?

Responding/Dependent Variable (Effect) – What will you measure because of what you changed?

DATA COLLECTION (50 points)

CHART #1 ____ (15 points)

Fabric	Initial Mass (g)	Mass of Ziplock bag with Fabric (g)	Mass of Ziplock Bag (g)	Final Mass (g)	Mass of Water Absorbed (g)

CHART #2 ____ (15 points)

Fabric	Initial Mass (g)	Mass of Ziplock bag with Fabric (g)	Mass of Ziplock Bag (g)	Final Mass (g)	Mass of Water Absorbed (g)

GRAPH Title ____ (20 points)

DATA ANALYSIS (10 points)

What did you discover from the data you collected?

How do you think your results would compare to a similar experiment conducted in a weightless environment?

CONCLUSION (10 points)

Address the following questions in your conclusion summary. You can write your conclusion on the back of this page.

- Was your hypothesis correct? Why or why not?
- Did this experiment answer your investigation question?
- Use information in your fabrics research to help explain why some fabrics absorbed better than others.
- If you could combine fabrics to create a more absorbent material, what would you use and why?
- What new questions would you like to test about fabrics and absorption?