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SLIME TIME

A FUN AND FASCINATING GOOEY LOOK AT THE WORLD OF NON-NEWTONIAN FLUIDS

By Brad Fulton
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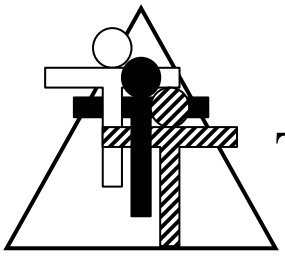

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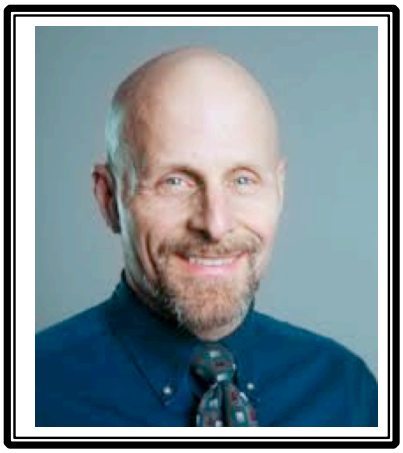
Brad Fulton

Educator of the Year



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- ♦ Consultant
- ♦ Educator
- ♦ Author
- ♦ Keynote presenter
- ♦ Teacher trainer
- ♦ Conference speaker

Known throughout the country for motivating and engaging teachers and students, Brad has co-authored over a dozen books that provide easy-to-teach yet mathematically rich activities for busy teachers while teaching full time for over 30 years. In addition, he has co-authored over 40 teacher training manuals full of activities and ideas that help teachers who believe mathematics must be both meaningful and powerful.

Seminar leader and trainer of mathematics teachers

- ♦ 2005 California League of Middle Schools Educator of the Year
- ♦ California Math Council and NCTM national featured presenter
- ♦ Lead trainer for summer teacher training institutes
- ♦ Trainer/consultant for district, county, regional, and national workshops

Author and co-author of mathematics curriculum

- ♦ Simply Great Math Activities series: six books covering all major strands
- ♦ Angle On Geometry Program: over 400 pages of research-based geometry instruction
- ♦ Math Discoveries series: bringing math alive for students in middle schools
- ♦ Teacher training seminar materials handbooks for elementary, middle, and secondary school

Available for workshops, keynote addresses, and conferences

All workshops provide participants with complete, ready-to-use activities that require minimal preparation and give clear and specific directions. Participants also receive journal prompts, homework suggestions, and ideas for extensions and assessment.

Brad's math activities are the best I've seen in 38 years of teaching!
Wayne Dequer, 7th grade math teacher, Arcadia, CA

"I can't begin to tell you how much you have inspired me!"
Sue Bonesteel, Math Dept. Chair, Phoenix, AZ

"Your entire audience was fully involved in math!! When they chatted, they chatted math. Real thinking!"
Brenda McGaffigan, principal, Santa Ana, CA

"Absolutely engaging. I can teach algebra to second graders!"
Lisa Fellers, teacher

References available upon request

Like my activities? How about giving me a favorable rating on the Teachers Pay Teachers website? Four stars would be much appreciated and would help me sleep better at night.

Like me even more? Then please don't make copies for your colleagues. I know it's tempting when they say, "Wow! Groovy activity! Can I have a copy?" But this is how I make my money, and why are they still saying "groovy" anyway?

If we make copies for our friends, can we honestly tell our students not to copy or take things that don't belong to them? (Ouch!)

Half priced site licensed copies are available on the TPT website. Please encourage them to take advantage of this affordable option. Okay?

Thanks and happy teaching,

Brad 

I want...

- ☐ a) Effective staff development
- ☐ b) Affordable staff development
- ☐ c) Ongoing staff development
- ☒ d) *ALL OF THE ABOVE!*

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Great DVD presentations offer quality mathematics staff development at a fraction of the cost!

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- **Ongoing because** when you hire new staff, simply hit "play" and the training begins. There's no need to bring back the consultant.

Slime Time:
A Fun and Fascinating Gooey Look at the World of Non-Newtonian Fluids

Required Materials:

- ☒ Re-sealable plastic bags
- ☒ Slime article
- ☒ Slime Time student worksheet
- ☒ See recipes for other materials

Optional Materials

- ☐ A copy of the optional Power Point on non-Newtonian fluids sold separately
- ☐ A copy of the movie *Ghost Busters*

Procedure:

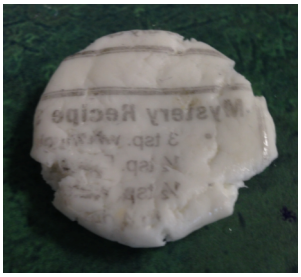
1. You may ask students if they know the three states of matter: solid, liquid, and gas. Ask them how they would define these three states.
   a. Solids retain their shapes.
   b. Solids can be bent or broken.
   c. Liquids take on the shape of their container.
   d. Liquids and gases flow, thus they are both called fluids.
   e. Fluids respond to convection, that is hotter fluids rise and colder fluids sink.
2. Ask your students if it is possible for a material to behave as both a solid and a liquid? They probably cannot think of examples, but what about a bottle of thick ketchup? It seems to resist flowing, yet once you get it going, sometimes it is difficult to stop. What about belly-flopping from a high dive? Does the water flow out of your way when your body hits it? What about gelatin? Is it a solid or liquid? Sometimes certain types of fluids can behave as both solids and liquids.. These are called **non-Newtonian fluids**.
3. Explain that the students will be making some non-Newtonian fluids, but first they must gather some research. Distribute copies of the article "Slime" and a copy of the Slime Time worksheet. **You may wish to use the Power Point file on non-Newtonian fluids sold separately in my store at the Teachers Pay Teachers website.**
4. I typically have students work in pairs reading the article and gathering the information necessary to complete the Slime Time worksheet.
5. Once they have the article finished, they can then use the recipes on the back to make the slimes.
6. The first recipe creates a slime that behaves like a liquid when a mild force such as pouring is applied and like a solid when a sudden force is applied. These are called ***rheopectic*** fluids because they have low ***viscocity*** when the force is mild and much higher viscocity when a sudden force is applied. Viscocity

Recipe 1

is resistance to flow. Here is a link for a You Tube video of a *Mythbusters* episode showing how this fluid reacts when Adam tries to walk on it: www.youtube.com/watch?v=5GWhOLorDtw

7. The second recipe is similar in some ways. With a sudden force, you can break it, but it also flows if affected by only gravity. It is less messy to handle than the previous recipe. However, it still is pretty messy at first. The more you handle it, the better it sets up. If quickly rolled into a ball and thrown on the ground, it will even bounce a little. The less water you use, the better it will bounce. The more water you use, the better it will flow.
8. The third recipe is the thickest one, so it bounces better. It also has the unique property that if you press it onto a newspaper, it picks up the image.

Recipe 2



Recipe 3

Answer Key

1. shape	2. flow	3. non-Newtonian
4. rheopectic	5. liquids	6. solids
7. quicksand	8. viscocity	9. Borax
10. polyvinylacetate	11. polyvinyl alcohol	12. longer-lasting
13. methylcellulose	14. compound	15. sink

SLIME TIME

A FUN AND FASCINATING LOOK AT THE WORLD OF NON-NEWTONIAN FLUIDS

What is slime?

All matter is either a solid, liquid, or gas, right? Are you sure? How do you know when something is a solid? What are the characteristics of liquids? Well, let's think about that. Your chair is a solid; aren't you glad? If you tip it over (don't actually try that) it is still shaped like a chair. But what shape is the water in your glass? It's shaped like the glass, isn't it? If you tip it over, then it's shaped like the floor!

Solids have a shape of their own, and they resist change. One of the characteristics of liquids is that they take the form of the solid that contains them. Liquids also flow. But there are some strange solutions that share properties of both solids *and* liquids. Have you ever tried to get some stubborn ketchup out of a bottle only to have it suddenly turn liquid and flow all over your burger?

Some glues, gelatins, and even quicksand also behave like liquids in some situations and solids in other ways. They seem to flow at times, yet in other situations they resist sudden movements. It's sort of like when you wade into the water as opposed to belly flopping from the high dive. It suddenly doesn't feel so liquid, does it?

Non-Newtonian fluids

These slimes are called *non-Newtonian* fluids for they don't seem to obey Isaac Newton's ideas of how solids and liquids should behave. Scientists say that the slimes we will be making are *rheopectic* slimes. That means that they are harder when you apply a force to them. The greater the force, the more they resitst flow. This resistance to force is called the *viscocity* of the fluid. Water has a low viscocity, while syrup has a much higher viscocity. Butter at room temperature has an even higher viscocity. Whew! That's a lot of big words to learn, but now you will sound pretty smart when you talk about your pancakes!

Types of slime

So where can you get your hands on some slime? Your kitchen or classroom is a good place to start. The simplest slime can be made using only warm water and

cornstarch. This will create a slime that appears to flow like thick syrup, but when you apply a *shearing force*, that is a force that brings a sudden change in direction, it actually cracks. Then it flows together once again. This slime can be messy, because in your hands it behaves more like a liquid such as paint.

Another slime is made with white glue and Borax. This one is less messy, and it also flows differently. It's more like an ooze than a liquid. It can even be rolled in a ball and bounced on the floor, but if you leave it there, it will flow out and form a puddle.

The third non-Newtonian fluid in this lab uses water, white glue, and Epsom salts. It is more like putty. It seems much more solid, but it will flow very slowly over a long period of time. It's probably the least messy of the bunch.

Polyvinylacetate and polyvinyl alcohol

What makes this slime work? Glue contains *polyvinylacetates* (PVAC) molecules. These are long *polymers* that are like long strands of spaghetti tangled together on your plate. The Borax hooks these together so they don't flow so well and begin to act more like a solid. That is, their viscocity increases. (There's that word again!)

Increasing the water in your slimes will help them flow better, while increasing the amount of Borax or the cornstarch will make them firmer.

Another type of slime is called PVA. This is made with a chemical called *polyvinyl alcohol* not to be confused with *polyvinylacetate*. This is what is typically sold in toy stores as slime. It's more difficult and dangerous to make, but it lasts longer than the slimes you'll be making.

Movie slime

If you have seen the movie *Ghost Busters* you have seen a lot of slime. Movie slime is called *methylcellulose*. Methylcellulose is not the best choice for our slimes as it tends to get pretty smelly after a while. That's because methylcellulose is an organic compound used it foods. It also doesn't last as long as our slimes, but if you are filming a movie scene, you don't need it to last too long.

Safe sliming

First and most importantly, don't discard your slime in the sink. Can you imagine what it would do to the drain? Because all of the ingredients in our slimes are common household materials, you can simply throw the slime in the trash when you are done.

Also keep in mind that the food coloring can stain clothing and some surfaces.

Some people may find that the Borax irritates their skin. You may wish to wear protective gloves if you have an allergy to Borax.

Name_____

Date_____ Class_____

Read the article on slime. Then answer these questions. Once you have finished, you can begin making your slime.

1. Solid objects tend to resist changes in their _____.
2. Liquids tend to _____.
3. Slimes are examples of _____ fluids.
4. _____ slimes seem to increase in hardness when you apply a force to them.
5. Slimes behave like _____ when you stir them slowly.
6. They behave like _____ when you apply a sudden force to them.
7. _____ is a naturally occurring slime.
8. _____ refers to the way a fluid flows or resists flowing.
9. To make your slime firmer, you can add _____.
10. The long molecules in slime are examples of _____.
11. PVA slime is made with polyvinyl _____ instead of acetate. This is the commercially available slime sold in toy stores.
12. PVA slime is _____ than our classroom version.
13. _____ is the name of the slime used in movies such as *Ghost Busters*.
14. Movie slime is an organic _____ so it doesn't last very long.
15. Slime should never be disposed of in the _____.

Here is your word bank. There are five extra words that you will not use.

alcohol	Epsom salts	matter	rheopectic
Borax	flow	Methylcellulose	shape
carbon	jelly	non-Newtonian	sink
chemical reaction	liquids	polyvinyl acetates	solids
compound	longer-lasting	quicksand	viscocity

Slime Recipe 1:

- 2 tablespoons warm water
- 3 tablespoons cornstarch
- 1 to 4 drops food coloring (optional)
- Re-sealable plastic bag

Add food coloring and then the cornstarch while stirring constantly. Pretty simple, huh? As long as you keep that 2:3 ratio of water to cornstarch, you'll get a good mix.

Slime Recipe 2:

- 8 tablespoons warm water (in two batches of 4 tablespoons each)
- 4 tablespoons white glue
- 1 tsp. Borax
- 1 to 4 drops food coloring (optional)
- Small cup
- Re-sealable plastic bag

Put half the water (4 tablespoons) into the plastic bag and add the food coloring if desired. Add the white glue. Add the borax to the remaining 4 tablespoons of water in a small cup. Stir until dissolved. Add the water and borax mixture to the baggie. Seal the bag and knead the mixture thoroughly. This slime will seem very messy at first, but the more you handle it, the better it behaves. To keep your slime longer, keep it refrigerated in the sealed bag.

Slime Recipe 3:

- 3 tsp. white glue
- ½ tsp. Epsom salts
- ½ tsp. water
- 1 to 4 drops food coloring (optional)
- 2 small cups
- Re-sealable plastic bag

Mix the Epsom salts and water in a small cup. Stir until dissolved. Put glue in a second cup and add food coloring if desired. Add salt and water mixture and stir well. When substance has formed, take it out and experiment with it. If you press it onto a newspaper, the writing will appear in reverse on the slime. Store it in the plastic bag. Refrigerate it when not in use.