The Science of Slime

A Hands-On Maker & Chemistry Curriculum

Explore polymers, non-Newtonian fluids, and iterative design through the ultimate tactile learning experience.

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Educator's Guide & Syllabus

> ***Note to Educators:*** *This curriculum bridges the gap between traditional chemistry and hands-on maker education. By treating slime not just as a craft, but as a dynamic material for experimentation, students will engage in the iterative design process, apply the scientific method, and even explore basic product development. Feel free to adapt the ratios and challenges to fit your classroom's needs!*

Course Description

The Science of Slime is an interactive, project-based course that explores the fascinating world of polymers through chemistry, physics, and creative engineering. Students will experiment with various formulas, study viscosity and non-Newtonian fluids, and use empirical testing to refine their creations. The course culminates in an entrepreneurial challenge where students finalize a custom formula, design a brand, and analyze the market economics of their product.

Core Learning Objectives

- **Scientific Inquiry:** Conduct hands-on experiments to manipulate and test chemical characteristics.
- **Material Science:** Understand the behavior of polymers, viscosity, and non-Newtonian (shear-thinning and shear-thickening) fluids.
- **Maker Pedagogy:** Develop critical thinking, iterative problem-solving, and prototyping skills.
- **Product Design:** Engineer a unique formula and compare the cost-analysis of homemade versus store-bought alternatives.
- **Communication:** Present final creations with a clear explanation of the underlying science and unique material properties.

Lesson 1: The Viscosity Variable

Objective: Test how varying concentrations of a cross-linking agent (Borax) affect the viscosity and elasticity of PVA polymers.

Materials Required:

½ cup white PVA glue • ½ cup warm water • Borax solution (1 tsp Borax dissolved in 1 cup warm water) • Measuring spoons • Mixing bowls & stir sticks

Procedure

1. Prepare the activator by completely dissolving 1 teaspoon of Borax in 1 cup of warm water.
2. In a primary mixing bowl, thoroughly blend ½ cup glue with ½ cup water. Divide this base mixture evenly into three separate testing bowls.
3. To Bowl 1, add 1 tsp of Borax solution. To Bowl 2, add 2 tsp. To Bowl 3, add 3 tsp.
4. Stir each mixture vigorously and knead by hand until the polymer matrix fully forms.
5. Observe the differences in stretchiness, stickiness, and structural thickness.

Data Collection

Amount of Borax	Stretchiness (1-5)	Stickiness (1-5)	Thickness (1-5)
1 tsp (Low Concentration)			
2 tsp (Medium Concentration)			
3 tsp (High Concentration)			

Lab Discussion

1. Which sample displayed the lowest viscosity (resistance to flow)? Which had the highest?

2. On a molecular level, why does increasing the Borax solution make the slime thicker?
3. If your goal was to engineer an ultra-stretchy slime for a specific product, how would you adjust your activator ratio?

Lesson 2: Cross-Linking Activators

Objective: Compare the material properties yielded by different chemical activators on a standard PVA glue base.

Materials Required:

½ cup white PVA glue • ½ cup warm water • Borax solution • 1 tbsp liquid starch • 1 tbsp saline solution (must contain boric acid) • Measuring spoons • Bowls & stir sticks

Procedure

1. Prepare three identical base mixtures by mixing ½ cup glue with ½ cup water in each bowl.
2. Introduce a unique activator to each bowl:
   - **Bowl 1:** Add 1 tsp Borax solution.
   - **Bowl 2:** Add 1 tbsp liquid starch.
   - **Bowl 3:** Add 1 tbsp saline solution.
3. Knead each sample until cross-linking is complete. Evaluate the tactile differences.

Data Collection

Activator Used	Stretchiness (1-5)	Stickiness (1-5)	Firmness (1-5)
Borax Solution			
Liquid Starch			
Saline Solution			

Lab Discussion

1. Which chemical activator produced the most elastic polymer? Which was the most rigid?
2. Why do you think different cross-linking agents result in distinct physical textures?
3. How does the density of cross-links affect the final state of the slime?

Lesson 3: Shear-Thinning Mechanics

Objective: Explore how non-Newtonian polymers react to varying application of kinetic force.

Materials Required:

½ cup white PVA glue • ¼ cup water • ½ tsp baking soda • 1 tbsp saline solution • Mixing bowls & stir sticks

Procedure

1. Combine ½ cup glue and ¼ cup water. Add ½ tsp baking soda and stir thoroughly to adjust the pH.
2. Gradually mix in 1 tbsp saline solution. Knead until a stable slime forms.
3. Subject the slime to three kinetic tests: a slow stretch, a rapid pull, and a compression/rolling test.

Data Collection

Kinetic Test	Observation of Polymer Behavior	Structural Integrity Maintained?
Slow Stretch		
Fast Pull (Snap)		
Compression (Rolling)		

Lab Discussion

1. Why does the slime stretch organically under slow, steady force, but cleanly fracture under rapid force?
2. In what ways is this fluid dynamic similar to everyday materials like paint or ketchup?

Lesson 4: Shear-Thickening vs. Shear-Thinning

Objective: Directly compare the mechanical behavior of a shear-thickening fluid (Oobleck) against a shear-thinning fluid (Slime).

Materials Required:

1 cup cornstarch • ½ cup water (for Oobleck) • Standard Slime Batch (from Lesson 3)

Procedure

1. **Formulate Oobleck:** Place 1 cup of cornstarch in a bowl. Slowly mix in ½ cup water until the mixture feels rigid upon impact but flows freely when released.
2. **Formulate Slime:** Prepare a standard batch of saline-based slime.
3. Apply the slow stretch, rapid strike, and compression tests to both materials side-by-side.

Data Collection

Kinetic Test	Oobleck (Shear-Thickening)	Slime (Shear-Thinning)
Slow Tension		
Rapid Impact / Tap		
Compression		

Lab Discussion

1. Why does Oobleck instantaneously harden upon impact while slime tends to fracture or yield?
2. Consider real-world engineering: How could shear-thickening materials be utilized in protective gear or automotive design?

Lesson 5: Environmental & pH Stress Testing

Objective: Investigate how extreme temperature shifts and chemical pH alterations degrade or reinforce the polymer structure.

Materials Required:

Basic slime batch • Vinegar (acidic compound) • Baking soda solution (alkaline compound) • Ice bath • Warm water bath

Procedure

1. Prepare a large, standardized batch of basic slime and divide it evenly into four test groups.
2. **Temperature Stress:** Submerge one sample in an ice bath and another in a warm water bath for 5 minutes.
3. **Chemical Stress:** Knead a few drops of vinegar into the third sample. Knead a concentrated baking soda solution into the fourth.

Data Collection

Stress Condition	Initial State	Post-Stress State	Viscosity Change?
Cold Exposure (Ice)			
Heat Exposure (Warm)			
Acidic Exposure (Vinegar)			
Alkaline Exposure (Base)			

Lab Discussion

1. How did thermal energy (heat) affect the molecular mobility of the polymer chains?
2. Did the acidic introduction break down the cross-linking? Explain your observation.

Lesson 6: Engineering Special Effects

Objective: Introduce functional additives to the polymer matrix to create responsive, "smart" materials.

Materials Required:

3 batches of basic slime • Glow-in-the-dark powder (phosphorescent) • Iron filings & strong neodymium magnet (ferromagnetic) • Thermochromic pigment

Procedure

1. Prepare three independent batches of baseline slime.
2. **Phosphorescence:** Knead glow powder into Batch 1. Expose to strong UV/LED light, then observe in darkness.
3. **Ferromagnetism:** Fold iron filings thoroughly into Batch 2. Test its responsiveness to the neodymium magnet.
4. **Thermochromism:** Blend color-changing pigment into Batch 3. Apply body heat or cold water to trigger the shift.

Data Collection

Additive Type	Pre-Stimulus Observation	Post-Stimulus Observation	Effect Intensity (1-10)
Phosphorescent (Light)			
Ferromagnetic (Magnetic)			
Thermochromic (Heat)			

Lesson 7: Iterative Product Formulation

Objective: Utilize the iterative design process to engineer a custom slime formula tailored to specific sensory or functional criteria.

Materials Required:

PVA glue • Water • Choice of Activators • Baking soda • Assorted mix-ins (glitter, foam beads, pigments, scents)

Procedure

1. **Define the Goal:** Outline the specific tactile, visual, and auditory properties you want your final product to possess.
2. **Draft the Formula:** Start with a theoretical baseline ratio of $glue + water + activator$.
3. **Prototyping & Iteration:** Mix your first prototype. If it fails to meet criteria (too stiff, too sticky), adjust one variable at a time and document the change.

Prototyping Log

Material Used	Volume/Mass	Intended Purpose	Adjustment Made?
Glue Base			
Hydration (Water)			
Cross-linker			
Sensory Add-ins			

Lesson 8: Market Research & Branding

Objective: Apply principles of entrepreneurship to package, brand, and conduct a comparative cost-analysis of the engineered product.

Materials Required:

Finalized custom slime (from Lesson 7) • Packaging containers • Label design materials • Store-bought slime (for reference)

Procedure

1. **Brand Identity:** Develop a compelling product name and design a visually striking label that highlights the slime's unique selling points (USP).
2. **Market Analysis:** Evaluate your homemade product against a popular retail alternative based on quality, volume, and cost of goods sold (COGS).

Comparative Analysis

Product Metric	Your Prototype	Retail Competitor	Market Advantage
Texture / Durability			
Visual / Sensory Effects			
Packaging Appeal			
Estimated Cost per Unit			

Lab Discussion

1. Based on your COGS, what is a viable retail price for your product that ensures a profit margin?

2. How does branding influence a consumer's perception of the product's value?

Lesson 9: The Slime Showcase & Testing Trials

Objective: Conduct peer-reviewed performance testing in a competitive and engaging environment to validate material properties.

> ***Challenge Rules:*** *Form testing groups. Each product will be subjected to the standardized trials below. Record the empirical performance of each competitor.*

Performance Trials

- **Tensile Strength (Longest Stretch):** Measure the maximum distance the polymer can stretch before structural failure.
- **Kinetic Return (Best Bounce):** Drop a spherical sample from a fixed height and measure the rebound apex.
- **Acoustic Resonance (Loudest Pop):** Measure or vote on the best auditory feedback during air-pocket compression (ASMR).
- **Viscosity Test (Slowest Drip):** Suspend a fixed mass of slime; time how long it takes to reach the floor.

Official Trial Scorecard

Trial Category	Competitor / Product Name	Metric / Score (1-10)	Class Rank
Tensile Strength			
Kinetic Return			
Acoustic Resonance			
Viscosity Duration			
Overall Innovation			

Final Reflection

In a short paragraph, reflect on the engineering process. What was your most significant chemical or mechanical failure during prototyping, and how did you iterate to solve it?

Student Signature / Date