Lesson Name: Gak!
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Grade Level: 5th
Standards Connection(s): During chemical reactions atoms rearrange into different products with different properties

Teaser: New scientists! You are given the task of making the best gak. The head scientists have come up with three recipes but they need your help to find the best one. Using concepts of engineering and science, together we will explore the new materials and learn methods to test for which one has the best properties.

Objective: As a result of your lesson, what will students learn? What will they be able to do? Exploring materials and testing them for applications. Combining materials can produce materials of new properties

Vocabulary/Definitions: 3 – 6 important (new) words
- Chemical Reaction - when atoms rearrange, causing one or more substances to change into one or more new substances with different properties
- Property – characteristics of a substance (e.g., color, taste, smell, mass, attraction to a magnet)
- Elasticity – how easily a material returns to its original shape after being stretched or bent
- Stiffness – how hard it is to stretch a material
- Shape Memory/Retention – how well an object holds its shape

Materials:
What will you bring with you?
- Glue, – Spoons,
- Borax, – Water,
- Corn starch, – Worksheets,
- Paper towels, – rulers,
- Cups, – paper,
- – trash bags,
- – goo gone,
- – Ziploc bags

What should students have ready (pencils, paper, scissors)?
Pencils, paper.
Classroom Set-up: Student grouping, Power/Water, A/V, Light/Dark, set-up/clean-up time needed
6 groups of 4-6 students: each group will receive three different gak formulations. Kids need to wash their hands after the experiments. Set-up time: 15 minutes, Clean-up time: 10 minutes

Classroom Visit

1. Personal Introduction:  
   Who are you? What do you want to share with students and why? How will you connect this with students’ interests and experiences?

   We are engineers. We use science to solve really cool problems. I am Kathryn, and I am working with chemistry and biology to make processes more environmentally friendly. I am Edwin, and I work on building new materials to speed up chemical reactions. I am Barbara and I modify materials to help us grow organs outside of the body. I am Jorge and I am using viruses to cure diseases.

   Topic Introduction:  
   What questions will you ask to learn from students? Big Idea(s), vocabulary, assessing prior knowledge...

   Engineers think a lot about the properties of the materials we’re working with. Who can tell me what the word “property” means? What are some examples of properties? (e.g. Physical properties: color, texture, odor, mass, conduct heat, conduct electricity, magnetic, floats or sinks in water, solubility. Chemical properties: burns, rusts, reacts with acids...) Hold up a classroom object, such as a pencil, and ask the students to identify some of its properties. As students name properties, write them on the board. How do the properties of a pencil make it right for the job of writing? It’s a solid, it’s a good size and shape for holding, it leaves a mark on paper. These are all important properties. Some of the other properties – like color – are interesting, but are not as important. The outside color of a pencil doesn’t affect how well suited it is to writing.

   Who here has ever played with gak? What were some of its properties? What did you use it for? What did you like about it?

   What are the important properties of gak that make it “gak-y”? Do you think it should be stretchy, bouncy, etc.? Should it hold its shape? There are 3 properties of gak that are especially important:
   - One is called elasticity. Has anyone heard the word “elasticity” before? Or a word like it? What do you think it means? “Elasticity” is a lot like the word “elastic” – when you bend or stretch a material with high elasticity goes back to its original shape easily, just like how when you stretch a piece of elastic it goes back to its original shape right away. (Silly Bandz have high elasticity!)
- Another is called **stiffness**. You might have heard this word before – can anyone guess what stiffness is? Stiffness is how hard it is to stretch a material. What are some things in the room that are hard to stretch? These are all high in stiffness.
- The third important property of gak is called **shape retention**. Can anyone guess what this means? Shape retention means how well an object holds its shape. Solids – like pennies – are usually very good at holding their shape. Have you ever seen a penny change shape on its own? Liquids, on the other hand, are not very good at holding their shape. What happens if I pour water from a cylindrical (round) cup into a square container? It takes the shape of the container.

Today you are going to be engineers - you will make 3 different types of gak and compare their properties! We have three different recipes for gak, and we need to figure out which gak is highest in elasticity, which is highest in stiffness, and which is highest in shape retention.

**Safety:**
- Don’t eat borax/glue
- Gak will stick to clothing and carpet: BE CAREFUL!

2. **Learning Experience(s):**

   **What will you do, what will kids do?** Demonstrations, hands-on activities, images, games, discussion, writing, measuring... Describe in order, including instructions to kids.

First, we’ll demonstrate up here how to make the gak. (As one or more people are demonstrating, have one or more volunteers walk around and distribute materials to each desk group or station – cover the table in newspaper, then place glue, Borax, water, a measuring device, cups, spoons, and recipes on top.) We’ll need to mix three substances: glue, water, and a powder called “Borax.” (Or two if the Borax is pre-dissolved in water.) Our recipe card tells us how many parts of each substance we need. Notice how carefully we’re measuring the amount of each substance. It’s very important for you to measure carefully today because we want to be able to compare three different recipes that use three different measurements.

Also notice that we’re being careful not to spill or drop our substances. Scientists need to make sure they don’t damage the room they’re working on – or themselves. We never eat any parts of our experiments, and we try never to spill them.

What do you notice as we’re mixing the gak ingredients together? Has anyone heard of a chemical reaction? What happens in a chemical reaction? In a **chemical reaction**, one or more substances change into one or more new substances because the atoms are rearranging into different products with different **properties**. How is this different from a physical reaction? Do you think a chemical or physical reaction is occurring when we make gak?

Now it’s your turn to make your own gak. You’ll work in groups to make three different recipes, using different measurements in each. Be sure to measure carefully so that we can compare the three different gaks when you’re done. As you’re making the gaks, think about the properties of
the starting materials (glue, Borax, water) and the properties of the gak. Decide whether you think a chemical reaction is occurring. Why or why not?

Have each group make their three gaks, and walk around distributing food coloring into each cup so that each recipe produces gak of a particular color. Ask the kids to write down on their worksheets which recipe is which color. Prompt them to observe what the starting materials look like and then what the finished product looks like, and think about whether a chemical reaction is occurring.

After the gak is made, have the kids move to the front of the room, where we will demonstrate how to test the material. The tests to be performed are:
- **Bounce**: drop the gak from a standard height and see if they bounce (and if so, how high)
- **Imprint**: press a paper clip the gak and count how long the imprint of the paper clip lasts
- **Shape retention**: roll the gak into a ball observe how well/long it keeps its shape
- **Stretch**: pull the gak into a rope until it snaps and measure how long each rope could get before breaking.

The first three are qualitative observations (on a relative scale); the last test is quantitative (measurement with ruler). Have them write down their findings on their data sheets, and then write the results on a table pre-drawn by us on the board. When all groups are done with testing, have the kids put the gak in the front of the room.

Go over the results, discuss the repeatability between groups. Ask them whether or not it makes a difference when different people perform the same experiment.

**3. Wrap-up: Sharing Experiences**

**10** Minutes

*Putting the pieces together – how will students share learning, interpret experience, build vocabulary?*

- Ask for a volunteer:
  - Who had a favorite gak? Why?
  - Relate answers to vocabulary words.
- Go over how we mixed things together, tested them, and saw which one gave the best gak.
- Ask if they think a chemical reaction occurred. Why or why not?
- Give an engineering example of a similar application (e.g. shoe rubber, compare that to elasticity)
4. Connections & Close:  

What else might kids relate this to from their real-life experience? How can they learn more? Thanks and good-bye! Clean-up.

- Talk about processes and applications like baking, comparing shoe rubber vs. rubber band rubber, where similar concepts are applied.
- Suggest kid-friendly websites about materials, product testing, etc.
- Give them a recipe card where they can fill in the recipe for their favorite formulation (glue, borax solution).
- Mention examples of fields they could work on where they could optimize properties for materials (e.g. rubber for shoes of basketball players, car bumpers).

Total 60 Minutes

Follow-up – After Presentation

Suggest students write a letter explaining “How we learned about Gak!”

What’s Happening?  
from California Science Center:  
http://www.californiasciencecenter.org/FunLab/DoytYourself/Gak/GlobbyGooeyGak.pdf

Q. Why does Gak stretch, even though glue and Borax don’t?
A. Mixing materials can cause a chemical reaction. The chemical reaction creates a new material (in this case Gak) different from the two original materials.

Q. How does the chemical reaction work?
A. Glue is made up of long, spaghetti-like molecules that sometimes get tangled together. That’s why glue doesn’t flow fast like water. Borax reacts with the glue to loosely tie the long molecules together. The molecules of the new material, Gak, look more like a poorly woven rug than a plate of spaghetti. The new material feels and looks different from what you started out with.

Q. Can we find substances like Gak in everyday products?
A. Like the plastic used to make soda bottles or the nylon fabric of a windbreaker, Gak is a kind of polymer—a type of chemical we use in our daily lives. Can you think of a way we could use Gak?