OHIO STATE UNIVERSITY EXTENSION

STEM PATHWAYS
Corny Polymer Balls STEM Challenge!

The Problem

The 4 Clovers Toy Company is looking to change the formula they use to make a popular bouncing ball. Market studies show that consumers want to purchase disposable bio-friendly toys. The company's senior chemist has requested that biodegradable ingredients be studied for their practical use in the bouncing ball's new formula.

The Challenge

To develop and test an hypothesis to determine the practical use of glue, borax and corn starch to enhance the bounce factor for a children's disposable toy ball.

Find a Measurable Solution

ASK: What is your hypothesis?

HYPOTHESIZE: Identify independent & dependent variables.

TEST: Conduct an experiment.

ANALYZE: Results, draw conclusions, try again!

COMMUNICATE: Findings and make recommendations.

Things to Consider

1. What properties do you want your corny polymer ball to possess?
2. What properties do you think each ingredient offers to the corny polymer ball?
3. How will you test for the various properties and compare product formulations for desired end product?

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What Properties Should Your Ball Have?

- Slimy?
- Bouncy?
- Sticky?
- Stretchy?
- Goopy?

What Ingredient(s) Impacts Which Property?

What is Your Hypothesis?

Identify Independent & Dependent Variables

- Glue (white, clear, all-purpose, school, wood, washable, different brands, etc.
- Borax (laundry-booster)
- Cornstarch
- Ration of ingredients
- Mixing time
- Ingredient order
- Water temperature

SAFETY ALERT:
Don't eat the materials used to make the ball or the ball itself. WASH YOUR HANDS!

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FACILITATOR PROCESSING

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- **Did you accept or reject your hypothesis?**
- **What changes will you make?**
- **What questions do you still want to explore?**

TIME: 15 - 30 MINUTES

Materials & Supplies

- Glue (different types)
- Cornstarch
- Food Coloring
- Measuring spoon/cup
- Water (warm)
- Plastic cups or zipper-type bags
- Plastic spoon or craft stick to stir
- Borax (laundry booster found in detergent section)

Design Space

- Table space sufficient for each group to work.
- Cover tables for easy clean-up.
- Ingredients in labeled containers; small amounts can reduce waste.
- Basic formula.

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Engage the Learner

- How do scientists come up with their experiment?
- What do you already know about the properties of your variables? What might you need to research?
- How can you test for various properties?
- What safety considerations are needed in mixing chemicals?
- How would you report your findings to consumers, the toy company or other scientists?

Observations & Conclusions

- Observe your corny polymer ball. What changes would you like to make?
- How will you test for that change?
- What do you think would happen?
  - ☛ if you left an ingredient out;
  - ☛ used more or less of one ingredient;
  - ☛ used cold water;
  - ☛ did not stir; etc.

STEM Career Path… Polymer Scientist

- Who else might be involved? *Chemist, engineer, electrical technician, quality control manager*
- Who benefits? *Consumers and future generations with more alternative products to petroleum fuel based products, agriculture producers with more market options for commodities, and science community through new discoveries.*
- What other industries might benefit from this work? *Water treatment, soil erosion, horticulture, any industry that uses a plastic for product development or packaging*

Refer to Career Focus Card for more details.

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FORMULA

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Working in Groups of 4 to 6…

Step 1: Make Borax Solution in Cup A.

- Place 2 T of warm water into Cup A.
- Add ½ tsp. of Borax powder and stir until borax dissolves.
- Add a drop of food coloring.

Step 2: Make Ball Mixture in Cup B

- Place 1 T of glue into Cup B.
- Add a ½ tsp. of the borax solution from Cup A on top of the glue.
- Add 1 T of cornstarch.
- DO NOT STIR YET! Wait 15 to 20 seconds to allow ingredients to interact. Then STIR!

- Step 3: Mixing Together
- Stir materials together in cup B until the mixture is impossible to stir.
- Take mixture out of Cup B and start molding the ball with your hands.
- Ball will be sticky and messy at first, but kneading will form it into a solid.

- Step 4: Test It and Make Observations
- Bounce your ball on the table. How bouncy is it?
- What would you like to change?
- How can you test for that change?
- What is your hypothesis and independent and dependent variables?

Step 5: Store Ball with Safety Reminder in a zipper type bag.

DO NOT EAT THE BALL or the ingredients to make the ball! Wash hands with soap and water!

Test Your Hypothesis

Record Your Findings

Share Your Results

What is your hypothesis?

What are your variables?

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STEM PATHWAYS Corny Polymer Ball Lab Analysis Data Sheet

Hypothesis: _____

_____ ❒ Accepted ❒ Rejected

Independent Variable: _____ **Dependent Variable:** _____

Glue Tested	Describe Bounce Factor	Height of Balance	Length of Bounce	Ball Diameter, Elasticity, Texture, etc.
All-Purpose Glue **Brand:**				
White School Glue **Brand:**				
Clear School Glue **Brand:**				
Wood Glue **Brand:**				
Washable Glue **Brand:**				

Your Recommendation to 4 Clover Toy Company

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STEM Pathways Safety Alert

The Corny Polymer Ball You Made Contains Glue and Borax (a laundry booster).

DO NOT EAT THE BALL!

Wash Your Hands After Handling!

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STEM PATHWAYS

career

Corny Polymer Ball STEM Challenge

Did You Know? Polymers are what helps keep your hair in place when you use hairspray, a gel or mousse. There are both natural and synthetic polymers used in hundreds of products we use everyday. View: : http://science360.gov/obj/tkn-video/1267e29c-f852-4cbd-bb01-331c72bb4fb4

SCIENCE

Polymer Scientist

What causes the mixture to become a bouncy ball?

- Polymers are molecules made up of repeating units connected by chemical bonds. How those chains are put together determines how the product acts – some are rubbery, some are hard and tough while others are sticky and gooey.
- For the polymer ball, if you add more glue, the ball is slimy, add more corn starch, the ball becomes more stretchy or add less borax and the ball will be goopier. None of which is optimal for a ball the consumer wants to bounce.
- There are natural polymers like DNA, proteins and cellulose as well as synthetic polymers like nylon, silicone, neoprene and polystyrene.

TECHNOLOGY

Electrical
Mechanical
Technician

What factors need to be considered when designing, maintaining and monitoring machines to manufacture polymer products?

- Improper ratios of ingredients or inadequate mixing time will lead to a poor or inconsistent product.
- Understanding of the product and the equipment used in making the product is essential.
- Many on-line and computer based systems allow for automation of monitoring, but require technicians with diagnostic and analysis skills to troubleshoot and interpret data collection.
- Not all STEM jobs require a college degree! Technical training is in high demand as well.

ENGINEERING

Polymer Engineer

How can this polymer be modified to make a different ball?

- If you used salt, sugar, baking soda, corn meal, flour or oatmeal in place of the corn starch, would you be able to create a different type of ball? What if you used liquid starch instead of borax? That's what polymer engineers do, look for ways to modify polymers to improve performance or make new products.
- Polymer engineers not only design new products and modify existing ones, but make process changes to improve efficiency.

MATH

Quality Manager

Why is quality control important to a polymer manufacturer and the consumer?

- Competitive edge comes when polymer properties are consistent over the entire production process, maximizing production performance while keeping safety regulations.
- Manufacturers and customer satisfaction happens when quality managers assure product performance.

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career

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Polymer Scientist

Finding Solutions For...

- Fine-tune existing polymers, create new polymers that cost less and perform better and create special application plastics.
- Plastics and synthetic fibers; agricultural chemicals; paints and adhesives; and biomedical applications such as artificial skin, prosthetics, and the nicotine patch to name a few.
- Environmental friendly polymers that biodegrade.

Job Forecast Looks Like...

- **Median Income:** $88,990 per year
- **Job Outlook:** 6% growth from 2012-2022
- **Job Environment:** Laboratories, offices, production sites.
- **Expected Growth Areas:** As many as 50% of all chemists, will work in polymers sometime in their careers. Industries where adhesives, coatings, synthetic rubber, synthetic fibers, agricultural chemicals, packaging, automotive, aircraft, aerospace, biomedical industries.

Skill Set Needed...

- **High School Courses:**

  - Math: algebra, calculus

  - Science: biology, chemistry, and physics

- **Critical-thinking:** analytical and problem-solving skills to conduct precise and accurate scientific experiments to develop new and improved products, processes and materials
- **Communication**: writing and speaking skills to share experiments and results
- **Teamwork:** to motivate and work well with others on a research group

Education and Training Required...

- **Entry Level Jobs:** Require Bachelor's degree
- **Additional Training and Certifications:** most polymer scientists have a Ph.D. and were trained as organic chemists. Only a few colleges and universities have a degree in polymer science, internships provide useful training.

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Source:
American Chemistry Society:
http://www.acs.org/content/acs/en.html