

STEM PATHWAYS

Natural Glue **STEM** Challenge!

The Problem

Glue is used to help manufacture furniture and typically made from petroleum. Emily owns a furniture store and is looking for ways to make her company more environmentally-friendly by using a glue made from renewable agricultural materials.

The Challenge

Help Emily by formulating a glue using known bio-friendly ingredients then comparing the glue's performance against a standard wood glue for drying time, strength and adhesion.

Find a Measurable Solution

ASK: What is your hypothesis?

HYPOTHESIZE: Identify your variables.

TEST: Conduct an experiment.

ANALYZE: Results, draw conclusions, try again!

COMMUNICATE: Findings & make recommendations.

Things to Consider

1. Why do we use glue and for what applications?
2. What performance features need to be in glue in order for customers to purchase it?
3. What type of experiment will you design to test the strength of your glue mixture?

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What is Your Hypothesis?



What are your variables?

Identify Independent and Dependent Variables

- Types of Flour
- Ratio of Ingredients
- Amount of Water
- Mixing Time
- Drying Time
- Amount of Adhesive Applied
- Adhesion
- Strength



SAFETY ALERT:

Do not eat the adhesive glue and wash your hands after handling the glue.



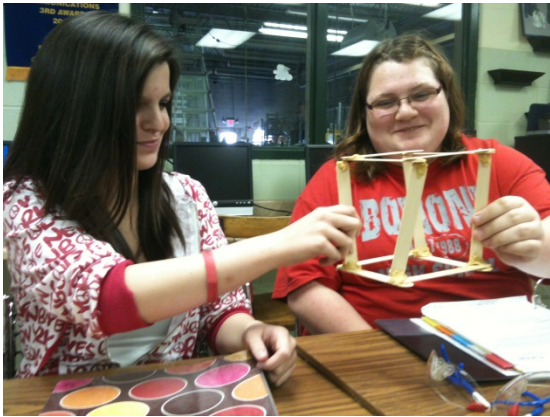
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TIME: 30 MINUTES

Materials & Supplies

- Craft sticks
- Large plastic cups or zipper type bags
- Wooden stir stick
- Measuring tools; cups & spoons
- Stopwatch to measure drying times
- Standard Wood glue
- Different Flours
- Sugar
- Vinegar
- Water

Design Space

- Table space for teams of two.
- Table covers for easy clean-up
- Ingredients measured out in labeled containers.
- Basic formula



SAFETY ALERT: Do not eat the adhesive glue and wash your hands after handling the glue.

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

Engage the Learner

- What environmental factors could affect the glue's ability to bond materials together?
- How might the materials being bonded affect the glue's hold?
- What are the positives and negatives of using an agricultural-based glue versus a petroleum-based glue?
- Identify objects in nature that are naturally "sticky"?

Observations & Conclusions

- How might you alter the ingredients next time to improve the glue's adhesiveness?
- What other experiments could you design to test the glue's bonding ability under different conditions?
- What other agricultural materials could be substituted in the ingredients' list to make the glue?
- Why is it beneficial to make natural glue that does not contain harmful chemicals, which are found in some petroleum-based glues?

STEM Career Path... Chemist

- Who else might be involved? *Agricultural producers, processing operator, materials engineer, manufacturer and marketer*
- Who benefits? *Consumers with more sustainable choices, agricultural producers with expanded commodity market opportunities, and new jobs.*
- What other issues are chemists helping to solve? *Producing lighter and stronger materials for vehicles to increase fuel mileage and safety, creating more nutritious foods, and discovering new medicines to treat illness.*

Refer to Career Focus Card for more details.



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FORMULA

Each group of 2 will ...

Step 1: Gather two craft sticks, a wooden stirring stick and a plastic cup or zipper type bag.

Step 2: Place 1 cup flour of your choice into the plastic cup or zipper type bag.

Step 3: Add

- ☛ 1 ½ cups water
- ☛ 1/3 cup sugar
- ☛ 1 teaspoon vinegar

Step 4: Using the stir stick, mix the contents very thoroughly.

- Step 5: Now design an experiment to test the glue's adhesiveness. An example may include using the stir stick to apply the mixture to the end of one craft stick. Place the end of another craft stick on top of the mixture to adhere them together.
- Step 6: Allow a few moments for the adhesive to dry; use the stopwatch to time drying length.
- Then develop a series of different tests to determine the adhesive's strength.
- Repeat experiment and alter variables to test.
- Record and discuss procedures, results and observations.



Test Your Hypothesis

Analyze Your Findings

Communicate Your Results



What is your hypothesis?

What is your independent and dependent variables?



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STEM PATHWAYS Natural Glue Lab Analysis Data Sheet

Hypothesis: _____
 _____ Accepted Rejected

Independent Variable: _____ Dependent Variable: _____

Glue Tested	Drying Time Record Time	Amount Applied Record Measurement	Describe Adhesive Bond	Describe Strength Test Conducted
Wood Glue				
Natural Glue Record Flour Type Used				
Natural Glue Record Flour Type Used				
Natural Glue Record Flour Type Used				
Natural Glue Record Flour Type Used				

Your Recommendation to Emily



STEM PATHWAYS

career

Natural Glue STEM Challenge

Did You Know? Nature produces many kinds of glues/adhesives including tree sap, mud, mussel byssus, and spider silk. Can you think of other sticky things that occur in nature?

SCIENCE

Chemist

What causes the mixture to become adhesive?

- Grinding grains, such as wheat, makes flour and releases starches and proteins.
- Starch molecules are long polymer chains of simple sugars linked head to tail by chemical bonds.
- Proteins are more complex- a single protein contains amino acids strung together like beads on a necklace.
- When water is added to flour and mixed, the proteins form a tough elastic substance called gluten.

TECHNOLOGY

Computer
Programmer

What factors need to be considered when designing machines to manufacture the adhesive on a large scale?

- An incorrect ratio of ingredients or inadequate mixing time will not produce a consistent product and cause irregular adhesion.
- The temperature of the mixture will affect its viscosity, or ability to flow throughout the manufacturing plant.
- Varying particle sizes will cause the glue to have mixed properties, so machines need to be able to detect particle size and adjust mixing accordingly.
- Agricultural inputs, such as wheat and sugar, need to be stored in cool, dry environments to reduce spoilage.

ENGINEERING

Materials Engineer

What other performance characteristics should the glue possess to be purchased by consumers?

- The vinegar in the glue serves as a mild natural preservative to reduce rate of spoilage.
- Mixtures made from higher protein content flour are harder and stronger. Soybean flour is higher in protein than wheat flour.
- The natural glue produced through this activity is non-toxic in case of ingestion or skin contact.

MATH

Logisticians

How will the ingredients be acquired and stored? How and when will the glue be delivered to customers?

- Agricultural inputs, such as wheat and sugar, have shelf lives and need to be used within a specified time to avoid spoiling.
- It is critical to monitor ingredient sources to optimize production to meet demand and keep costs low.
- Streamlining transportation of ingredients to the manufacturer and glue to the consumer will reduce costs and make the business more profitable.



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Chemist

Finding Solutions For...

- Cheaper, safer and more sustainable materials
- Reducing pollution
- Improving energy efficiency and alternative sources of energy
- Treatment of diseases and illnesses

Job Forecast Looks Like...

- **Median Income:** \$73,060 per year
- **Job Outlook:** 6% growth from 2012-2022
- **Job Environment:** Full-time and regular hours in laboratories and offices
- **Expected Growth Areas:** materials research, environmental research, alternative energy sources research, and pharmaceutical/drug research

Skill Set Needed...

- **High School Courses:**
 - Math: algebra and 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:** Chemists with advanced degrees, particularly those with a Ph.D., tend to experience better opportunities through senior research, upper-management and faculty positions.



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Sources:
U.S. Department of Labor, Occupational Outlook
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