Dear Parent or Guardian,

Your child has been learning about properties of materials and how they change. Today your child worked on an engineering team to develop a formula for homemade glue. Select one of the following tasks to complete together with your child to help reinforce and apply his/her understanding of science concepts:

- Combine melted butter and marshmallows in a saucepan to make a sticky edible adhesive. Add cereal to create tasty marshmallow cereal treats! (Be sure to take the appropriate safety precautions when cooking together to avoid burns or other injuries when using heated materials.)

- Explore ways to use flour and water to make a paste suitable for paper mache. First, cut newspaper strips. Next, blow up a balloon. Third, dip a newspaper strip into the paper mache paste and wring out excess liquid. Finally, spread the newspaper strip onto the balloon. Repeat until the balloon is fully covered. Let the paper mache dry. Decorate and fill with candy to create a colorful piñata.

The complete lesson plan for this topic is below.
Fun with Adhesives

Lesson Overview: Adhesives are all around us. They cause bandages to stick to our skin, enable us to wrap gifts, and help us post reminder notes. Adhesives vary in stickiness depending on the purpose of their use. In this lesson, students encounter a real world problem that requires an inventive solution. When an art teacher runs out of glue for her classes, students work together as engineering teams to create a formula for homemade glue. Then students test their glue concoctions using various materials (e.g. paper, cardboard).

Learning Objectives:
- Students will observe and record the properties observed when two substances are mixed together.
- Students will measure and record capacity using appropriate science tools and measurement units.
- Students will work in teams to develop a solution to a technology problem.

Academic Standards:
National Science Education Standards
Science and Technology Content Standard E: Abilities of Technological Design
- Identify a simple problem
- Propose a solution
- Implementing proposed solutions
- Evaluate a product or design
- Communicate a problem, design, or solution

Physical Science Content Standard B: Properties of Objects and Materials
- Objects have many observable properties including size, weight, shape, color, temperature, and the ability to react with other substances. Those properties can be measured using tools such as rulers, balances, and thermometers.

Benchmarks for Science Literacy
The Nature of Technology: 3C Issues in Technology K-2
- People alone or in groups are always inventing new ways to solve problems and get work done. The tools and ways of doing things that people have invented affect all aspects of life.

Time Frame: Approximately 2 days (This lesson may take 2-3 sessions depending on the pace of your students. To maximize your use of time, limit the supplies and time given for students to complete the collage on the first day or allow them to complete this prior to the lesson with the art teacher.)
Background for the Teacher:

A major emphasis in the primary grades is on children observing and describing the properties of objects. However, in addition to describing how objects look, feel, sound, etc., children also benefit from exploring what happens when materials are manipulated through actions such as mixing, heating, cutting, wetting, etc. Sometimes when materials are mixed together, they retain their original properties. Other times when materials are combined, the result is a substance with properties very different than the properties of the original materials.

In this lesson, students observe what happens when flour gets wet. A major component in flour is starch which exists as tiny granules. When these granules come in contact with enough water, they swell and break releasing tiny starch molecules that stick together. This gluey substance is good for adhering paper materials such as construction paper and cardboard. Heat also helps the starch molecules to be released and this is why you will find that many recipes for paper mache paste use boiled water. For safety reasons, the primary students in this lesson use warm water, but should still be able to observe and create sticky glue. Glue is an adhesive or substance that sticks surfaces together. As an adhesive or glue sets, it either reacts with oxygen in the air or loses a solvent by evaporation. Bonds form between surfaces when an adhesive hardens.

While students in the primary grades will not discuss what is going on in the reaction at a molecular level, teachers should emphasize the problem solving and inquiry skills required in this lesson such as measuring, observing, and describing. Helping students develop a positive science disposition and motivation for invention and innovation are equally important goals in this lesson.

Materials:

For the teacher
- Sample student data table for explanation
- Sample student testing chart for explanation
- Cover tables with newspaper or water proof table cloth for easier cleanup

For the student
- Construction paper for collage
- Glue stick for collage
- Cardboard for collage
- Markers or paint for collage
- Stick Together: Fun with Adhesives: Student Resource Page 1
- Stick Together: Fun with Adhesives: Student Resource Page 2
- Stick Together: Fun with Adhesives Home Connection Resource
- Pencil
- Science journal
- Magnifiers for examining flour
10 by 10 cm of wax paper
Dropper

(For each Student Group)
- “Testing Board” (Large piece of cardboard divided into three columns labeled paper to paper, paper to cardboard, cardboard to cardboard; tape an 8½ by 11 piece of construction paper to the paper to paper column.)
- Triangles cut from construction paper (at least 12, depending on number of tests)
- Triangles cut from cardboard (at least 6 depending on number of tests)
- Paper or plastic cups (approximately 6 per group)
- Sticky back labels for labeling cups or permanent marker
- Spoon for scooping flour
- Metric measuring cups or graduated cylinders as appropriate for your students
- Flour (approximately 500 g)
- Pitcher of warm water
- Craft sticks for stirring (6)
- Paper towels or rags for spills

Classroom Activities:

1. Provide students with glue, construction paper, cardboard, markers and/or paint to make a collage using various shapes. (See suggestions for time management stated earlier in the Time Frame section of this lesson.)

2. Discuss how an adhesive/glue was used to create the artwork. Locate other examples around the classroom of products that have sticky properties. (e.g. tape, notepads, labels, etc.)

3. Present students with the following problem:
   - An art teacher at a different school wants students to make collages, but the school has run out of glue. She has heard that a combination of flour and water can be used as a substitute, but what is the best combination?

4. Tell students that in this lesson, they will explore different combinations of flour and water to invent a glue that can stick together paper to paper, paper to cardboard, and cardboard to cardboard—just like they used when making the collage. Discuss how teams of scientists can work together to solve problems and invent new products.

5. Distribute Stick Together: Fun with Adhesives: Student Resource Page 1. Provide students the opportunity to use their senses of touch and sight to observe and describe the physical properties of a small amount of flour (about one spoonful placed on a wax paper). If available, allow students to
explore with magnifiers. Next students should observe and record observations of the flour when 5, 10, and 20 drops of water are added to the flour. As necessary, provide instruction for the use of droppers. Allow students to predict which combination of flour and water will make the best glue. Remind them to explain their reasoning.

6. Provide instruction on how to use science tools. For instance, model how to use graduated cylinders or metric measuring cups to measure. Discuss measurement symbols/abbreviations and how to label each metric measurement when students are recording their work. Model how to scoop the flour into the measuring cup and how to hold the cup when pouring water to avoid a big mess.

7. Divide students into small groups. Distribute Stick Together: Fun with Adhesives: Student Resource Page 2. Discuss and model how to complete the table. Provide each group with about 500 ml of flour, a small pitcher of warm water, scissors, cardboard, construction paper, 6 plastic cups, craft sticks for stirring, and paper towels to complete the investigation.

<table>
<thead>
<tr>
<th>Trial #</th>
<th>Amount of Flour</th>
<th>Amount of Water</th>
<th>Description of Mixture</th>
<th>Paper to Paper</th>
<th>Paper to Cardboard</th>
<th>Cardboard to Cardboard</th>
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<tbody>
<tr>
<td>1</td>
<td>10</td>
<td>100</td>
<td>Very watery</td>
<td>No</td>
<td>No</td>
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Distribute “Testing Boards” to each group. Students will attempt to use the invented glue samples to adhere shapes to the “Testing Board.” Model how students should label the samples.

8. After student groups have completed the table and the Testing Board, bring the whole class together to share their findings. Which combinations appeared to work best? Did some combinations work well with only certain materials? How did the properties of flour change when it was mixed with different amounts of water? What were the benefits of working together as a team?

9. Remind students of the art teacher’s problem discussed at the beginning of the lesson. What combinations of flour and water would students recommend to the art teacher? Students should write their recommendations and explain their reasoning in a science journal. Bring closure to the lesson by allowing students to share their journal responses.
Home Connections:

Allow students to select one of the following activities to complete at home with a parent.
- Students should work with their parents to complete a paper mache project at home using flour and water as glue.
- Students and their parents can explore how melting can change the physical properties of an object and change it into a sticky adhesive. With parent supervision, students can make marshmallow cereal treats.

Assessment:
- Evaluate student journal responses in Step 9 of the lesson. The following rubric can be used to score student responses.
  - Complete Understanding: The student includes a viable solution and includes accurate reasoning.
  - Partial Understanding: The student includes a viable solution with flawed reasoning or a flawed solution with accurate reasoning.
  - Minimal Understanding: The student does not include a solution or reasoning but shows some understanding that the properties of materials can change when mixed.
Flour Observations

1. Observe the flour. Record your observations on the chart below. Use pictures and words to describe your observations.

<table>
<thead>
<tr>
<th>Dry Flour</th>
<th>Flour + 5 drops of water</th>
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<tr>
<th>Flour + 10 drops of water</th>
<th>Flour + 25 drops of water</th>
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2. How much flour and water should be put together to make glue for an art collage using paper and cardboard? Write your prediction below and explain your reasoning.
Problem: A Sticky Situation
An art teacher at a different school promised her class they would make a collage, but the school has run out of glue. She has heard that a combination of flour and water can be used as a substitute, but what is the best combination?

Directions: Complete the table below with your group. Which combinations of flour and water will make the best glue for the materials in the table?

<table>
<thead>
<tr>
<th>Trial #</th>
<th>Amount of Flour</th>
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<th>Description of Mixture</th>
<th>Paper to Paper</th>
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