NASA's Student Glovebox-Droplet Investigation of Liquids

NASA SUMMER OF INNOVATION

UNIT
Engineering—Design Process

GRADE LEVELS
5 – 8

CONNECTION TO CURRICULUM
Technology

TEACHER PREPARATION TIME
1 hour

LESSON TIME NEEDED
4 – 8 hours *Complexity: Moderate*

LESSON THEME
Inquiry-based technology lesson to construct a sealed container with built- in gloves and explore the properties of liquids.

OBJECTIVES
Students will
- Design their own experiment and hardware to use in their teams' Glovebox
- Experiment with various fibers and liquids to determine which fiber and which liquid will produce the most spherical droplet
- Investigate the best way to mount the fiber
- Write instructions to conduct the activity
- Present conclusions at a science conference

NATIONAL STANDARDS

National Science Education Standards (NSTA)
Science as Inquiry
- Understanding of scientific concepts
- An appreciation of "How we know" what we know in science
- Skills necessary to become independent inquirers about the natural world
- Sispositions to use the skills, abilities, and attitudes associated with science

Science in Technology
- Abilities of technological design

ISTE NETS and Performance Indicators for Students
Creativity and Innovation
- Apply existing knowledge to generate new ideas, products, or processes

Critical Thinking, Problem Solving, and Decision Making
- Plan and manage activities to develop a solution or complete a project

Research and Information Fluency
- Plan strategies to guide inquiry
- Locate, organize, analyze, evaluate, synthesize, and ethically use information from a variety of sources and media
- Evaluate and select information sources and digital tools based on the appropriateness to specific tasks
- Process data and report results

Technology Operations and Concepts
- Understand and use technology systems
- Select and use applications effectively and productively

MANAGEMENT

- Send a note home to parents telling them about the project a week or two ahead of time. Include the materials list and ask them to send in materials from this list.
- Discuss properties of liquids, such as how different liquids and materials interact, surface tension, and viscosity, so students will know what to look for while making observations.
- Review the scientific process and how to design an effective experiment. Go over ways students should have access to information-gathering and research equipment.
- Students should have room for small group and whole class discussions.

CONTENT RESEARCH

There are good reasons for doing an experiment in a Glovebox on
orbit. The sealed Glovebox keeps flames, particles, fumes, and spilt
liquids away from crew members and out of the cabin air. Fumes or
particles can irritate crew members' skin and eyes or make the crew
sick. Spills could damage electrical equipment. Any work with flames requires precautions, especially on a spacecraft. For some studies, it is important to protect experiment samples from the cabin air and crew.
A closed environment may be essential to control experiment variables.
A Glovebox is a valuable research tool. It helps scientists find more effective methods for performing an experiment. Scientists can use the Glovebox to make sure small parts of a large experiment work. This helps build more reliable equipment. One reason NASA created the Glovebox was so researchers could fly simple investigations into space more quickly. Normally, science teams work with NASA about 7 years before their experiment is ready to go into space, which may seem long, but the process is complex and takes careful planning. Glovebox research has a shorter development time, usually taking 3 to 5 years.

KEY Concepts:

- **MIR**: Soviet and later Russian space station, operational in low Earth orbit from 1986 to 2001. With a greater mass than that of any previous space station, Mir was the first of the third generation of space stations.
- **International Space Station** (**ISS**): Internationally developed research facility that allows for student participation in classroom versions of ISS experiments.
- **Glovebox**: Sealed container with built-in gloves. Astronauts perform small experiments and test hardware inside of them. Gloveboxes have flown on the space shuttle and Mir. ISS

MATERIALS

For the chamber:
- Empty copier paper box with lid
- Glovebox artwork
- Masking tape
- Utility knife
- Metal edge ruler
- 2 pieces of 11- by 17-inch construction paper
- Heavy cardboard cutting surface
- Clear contact paper

For the lid
- Copier paper box lid
- Clear 2-inch packing tape
- Ruler
- Duct tape
- Utility knife
- 2 overhead transparency sheets

For the gloves
- 4 plastic cups (32 ounce)
- Thick rubber bands (size #64 or wider)
- Dish washing gloves (long)
- Disposable surgical gloves
- Utility knife

Liquid drop materials list
- Assorted fibers (waxed dental floss, unwaxed dental floss, jewelry wire, nylon fishing line, thread, and string)
- Small containers to hold liquids (such as beakers, paper cups, film canisters, or yogurt containers)
- Materials to build experiment apparatus (margarine tubs)
- Different liquids (cooking oil, water, rubbing alcohol, and corn syrup)
- Velcro
- Push pins and binder clips
- Plastic beads (small and very small)
- Eye droppers, pipettes, or needleless syringes (2 ml or less)
- Styrofoam meat trays or plates to catch spills
- Re-sealable bags (to store team materials)
- NASA Student Glovebox
- DIL Data Table worksheets (3 per student)
- Instant or digital camera (optional)

will have a permanent Glovebox on the U.S. Laboratory Destiny.

- **Microgravity**: Condition, especially in space orbit, where the force of gravity is so weak that weightlessness results.
- **Viscosity**: Property of fluid that resists flowing: the property of a fluid or semifluid that causes it to resist flowing.
- **Surface Tension**: Cohesive quality of surface of liquid: the property of liquids that gives their surfaces a slightly elastic quality and enables them to form into separate drops.
- **STS–118:** Space shuttle mission to the ISS flown by the orbiter Endeavour in August 2007. Educator Astronaut Barbara Morgan took educational payloads with her on this mission.

LESSON ACTIVITIES

- Students will build a Glovebox and then design their own DIL experiment and experiment hardware that can be used in their team's Glovebox. To conduct this activity, students will need to experiment with various fibers and liquids to determine which fiber and which liquid will produce the most spherical droplet.
  http://virtualastronaut.tietronix.com/teacherportal/pdfs/StudentGlovebox.pdf

ADDITIONAL RESOURCES:

- Space Station Glovebox: http://www.spacehike.com/microgravity.html
- Microgravity Glovebox: http://msglovebox.msfc.nasa.gov
- NASA's Kids YouTube on Gloveboxes: Videos
- Drinking Water in Space YouTube: http://www.youtube.com/watch?v=Ta5ziJJ1exM&feature=related
- Microgravity Teachers Guide: 15 Activities Including Fluid Physics:
  http://quest.arc.nasa.gov/space/teachers/microgravity

DISCUSSION QUESTIONS

- **Describe three characteristics of this liquid based on the way it interacted with the fiber.**
  Canola Oil—Pale yellow, thicker liquid than water, surface tension is less than water, and coats most fibers except for wire
  Corn Syrup—Thick, tacky, pale yellow, moves slowly, high viscosity, so heavy it rolls off fibers, holds shape well, and forms best spheres
  Rubbing Alcohol—Strongly scented thin liquid, has low surface tension, evaporates quickly, forms unstable droplets, and absorbs into cotton and twine
  Water—Has high surface tension, clear, absorbs into cotton and twine, does not interact with wire, and bounces off of wax
- **How successful was the anchor method you used? Explain**.
  For each fiber, we used the following anchor methods: no anchor, a knot, a small bead, and a large bead. We even tried a drop of super glue as an anchor, which was a total mess. The knot and the smaller beads acted as better anchors for droplets.
  Water—Water droplets clung to the bead but not the fiber. The knot did anchor a droplet to the unwaxed floss.
  Oil—The oil acts the same on the bead regardless of the fiber used, coating the bead completely. With time the droplet hangs more from the bottom of the bead.
  Alcohol—For both flosses, the bead provided a good anchor, otherwise, alcohol did not form much of a droplet on the various fibers.
  Corn Syrup—Corn syrup formed droplets on the knots of the waxed and unwaxed floss. The syrup anchors to the bead, not the fibers.
- **Compare and contrast your data. Conclude which fiber anchor and liquid produced the best droplet.**
  We tested corn syrup, canola oil, rubbing alcohol, and water using waxed and unwaxed dental floss, fine jewelry wire, cotton sewing thread, nylon fishing line, and twine. Here is our ranked

list of the combinations for the most spherical droplets, from most to least spherical.
1. Corn syrup and nylon fishing line or unwaxed floss—By far the most spherical droplets resulted from the corn syrup on the plain nylon fishing line, and next best on the unwaxed dental floss. Corn syrup was also the most interesting liquid to observe because it is so viscous. Droplets held their shape even if the fiber was held vertically.
2. Water and cotton sewing thread—Water has the highest surface tension of the liquids we tested. Fibers with plastic bead anchors could hold up to two droplets; however, the shape was not spherical.
3. Canola oil and nylon fishing line—Oil on the knot of the nylon fishing line produced a small semispherical droplet. Single drops formed below most plain fibers once the fiber was coated with oil. Small droplets hung from the bottom of the beads for all of the fibers.
4. Rubbing alcohol—On the knot of the nylon fishing line and fine jewelry wire, alcohol produced the smallest droplets and it formed the least spherical droplets

- **Did this liquid have strong or weak surface tension? How do you know?**
  From lowest to highest surface tension: (1) alcohol, (2) corn syrup, (3) canola oil, and (4) water. Students may notice surface tension by the way a liquid seems to "stick" to itself and the way it interacts with fibers. Water has the greatest surface tension of these liquids, forming the largest droplets. As a droplet falls, it forms a sphere. Drops of water suspended from a dropper seem to bounce off waxed floss. In contrast, alcohol forms the smallest droplets, and does not cling well to fiber.
- **Describe the viscosity of this liquid. Explain your reasoning.**
  From lowest to highest viscosity: (1) alcohol, (2) water, (3) canola oil, and (4) corn syrup. Corn syrup forms spherical little balls that keep their shape, even when the string dangles. When corn syrup drips, it may form runny tails. The International Space Station (ISS) Glovebox is larger and has more capabilities than shuttle Gloveboxes. In fact, the entire shuttle Glovebox is about as big as the sample storage area of the ISS Glovebox.

ASSESSMENT ACTIVITIES

Hold a Glovebox Research Conference where teams present their conclusions using data tables and charts to support their findings.

ENRICHMENT

Would you feel comfortable designing and conducting an investigation of your own if asked? Why or why not?