Bio Inspired Design Paper Flowers

Grade Level:	Total Time Required:
3	4 periods (30 minutes each), approximate

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Lesson Objectives:

In this lesson, students will design and build a flower that mimics properties of a plant (i.e., a bio-inspired design).

Students will be able to:

1. Identify the common structures of a plant.
2. Understand how these common plant elements function.
3. Describe how the flower was colored through capillary action.
4. Design a root system that uses wicking/capillary action to dye a paper flower.
5. Produce a tie dyed paper flower.
6. Gather evidence about how well the design meets the needs of the problem.
7. Document the design so that it can be easily replicated.

Indiana Standards:

3.LS.3 Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction.

3-5.E.1 Identify a simple problem with the design of an object that reflects a need or a want. Include criteria for success and constraints on materials, time, or cost.

3-5.E.3 Construct and perform fair investigations in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

Next Generation Science Standards:

Discipline Core Ideas

4-LS1-1. Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction.

3-5.ETS1-1 Identify a simple problem with the design of an object that reflects a need or a want. Include criteria for success and constraints on materials, time, or cost.

Crosscutting Dimensions

4. *Systems and system models.*

Science/Engineering Practices

1. Asking questions (for science) and defining problems (for engineering)
2. Developing and using models
7. Engaging in argument from evidence

Common Core Mathematics:

3.MD.B.3; 3.MD.B.4

Common Core English and Language Arts:

W.3.1.b; SL.3.1; SL.3.1.a; SL.3.1.b; SL.3.1.c; SL.3.1.d

Concepts and Vocabulary

Term	*Defined by a scientist or engineer*	*Defined by a student*
Words for Students		
Root	The usually underground portion of a plant that lacks buds, leaves, or nodes and serves as support, draws minerals and water from the surrounding soil, and sometimes stores food.	Base word, tree root
Stem	A slender stalk supporting or connecting another plant part, such as a leaf or flower.	flower stem
Seed	A ripened plant ovule containing an embryo.	What a plant grows from.
Fruit	The ripened ovary or ovaries of a seed-bearing plant.	Something you eat.
Flower	The reproductive structure of some seed-bearing plants, characteristically having either specialized male or female organs or both male and female organs, such as stamens and a pistil, enclosed in an outer envelope of petals and sepals.	Colorful part of a plant.
Leaf	A usually green, flattened, lateral structure attached to a stem and functioning as a principal organ of photosynthesis and transpiration in most plants.	Green part of the plant
Cotton	The fiber of a cotton plant used in making textiles and other products.	cotton ball
Wool	A material or garment made of hair from a sheep, goat, alpaca or similar animal.	sheep's wool
Words for Teachers		
Capillary Action Or Wicking	The movement of a liquid along the surface of a solid caused by the attraction of molecules of the liquid to the molecules of the solid.	
Synthetic	Not natural or genuine; artificial or contrived.	
Bio Inspired Design	Design or engineering solutions that gain inspiration or borrow ideas from nature, especially biology. Engineers are able to learn the ways in which plants or animals perform certain functions and apply it to man-made products.	
Acrylic	Any of numerous synthetic fibers polymerized from acrylonitrile.	

Sources: 1) http://www.thefreedictionary.com

Equipment, Materials, and Tools

Materials		
Multiple types of yarn and string (Cotton, Acrylic, Wool)	Thin walled plastic tubes	Pieces of cloth
Coffee filters	Paper towels	Facial tissues
Plastic cups	Food coloring	Tissue paper
Craft sticks (varying sizes)	Pipe cleaners	Droppers
String	Clay	Skewers
White shop towels	Clothes pins	Wire twisty ties (bread closures and in trash bag containers)
Straws		

Tools		
Scissors	Meter Ruler	

Science Content - Basics

Plants are Living Things

Plants have specialized parts that help them perform functions that allow them to grow and respond to their environment. Vascular plants have roots, stems, and leaves. Roots anchor the plant in the soil and help absorb water, oxygen, and minerals from its environment. From the roots, the water and minerals enter the stem. The tissues within the stem help carry water and mineral nutrients from the roots up to the leaves and carry food made in the leaves by photosynthesis to other parts of the plant. Plants also have colored molecules known as pigments that help them perform photosynthesis and provide them with color. Different pigments can make plants look green and other parts of a plant, like tulip flowers, to appear red.

Plants are living things, just like people and animals. Much like animals and people, plants must take in nutrients to stay alive. Plants get their nutrients through their roots. Roots are a part of a plant that brings in water and nutrients. Nutrients are little things that help keep a plant healthy. There are nutrients in the water that a plant brings in through its roots.

Water and all of these different nutrients taken in from a plants roots travel through what is called the stem, and this process of water and nutrients moving up the stem is called capillary action. A stem is what allows the plant to stay alive. It is an important part of the plant. Stems come in all different shapes and sizes. Some look like a dandelion stem, small and green, while others look like a tree trunk. A tree's trunk is like the stem of a tree.

Synopsis of Engineering Design Activity

Synopsis of the Design Activity:

Problem:	The Student Counsel planned an outdoor event* to benefit the community. The event location had a wide variety of lovely flowers. However, after hearing that heavy rain was expected on the day of their event, they had to move it inside. The only problem is that moving the event inside meant they had no flowers! *optional: teacher can choose an event or link it to a cultural experience
Goal:	Design a dyed flower using principles of capillary action and root structure.
Who is the client:	Student council members needing flowers for their event.
End-User:	The local community/those who will enjoy the flowers.
What is the design:	A bio inspired paper flower that is tie dyed.
Criteria:	• Flower must be colored by water absorption of dye through various strings and yarn. • Must have a stem.
Constraints:	• Materials provided • Type of yarn (cotton, wool, acrylic) • Type of paper (coffee filter, paper towel, tissue paper) • Time (must be ready for use within 2 days)

Lesson Plan #1
Guiding Question –How is water absorbed through capillary action?

Time: Four 30 minute class sessions

1. Inquiry – how is water absorbed through capillary action?

In this activity, students will learn how water is absorbed through capillary action in the stem.

Procedure:

1. Obtain real white carnations or roses (Note: in order for the inquiry to be effective, it is best to use freshly cut flowers.)
2. Keep flowers in water until time of inquiry.
3. Put colored dye in multiple cups (See picture below for a set-up that helps contains spills).
4. Use a clothes pin or other device to help hold up the flower in the cup. Be careful not to pinch the flower or break the stem. Once the capillary tubes are broken in the stem, the colored water will not flow to the flower. This is also an important design issue to account for in the next steps.
5. The teacher should divide the stem into two parts using a sharp knife. (Note: for maximum absorption, the stems should be shorter in length. Cut carefully to ensure that stem does not break.)
6. Put the stem in two different dyes.
7. Have one example stem that is broken – did it dye?
8. Observe change of color of the flower petals over multiple days.

Link showing the steps involved in dyeing roses:
http://hypervocal.com/culture/2012/how-to-tie-dye-roses-aka-how-to-become-the-ultimate-hippie/

2. Choose Best Yarn for Task (Root System)

The first step is to set-up a procedure to test the best type of yarn.

1. You can use a single cup glued to a tray, as shown below.

2. The multiple types of yarn can be draped over the edge of the cup to see which one will start to wick the colored water the quickest. This step demonstrates how the some material will wick the water. This can be related to the stem moving water through capillary action.
3. Diagram (i.e., draw) to show progression of wicking of yarn (3 minutes, 6 minutes, 9 minutes, etc.)
4. In the design notebook, students should note the rationale for choosing the type of yarn. After the yarn is chosen, students may have 1 meter of yarn for their project.

Notes: The cotton yarn should work the best and should be chosen for the project. If they want to choose another material they may want to re-examine this test. The wool works but it will be slow. The acrylic yarn will not wick water.

The paper test can be done in conjunction with the wicking test.

3. Choose the Paper for the Flower

Three types of paper are provided (additional paper may be used). They include:

1) Paper towel
2) Tissue paper
3) Coffee filters

1. The students can "test" which paper they would like to use by putting a drop of water on a sample piece of paper. This is a qualitative test only and can be used by the students to pick the paper they think is best.
2. In the design notebooks, the students should note the rational for choosing the type of paper.

Note: Each paper will work and provide a different aesthetic look for the flower.

4. How to Fold the Flower

Once a paper for the flower and a yarn for the root system are chosen, the students can start to build their flower. An easy technique to make the flower is shown in the link below. It is an accordion fold method.

http://www.firstpalette.com/Craft_themes/Nature/mexicantissuepaperflowers/mexicantissuepaperflowers.html

Other more advanced techniques shown at the end of this lesson plan.

Lesson Plan #2
Guiding Question –Can you design a bio-inspired paper flower?

Students are introduced to the design task (see last page). Depending on where students are with their learning of engineering design, students may individually or as a whole class, identify the essential features of the problem. Students then devise an individual plan. Students then share their plans with other team members to decide on one mutually agreed upon solution.

1. Distribute copies of the design brief. Encourage to read and review the design brief. Ask students the following questions:

   - *What is the problem?*
   - *What is the goal?*
   - *Who is the client?*
   - *Who is the end user?*
   - *What is/are the criteria?*
   - *What are the constraints?*

   Constraints:
   1. Type of yarn (e.g., cotton, wool, acrylic)
   2. Type of paper (e.g., coffee filter, paper towel, tissue paper)
   3. Flower must have a stem.

2. Students then work on individual plans. Encourage students to think about the design of the entire plant system (i.e., flower, root system, and stem). Encourage students to label their drawings, list materials needed, and provide several different perspectives (e.g., front view, back view, side view).

3. Once students have developed an individual plan, instruct students to share their plans and to identify one plausible solution. The students should sketch their design of flower, root system, and stem.

4. In their design teams, students now construct their plant system using materials provided on to make a flower and attach the roots and stem.

5. Test the flower design. Place the flower in a cup of dye to see how well it works. The yarn should absorb the colored water and wick it to the flower. A common design issue can be if the roots (i.e., yarn) are restricted in any way. Students may see the wicking stopped where they tied something around the yarn to tightly.

   Variations: The students can try various different configurations to see other types of patterns in the flowers. For example, they can vary paper material type and different ways to structurally hold up the flower.

Assessment

The following are possible sources of formative and summative assessment:

- Design notebooks (individual) –
  - Note how students identify and clearly label their drawings;
  - Identify the types of science vocabulary students use in their notebooks (tally the number of times each concept is used);
  - Note how students record data from testing their prototypes and how well they explain their results (patterns in the data).

- Presentation of design to class by the team. Provide positive design attributes, how design criteria where met, and possible redesigns.

- Participation (group) –
  - Note level of engagement;
  - questions students asked;
  - how well they worked in a group;
  - how well each team met the goals of the task.

- Other (individual and/or group) – Create a short pre and posttest that highlights key science vocabulary terms; present a new situation or new problem on the same theme.

Lesson Extensions and Resources

Activity Extensions:

Tulip Dissection
http://www.classichousewife.com/2010/02/18/flower-dissections-tulips-and-daisies/

Resources:

Paper Flowers from Mexico

Image from: www.riviera-maya-holidays.com/mexican-paper-flowers.html

The Student Counsel planned an outdoor event* to benefit the community. The event location had a wide variety of lovely flowers. However, after hearing that heavy rain was expected on the day of their event, they had to move it inside. The only problem is that moving the event inside meant they had no flowers! One member of the student counsel proposed making paper flowers similar to the ones she saw during Cinco de Mayo last year. After checking out the materials they had in the school, she suggested creating tie dye paper flowers to do something new and unique. They had a variety of paper products available, as well as some food coloring, straws, sticks, and pipe cleaners. They wanted each flower to have a stem to hold the flower up and a root system that would carries water and nutrients to the flower petals like a real stem. With only one day to get all of this done, they need the help of their classmates! Can you come up with a way to create tie dye flowers in the fastest way possible?

*optional: teacher can choose an event or link it to a cultural experience