MAKING STUFF WILDER

NOVA PBS WGBH

How do engineers learn from the natural world to develop new technologies and improve our lives?

THE STORY OF WILDER

Nature is an amazing place to find design inspiration. From robotic mules to swarms of robotic bees, scientists and engineers are using the natural world as inspiration for the "wildest" new inventions. Will the stuff of the future soon take on a life of its own?

TALKING "WILDER"

Start the conversation with the following questions:

- What does "wild" mean to you?
- Can you name things that you might encounter in your daily life that are wild?
- What are some examples of things that you use in your life that look or act like something found in nature?
- Why do you think scientists and engineers use nature as inspiration for their research and designs?

REAL-LIFE EXAMPLES

- "Wild-Inspired Robotic Arms" clip from *MAKING STUFF Wilder*
- Wilder PPT Slides

PROJECT PREVIEW

In the following series of investigations, students will experience firsthand how nature can inspire design. Students will take their inspiration from the form and function of an eagle's foot, and learn how the various parts of a foot can come together to form a working model.

ACTIVITY: FIND THE STRENGTH OF THE WILD

Overview

Students create a single "eagle toe" out of various materials, then test its motion control and strength.

Brainstorm & Discuss

Watch the video clip "Wild-Inspired Robotic Arms" from *MAKING STUFF Wilder.*

Begin the brainstorm. Ask students:

- In the video clip, which animals inspired the designs for new robotic grippers and grabbers?
- What other animals might inspire new designs?

At this point, mention birds of prey. Ask students:

- What does a claw look like? Can you make one with your hand?
- Is the shape of your "claw" similar to that of other students? Describe the similarities.
- How would you describe a claw to someone who couldn't see your hands right now?
- Can you name any animals that have feet that look similar to this?

Optional: *Show slides of different clawed feet in nature. Focus on birds, especially eagles.*

- Looking at all of these different kinds of clawed feed, what basic shapes and parts do they have in common?
- What kinds of things do these animals do with their feet?

Materials

Recommended for each student:

- 6" piece of 1/4" plastic tubing
- 12" length of dowel rod, 1/4" in diameter
- Plastic straws
- Electrical tape, 1/4" wide
- Small paper clip
- 12" piece of nylon line
- Ping-pong balls
- Ruler
- Permanent marker
- Utility knife

Tips and Tricks for Inclusion

It would be difficult for children with visual impairments or who are blind to participate in this activity. Consider the following adaptations to make this more inclusive:

- Provide enlarged photos of an eagle's claw to help children with visual impairments.
- Provide a physical model for children with visual impairments or who are blind (note: this would help *all* children understand the concepts).

DESIGN & BUILD

Tell students that they'll be designing and constructing their own mechanical "eagle toes" to pick up things.

1. Provide each student with the materials, giving a description of what they'll have to work with. Address any necessary safety guidelines.

2. If necessary, demonstrate how to safely make a joint in the plastic tubing by:

a. Marking where you want a joint to be, then

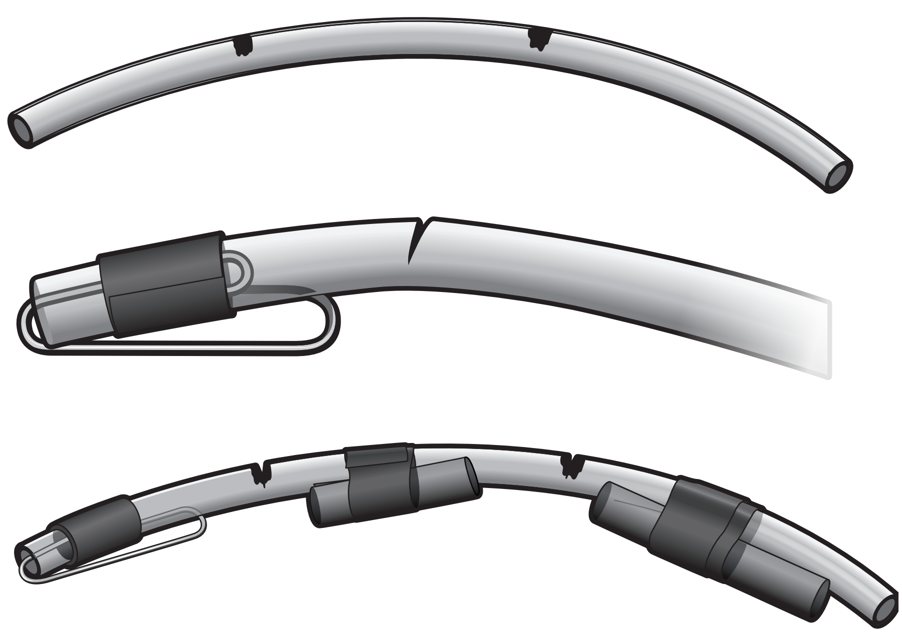
b. Using the knife or scissors to cut a notch in the tubing, being careful not to cut all the way through. The size of the notch (how much of the tubing you cut through) will determine how flexible the joint will be.

c. Once students know how to make a joint, they can use this technique to place joints wherever they want to in their toe.

Tips and Tricks for Inclusion

It may be difficult for students with impairments to perform the steps described above. To make this activity more inclusive, considering the following adaptations:

- Provide a collection of pre-cut tube pieces for students to select.
- Have an adult or peer help line up and cut the tubes.
- Provide ergonomic craft knives and/or adapted scissors which may be safer for students (See Tools C9,C10,C11 in Tools Table in Appendix).



DESIGN & BUILD (CONTINUED)

3. Have students experiment with making their own joints in different configurations. They should leave at least one inch at one end of their toe to attach a paper clip.

4. After they have cut joints, students should slide a paper clip onto the end of their tubing and secure it with electrical tape. The paper clip should be secured on the side opposite the joint slits. Make sure that students only tape the part of the paper clip that is touching the plastic tube—and not the entire paper clip.

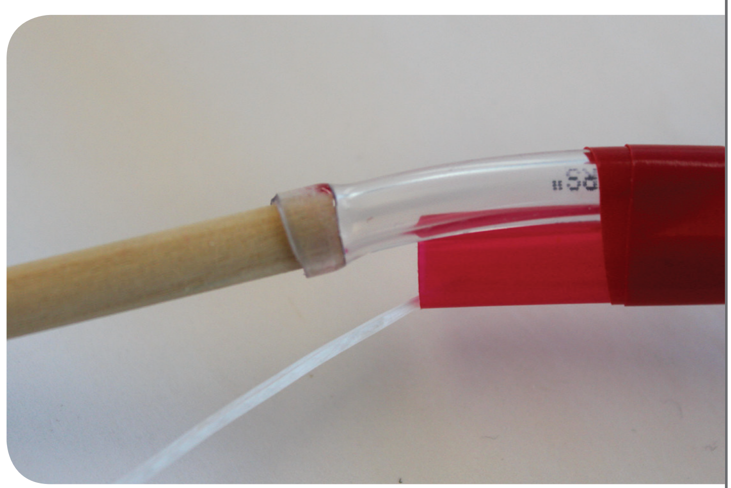
5. Next, students should cut a straw into pieces that are slightly shorter than the length of the space between their joints. Have them use electrical tape to attach the straw sections onto the tubing, being careful to attach the straws on the side of the tube opposite the joint slits.

6. Students will use the nylon fishing line as the "muscle." Have them tie the fishing line to the paper clip (attach it with tape if needed) and then slide it through the straw sections.

7. Lastly, students should insert one of the dowel pieces into the bottom of the claw. In order to ensure that the dowel fits snugly, students can wrap the ends with tape. Finally, hold the toe up with the dowel and pull the string to make it work!

Tips and Tricks for Inclusion

Students with visual or physical impairments may struggle with the activity because using certain tools may be unsafe, and assembling the toe may be difficult. Consider the following adaptations to make this activity more inclusive:



- Replace the cut straw with Legos, K'nex or another commercially available building kits for children (See Tools K1,L1 in Tools Table in Appendix). This will allow all students to more easily and safely assemble the toe.
- Pair students with and without disabilities to build the toe, so each can help the other perform the activity.
- Provide glue, double-stick tape, or Velcro which would be easier to use than electrical tape for some students with impairments (See Tools A1,A2 in Tools Table in Appendix).
- Provide paperclip with the filament pre-attached.

TEST & REBUILD

1. Students can test the strength of their design by placing a lighter object (like a ping-pong ball) on the table in front of them and then flicking it or picking it up.
2. Allow time for students to make revisions to their design in order to improve it for ease of use and to work with heavier objects.

Tips and Tricks for Inclusion

Students with physical or visual impairments may have difficulty performing the ping-pong ball test. Students with physical impairments may be challenged to hold the talon still and pull the filament wire at the same time. Students with visual impairments may not be able to tell how far the ping-pong ball has traveled. To make the testing activity more inclusive, consider these changes:

- Develop a way to attach the dowel to a table, so the toe hangs off of the end of the table. This could be done by placing heavy books over the dowel, or by using duct tape or some other adhesive.
- Place a weight on the ground and attach it to the assembly with a string. Lift the weight by pulling on the talon filament; change weights to see how much the talon can pick up, or encourage the students to notice if a different amount of force is required for different toes.
- Tie the end of the filament to a popsicle stick/craft stick or other large object to allow students with difficulty grasping to pull on the filament (See Tool C5 in Tools Table in Appendix).

WRAP UP

Ask students to reflect on the activity:

- Which designs seemed to work the best? What made them the most successful?
- How could you make your design stronger?
- How else could you improve on your design?

DESIGN CHALLENGE: CONSTRUCT A MECHANICAL CLAW

Overview

Students apply what they learned in the previous activity and use their single-toe design to build a mechanical claw. Students will then test their claws by using them to transport various objects from one place to another.

Materials

Recommended for each student:

- 6" piece of 1/4" plastic tubing* (x4)
- 12" length of dowel rod, 1/4" in diameter (x3)
- Plastic straws
- Electrical tape, 1/4" wide
- Small paper clip (x4)
- 12" piece of nylon line (x3)
- Ping-pong balls
- Ruler
- Permanent marker
- Utility Knife
- Foam or sponges to separate the toes

(Note: the materials required for the Design Challenge are the same as those required for the Activity, but multiplied to accommodate more toes.)

Brainstorm & Discuss

Begin the brainstorm. Tell students that they will be constructing a mechanical claw that functions like an eagle's foot. Guide the conversation toward a discussion about how an eagle moves each of its toes when picking up its prey.

Ask:

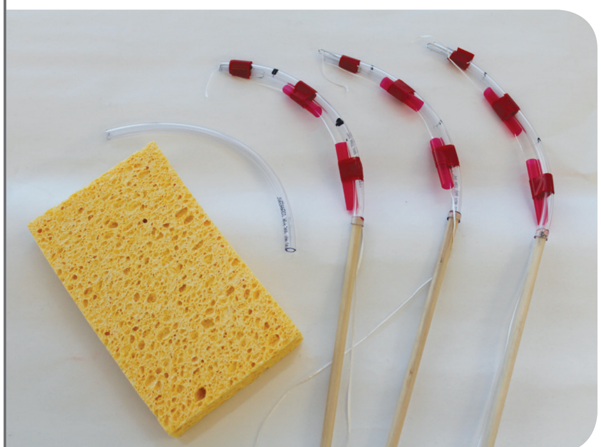
- How does an eagle hold onto its prey?
- How are eagle toes similar to or different from human fingers?
- How many toes does an eagle have?
- Does each toe function in the same way?
- How do the toes work together?

Ask the students how they would apply what they learned in the first activity to make a mechanical claw to grasp things.

DESIGN & BUILD

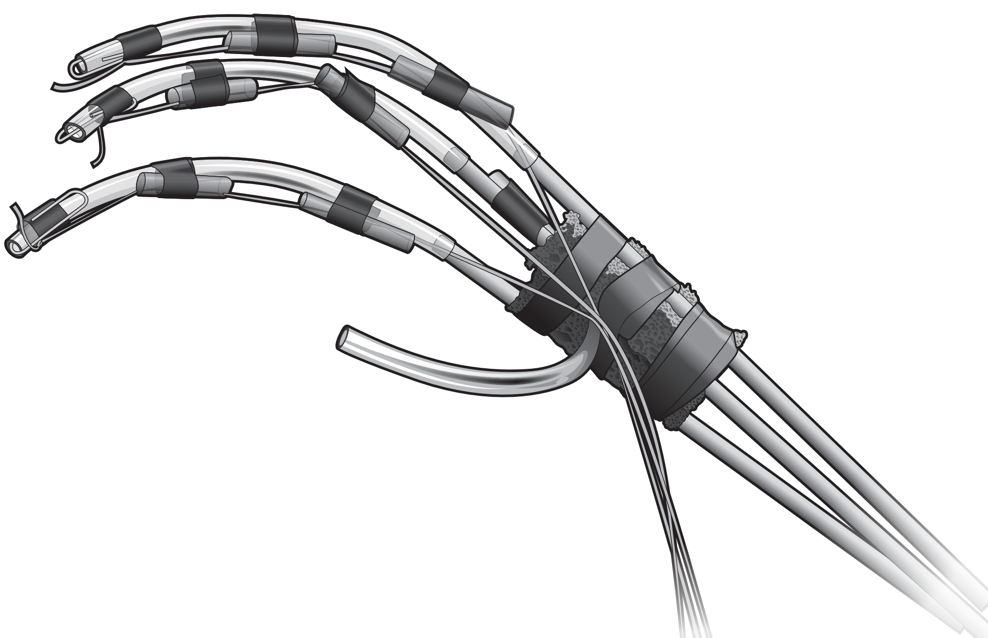
1. Have students begin by deciding how many toes they'll use to make their device, and how many joints each toe will have.

2. Students should follow the same procedure that they used to make the first toe, and build at least two more. If enough supplies are available, encourage students to rebuild their original product based on what they learned.



3. After they've made at least three toes, students can combine the toes to begin forming the claw. Students should place one small piece of foam between each of the toes to separate the dowels. This separation will allow the toes to move more freely. The students should then sandwich the foam between each of the three dowels and pinch the foam in place. Students can then create a "skin" to help hold the foot together by wrapping electrical tape tightly around the dowels/foam assembly.

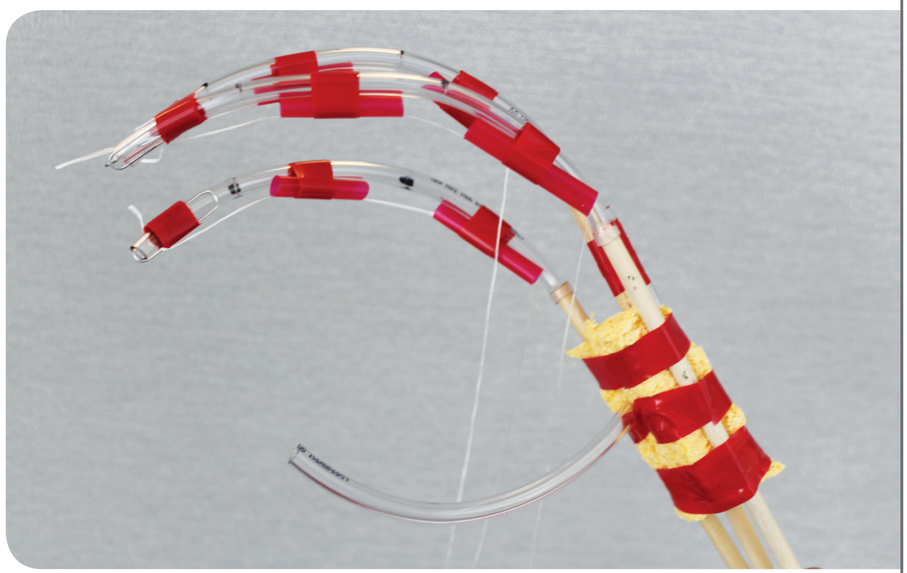
4. The last step is to make the fourth opposing toe, which acts like a human thumb, and is used by eagles to secure prey. Students should cut a small hole in the "skin"/electrical tape just below one of the foam spacers, and slide a plastic tube into the hole. This toe will be stationary; students can decide how far they would like it to protrude.



TEST & REBUILD

Once students are satisfied that their mechanical claw can open and close easily, they should test it.

1. Provide each student with the materials, giving a description of what they'll have to work with. Address any necessary safety guidelines.
2. Place two tables 10 feet apart, using one as the pick-up area and one as the drop-off area.



3. Students should start with light, round objects (such as ping-pong balls), increasing the weight of the objects to be carried as students successfully transport objects from one spot to the other. Tables can also be moved farther apart to increase difficulty.
4. To assess the success and strength of their designs, students can ask themselves questions such as:
   a. What kinds of objects could my mechanical claw transport?
   b. What was the heaviest object I could lift with my design?
   c. How could my design be improved?
5. Students should continue to redesign and test their devices for as long as time allows.

WRAP UP

After students are done testing and revising, reconvene and debrief as a group.

Start the conversation by asking:

- How is your design similar to an eagle's foot? How is it different?
- What sort of revisions did you make to your initial designs? How well did these improvements work?
- How might you further revise your design given different materials or more time?
- What other animals might inspire new designs, and what might those designs look like?

Tips and Tricks for Inclusion

All of the tips and tricks described in the previous activity apply to the Design Challenge. In addition, the task of having students move objects from one table to another may be difficult for some students with physical or visual impairments. The following adaptations may be helpful in making this activity more inclusive:

- If possible, a student with a physical or visual impairment can serve as record-keeper. Recording the data on paper, or in a computer spreadsheet also facilitates review by children with visual impairments.
- Provide a block of foam with four pre-cut slots to eliminate the need for taping and cutting. Students can insert the dowel rods for each toe into the slots in the foam. Some students may be able to cut the slots themselves, allowing them to choose the distances between toes, but would still benefit from not needing to hold the toes while placing foam spacers and wrapping tape.