

Major Project: Engineering Design Challenge Phase II - Implementation

Engineering Design Challenge Activity:

PBS Design Squad: Helping Hand

https://pbskids.org/designsquad/parentseducators/resources/helping_hand.html

Given materials, students design a device that allows them to pick up and drop objects that are at least two feet away.

Design Process:

NASA's BEST Engineering Design model was selected to implement this activity. This model was selected because it clearly communicates stages of the design process in simple and clear language appropriate for elementary students. Additionally, NASA's BEST ED provides a concise, streamlined model appropriate for introducing elementary students to the design process.

The stages of NASA's BEST Engineering Design Model correspond with sections of the engineering design notebook as indicated in the table below. The implementation time for each stage is also noted below.

NASA's BEST Engineering Design Model	Corresponding Engineering Design Notebook Section	Implementation Time
Ask	Identify the problem	15 min
Imagine	Brainstorming	15 min
Plan	Design	20 min
Create	Build	60 min
Test	Test and Evaluate	15 min
Improve	Redesign	30 min
	Share the solution	15 min

Engineering Design Notebooks:

The following pages show the engineering design notebooks for myself (teacher) and three student participants. Design notebooks were organized into the following sections: 1) Identify the problem, 2) Brainstorming, 3) Design, 4) Build, 5) Test and Evaluate 6) Redesign, 7) Share the solution (students orally presented final designs to the group).

Identify the Problem

After introducing the engineering design challenge, students explicitly identified the criteria by stating the project criteria in their own words. Time was spent clarifying student questions.

**Helping Hand
Engineering Design Challenge**
Inspired by NASA/PSC Design Squad

Identify the problem
Design and build a device that lets you grab different objects and drop them into a container that's at least two feet away from you.

Device must:

- pick up objects
- release objects
- reach at least 2ft.

Research:



The research section shows three images. The first is a pair of scissors with labels 'grip' pointing to the handles and 'fulcrum' pointing to the pivot point. The second is a pair of pliers with labels 'fulcrum' pointing to the pivot and 'lever' pointing to the handles. The third is a robotic arm with a label 'grip' pointing to its end effector.

Teacher

Helping Hand Engineering Design Challenge

ask: Identify the problem

design and build a device that lets you grab different objects and drop them into a container that's at least two feet away from you.

- pick things up and drop.
- strong
- it has to be 2 feet long

Student A

Helping Hand Engineering Design Challenge

ASK:

① Identify the problem.

Design and build a device that lets you grab different objects and drop them into a container that's at least two feet away from you.

- pick things up
- put things down
- at least 2 feet

Student B

Helping Hand Engineering Design Challenge

Ask: Identify the problem

Design and build a device that lets you grab different objects and drop them into a container that's at least two ft. away from you.

- pick stuff up
- length of two ft.
- drop stuff
- is it strong?

Student C

Exploration and Research

Prior to beginning the design phase, we spent time exploring real-world things that can grab, pick up and drop objects. This helped activate students' background knowledge, border concepts of "grabber" devices, and tied the activity to grade level NGSS content.

Topics explored included:



Tendrils of climbing vines



Cephalopod tentacles



Crustacean claws

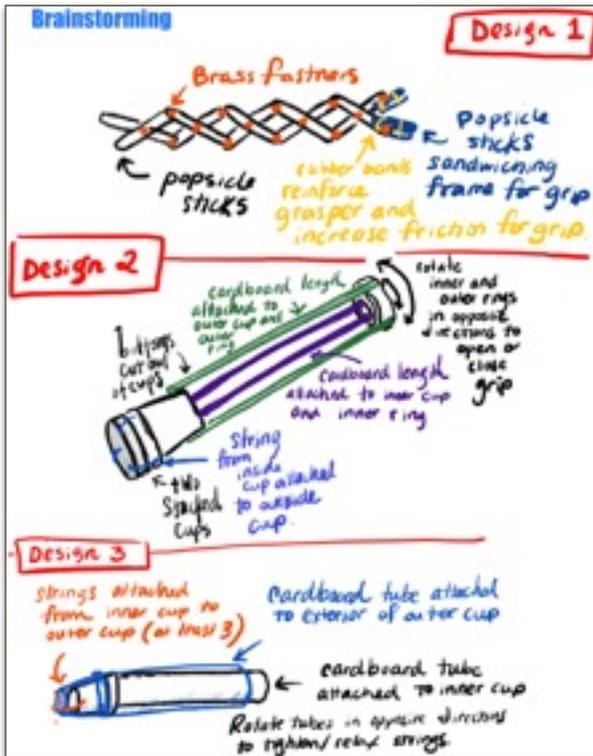


Human-made tools

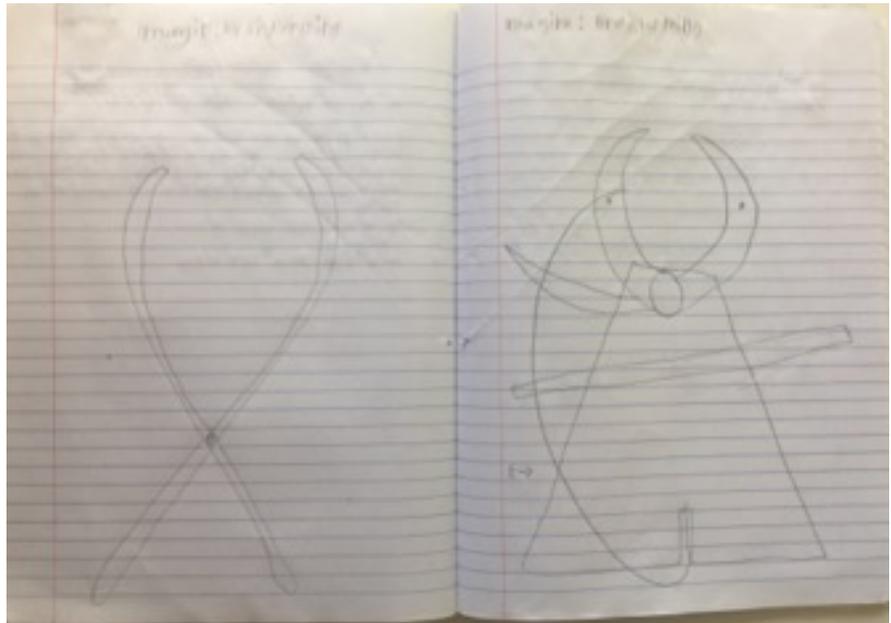


Prosthetic hands

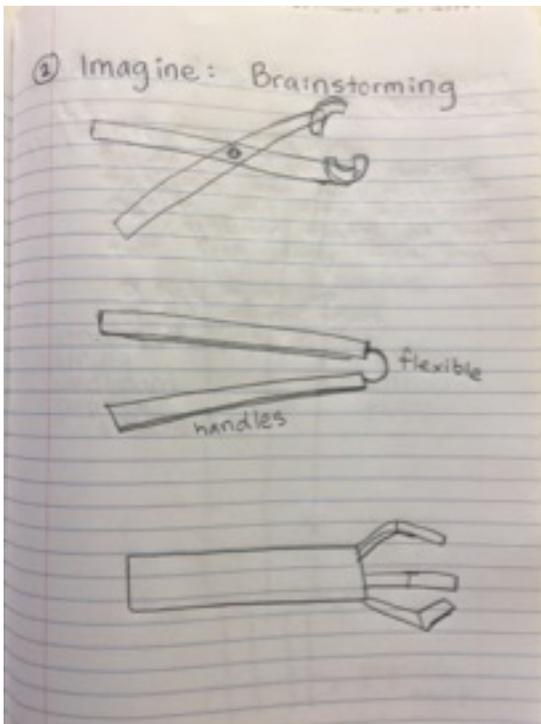
Brainstorming



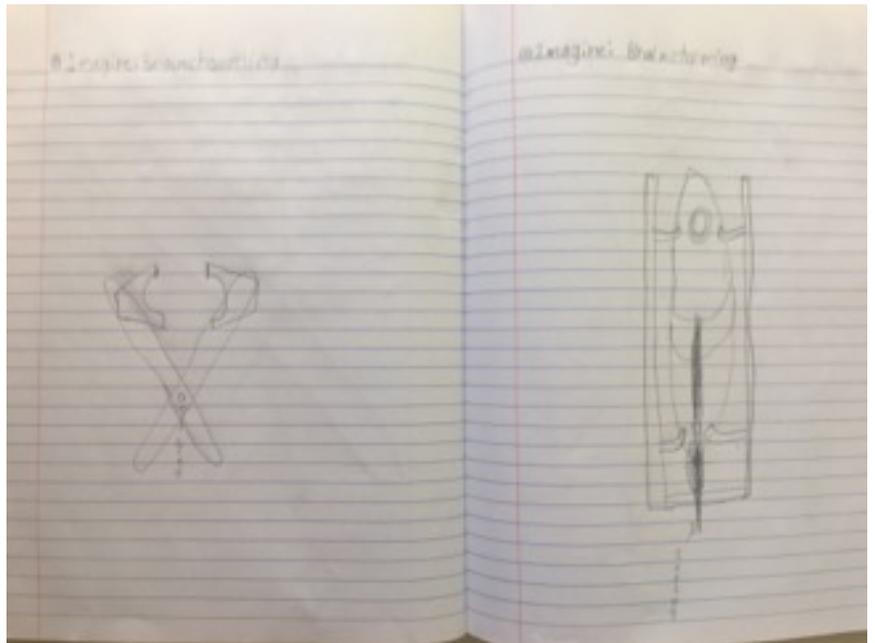
Teacher



Student A

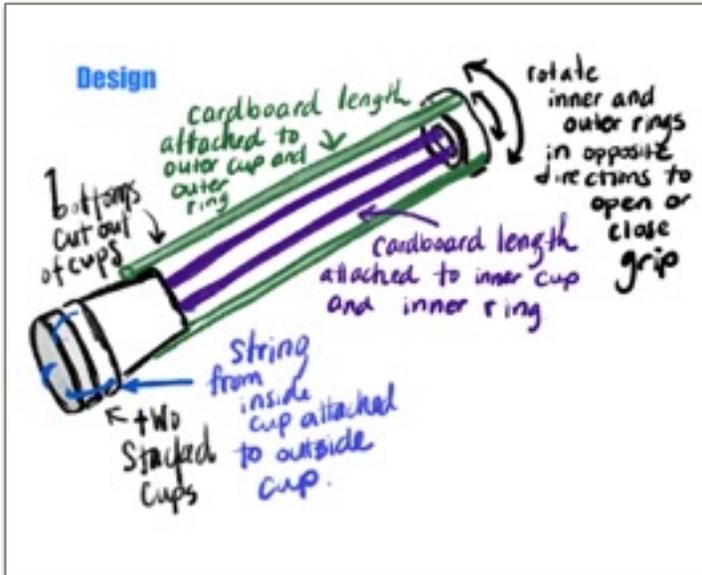


Student B

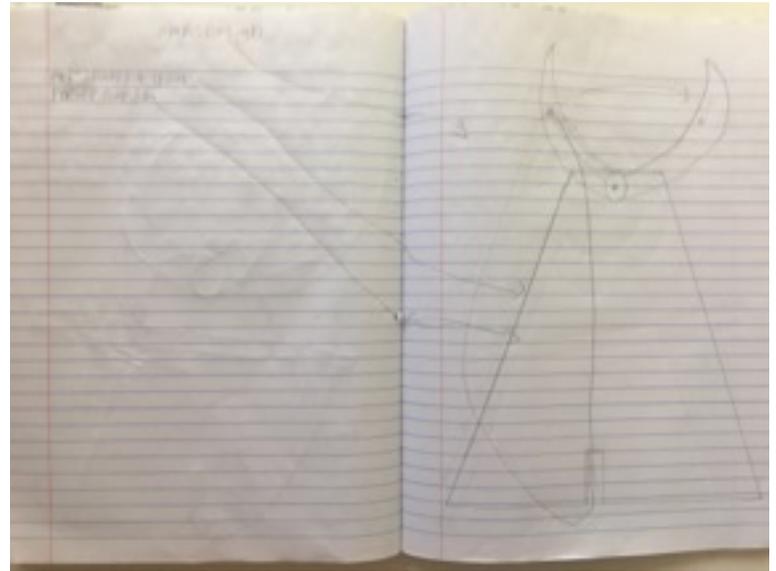


Student C

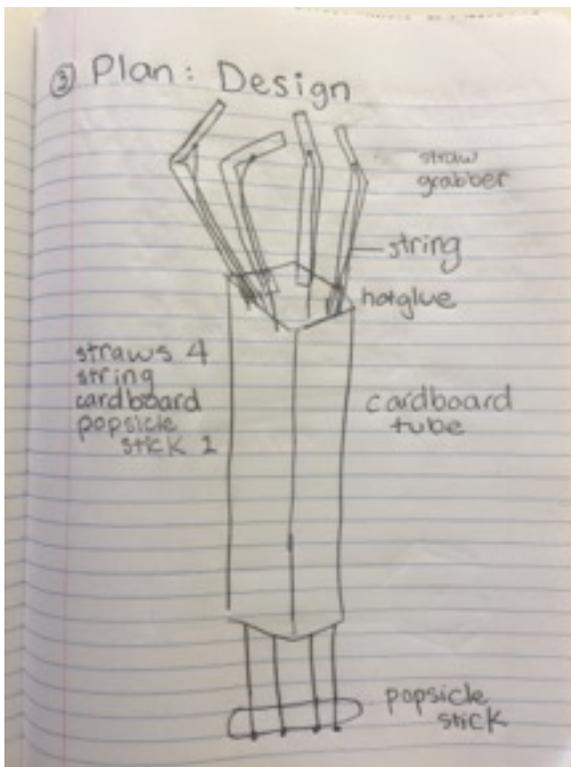
Design



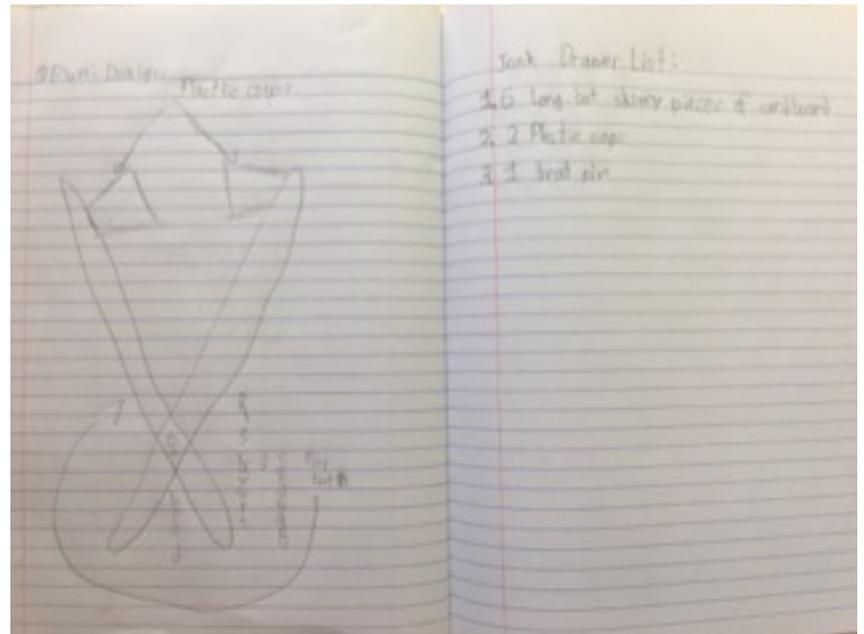
Teacher



Student A



Student B



Student C

Build



Teacher



Student A



Student B



Student C

Test and Evaluate

	Try 1	Try 2	Try 3
cotton ball	Yes	Yes	broke
tiny lion	No	No	No
tennis ball	No	No	No
bottle	No	No	No

Teacher

Test	1	2	3	
	No	OK	OK	cotton ball
	OK	OK	NA	tiny lion
	No	No	No	tennis ball
				bottle

Student A

⑤ Test!

	Try 1	Try 2	Try 3
cotton ball	✓	✓	✓
tiny lion	X	X	X
tennis ball	x	x	x
bottle	X	X	X

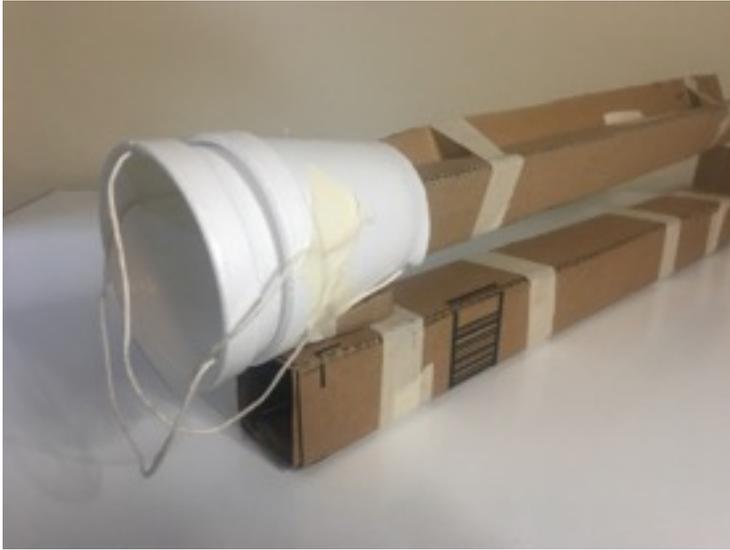
Student B

⑤ Test

	Try 1	Try 2	Try 3
① Cotton ball			
② Childhood Lion (strange out!)	✓	✓	✓
③ Tennis ball	✓	✓	✓
④ water bottle	✓	✓	✓

Student C

Redesign



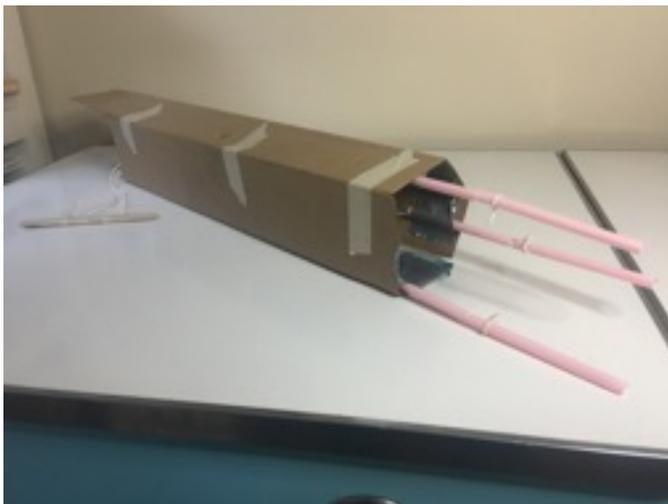
Teacher

Triangular handle to rotate inner cup offers more stability and torque. Fewer strings with more slack improved grip and reduced snagging



Student A

Increased length of handles to reach nearly four feet



Student B

Increased tube diameter to separate grabber straws



Student C

Changed angle of rubber bands to have grabber claws pull open and close.

Share

Students shared their builds and reflections on their design experience orally with the group. Students described their plan, improvements made through redesign, effectiveness of their device as evidenced by performance during the testing, and their successes and challenges.

Reflection on experience:

This was a fun and engaging engineering design challenge that students were excited to participate in. Scaffolding student planning stages and fostering collaboration helped to contribute to the success of this activity. Giving students the option to discuss and share ideas during the design phase had a synergistic effect. Students were very enthusiastic to help peers develop more complete design plans. As students finished their design plans, I encouraged them to list or label the materials they are using to construct each part of their design and plan how they are attaching and operating each of the components of their build. This helped students to think through plans in greater detail and work through several potential challenges mentally. In turn, this allowed students to more efficiently gather materials and helped students have a clear plan in mind as they began their builds quickly. Finally, the opportunity to redesign the initial builds was absolutely critical to the success and impact of the lesson. Many of the initial builds struggled or failed in the first test phase. Had the activity ended at that point, it could have left students discouraged and frustrated. However, with the opportunity to improve their builds, students turned failure into an opportunity for growth. They eagerly pointed out ways to refine and strengthen builds on their own projects and for their peers. Students continued to extend newly learned cardboard construction skills, reflected on test results, and utilized creativity and critical thinking skills to rebuild their designs. Subsequently, all showed tremendously improved performance and functionality. Moreover, students felt successful, accomplished, and empowered by their experience.

While the activity went very well, the most difficult part of the challenge was the initial build. Younger students may require support, an introduction to using some tools, or assistance cutting materials. The use of some tools such as a hot glue gun or large scissors for cutting cardboard may not be appropriate for all children. The youngest students in early elementary grades might require considerable adult scaffolding.

In constructing a device to pick up and drop objects from two feet away, students explored the following standards to develop designs, build their devices, and meet distance criteria of the challenge as they worked through the engineering design process.

NGSS 1. Structure, Function, and Information Processing

1-LS1-1 Use materials to design a solution to a human problem by mimicking how plants and/or animals use their external parts to help them survive, grow, and meet their needs.

NGSS Engineering Design

K-2-ETS1-1. Ask questions, make observations, and gather information about a situation people want to change to define a simple problem that can be solved through the development of a new or improved object or tool.

K-2-ETS1-2. Develop a simple sketch, drawing, or physical model to illustrate how the shape of an object helps it function as needed to solve a given problem.

K-2-ETS1-3. Analyze data from tests of two objects designed to solve the same problem to compare the strengths and weaknesses of how each performs.

CCSS Mathematics

CCSS.MATH.CONTENT.1.MD.A.2 Express the length of an object as a whole number of length units, by laying multiple copies of a shorter object (the length unit) end to end; understand that the length measurement of an object is the number of same-size length units that span it with no gaps or overlaps.

CCSS.MATH.PRACTICE.MP1 Make sense of problems and persevere in solving them.

CCSS.MATH.PRACTICE.MP5 Use appropriate tools strategically.

The engineering design process supported the teaching of science and math concepts by creating a meaningful opportunity to apply content knowledge. Students made comparisons to animal and plant structures in planning and building their device. Students also measured the lengths of various materials while building to ensure their prototypes met the minimum reach criterion. Students also measured the distance to each object for testing requirements. The real-world relevance of this activity further provided a compelling need for the skills and development of engineering practices. Students utilized both declarative and procedural knowledge to develop their solutions.

NASA's BEST Engineering Design model was an appropriate selection to implement this activity. It is appropriately condensed for lower elementary grades while still highlighting core phases of the design process. In particular, NASA's BEST Engineering Design Model places emphasis on the iterative process, which was integral to student learning and growth in this activity. I would modify this design model by adding a phase for sharing solutions and possible next steps as we did in this application.

I made some modifications in implementing this engineering design challenge that helped to support elementary students. Conducting some scaffolded exploration and research prior to the design phase helped to generate diverse design concepts and activate student's background knowledge. Furthermore, it helped students recognize the wide variety of "grabbers" that exist. This is especially helpful for younger students who may not have as broad or extensive range of experiences or declarative or procedural knowledge. Having students label design plans as thoroughly as developmentally appropriate including the materials used for each part and how to construct and attach each piece facilitated students in collecting materials efficiently and having a clear plan as they began building. I would maintain these modifications in using this activity with future students.

This was an engaging engineering design challenge that can easily be modified to fit a range of grade levels. Its open ended nature, and emphasis on critical thinking, creativity, and problem solving makes it an excellent activity that can be easily differentiated for students in a class while integrating content of STEM fields and building engineering practices.