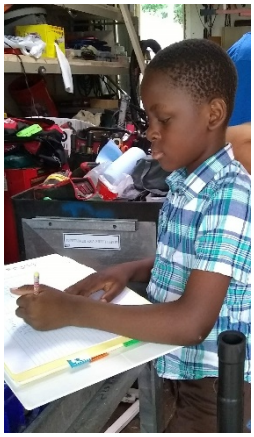
I Can Engineer!
A 4-H STEM Curriculum for Grades K-2



University of Minnesota Extension

I Can Engineer!

A 4-H STEM curriculum for Grades K-2

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About Minnesota 4-H Youth Development

Minnesota 4-H Youth Development is a part of the University of Minnesota Extension Department of Youth Development. It is the largest youth-serving organization in the state and its programming is grounded in research-based practice. Minnesota 4-H is committed to creating a force of young people who are able to learn and lead in a global society.

Overview

4-H Engineering Design Curriculum Overview

This curriculum for youth in grades K-2 uses the experiential learning process to explore engineering. Through hands-on discovery using the Engineering Design Process, youth develop a greater understanding of how objects can be developed, changed or improved through engineering. Lessons follow the Engineering Design Process of: **ASK, EXPLORE, PLAN, CREATE & TEST and MAKE IT BETTER.**

There are five Engineering Design Modules in this curriculum. Each is approximately 60 minutes in length and can be extended by allowing youth additional time to improve their design. An emphasis has been placed on exciting, age appropriate, low cost, hands-on activities that will reinforce the Engineering Design Process and help youth to "think like engineers."

Each Module includes these sections:

Introduction

- Module Summary
- Learning Objectives
- Science and Engineering Practices
- Concepts and Vocabulary
- Life Skills

Getting Ready

- Preparing to Teach
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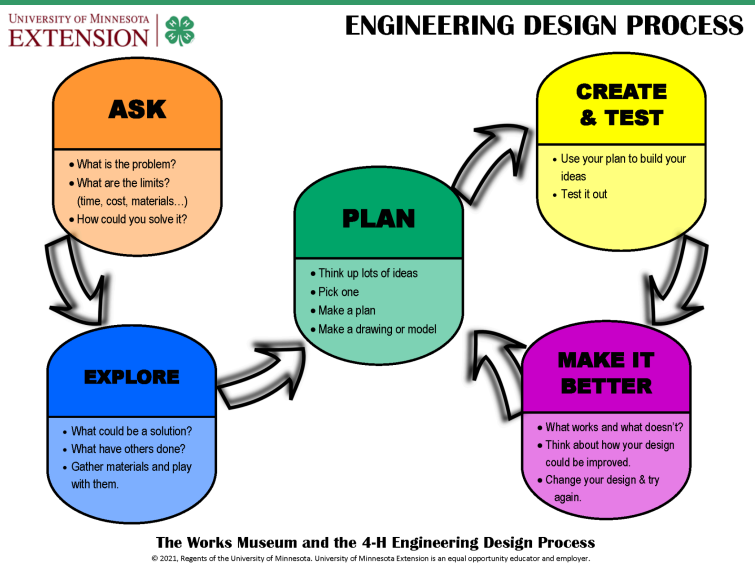


Engineering Design in grades K–2 explores these questions:

- What is the Engineering Design Process?
- What is a local example of engineering design?
- What materials were used to construct the project, and how do properties of materials affect the design?
- What kinds of problems can be solved through engineering?

You will find a full-sized copy of this model in the Resources section.

4-H uses the Experiential Learning model

4-H engages youth in hands-on experiences in which they DO, REFLECT, and APPLY. Each lesson follows this five-step model of Experience, Share, Process, Generalize and Apply. You will find a full-sized copy of this model in the Resources Section

Sources: Cooperative State Research, Education, and Extension Service (1996). *Curriculum Development for Issues Programming - A Handbook for Extension Youth Development Professionals*. Based on the work of Kolb, D. (1984). *Experiential learning: Experience as the source of learning and development.* New Jersey: Prentice-Hall.

Youth build skills

Through the lessons, youth will build their skills in these four Practices of Science & Engineering, identified in the Next Generation Science Standards (NGSS):

1. Asking questions and defining problems.
2. Developing and using models
3. Planning and carry out investigations
4. Constructing explanations and designing solutions

Each lesson also notes the Life Skills which are being learned and practiced. You will find a copy of the Life Skills Wheel in the Resources section.

Module Descriptions

Module 1 - BLOW!

Using the story, *The Three Little Pigs*, youth identify the problem that the three little pigs need to solve: how to build a strong house and protect themselves from the wolf. Using the Engineering Design Process, youth use materials of their choosing to create a house that will withstand the wolf's blow.. Youth can test, rebuild, and retest as time allows. Youth will discover properties of materials, ask questions, make observations, and gather information about a situation.

Module 2 - ZOO!

Using the story *Curious George Goes to the Zoo* by H. A. Rey, youth identify similarities and differences between the animals and their needs for safe bridges. The bird can fly from place to place but the lion needs a bridge to get from place to place. Youth then use the Engineering Design Process to design, build and test bridges to meet the needs of the animals.

Module 3 - WHOOSH!

Using the story, *WHOOSH! (The story of Lonnie Johnson)* by Chris Barton, youth identify characteristics of super soakers that make them fun to use. Youth will create a water soaker out of recycled materials. After testing the soakers made with one design, youth will decide how to make their individual soaker spray farther. Youth will use the Engineering Design Process to design and make their individual water soakers meet their specifications.

Module 4 - TIP!

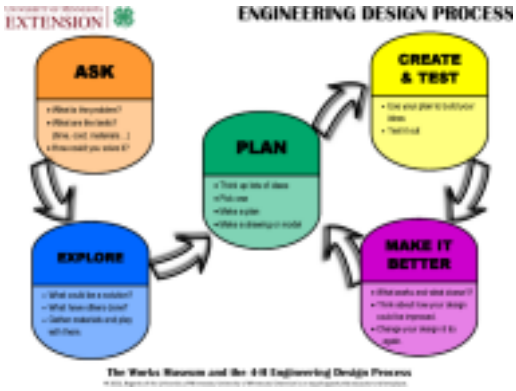
In this module, youth will explore the concept of balance using a balance scale, a stick and a variety of objects. Youth will build their own balance scale and use the Engineering Design Process to identify and create two examples of balance using different objects.

Module 5 - BOT!

Using the story, *Boy & Bot* by Ame Dyckman, youth identify the similarities and differences between robots and humans. Youth will use the Engineering Design Process to design, build, and test their own Wiggle Bot, made out of a pool noodle and a battery-operated toothbrush. Youth identify ways that humans and robots may work together to solve problems and create art.

MODULE 1 – BLOW!

Module Introduction



Module Summary

Using the story, *The Three Little Pigs*, youth identify the problem that the three little pigs need to solve: how to build a strong house and protect themselves from the wolf. Using the Engineering Design Process, youth use materials of their choosing to create a house that will withstand the wolf's blow (fan or hair dryer). Youth can test, rebuild, and retest as time allows. Youth will discover properties of materials, ask questions, make observations, and gather information about a situation.

Learning Objectives	Youth will: • explore the concepts of structural design including stability and strength • work together as a team • design a house to solve the pigs' problem by using the Engineering Design process
Science & Engineering Practices	• Analyzing and interpreting data • Constructing explanations • Designing a solution
Words to Know	• **Structural design** - inventing, designing, building • **Stable** - fixed, firm or steady in position • **Strength** - the ability to be strong • **Materials** - items used in the building process
Life Skills	• Cooperation and communication • Decision making • Teamwork • Contributing to group effort

Getting Ready

Preparing to teach this module

- Assemble materials
- Create "Big Bad Wolf" wind source (Handout 1.1)
- Make copies of the Data Table (Handout 1.2) and Reflection sheets (Handout 1.3) 1 per youth.


The "Big Bad Wolf" box fan.

Background information for the facilitator

The Engineering Design Process consists of five steps:

Ask
Explore
Plan
Create and test
Make it better

You will help youth understand new words as they consider what materials to use and what makes something strong and stable. Review the "Words to Know" definitions above so you are comfortable helping youth understand these terms and can give them real-life examples.

Some common misconceptions for youth this age include:

- More tape equals more strength. (This is why the tape amount is limited to 36 inches.)
- Heavier building materials will make a stronger house.

Time required

- Set up (20 min)
- Activity (30 min)
- Reflection (10 Min)

Materials needed

For whole group:

- 1 copy of *The Three Little Pigs* book or technology to show video: https://www.youtube.com/watch?v=-gdcgnSrUvU
- 1 multi-speed air source such as an electric fan or hair dryer, decorated to look like the Big Bad Wolf (Handout 1.1). ***Note:*** *Make sure the air source is strong enough to blow over the houses.*

For each youth or pair of youth:

- Any kind of materials that can be used to build your house(s) such as craft sticks, paper, cardboard, plastic containers, string, paper clips, or yarn
- 1 thick cardboard base (e.g., 5 ½ in. X 8 in.) to serve as a foundation for each house
- 1 yard (36 in.) of masking tape for each house
- 1 piece of paper and a pencil
- 1 Data Table (Handout 1.2)
- 1 Reflection Page (Handout 1.3)

Online learning tool
Three Little Pigs Design Challenge:
http://teachers.egfi-k12.org/wp-content/uploads/2014/08/Three-Little-Pigs-STEM-Design-Challenge-and-Standards-Connections.pdf

Activity Plan

Activity: The Three Little Pigs Design Challenge

Overview:
Youth will use the Engineering Design Model as they become structural engineers and solve a problem for the three little pigs (how to build a house that the Big, Bad Wolf can't blow down).

Opening questions and prompts:

- How many of you have heard the story of the Three Little Pigs?
- If you have, who can tell me something about it?
- Tell the youth we're going to listen to the story and figure out the problem the Three Little Pigs need to solve.
- Read the story of *The Three Little Pigs* or click on this link to hear the story: https://www.youtube.com/watch?v=-gdcgnSrUvU
- Share the Engineering Design Process with the youth, using the diagram in the Resources section.
  ASK
  EXPLORE
  PLAN
  CREATE & TEST
  MAKE IT BETTER

Experience
Step 1 in the Experiential Learning Cycle

Ask: Tell the youth that **Ask** is the first step in the Engineering Design Process.

- What is the problem that the Three Little Pigs have?
- Are you willing to be engineers and help the Three Little Pigs by building sturdy houses?
- Have the youth think about the things that are needed to build a **stable**, **strong** house. Help them identify factors that need to be considered such as **materials** and weather conditions.

Explore: Tell the youth the second step of the Engineering Design Process is to **Explore**. You will have a chance to explore the supplies you could use to make your houses. What are the parts of a house that would help it be sturdy? Guide the youth to think of the following basics:

- A foundation
- A roof and sides of the house
- Next, invite youth to explore the building material options provided. They may choose any supplies they'd like (or explain any limitations you have for materials use). Show them that each house may use up to 36" (3 feet) of masking tape.

Plan: Have the youth draw or sketch a design idea for their house. Tell youth that this is the third step of the Engineering Design Process. Using Handout 1.2, have youth draw or write down the building materials they plan to use.

Create & Test

Create: Now the youth will begin the fourth step of the Engineering Design Process. *NOTE: They should build their house using their design as a guide*. After youth complete the building of their houses, help them move to the testing step. It is suggested that the testing of the houses is done with the full group led by the facilitator.

Test: Test each house using your wind source. Use the Data Table to write or draw your results for each test. (Handout 1.2)

- Turn the air source on low (i.e., Huffing and Puffing Level 1) for 10 seconds.
- If it survives, go to medium (i.e., Huffing and Puffing Level 2) for 20 seconds
- If it survives, turn the fan to high (i.e., Huffing and Puffing Level 3) for 30 seconds
- If the house is still standing…Congratulations!

Note the differences between your house and the ones created by others. How do they compare? How are they alike? How are they different?

Make it Better: If the house does not survive, it is a good opportunity to think of design improvements. This is the fifth step of the Engineering Design Process.
If time allows, modify your house to **MAKE IT BETTER** and **RE-TEST.** (This would be an example of how an engineer continues to solve an identified problem.)

Share, Process and Generalize

Step 2, 3, and 4 of the Experiential Learning Cycle

- **Share:** Have the youth look at the answers that they drew or wrote down on their Data Table. Have the youth share one thing that was great about their house and one thing they would like to change.
- **Process:** How did your house compare to other houses? Why do you think that happened? What was the strongest building material(s)? What other things made some houses stronger than others? How did you use math today?
- **Generalize:** Have the youth look around the room at the materials used in the building. What materials were used for what purposes? (Wood, cement block, glass, etc.).

Apply

Final Step of Experiential Learning Cycle

If time allows, let the youth change another part of their house and repeat the process.

Reflection

- Ask the youth to think about what they changed and why they got the results that they did.
- Have the youth brainstorm other things they could change.
- Have the youth write or draw what they think on their Reflection Page (Handout 1.3).
- How was your plan the same or different from the actual house you built?

Wrap Up

Review the five steps of The Engineering Design Process. Have the youth stand up if they did this part of the Engineering Design Process today.

ASK
EXPLORE
PLAN
CREATE & TEST
MAKE IT BETTER

Final Reflection

Ask the youth:

- What is something new you learned today?
- Did you try something that you've never done before?
- How were you an engineer today?
- What questions did you explore the answers to?
- What questions do you still have?

Engineering-At-Home Activities

Take-Home Sheet

(Print or email the Engineering-At-Home handout to parents/guardians)

Today we helped the Three Little Pigs solve a problem: how to build a home strong enough to stand when the Big, Bad Wolf tried to blow it down. We tested different materials and ways to build.

Try these Engineering-at-Home Activities:

- Have a family engineering challenge using Legos. What did you learn in today's lesson that would make a Lego house stronger?
- Find a Lego Challenge Calendar and do a challenge each day.
- Watch an episode of the television show "Bob the Builder". Make a list of all the different jobs or people needed to build just one house or building.
- How do these jobs require an understanding of science, technology, and math?

Handouts

Handout 1.1 — Big Bad Wolf
Handout 1.2 — Data Table
Handout 1.3 — Reflection
Handout 1.4 — Engineering-At-Home — Take-Home Sheet — BLOW!

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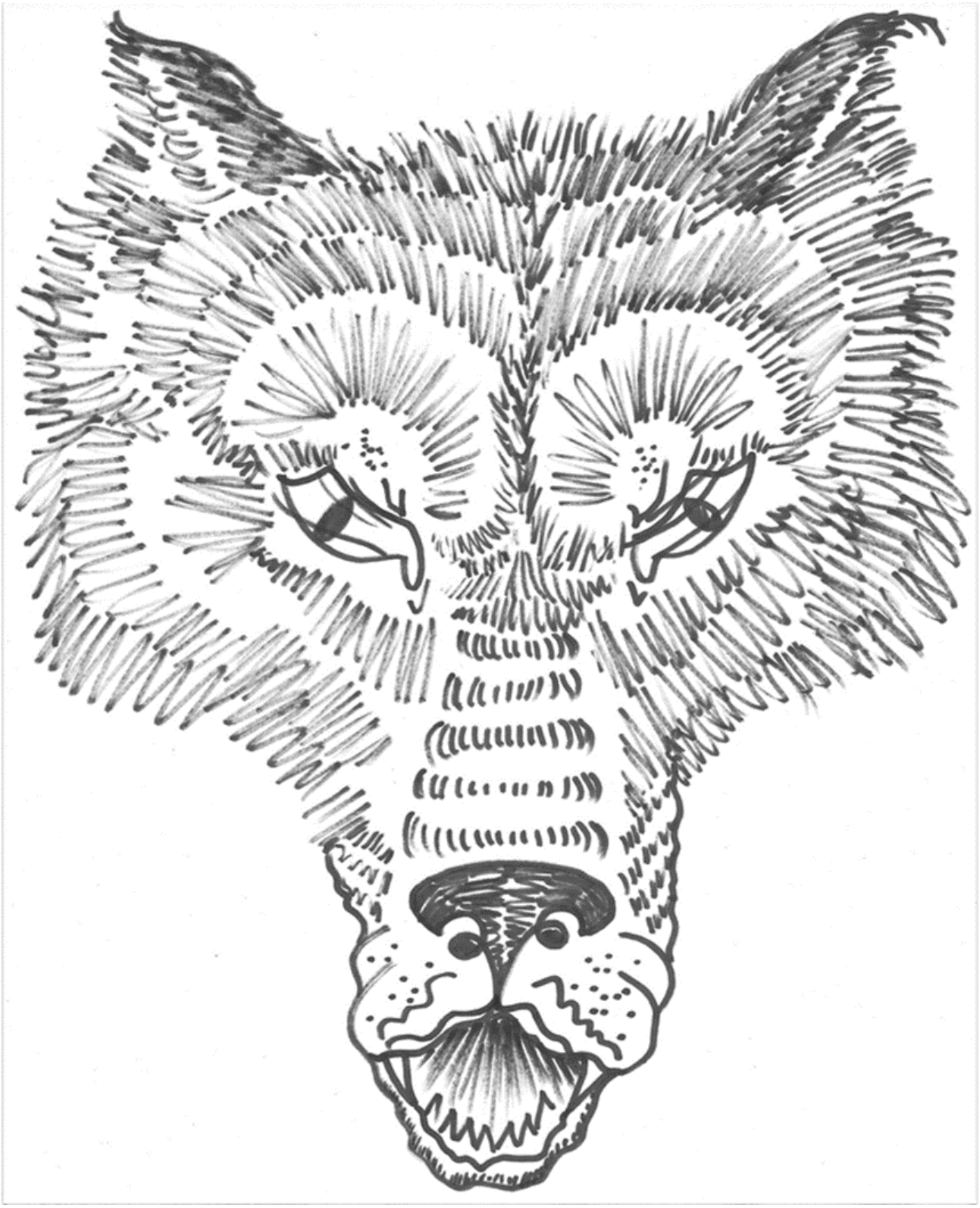
Module 1: BLOW! Handout 1.1
BIG BAD WOLF



Directions: Cut out wolf and attach to an air source. Color or enlarge image if desired.

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Data Table

For My Home

Building Materials

Huffing & Puffing		
Level 1 – Low	**Level 2 – Medium**	**Level 3 – High**

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Module 1: BLOW! Handout 1.3

1. Which house was the least sturdy? Why do you think that happened?

2. Which house was the most sturdy? Why do you think that happened?

3. How would you change your house design(s)?

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Module 1: BLOW! Handout 1.4 — Take-Home Sheet

Engineering-At-Home Activities

Today we helped the Three Little Pigs solve a problem: how to build a home strong enough to stand when the Big, Bad Wolf tried to blow it down. We tested different materials and ways to build. Ask your child about what they built, what materials they used and how sturdy or stable their house was.

We hope you will try these Engineering-at-Home Activities:

SOURCE:
https://www.mombrite.com/lego-stem challenge-calendar

- Have a family engineering challenge using Legos. What did you learn in today's lesson that would make a Lego house stronger?
- Find a Lego Challenge Calendar and do a challenge each day.
- Watch an episode of the television show "Bob the Builder." Make a list of all the different jobs or people needed to build just one house or building.
- Talk with your child about how each of these jobs require an understanding of science, technology, and math. Ask: Where do you see someone using math? What technology might this person need to use in their job? How might this person use science skills such as asking questions, making observations, or analyzing data?

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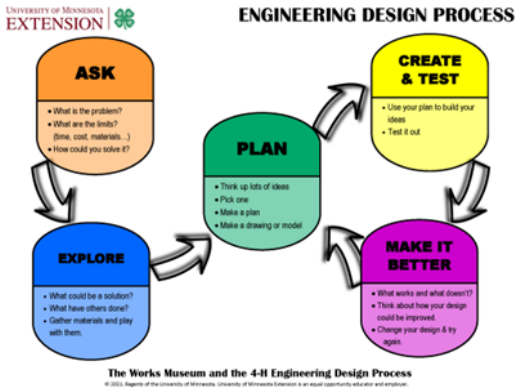
MODULE 2 – ZOO!



Module Introduction

Module Summary

Using the story *Curious George Goes to the Zoo* by H. A. Rey, youth identify similarities and differences between the animals and their needs for safe bridges. The bird can fly from place to place but the lion needs a bridge to get from place to place. Youth then use the Engineering Design Process to design, build and test bridges to meet the needs of the animals.

Learning Objectives	Youth will use the engineering design process in designing a bridge for zoo animals.
Science & Engineering Practices	• Asking questions • Planning and carrying out investigations
Words to Know	• **Zoo** - A place where animals live in captivity and are on display for people to view. • **Habitat** - The place where an animal lives or exists in the wild • **Zoo Habitat** - A habitat that is created by humans so that it is similar to where an animal lives in nature.
Life Skills	• Contributing to a group effort • Keeping records • Planning/Organizing

Getting Ready

Preparing to teach this module

- Gather materials
- Make copies of the Data Collection Sheet (Handout 2.1)) and the Reflection sheet (Handout 2.2) 1 per youth

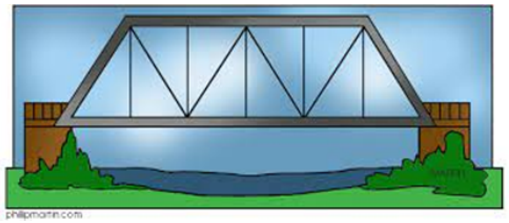
Background information for the facilitator

There are a wide variety of bridges that are all around us. Famous bridges include the Brooklyn Bridge in New York, New York, and the Golden Gate Bridge, in San Francisco, California. Bridges can also be found in overpasses on a busy highway, or over a smaller body of water such as a culvert.

The Engineering Design Process consists of five steps:

Ask
Explore
Plan
Create and test
Make it better

This module covers the creation of a Beam bridge. A Beam bridge is one of the simplest bridges that can be created. They are supported by columns below the bridge that go from one point to another.



http://clipart-library.com

Time required

- Set up (15 min)
- Activity (30 min)
- Reflection (10 Min)

Materials needed

For whole group

- Water source
- Various paper products such as paper towels, toilet paper, facial tissue, napkins • Rubber bands
- Paper clips
- Twist ties
- String
- Chart paper, white board or chalk board
- Book *Curious George Visits the Zoo* by Margret Rey or a recorded version
- Computer
- Internet source

For each youth or pair of youth:

- Small plastic animals
- Pencil — 1 per youth
- 1 — ½ cup container that will hold water
- 1 — 2 cup container that will hold water
- Data Collection Sheet (Handout 2.1) — 1 per youth
- Reflection sheet (Handout 2.2) — 1 per youth

Online learning tool
Book *Curious George Visits the Zoo* by Margret & H. A. Rey or a recorded version on YouTube: https://www.youtube.com/watch?v=9RNpRjMcZDA (This book is about George's trip to the Zoo.)

Activity Plan

Activity: Bridges for Zoo Animals

Overview of the activity:
In this activity, youth are challenged to solve a problem at the zoo. How can we build a bridge that is strong enough for the animals to cross over a stream of water? Youth will first be shown how to make the general structure for the paper bridge using toilet paper or a similar lightweight paper. Next, they become zoo engineers and create their own paper bridges out of other materials provided, in order to find out which material can hold the most weight. They begin by testing with paper clips; after testing with paper clips youth will test with small plastic animals.

Opening questions and prompts:

- What is your favorite animal?
    - Where does it live?
    - What does it eat?
- Read the book or watch the video of *Curious George Visits the Zoo* by Margret Rey: https://www.youtube.com/watch?v=9RNpRjMcZDA
- Have the youth draw their favorite animal from the story on the Data Collection sheet.
- Ask the youth what animals need to live (water, food, a place to live).
- Ask the youth if they know a word that describes all the things that the animals need to live. Help them come to the word Habitat. Share that engineers at zoos create habitats similar to where animals live in nature. This way visitors to the zoo can learn more about the animals.
- Share the Engineering Design Process with the youth.
  ASK
  EXPLORE
  PLAN
  CREATE & TEST
  MAKE IT BETTER

Experience

Step 1 in the Experiential Learning Cycle

Activity 1—Build a bridge as a group

Ask the youth if they could become engineers today and use the Engineering Design Process to solve a problem at the zoo. Tell the youth that the animals need a safe place to cross a stream so as a group we will be creating a paper bridge (Figures 1 & 2). Make sure the youth can see the following materials on the table or workspace:

- One ½ cup plastic container
- One 2 cup plastic container
- Tape
- Toilet paper
- Small Plastic Animals
- Paper clips (in the small container filled with water)

Figure 1

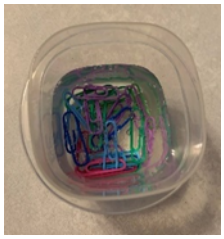


Figure 2

Explore: As a large group, brainstorm ways the materials on the table or workspace could be used to create a bridge that the animals could use to cross over the stream of water. Encourage the youth to think of as many possibilities as they can. Some will be more realistic than others, but encourage as much creativity as possible.

Record the youth's ideas on a large sheet of chart paper white board or chalk board.

Plan: As a large group, ask the youth to create a bridge over the 2-cup plastic container using toilet paper and tape.

Create: Help the group decide on the plan and create the bridge similar to Figure 1. (For the large group activity, tape would be used instead of rubber bands).

Figure 3

Test: Guide the youth in testing and recording on the Data Collection sheet.

- Have the youth guess how many wet paper clips the bridge will hold before it collapses. Write these numbers on their data collection sheet.
- ***Test:*** Place the wet paper clips on the bridge. Count together how many wet paper clips the toilet paper holds. (This number should be rather low). (See Figures 3 & 4).

Figure 4

Make it Better: Help the youth identify what happened and how they could change the design so that the bridge could support more wet paper clips. Write these ideas on a large sheet of chart paper, white board or chalk board. (The water soaked the toilet paper thus making the toilet paper break).

Activity 2: Build your own bridge

Review the ideas youth generated in the **MAKE IT BETTER** section. The youth are now going to become zoo engineers and make stronger bridges using the same plastic containers and paper clips but also using additional materials.

Provide enough of the materials for each of the engineers or pair of engineers.

- One small plastic container
- One medium container
- Tape
- Toilet paper
- Paper clips
- Rubber bands
- Various paper products such as paper towels, toilet paper, facial tissue, napkins (a variety of brands of each kind of paper product would also be a possibility)
- String or yarn
- Small toy animal figurines

Ask: How might you build a structure that will hold your animal (or the most animals)?

Design: Tell the youth that the containers must be used in their design. The youth will then decide what they are going to do. They should draw their new design on their Data Sheet. Tell youth they will first test their design with wet paper clips, then animal figures.

Create & Test

Create: Have the youth build their own bridges.

Test: Have the youth test their bridges by seeing how many wet paper clips their designs can hold before collapsing. Did it hold more than our original group bridge design? Have the youth recreate their bridge and then test it with the toy animal figurine.

Share, Process and Generalize

- **Share**: Have the youth share with the large group how they made their bridge.
  - What paper products did you use?
  - How did you attach the paper to the container?
  - What happened when you put on the wet paper clips?
  - How many paper clips were you able to put on your bridge before it collapsed?
  - Why do you think this happened?
  - Were you able to build a bridge that supported your animal? What worked or didn't work?
- **Process:**
  - What was different about your bridge than the one that the group created?
  - What other things would you do differently in future bridges?
  - How would you MAKE IT BETTER?
  - What other kind of paper or way of attaching the paper to the container could you change and what do you think will happen?

- **Generalize:**
  As a large group, help the youth discuss what is the best combination of paper products and fasteners for the paper bridges. (This will be determined by the number of wet paper clips that the bridge can hold before it falls.)

Apply: If time allows, let the youth change another thing and repeat the process.

Reflect:

- Ask the youth to think about what they changed and why they got the results that they did.
- Have the youth brainstorm other things they could change.
- Have the youth write or draw what they think on their Reflection Page.

Wrap Up

Reflection: *Reflecting on experience is an essential part of learning and "making meaning of" an experience.* Review the five steps of The Engineering Design Process. Have the youth stand up if they did this part of the Engineering Design process today.

ASK
EXPLORE
PLAN
CREATE & TEST
MAKE IT BETTER

Final Reflection - (Complete the Reflection page together.)
Ask the youth:

- What is something new you learned today?
- Did you try something that you've never done before?
- How were you an engineer today?
- What questions did you explore the answers to?
- What questions do we still have?

SOURCES

Schul, C. H. (2019). *Awesome Engineering Activities for Kids: 50+ Exciting Steam Projects to Design and Build.* Rockridge Press.

Davey, L. (2018). *How to be an Engineer.* DK Publishing.

Engineering-At-Home Activities

Take-Home Sheet

Today we learned about bridges and the many factors that are needed in creating a bridge. We focused on suspension bridges specifically. This was explored through the lens of a zoo engineer. Youth were asked to create the strongest bridge for the animals to cross. This was measured by the number of wet paper clips their creations could hold.

If you would like to continue learning more about different types of bridges and how to create more, here are some possible resources.

Links:

Suspension Bridges: https://leftbraincraftbrain.com/engineering-201-diy-recycled-suspension-bridge/
Cardboard Bridge for Trucks and Trains: http://www.pinkstripeysocks.com/2014/01/make-cardboard bridge-for-trains-and.html
More about Bridges: https://www.youtube.com/watch?v=oVOnRPefcno
Gumdrop bridges: http://www.tallbridgeguy.com/gumdrop-bridges-for-kids/

Books:

How to be an Engineer edited by Lizzie Davey. Penguin Random House 2018.
Curious George Visits the Zoo by Margret & H. A. Rey, Houghton Mifflin, 1985. Or a recorded version is available on YouTube: https://www.youtube.com/watch?v=9RNpRjMcZDA

Learning about bridges in our world:

Go for a walk or take a drive and look for any type of structure resembling a bridge. Examples could be a road over a water area, a pedestrian bridge, a railroad bridge over a road, or a road over a railroad track. The possibilities are endless. When you find a bridge, if it can be done safely, identify the beginning and end of the bridge, supports it uses and any other features you can see unique to this structure. Have your youth draw the bridge on the back of the Data Collection Sheet. Share this at the next meeting of the group.

Handouts

Handout 2.1 — Data Collection Sheet – ZOO!
Handout 2.2 — Reflection
Handout 2.3 —Take-Home Sheet

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MODULE 2: ZOO! Handout 2.1

Data Collection Sheet — ZOO!

1. What is your favorite zoo animal?

2. What does your favorite animal's habitat look like?
Draw your favorite animal in its habitat here:

3. Predict: I think the first bridge will hold _____ paper clips.

4. The problem with the first bridge is...

5. I want to make a stronger bridge. I am going to change one thing. Draw a picture of what your new bridge will look like. Put an arrow to show the thing you are changing.

6. How many paperclips did your bridge hold? _____ Paper clips

7. Draw one thing you could change to make a bridge that was even stronger?

8. Try out your new bridge idea if you have time and draw what happened.

Module 2: ZOO! Handout 2.2

Reflection

1. Draw a picture of something new you learned today.

2. Draw a picture of something that you have never done before.

3. How were you an engineer today?

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Module 2: ZOO! Handout 2.3 — Take-Home Sheet

Engineering-At-Home Activities

Today we learned about bridges and the many factors that are needed in creating a bridge. We focused on suspension bridges specifically. This was explored through the lens of a zoo engineer. Youth were asked to create the strongest bridge for the animals to cross. This was measured by the number of wet paper clips their creations could hold.

If you would like to continue learning more about different types of bridges and how to create more, here are some possible resources.

Links:

- Suspension Bridges: https://leftbraincraftbrain.com/engineering-201-diy-recycled-suspension bridge/
- Cardboard Bridge for Trucks and Trains: http://www.pinkstripeysocks.com/2014/01/make cardboard-bridge-for-trains-and.html
- More about Bridges: https://www.youtube.com/watch?v=oVOnRPefcno
- Gumdrop bridges: http://www.tallbridgeguy.com/gumdrop-bridges-for-kids/

Books:

How to be an Engineer, edited by Lizzie Davey. Penguin Random House 2018.

Curious George Visits the Zoo, by Margret & H. A. Rey, Houghton Mifflin, 1985. Or a recorded version is available on YouTube: https://www.youtube.com/watch?v=9RNpRjMcZDA

Learning about bridges in our world:

Go for a walk or take a drive and look for any type of structure resembling a bridge. Examples could be a road over a water area, a pedestrian bridge, a railroad bridge over a road, or a road over a railroad track. The possibilities are endless. When you find a bridge, if it can be done safely, identify the beginning and end of the bridge, supports it uses and any other features you can see unique to this structure. Have your youth draw the bridge on the back of the Data Collection Sheet. Share this at the next meeting of the group.

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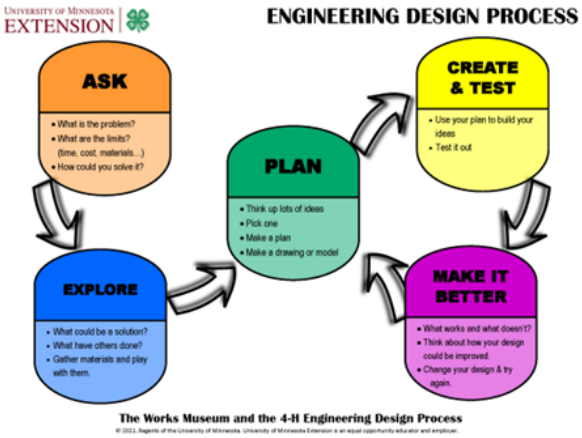
Module 3 — WHOOSH!



Module Introduction

Module Summary

Using the story *WHOOSH! (The story of Lonnie Johnson)* by Chris Barton, youth identify characteristics of super soakers that make them fun to use. Youth will create a water soaker out of recycled materials. After testing the soakers made with one design, youth will decide how they could make their individual soaker spray farther. Youth will use the Engineering Design Process to design and make their individual water soakers to meet their specifications.

Learning Objectives	Youth will practice the Engineering Design process by redesigning a water soaker to meet new specifications.
Science & Engineering Practices	• Asking questions • Planning and carrying out investigations
Words to Know	• **Super Soaker** - a fun toy that is used to shoot water • **Stream of Water** - water that is moving in a line
Life Skills	• Contributing to a group effort • Keeping records • Planning/Organizing

Getting Ready

Preparing to teach this module

- Gather materials
- Make copies of the Data Collection sheet (Handout 3.1) and the Engineering-At-Home sheet (Handout 3.2) 1 per youth.

Background information for the facilitator

Lonnie Johnson is the inventor of the Super Soaker Water Gun. He is an aerospace, mechanical and nuclear engineer who has worked on designs to explore Jupiter, Saturn and Mars while working for NASA. He now has his own engineering company.

The Engineering Design Process consists of five steps:

Ask
Explore
Plan
Create and test
Make it better

This module covers the creation of a water bottle soaker by youth and then youth make changes to the basic design to create a longer stream of water. The water bottle soaker is similar to a Super Soaker but created with recycled materials readily available to the youth.

Words to Know

- Super Soaker – a fun toy that is used to shoot water
- Stream of water – water that is moving in a line

Time required

- Set up (10 minutes)
- Activity (30 minutes)
- Reflection (10 minutes)

Materials needed

For the whole group:

- Water source
- *Whoosh! (The story of Lonnie Johnson)* by Chris Barton (YouTube video or the book is available on Amazon.)
- Computer
- Internet source
- Chart paper, white board or chalk board
- Open space that can get wet, preferably outside
- Picture or example of a current Super Soaker (search for an image online or bring in an actual Super Soaker)
- Picture of the first Super Soaker

- Paper clips
- Binder clips
- Rubber bands
- Plastic bags
- Various kinds of tape
- Tape measure, yard/meter sticks, and chalk for measuring distance of spray (optional)

For each youth:

- Empty Water bottle (16.9 oz) with a push pin hole in the cap (Bottles with semi-clear caps are the best.) 1/youth
- Additional caps for the water bottles (2/youth)
- Data Collection sheet (Handout 3.1) - 1/youth
- Pencil or pen - 1/youth
- Self-sticking labels for names on the bottles - 1/youth
- Markers 1/youth

Online learning tools

- *Whoosh! (The story of Lonnie Johnson)* by Chris Barton. Book available on Amazon or YouTube video: https://www.youtube.com/watch?v=zL99Ky6fjas
- Interview with Lonnie Johnson (optional): https://www.youtube.com/watch?v=-1zAO1WkG58
- The Story of Lonnie Johnson (optional): https://www.youtube.com/watch?v=j7m1L16tQrQ

Activity Plan

Activity: Making a water bottle soaker

Overview of the activity:

Youth are challenged to create a water bottle soaker that will spray farther than the one created by the large group. First youth will learn to make a general water soaker using a filled water bottle. Then they will become engineers and design and create their own water bottle soaker out of other materials provided to find out which design can create the longest stream of water.

Opening questions and prompts:

- Have the youth look at a picture of a super soaker (find one online) OR show them an actual Super Soaker-type water toy that you bring.
- Ask how many have used a Super Soaker.
- What was their favorite part of using a Super Soaker?
- What made using the Super Soaker fun? (Reinforce any ideas and stories they share.)
- Read or watch the story *Whoosh!* Show the youth Lonnie's first super soaker. Lonnie's First Super Soaker
- Have the youth draw a picture of their favorite part of the story on their Data Collection sheet.

- Ask the youth if they can describe why they think the Super Soaker works better than other water soakers.
- Lonnie is an Engineer. Engineers have a process they use to design things. The Engineering Design Process we will use is:
  ASK
  EXPLORE
  PLAN
  CREATE & TEST
  MAKE IT BETTER

Experience

Step 1 in the Experiential Learning Cycle

Activity 1—Create a water bottle soaker prototype

Ask the youth if they could become engineers today like Lonnie and use the Engineering Design Process to create a water bottle soaker that they can use to get someone wet.

Create a water bottle soaker with the youth Make sure the youth can see the following materials on the table or workspace:

- empty water bottles
- water
- water bottle caps
- push pins
- tape
- name label with "sample" written on it

Explore: As a large group, brainstorm ways the materials on the table or workspace could be used to create a water bottle soaker that would spray a stream of water. Encourage youth to think of as many possibilities as they can. Some will be more realistic than others, but encourage as much creativity as possible.

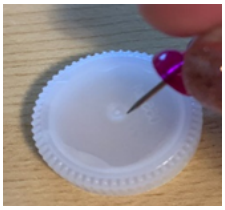
Record the youth's ideas on a large sheet of chart paper, white board or chalk board. Note that we will come back to these ideas when we do the Part 2 Redesign activity.

Plan: As a large group, task the youth with creating a water bottle soaker. Lead the children to the concept of poking a hole in the cap of the water bottle with a push pin for the water stream to exit the bottle. Explain that we are first creating a "prototype" or sample to test, so our soakers will look similar.

Create & Test

Create:

- Fill the empty bottles with water. **NOTE:** Fill the bottles with the youth so they understand the concept of reusing the water bottles.
- Show the youth how a push pin can be used to make a hole in the water bottle cap.



- Put the cap back on the filled water bottle and secure it with tape.
- Put the label with "sample" on the water bottle.
- Have the youth guess how far the stream of water will go. (Have the youth stand in a line and then count their steps to show how far they think the stream of water will go.)
- Have the youth record the number of steps from the starting line to where they think the group water bottle soaker stream will go and write this number on their Data Collection sheet (Handout 3.1).

Test:

- Squeeze the water bottle with a light amount of pressure and a stream of water will come out of the water bottle cap.
- Have the youth determine who had the closest guess as to how far the stream of water would go.
- Mark this spot with a cone, chair or something else.
- Have the youth write how many steps the water bottle soaker went on their Data Collection sheet (Handout 3.1). To add some math to the lesson, you may use a tape measure or yard/meter stick to measure distance.

Make it Better: Have the youth describe what happened when the water bottle was squeezed and how they could change the outcome so that the stream of water goes farther. Write these ideas on a large sheet of chart paper, white board or chalk board. Examples of questions could be:

- Did they expect the water stream to go as far as it did?
- What did the stream of water look like?
- What other things did you see?

Activity 2: Build your own water bottle soaker

After completing the group water bottle soaker, review the ideas youth generated in the ***Make it Better*** section. The youth are now going to become engineers and make a water bottle soaker that will go farther using the same plastic water bottles but with additional materials.

Provide enough materials for each of the engineers.

- Water bottles
- Water
- Water bottle caps (2/youth)
- Push pins
- Various kinds of tape
- Paper clips
- Binder clips
- Rubber bands

Ask: What changes could you make to build a water bottle soaker that will shoot a stream of water farther than the one made by the group?

Design: Pass out the water bottles and name labels. Have the youth write their name(s) on the label and attach it to their water bottle.

- Tell the youth that the bottles and a cap must be used in their design.
- The youth will then decide what they are going to do/use to make their water bottle soaker make a longer stream of water.
- Additional materials are listed above.
- The youth should draw what they are changing on the Data
- Collection sheet (Handout 3.1)

Create & Test

Create: Have the youth build their own water bottle soaker.

Test: When all of the youth have completed their version of the water bottle soaker, go outside with the youth. (Depending on the group, you may want to make a time limit.)

- Have the youth stand in a line to see if their water bottle soaker goes farther than the group water bottle soaker. You may want to use measuring tools such as a measuring tape and chalk to mark the distance.
- Have the youth circle the answer on their Data Collection sheet (handout 3.1) to indicate if their soaker went farther or closer than the group water bottle soaker.
- Have each youth share with the group what they changed in their design and what results they observed.

Share, Process and Generalize

- **Share**: Have the youth share with the large group how they made their water bottle soaker.
    - What did you use to make the changes in your water bottle soaker?
    - What happened when you squeezed your water bottle soaker?
    - How far did your water bottle soaker spray?

- **Process:**
    - What was different about your water bottle soaker and the one the group created?
    - What other things would you do differently with future water bottle soakers?
    - How could you ***Make it Better***?

- **Generalize:** How could you use your water bottle soaker in other ways besides getting people wet? (Watering plants, washing something, etc.)

Apply: If time allows, let the youth change another thing and repeat the process. (Or see who can get the wettest or stay the driest.)

Reflect

- Ask the youth to think about what they changed and why they got the results that they did.
- Have the youth brainstorm other things they could change and write or draw these things on the Data Collection sheet (Handout 3.1).
- Have the youth write or draw what they think on their Data Collection sheet (Handout 3.1)
    - What was the "funnest" part of making your water soaker?
    - How can you use this in other things? (Water plants, doing any other water related activities)
- Lonnie was an inventor. What is something you'd like to invent?

Wrap Up

Reflection: *Reflecting on experience is an essential part of learning and "making meaning of" an experience.*

Review the five steps of The Engineering Design Process. Have the youth stand up if they did this part of the Engineering Design process today.

ASK
EXPLORE
PLAN
CREATE & TEST
MAKE IT BETTER

Final Reflection - Ask the youth:

- What is something new you learned today?
- Did you try something that you've never done before?
- How were you an engineer today, like Lonnie was in the story?
- What questions did you explore the answers to?
- What questions do we still have?

SOURCES

Barton, C. (2016). *WHOOSH!.* Charlesbridge Publishing, Inc.

Davey, L. (2018). *How to be an Engineer.* DK Publishing.

Schul, C. H. (2019). *Awesome Engineering Activities for Kids: 50+ Exciting Steam Projects to Design and Build.* Rockridge Press.

Engineering-At-Home Activities

Take-Home Sheet

Watch out, you may get wet! Today we made water bottle soakers. The Data Collection sheet will show you what we did as a group and how individual changes were made by youth.

Try these Engineering-at-Home Activities:

- Have the youth share their water soakers with their families and share what they changed and what happened.
- Have youth show their family how to create their own water soaker. Make sure they all test them outside together.
- Have the youth take pictures and share with the group next time.

Links:

- Learn more about Lonnie Johnson as a family, using one of the following links:
  The Story of Lonnie Johnson: https://www.youtube.com/watch?v=j7m1L16tQrQ
  Interview with Lonnie Johnson: https://www.youtube.com/watch?v=-1zAO1WkG58

Handouts

Handout 3.1 Data Collection Sheet
Handout 3.2 Take-Home Sheet

Module 3: WHOOSH! Handout 3.1

Data Collection Sheet — WHOOSH!

I changed **and** **happened.**

Something else I would change is:

The "funnest" part of making my water bottle soaker was:

I could also use my water bottle soaker to:

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Module 3: WHOOSH! Handout 3.2 — Take-Home Sheet

Engineering-At-Home Activities

Watch out, you may get wet! Today we made water bottle soakers. The Data Collection sheet will show you what we did as a group and how individual changes were made by youth.

Try these Engineering-at-Home Activities:

- Have your youth share their water soakers with you and share what they changed and what happened.
- Have your youth show you how to create their own water soaker. Make sure to test them outside together.
- Have the youth take pictures and share with the group next time.

Links:

- Learn more about Lonnie Johnson as a family, using one of the following links:
  The Story of Lonnie Johnson: https://www.youtube.com/watch?v=j7m1L16tQrQ
  Interview with Lonnie Johnson: https://www.youtube.com/watch?v=-1zAO1WkG58

Book:

- ***WHOOSH! (Lonnie Johnson's Super Soaking Stream of Inventions)*** by Chris Barton. Charlesbridge. 2016.
- The book is available on Amazon, or this YouTube video:
  https://www.youtube.com/watch?v=zL99Ky6fjas

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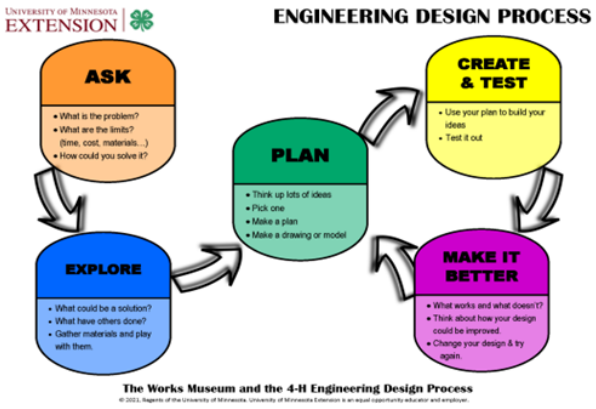
Module 4 — TIP!

Module Introduction

Module Summary

In this module, youth will explore the concept of balance using a balance scale, a stick and a variety of objects. Youth will build their own balance scale and use the Engineering Design Process to identify and create two examples of balance using different objects.



Learning Objectives	Youth will: • practice the concept of balance and how weight affects balance • document and reflect on the group activity and then their own • work together as a team
Science & Engineering Practices	• Asking questions • Developing and using models • Obtaining, evaluating and communicating information
Words to Know	• **Scale** - a tool for measuring mass or weight • **Balance** – the point where the weight of an object is even on all sides
Life Skills	• Cooperation and communication • Decision making • Teamwork • Contributing to a group effort

Getting Ready

Preparing to teach this module

- Gather materials
- Computer with internet access or downloaded video
- Make copies of the Data Collection sheet (Handout 4.1), Reflection sheet (Handout 4.2) and Take-Home sheet (Handout 4.3) — 1 per youth.
- Divide the children into pairs.

Background information for the facilitator

In these activities the youth will be introduced to the concept of balance using a scale, a stick and a variety of items.

The Engineering Design Process consists of five steps:

Ask
Explore
Plan
Create and test
Make it better

Words to Know

Balance – the point where the weight of an object is even on all sides
Scales – a tool for measuring mass and weight

Time required

- Set up (20 min.)
- Activity (30 min.)
- Reflection (15 min.)

Materials needed

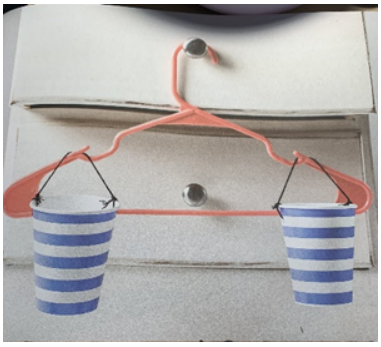
For the whole group:

- Three to four single hole punches
- Three to four rulers
- Variety of items such as pennies, small toys, rocks, fruit, etc. to illustrate balance on the plastic clothes hanger balance scale
- Chart paper, white board or chalkboard
- Masking tape (1 role)

For each pair of youth:

- Two lightweight cups (8 – 12 oz.)
- Scissors (1 per pair)
- String or yarn (36" per pair)
- Plastic clothes hanger with hooks or notches (1 per pair)

- Furniture with a knob to hang plastic clothes hanger balance scale or a dowel taped to a table with a portion of the dowel hanging over the edge (1 per pair)



Online learning tool
In this PBS Kids game, youth build a structure, and when the structure isn't balanced, it topples over:
https://pbskids.org/catinthehat/games/sketch-a-mite

Activity Plan

Activity: Designing and building a clothes hanger balance scale

Overview of the activity:
Youth are challenged to create a balance scale (from a clothes hanger) which will measure different items than the scale created by the group. Youth will first be guided in how to make a scale. Next, they will become engineers and design their own scale so they can compare items themselves.

Opening questions and prompts:
- Watch the following video *Measure Weights for Kids* with the children to introduce them to the concept of balance and a balance scale: https://www.youtube.com/watch?v=ybEU-6U7s8k
- What does balance look like?
- How does a balance scale work?
- What does it mean if one side is down and the other is up?
- Have the youth draw or write their description of balance on the Data Collection sheet.
- Today we are going to create our own scale. Think about how this could be done. We will use an engineer's way of thinking to change what happens. Engineers have a process they use to design things. The Engineering Design Process we will use is:
  ASK
  EXPLORE
  PLAN
  CREATE & TEST
  MAKE IT BETTER

Experience
Step 1 in the Experiential Learning Cycle

Ask the youth if they could become engineers today and use the Engineering Design Process to create a scale that will compare the weights of different objects.

Activity 1: Creating a hanger balance scale with the group

Make sure the youth can see the following supplies on the table or workspace:

- Single hole punch
- Ruler
- Variety of items such as pennies, small toys, rocks, paper clips, binder clips, pencils, pens, fruit, etc. to illustrate balance on the plastic clothes hanger scale
- Chart paper, whiteboard, or chalkboard
- Two lightweight cups (8 – 12 oz.)
- Scissors
- String or yarn (36")
- Masking tape
- Plastic clothes hanger with hooks or notches
- Furniture with a knob or taped dowel to hang the plastic clothes hanger balance scale on

Explore: As a large group, brainstorm ways the materials on the table or workspace could be used to create a scale. The scale will be used to compare the weights of different objects. Encourage the youth to think of as many possibilities as they can. Some will be more realistic than others, but encourage as much creativity as possible.

Record the youth's ideas on a large sheet of chart paper, whiteboard, or chalkboard.

Plan: As a large group, task the youth with creating a scale. Lead the youth to the concept of attaching the cups to the hanger with string or yarn and then placing it on the knob or dowel.

Create & Test

Create:

- To create the buckets - punch two holes in cups, close to the top of each cup.
- Use two 6" pieces of string. Secure the two 6" pieces of yarn or string to the hanger with tape.
- Loop the string through the cups and hang one cup on each end of the hanger. The balance should be level at this point.
- Hang the scale on a knob or dowel taped over the edge of a table or desk.

Test:

- Have the youth place items in the cups so that the scale is balanced. (Different items, different amounts of items, different combinations of items)
- Have the youth observe how items compare to each other when put in the cups.
- Have the youth draw or write their findings on their Data Collection Sheet.

Make it Better:

Have the youth describe what they found interesting about comparing items on the balance scale. Write these observations on a large sheet of chart paper, white board or chalkboard. Example questions could be:

- What items balanced the scale?
- What items were heavier or lighter than others?

Activity 2: Build your own hanger balance scale

After completing the group hanger balance scale, review the ideas youth generated in the ***Make it Better*** section. The youth are now going to become engineers and make their own hanger balance scale to compare additional items.

Provide enough materials for each pair of engineers

- Two lightweight cups (8 - 12 oz)
- Scissors (1 per pair)
- String or yarn (36" per pair)
- Plastic clothes hanger with hooks or notches (1 per pair)
- Furniture with a knob to hang the scale or a dowel taped to a table with a portion hanging over the edge (1 per pair)

***Ask*:** What ideas do you have for building your own scale? What materials can I use?

Plan/Design: Pass out the materials. Have the youth write their initials on the bottom of the cups.

- Tell the youth that they must use the hanger, cups and string to create their scale.
- The youth will then decide what they are going to do differently to make their scale balance. They should draw what their scale looks like, with their changes, on the Data Collection sheet.

Create & Test

Create: Have the engineer pairs build their own scale and compare weights of objects.

Test:

- When the engineer pairs have completed their version of the scale, have them choose two different types of materials, such as paper clips and pencils.
- Have the engineer pair determine how many paper clips it will take to make the scale balance the pencils and the paperclips.
- Have the engineer pairs draw their scale and the items they used to compare on their Data Collection sheet.
- Have each youth share with the group what they changed and how the change worked.

Make it Better: Have the youth brainstorm ideas of other things they could change to make an even better scale.

Share, Process and Generalize

- **Share:**
    - What happened and what did you observe?
    - What things did you change and what were the results?
    - What items did you put in the cups?
    - What happened when you put the items in the cups?
- **Process:** What did you do to make the scale balance when two items weigh different amounts? Why did it work or not work?
- **Generalize:** Have the youth identify times they have used balance to build things like Legos, building blocks, etc. Are there playground toys that use balance and if so, what ones do you think of? (balance beam, teeter totter, "wobbly" bridges, etc.)

  Where have you seen a balance or scale used? Lead the youth to the idea that a scale is used when shopping for groceries (weighing produce or items bought in bulk). These tell a person how much something weighs.

Wrap Up

Reflection

Reflecting on experience is an essential part of learning and "making meaning of" an experience

Review the five steps of the Engineering Design Process. Have the youth stand up if they did this part of the Engineering Design Process today.

ASK
EXPLORE
PLAN
CREATE & TEST
MAKE IT BETTER

Final Reflection

Have the youth reflect on the following questions. They may write or draw their answers on the Reflection Sheet.

- When is a balance scale used?
- What is something new you learned in this class/session/activity?
- Did you try something that you've never done before?
- How were you an engineer today?

SOURCES

Hale, C. (2021). *dreaming UP*. Lee & Low Books Inc.

Schul, C. H. (2019). *Awesome Engineering Activities for Kids: 50+ Exciting Steam Projects to Design and Build*. Rockridge Press.

Engineering-At-Home Activities

Take-Home Sheet

Today we made balance scales out of plastic clothes hangers, cups and strings. We wanted to compare a variety of items.

Try these Engineering-at-Home Activities:

- Have the youth share their balance scale results with people at home. Ask others, of a variety of ages, what balance means to them. Have the youth record the answers they are given. Share this with others in your group.

- Look at home for things that show balance between items. Bring an item back to the next session to share with the rest of the group, to show another example of balance.

- View these videos about balance. Has your family ever used a balance or scale in a similar way?
  Vegetable stand: https://www.youtube.com/watch?v=ybEU-6U7s8k
  Hike: https://www.youtube.com/watch?v=rE9b6E9FSa0

- Play The Cat in the Hat. Sketch-a-Mite | PBS KIDS game with your child:
  https://pbskids.org/catinthehat/games/sketch-a-mite

Handouts

Handout 4.1 — Data Collection Sheet
Handout 4.2 — Reflection
Handout 4.3 — Take-Home Sheet — TIP!

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Module 4: TIP! Handout 4.1

Data Collection Sheet — Balance Scale

Balance is:

Group Scale

Draw a picture of the two items and how your group made them balance

My Scale

Draw a picture of the two items you chose and how you made them balance

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Module 4: TIP! Handout 4.2

Reflection

Youth will write or draw their answers below.

When is a balance scale needed in everyday life? (Possible answers: To find out how much things weigh, which items are light and heavier, to choose the correct amount of produce in the grocery store.)

What is something new you learned today?

Did you try something that you've never done before?

What questions did you explore the answers to? What questions do you still have?

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Module 4: TIP! Handout 4.3: Take-Home Sheet

Engineering-At-Home Activities

Today we made balance scales out of plastic clothes hangers, cups and strings. We wanted to compare a variety of items.

Try these Engineering-at-Home Activities:

- Have the youth share their balance scale results with people at home. Ask others, of a variety of ages, what balance means to them. Have the youth record the answers they are given. Share this with others in your group.

- Look at home for things that show balance between items. Bring an item back to the next session to share with the rest of the group, to show another example of balance.

- View these videos about balance. Has your family ever used a balance or scale in a similar way?
  Vegetable stand: https://www.youtube.com/watch?v=ybEU-6U7s8k
  Hike: https://www.youtube.com/watch?v=rE9b6E9FSa0

- Play the The Cat in the Hat Sketch-a-Mite | PBS KIDS game with your child:
  https://pbskids.org/catinthehat/games/sketch-a-mite

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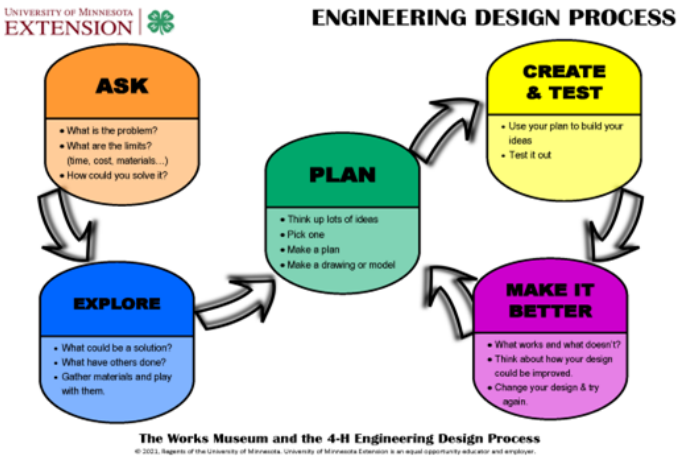
Module 5 — BOT!



Module Introduction

Module Summary

Using the story *Boy & Bot* by Amy Dyckman, youth identify the similarities and differences between robots and humans. Youth will use the Engineering Design Process to design, build and test their own Google Bot, made out of pool noodles and a battery operated toothbrush. Youth identify ways that humans and robots may work together to solve problems or create art.

Learning Objectives	Youth will: • learn how to build a motorized robot • practice the Engineering Design Process by redesigning their BOT to change how it works • explore how weight affects balance and results
Science & Engineering Practices	• Analyzing and interpreting data • Construction explanations
Words to Know	• **Robot** – a machine capable of carrying out a series of actions • **Motor** – a machine that moves • **Balance** – an even distribution of weight enabling something to remain upright • **Art** – something created through the use of imagination or creativity
Life Skills	• Asking questions • Planning/Organizing • Keeping records

Getting Ready

Preparing to teach this module

- Gather materials
- Computer with internet access or downloaded video
- Make copies of the Data Collection sheet (Handout 5.1) and Reflection sheet (Handout 5.2) 1 per youth.
- Print a copy of the Wiggle Bot picture located at the end of this lesson

Background information for the facilitator

The book, ***Boy & Bot*** by Ame Dyckman, shows how humans and robots are the same and different. In these activities the youth will be introduced to a simple motorized robot who creates art. Check out the **Words to Know** to share with the youth.

The Engineering Design Process consists of five steps:

Ask
Explore
Plan
Create and test
Make it better

Time required

- Set up (20 min.)
- Activity (30 min)
- Reflection (15 min)

Materials needed

For the whole group:

- Tarp (5' x 5' minimum)
- Paper - Large sheets
- Washable Markers (assorted colors)
- Craft sticks (50)
- Duct tape (1 roll)
- Screws (30 - 40)
- Washers (30 - 40)
- Nails (30 - 40)
- Large paper clips (100)
- Small paper clips (100)
- Binder clips (24)
- Chart Paper, White board or chalkboard

For each youth:

- Scissors (1 per youth)
- Self-Sticking Wiggle Eyes (2 per youth)
- Chenille Stems - Assorted (2 per youth)
- Rubber bands - size 16 (3 per youth)
- Paper 8.5" x 11" (4 per youth)
- Pool noodles - 6" (one per student)
- Battery powered toothbrush (inexpensive, skinny, lightweight ones work best) (one per student)
- Batteries for the toothbrush

Online learning tools

Boy + Bot (book by Ame Dyckman) video: https://www.youtube.com/watch?v=CmNude8rRD4
Google Bot Example: https://www.youtube.com/watch?v=gON6Gw9AjMA
How to make an Art Bot: https://www.youtube.com/watch?v=B80RWRIL4wQ
Tip: If using the online videos, you may want to download them prior to the lesson.

Activity Plan

Activity: Wiggle Bot Design Challenge

Overview of this activity

In this activity, youth are challenged to create a Wiggle Bot which will make a different drawing than the one created by the group. Youth will first be shown how to make a general Wiggle Bot. Next, they will become engineers and design their own Wiggle Bot using additional materials as weights to create different designs on their paper. (The Wiggle Bot will move around a piece of paper and create a design).

Opening questions and prompts

- Read or watch the story *Boy & Bot* by Ame Dyckman. (**Note**: It is important to remind the youth that they must tell their parents/caregivers where they are at all times and be aware of strangers).
- Have the youth draw their favorite part of the story *Boy & Bot* by Ame Dyckman.
- In what ways were the boy and the robot the same?
- In what ways were they different?
- Today we are going to create our own robots. Think about how this could be done. We will use an engineer's way of thinking to change what happened. Engineers have a process they use to design things. The Engineering Design Process we will use is:
  ASK
  EXPLORE
  PLAN
  CREATE & TEST
  MAKE IT BETTER

Experience

Step 1 in the Experiential Learning Cycle.

Ask the youth if they could become engineers today and use the Engineering Design Process to create a Wiggle Bot that will make different designs on paper

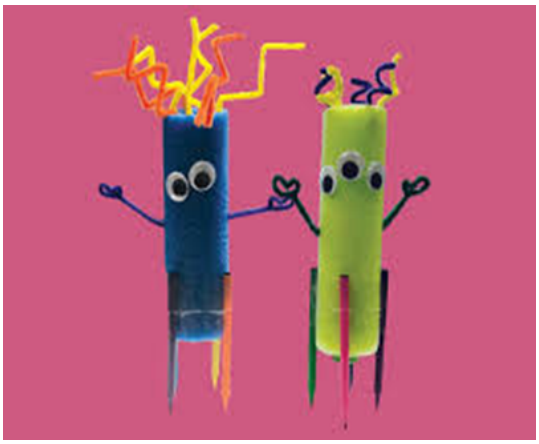
Activity 1: Create a Wiggle Bot with the youth

Make sure the youth can see the following materials (supplies) on the table or workspace.

- Scissors
- Markers
- Self-Sticking Wiggle Eyes
- Chenille Stems – Assorted
- Rubber bands – size 16
- Ruler
- Paper 8.5" x 11"
- Pool noodles – 6"
- Battery powered toothbrush (inexpensive skinny, lightweight ones work best)
- Batteries for the toothbrush

***Explore*:** As a large group, brainstorm ways the materials on the table or workspace could be used to create a Wiggle Bot that creates designs on a piece of paper. Encourage the youth to think of as many possibilities as they can. Some will be more realistic than others, but encourage as much creativity as possible. Record the youth's ideas on a large sheet of chart paper, white board or chalk board.

Plan: As a large group, task the youth with creating a Wiggle Bot. Lead the youth to the concept of attaching the markers to the pool noodle with rubber bands and inserting the toothbrush into the pool noodle. (See pictures below.)



Create & Test

Create:

- Put self-sticking wiggle eyes on a 6" piece of pool noodle.
- Use a rubber band to attach 3 markers to the pool noodle so the tips of the markers line up with the edge of the pool noodle. The markers should be spaced evenly around the noodle. Adjust them as needed,

Test: Place the Wiggle Bot on a large piece of paper so it sits on the marker tips.

- Ask the youth what they think will happen when the battery powered toothbrush is turned on and put in the middle of the Wiggle Bot. Have the youth write or draw these predictions on their Data Collection Sheet.
- Turn on the battery powered toothbrush and slide the toothbrush in the hole of the pool noodle, bristle-side down, so the toothbrush touches the paper.
- The Wiggle Bot should move across the paper, creating as it goes.
- Have the youth observe the creations of the group Wiggle Bot and draw or write their thoughts on their Data Collection Sheet.

Make It Better: Have the youth describe what happened when the battery powered toothbrush was turned on. Write these ideas on a large sheet of chart paper, white board or chalk board. Example questions could be:

- Did they expect the Wiggle Bot to move?
- What other things did the Wiggle Bot do that were a surprise?

Activity 2: Build your own Wiggle Bot

After completing the group Wiggle Bot, review the ideas youth generated in the ***Make It Better*** section. The youth are now going to become engineers and make a Wiggle Bot that will create different designs but using additional materials.

Provide enough materials for each engineer:

- Scissors
- Self-sticking Wiggle Eyes (2 per youth)
- Chenille stems – assorted (2 per youth)
- Rubber bands – size 16 (3 per youth)
- Ruler (1 per 3 youth)
- Paper 8.5" x 11" (4 per youth)
- Pool Noodles – 6" (1 per youth)
- Battery powered toothbrush (inexpensive, skinny, lightweight ones work best) (1 per youth)
- Batteries for the toothbrush

Ask: The engineers are to build their own Wiggle Bot that will make a different design than the one created by the group Wiggle Bot. What would you like your Wiggle Bot to do or draw?

Plan/Design: Pass out the 6" pool noodles. Have the youth write their initials on the one end of the pool noodle. Tell the youth that pool noodles, markers and the battery powered toothbrushes must be used in their design.

The youth will then decide what they are going to do/use to make their Wiggle Bot. They will create a different design than the group Wiggle Bot using the additional materials. They should draw what they are changing on the Data Collection Sheet.

Create & Test

Create: Have the youth build their own Wiggle Bot.

Test:

- When all the youth have completed their version of the Wiggle Bot distribute paper to each youth.
- Have each youth turn on the battery powered toothbrush and insert it into the pool noodle. (Youth may need additional help with this step.)
- Have the youth let their Wiggle Bot move around the paper as much as they would like.
- Have each youth share with the group what they changed in their design and what results they observed.

Share, Process and Generalize

- **Share:**
  - Did the Wiggle Bot do what you thought it would?
  - Were you surprised by what it did?
  - Have the youth draw or write their answers on the Data Collection Sheet
- **Process:** Tell the youth that part of being an Engineer is observing how something worked and then changing one thing to get different results. (Raising or lowering the markers, using other drawing items, different paper, adding other things to change the weight on each side, etc.) What would you like to change and what do you think will happen? Have the youth record their thoughts on the Data Collection Sheet and Reflection sheet.
- **Generalize:** What do you think your Wiggle Bot's drawing looks like?

Apply: If time allows, let youth change another thing and repeat the process.

Reflect: Have youth complete the Reflection Sheet by answering the following questions:

- What did you change?
- What happened as a result of the change?
- Was this what you wanted to happen?
- What would or could you change again?

Activity 3: Create art from your Google Bot's designs

Overview: In this activity the youth will use the creations their Google Bots designed in Activity 2 to create drawings that resemble things in nature.

Getting Ready: After the completion of the Activity, take the youth outside, IF possible, to observe some things in nature. Have them share what they see with others in the group as they are outside. If you are not able to go outside, have the children observe things in their surroundings.

Opening questions and prompts: Create a list of what the youth observed. Were there things that they recognized or have never seen before? Write these down on a piece of chart paper, a white board or a chalkboard.

Procedure: Have the youth choose one of the designs created by their Wiggle Bot. Using this design, have the youth add to it to create a drawing similar to something they observed in nature.

Share, Process and Generalize

- **Share:** Have the youth share which design was used, what they made the design into and why they created what they did.
- **Process:** Have the youth think of all the beautiful things they see in nature. Write these down on a piece of chart paper, a white board or a chalkboard.
- **Generalize:** Encourage the youth to think of what else they could create with their other Google Bot designs.

Reflect:

- Have the youth brainstorm other types of robots they wish they could create. What would their robot do or look like?

Wrap Up

Reflection: *Reflecting on experience is an essential part of learning and "making meaning of" an experience.*

Review the five steps of The Engineering Design Process. Have the youth stand up if they did this part of the Engineering Design process today.

ASK
EXPLORE
PLAN
CREATE & TEST
MAKE IT BETTER

Final Reflection - Ask the youth:

- What is something new you learned today?
- Did you try something that you've never done before?
- How were you an engineer today?
- What questions did you explore the answers to?
- What questions do you still have?

SOURCES

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Engineering-At-Home Activities

Take-home Sheet

Today we made Wiggle Bots. The Data Collection Sheets will show you what we did and what we created out of the Wiggle Bot creations.

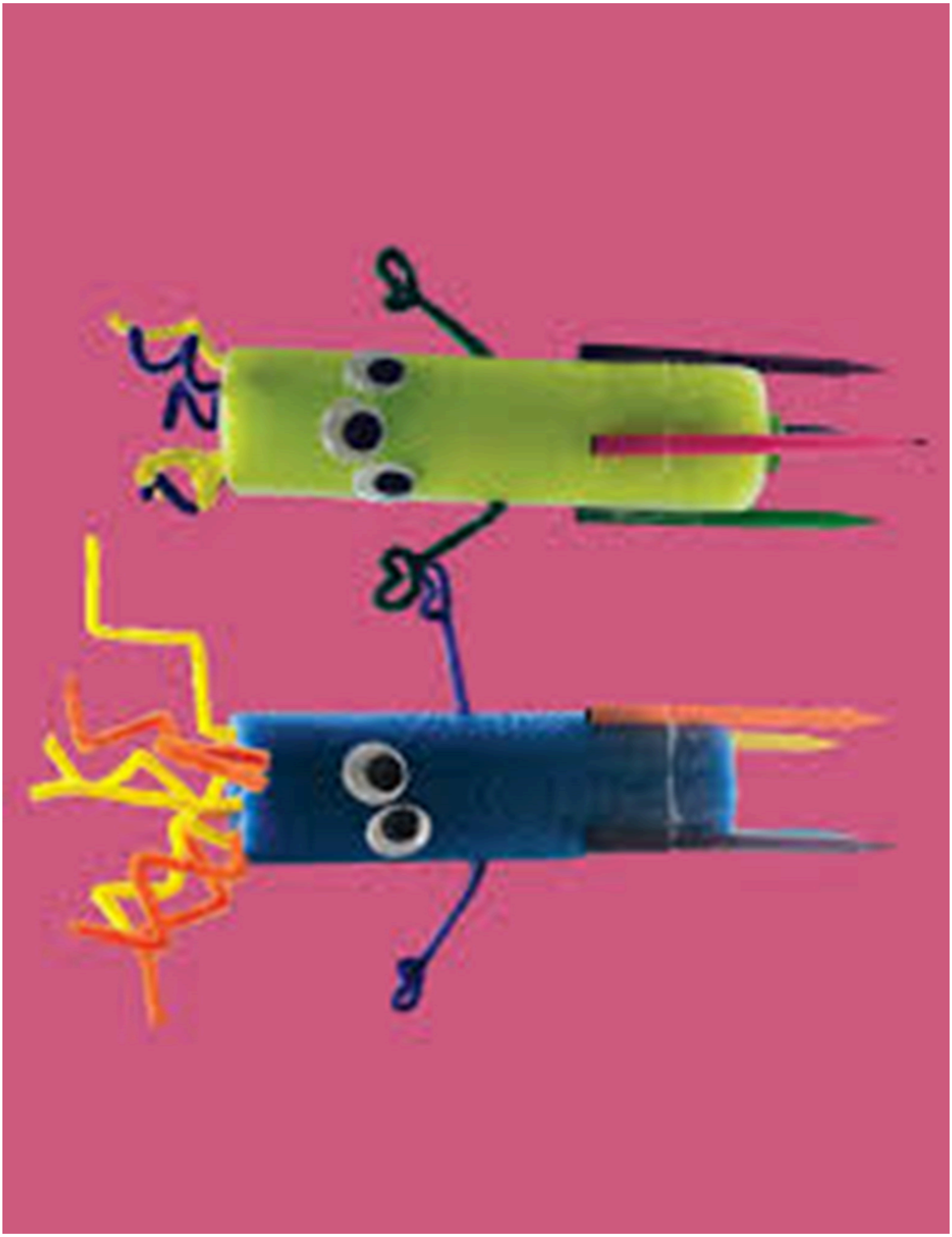
Try these Engineering-at-Home Activities:

- Make a list of all the things you notice in your home that are done by machines similar to robots. (i.e., an automatic ice maker, a coffee pot with a timer)
- Make a Robot • ABCya! - Create your own online robot: https://www.abcya.com/games/make_a_robot
- ArtBot Science Buddies (STEAM)—Watch this short video together: https://www.youtube.com/watch?v=daWU2Oh_xlg
- Watch this video and talk about why robots need people: https://www.brainpop.com/technology/computerscience/robots/

Handouts

Handout 5.1 — Data Collection Sheet
Handout 5.2 — Take-home Sheet — BOT!

Wiggle Bot



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Module 5: BOT! Handout 5.1

Data Collection Sheet

I want my Wiggle Bot to…

I changed something on my Wiggle Bot and now it looks like …

(Use an arrow to point to what is different.)

This is what my Wiggle Bot drew.

This is a _____ that I made from my Wiggle Bot's drawing.

Module 5: BOT! Handout 5.2 – Take-Home Sheet

Engineering-At-Home-Activities

Today we made Wiggle Bots. The Data Collection Sheets will show you what we did and what we created out of the Wiggle Bot creations. We read the book ***Boy & Bot***, by Ame Dyckman.

Try these Engineering-at-Home Activities:

- Make a list of all the things you notice in your home that are done by machines similar to robots. i.e., an automatic ice maker, a coffee pot with a timer)

- Make a Robot • ABCya! - Create your own online robot: https://www.abcya.com/games/make_a_robot

- Watch this short ArtBot Science Buddies (STEAM) video together: https://www.youtube.com/watch?v=daWU2Oh_xlg

- Watch this short video and talk about why robots need people: https://www.brainpop.com/technology/computerscience/robots/

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Resources

Engineering Design Process

Experiential Learning Model

Life Skills Wheel

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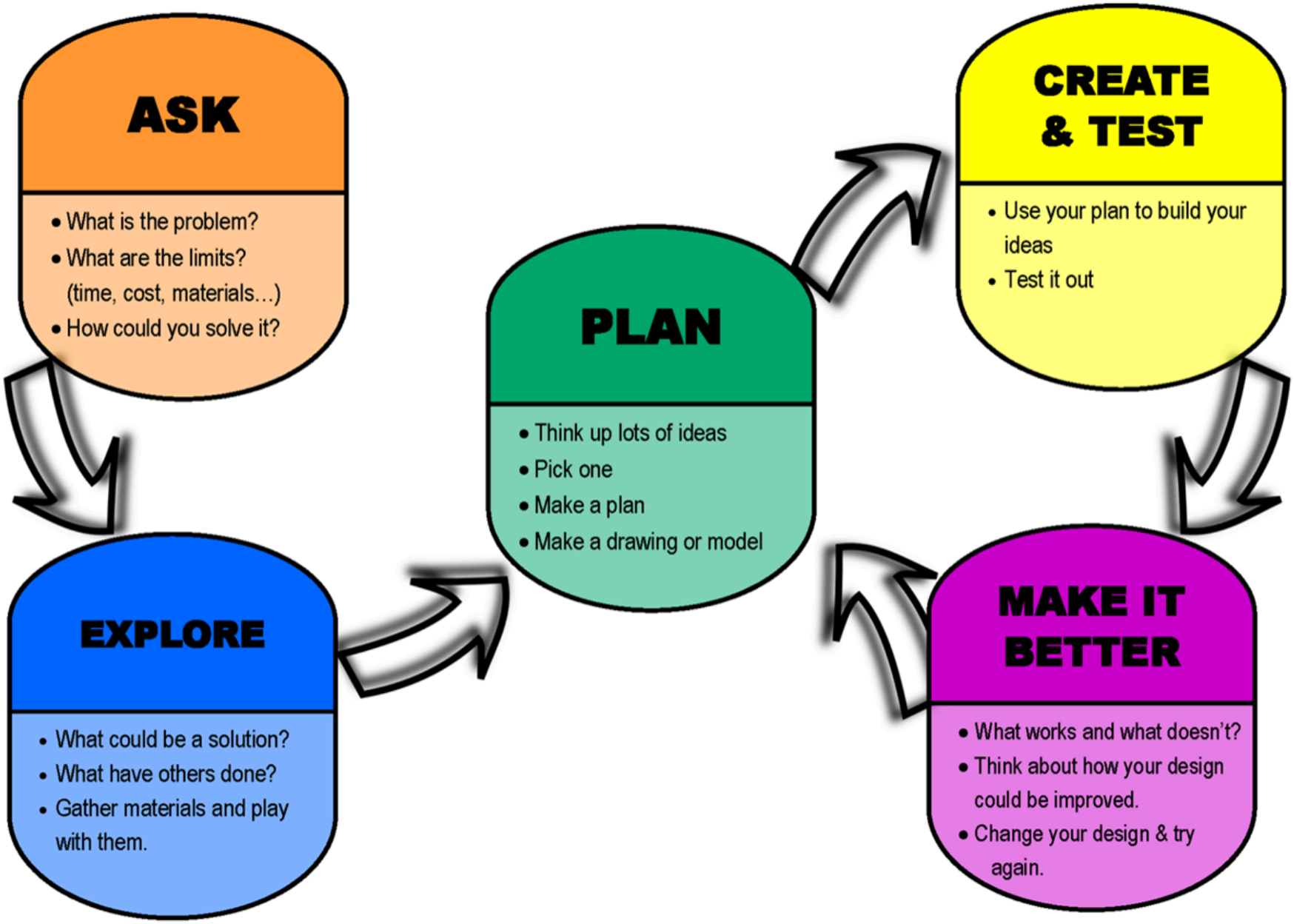
University of Minnesota Extension

ENGINEERING DESIGN PROCESS



The Works Museum and the 4-H Engineering Design Process

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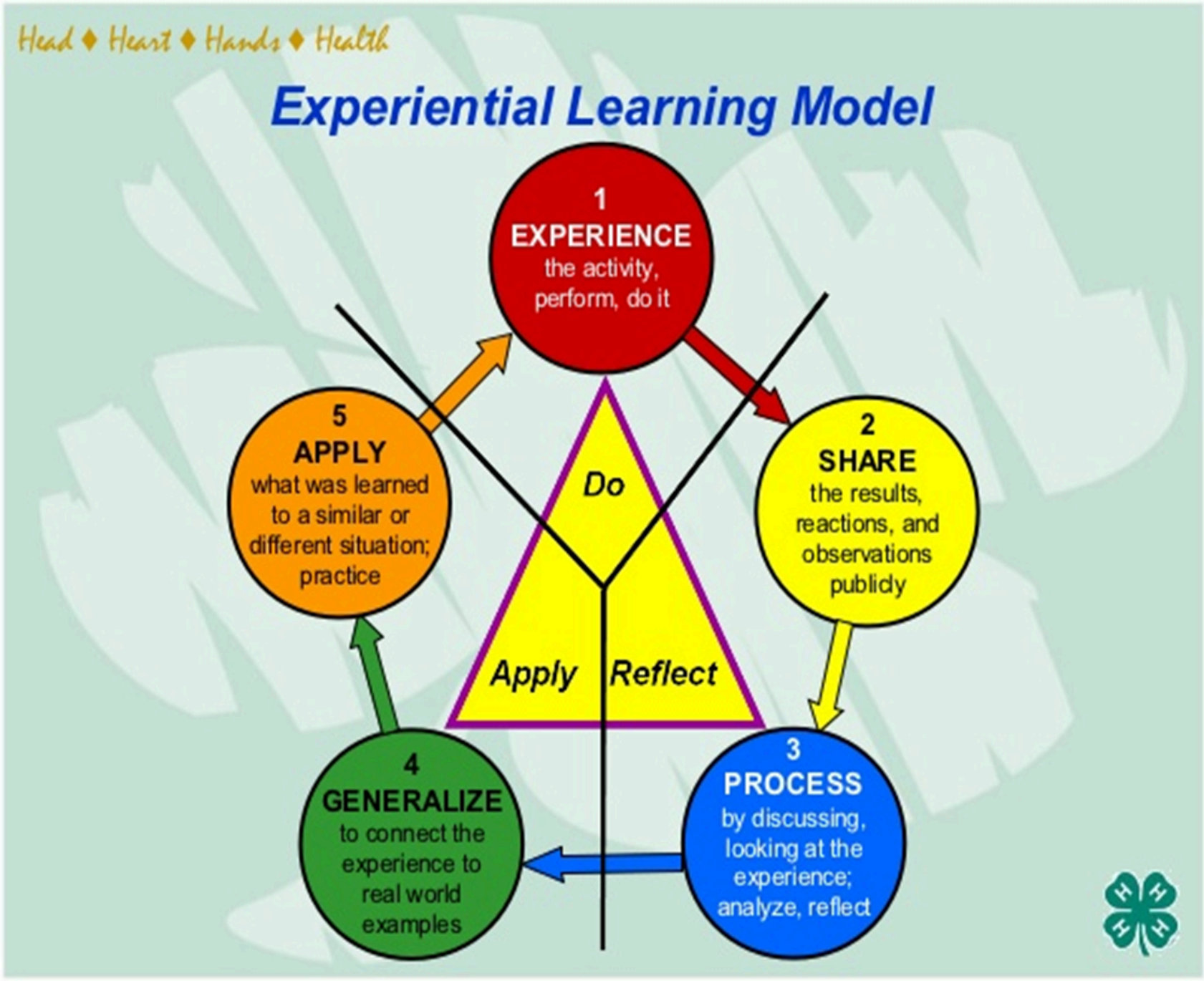

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Extension and Outreach

Targeting Life Skills Model

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