University of Minnesota Extension

Activity Guide

4-H Problem Solving During Club Meetings

Problem solving is a skill that is critical for success, not just in 4-H projects but in life. These activities will support you to engage youth in creative problem solving!

What will you find In this activity packet?

The purpose of this curriculum is to support adult volunteers with a practical strategy to teach through an experiential learning process: the engineering design process, the eight science and engineering practices, and 21st Century Skills.

Activities are most appropriate for upper elementary and middle school students.

These activities will

- Create opportunities for youth to identify engineering problems, develop sound reasoning skills and provide solutions that are backed by evidence.
- Provide opportunities for oral explanations and demonstrations of various STEM (Science, Technology, Engineering, and Mathematics) topics.
- Provide youth an opportunity to exhibit a team designed solution through an oral presentation (team/individual) to share their experience and celebrate their creation.

Authored by Margo A. Bowerman and Mark D. Haugen. Reviewed by Anne Stevenson (2016), Lisa Kasson-Bauer and Kelly Strei (2017), Aprille Albrecht, Mari Jo Lohmeier, Janet Malone, Tammy Nordick, Kaitlin Barbosa, Sandi Weiland, Sharon Weiss, and Kayla Maas (2018).

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How to use this guide

In 4-H we provide opportunities for youth to develop skills they will use throughout their life. The ability to solve problems is a transferable life skill that can be developed and nurtured through fun activities for youth. It is a skill that is valued among employers and a skill that is necessary for our country to remain competitive in the global economy.

This guide will provide you with a variety of activities that can be done as a sole focus activity for a program, or as an introductory activity for another program.

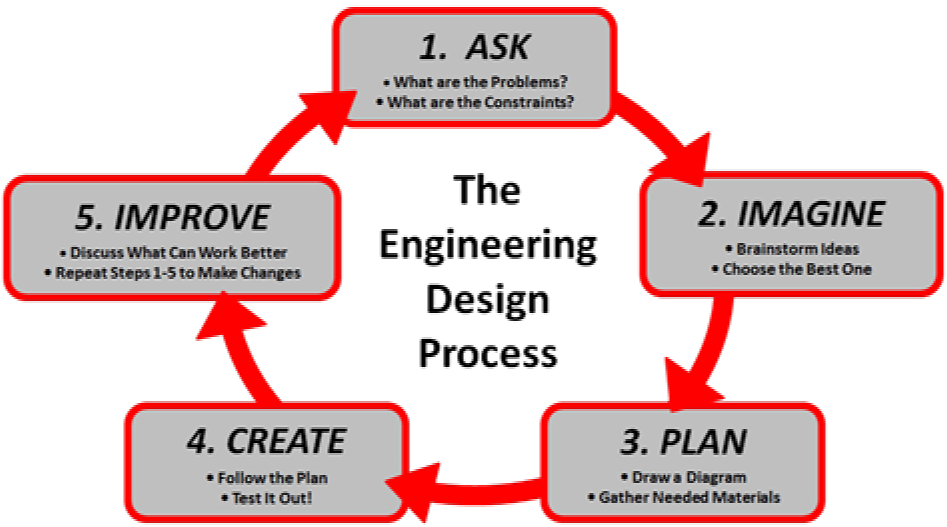
Materials are simple and easy to gather. Each activity will provide you with an explanation to complete the activity and suggestions of questions to use to focus and extend the learning of the skills involved in the activity.

We suggest reviewing the information on the Engineering Design Process and Using Questions to Build Problem Solving Skills prior to conducting the activity. Background information on the engineering design process is included to help the facilitator understand the process of systematically working through problems so that youth begin to use this skill as they work through problems. Information on how the facilitator can use questions to bring out how youth are gaining problem solving and other 21st Century Skills (skills necessary for youth to succeed in work, life and citizenship) is outlined in a format that identifies practices that scientists and engineers use in their work. Encouraging each group or team to present their solution to the larger group promotes public speaking and presenting in a less formal way. After all groups/teams have finished sharing, facilitators should acknowledge that this is a form of presentation

Engineering design process

Engineering is the use of science, math, economics and experience to design products, processes or services that solve human problems. The engineering design process is a systematic way to identify and solve a problem. So, engineers are problem solvers!

Problem solving has been identified as a skill that youth will need to succeed in work and life. It is a skill that needs to be developed and practiced. The activities in this guide provide opportunities to develop and practice problem solving skills, using a systematic process to identify solutions.



From NC State Engineering, retrieved on 7/25/18 from http://files.campus.edublogs.org/blogs.wcpss.net/dist/9/998/files/2012/07/engineering_design_process1-2fdq4vs.jpg)

ASK: In this step youth IDENTIFY THE PROBLEM and THE CONSTRAINTS or LIMITATIONS. Through this part of the engineering design process, youth should be able to describe the information they need to know in order to complete the task. Asking youth what they think they need to know, rather than just giving them the information helps to develop critical thinking skills.

IMAGINE: In this step youth GATHER INFORMATION, BRAINSTORM IDEAS, and decide on the one they think will best solve the problem, given the limitations or restrictions. In this step, youth should be encouraged to think creatively and develop more than one solution.

PLAN: In this step, youth DEVELOP THEIR PLAN for the solution they've selected.

Teamwork should be encouraged, as youth may combine their different ideas and will need to compromise and collaborate.

CREATE: In this step, youth will follow their plan to BUILD AND TEST their solution.

IMPROVE: In this step, youth should be encouraged to THINK CRITICALLY about what parts of their solution is working well, but also what parts aren't working so well. Lots of learning occurs when things don't work as planned but youth need help seeing the value of that learning. Based on their evaluation, youth should MAKE MODIFICATIONS TO IMPROVE THEIR DESIGN. This step should lead back to another step in the engineering design process if time allows.

Museum of Science, Boston. Engineering is Elementary: The Engineering Design Process. Retrieved on 7/25/18 from http://www.eie.org/overview/engineering-design-process).

Using questions to build problem-solving skills

Asking open ended questions that focus on the practices of science and engineering during and after a project/activity help youth to gain confidence and proficiency in problem solving skills. It is not necessary to cover all of the practices in one activity, but rather, focusing on a few of the practices allows youth to feel capable of performing those practices. These types of questions also encourage the planning and reflecting that promote problem solving. Having youth answer these questions in the group setting allows youth to contribute their own learning to the group's collaborative learning. Questions can also be asked during conference judging. For more information on the practices of science and engineering, see the appendix.

Practice: Asking questions (science) or defining problems (engineering)

These should be questions that help youth to think about why they are doing a particular activity or project. It is important that the answers are measurable in some manner so that youth will know if they answered the question or solved the problem. Consider questions such as:

- ➢ What do you see is the main question you're trying to answer (or problem you're trying to solve) with this project/activity?
- ➢ How are you considering other factors/variables in this project/activity?
- ➢ How will you know if you are successful in answering the question or solving the problem?
- ➢ What other project/activity have you worked on that was similar to this one? What did you learn in that one that might help you with this one?

Practice: Developing and using models

Models can help to explain or predict what will happen and is often useful when what is being studied is too big or too small to see what is happening. Creating a model also provides an opportunity for other group members to provide input. To encourage thinking about models:

- ➢ Ask youth participants to describe what is happening and follow up with a question to the group "Is that what you think is happening?"
- ➢ How would you draw what you think will be happening during your experiment/ solution?
- ➢ Using your materials, describe what you think will happen. Can you make a graph of what will happen when you change certain variables?

Practice: Planning and carrying out investigations

Youth should be able to explain or describe why and how they are doing a project/activity. This involves understanding the variables and being able to explain what they think might happen. Questions to encourage thinking about this practice:

- ➢ What is your prediction of what will happen?
- ➢ How can you show what you are thinking?
- ➢ How will you record your work?
- ➢ How are you measuring your results?
- ➢ What is the most important step in your project/activity and why do you think that?

Practice: Analyzing and interpreting data

Once the project/activity has been attempted, youth should consider the results. To help youth think analytically about their results, ask:

- ➢ What happened? How do you know that happened?
- ➢ What worked well in this project/activity? What didn't work well?
- ➢ How can you measure or describe what happened/your results?
- ➢ Did you get the results you expected? Why do you think that is?
- ➢ What do you notice about your results?

Practice: Using math and computational thinking

Math is a way to describe things in ways that are measurable. Computational thinking is a way of organizing information so that it can be used to represent ways to solve problems. Questions that lead to experience in this process include:

- ➢ How are your variables related to each other? Can you identify any patterns in their relationship to each other?
- ➢ Can you make any connections or classifications within your project?
- ➢ How can you organize/describe your results?
- ➢ What are other ways you can show your results?

Practice: Constructing explanations or designing solutions

Youth should be able to offer explanations of why their project turned out the way it did, why the activity had the results observed, or how their final result solved the problem. Questions to encourage youth to reflect on their efforts include:

- Why were the results what you expected, or why were they not?
- What were important factors or variables that affect the end result? Why were they important?
- How and why were the strategies/methods/materials you used important?

Practice: Engaging in argument from evidence

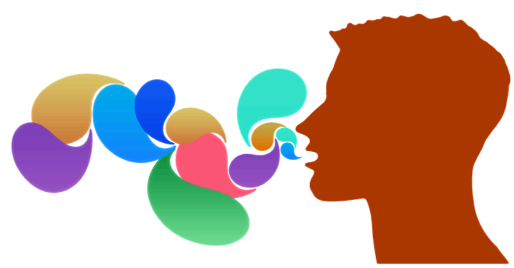
When youth gain proficiency in this practice when they can explain and justify why they are making the conclusions they are. They can defend their statements by interpreting data, from their own project/activity or other's projects/activities. To encourage development in this practice, ask questions such as:

- Why do you think this project/activity worked well? Why do you think it didn't work well?
- How are your conclusions based on evidence? What are your reasons for making the claims you do?
- Can you evaluate your claims with evidence?
- How do you know your conclusion is based on your (or other's) project/activity and not just an opinion?
- What do you consider the most important factor/variable in your project/activity? Why do you consider it important?

Practice: Obtaining, evaluating and communicating information

This practice helps youth to critically evaluate information and express their evaluation. Questions to encourage and promote this practice include:

- What did you learn in this project/activity?
- Could you use other materials/strategies and get the same results? How do you know this?
- How does your project/activity relate to something else you've done?
- Is there any other way you could have done your project/activity?
- How can you apply what you've learned to another project/activity?
- Would you get the same results if you tried this again? What makes you say that?
- What would you recommend to someone else who wants to do this project/activity?

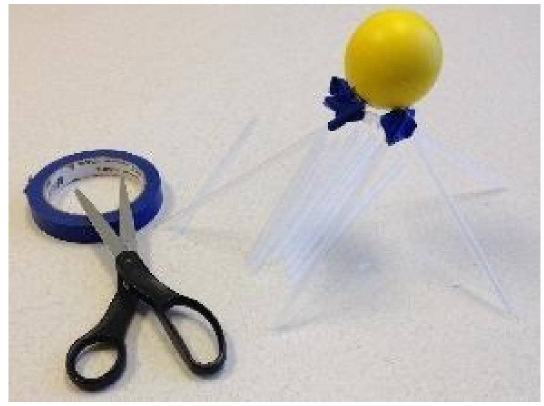


The Straw Tower Challenge!

Activity 1: Design and build a straw tower *(25 minutes)*

Materials for each group

- 15 straws for each group
- 1 foot of masking tape
- 1 tennis ball
- Scissor / Ruler



Activity steps

1. Give materials to small groups of 3-4 youth participants.
2. **PROBLEM:** Design and build a straw structure that can support a tennis ball at least six inches above the table for 15 seconds or more.
3. **CONSTRAINTS:** Teams can only use the materials provided. Teams have 10 minutes.
    a. At the end of 10 minutes, ask each group to briefly share the process they used to design and build their straw structure.
    b. (Optional adaptation) The facilitator can make the activity more competitive by telling youth that the highest straw structure that can hold a ball for 15 seconds is the winner of the challenge.
    c. (Optional adaptation) If groups complete the activity early, Challenge group to adapt their structure to catch and hold the ball after it has been dropped from six inches above the structure.

Discussion (5 minutes)

1. Reflect:
    a. Ask if anyone first thought of a design in their head before building?
    b. How might it have been helpful to draw a design before building the tower? This is an example of the practice of developing and using models.
2. Reflect:
    a. At the end of the activity, generate a discussion about how engineers do their work and how they solve a design problem. Ask youth to compare their procedures of how they solved the problem with how engineers solve a design problem.
    b. Ask youth to point out and elaborate on the similarities and differences of their problem-solving approaches and engineering design process.
3. Apply: Ask youth in what type of situation they will use the engineering design process to help them solve problems in their everyday life.
4. (Optional) Apply: How would using a different ball, like a heavier ball from a pool table, change your experience?

The Straw Tower Challenge! was adapted from Wang, H., Cole, D., Haugen, M., et al, (2016) Rube Goldberg Curriculum. University of Minnesota Extension, Youth Development.

Sorting the Candy

Activity 2: Communicating with a partner to sort candy into color groups *(20 minutes)*

Materials for each group

- 15-40 pieces of candy of various colors (M&M's, Starburst, Jolly Rancher, etc.)
- Blindfold

Sorting the Candy! Activity Steps

Split groups into two pairs and provide their materials.

PROBLEM: solve the problem of how to sort the candy given the following roles:

CONSTRAINTS:

a. Team member one
   i. is blindfolded, cannot see and cannot speak
   ii. can touch the candy
b. Team member two
   i. can see and speak
   ii. cannot touch the candy directly or indirectly

At the end of 5 minutes, ask each youth to briefly discuss with their small group the process they used to solve their problem. This is a way to verbalize the practice of planning and carrying out an investigation (or way to solve a problem).

Reflection Toss

Have participants form a circle. When one receives the ball, ask them to share their strategy to solve the problem.

After they share, they toss the ball to another person in the group. When each person and group has shared, move to additional questions.

Discussion (5 minutes)

1. Reflect:
   a. Which pair had the best solution? This is an example of the practice of analyzing and interpreting data.
   b. Can the group agree on defining what the "best solution" was? This could be an example of the practice of engaging in argument from evidence.
2. Reflect: Ask youth to share what works, what does not work, and how they changed their design to make it work.
3. Apply: Ask youth in what type of situation they will use the engineering design process to help them solve problems in their everyday life.

Reflection toss adapted from Olson, Carrie (2014) Have a Ball with 4-H: 2014 Fall Volunteer Training – Making 4-H More Fun! University of Minnesota Extension, Youth Development.

Super Scrumptious Smoothie!

Activity 3: Making decisions, a smoothie, and providing reasons with a small group! *(25 minutes)*

Materials used

- Blenders, knives, cutting boards, coolers, bowls and cups

Materials that may be used

- Vegetables: Raw vegetables, such as celery, carrots, cauliflower, broccoli, green pepper, green beans, cucumbers, mushrooms, or zucchini served with low-fat dips.
- Fruit: Fresh or frozen fruit cut in slices or halves, such as apples, bananas, peaches, grapes, melons, pears, plums or strawberries.
- Liquids: Ice, water, juices, low-fat milk or yogurt.
- Other food items of your choice.

Super Scrumptious Smoothie activity steps

Spit groups into groups of 3-5. After the smoothie is made, each member of the group should identify reasons their smoothie is, or is not, a Super Scrumptious Smoothie.

PROBLEM: Each group must create a smoothie that each of them will enjoy.

CONSTRAINTS

- Each smoothie must have a least 1 item from the vegetable, fruit and liquid categories.
- Each member of the group must add one item of their choice to the smoothie.

A Rose and a Thorn

Participants are asked to state one "rose" or good thing about making their group smoothie and one "thorn" or challenge that has arisen during the activity. *This activity can be used as a landing by asking about a rose and a thorn that occurred since the last meeting. It can also be used at the end of a session to gauge high and low points over the course of an experience*

Discussion (5 minutes)

1. Reflect:
    a. Ask each group to describe how they would tell someone how to make their exact smoothie recipe.
    b. Ask questions which lead them to describe their ingredients in terms of some type of measurement of the ingredient. This is an example of the practice of using math or computational thinking.
2. Reflect:
    a. Ask how the large group could decide which small group made the best smoothie?

b. What would be the criteria for defining “best”? This is an example of the practice of engaging in argument from evidence.

3. Apply

   Ask the large group if there were any ingredients not available to them that would have made a better smoothie. Follow up by asking if they have any examples of a time when they did the best they could with what they had available to them; what was missing that would have made it better? This line of questioning helps youth to think critically.

A Rose and a Thorn activity adapted from *Harrington, Rebecca and Olson, Carrie (2014) Making 4-H MORE Fun! Volunteer Resources Packet. University of Minnesota Extension, Youth Development*.

The Huff and Puff Challenge

Activity 4: How to solve a problem that can't be solved. *(15 minutes)*

Materials used

- Small paper ball
- 1-liter bottle
- Drinking straw
- Various small objects (small marshmallow, miniature bow, wedding mint, piece of popcorn)

PROBLEM: Blow a small lightweight object (such as a paper ball) into a bottle.

CONSTRAINTS

- You may not touch the object after placing it in the mouth of the bottle.
- You must use air from your mouth through a straw to try to get the object in the bottle.

The Huff and Puff Challenge activity steps

1. Create a small paper ball by bunching up a piece of paper. The ball needs to be able to loosely fit inside the mouth of the bottle.
2. Place the paper ball in the mouth of a 1-liter bottle that has been placed on its side.
3. Direct a straw towards the mouth of the bottle and attempt to blow the paper ball into the bottle.
4. The paper ball wiggles and jiggles around before flying out of the bottle!
5. Replace the paper ball in the mouth of the bottle and try again. The ball just will not go into the bottle.
6. Try doing the experiment with other objects! Try things that are small and lightweight like marshmallows or popcorn.

Why doesn't the paper go in?

"As you might have guessed, the Huff and Puff Challenge has a lot to do with air pressure and air movement. With an item like the paper ball resting in the mouth of the bottle, it would make sense that the air from the straw would blow it into the bottle, but the exact opposite happens.

The secret is inside of the bottle. Although we refer to the bottle as being "empty," it's actually full to the brim. That's impossible… we can't see anything! Well, can you see the air that you breathe? The bottle is filled with air! Trying to blow more air into the bottle is impossible, just like if you were to put your lips directly on the mouth of the bottle and blow. It doesn't work!

While you can't blow air into the bottle, you are moving quite a bit of air along the sides of the bottle. When the air blows past the mouth of the bottle, it creates an area of low pressure behind it. This is called Bernoulli's Principle. This area of low pressure is exactly what the paper ball needs to hop out of the bottle's mouth!"

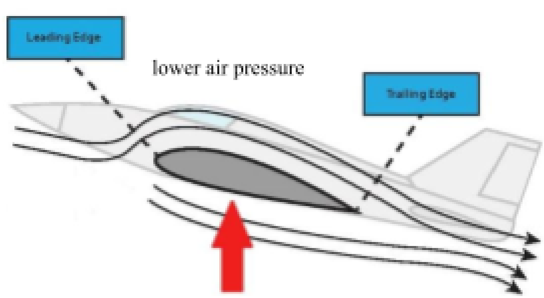
Discussion (5 minutes)

1. Reflect
    a. Ask the group if they think there is any other explanation for why the ball hops out of the bottle (this is an example of the practice of asking questions).
    b. Ask how they could test their idea (this is an example of the practice of planning and carrying out an investigation).
2. Reflect
    Ask youth if there were any times the object did go in the bottle? If there were times, ask youth if they can identify what they did differently that time.
3. Apply
    a. Ask if there are any other examples of air pressure youth can think of? This could be an example of developing and using models since air pressure is often not visible
    b. What makes them think it is an example of air pressure? (This could be an example of engaging in argument from evidence)

The Huff and Puff Challenge and the explanation was retrieved in its entirety from Steve Spangler Science (2015) at http://www.stevespanglerscience.com/lab/experiments/huff-and-puff/.

Optional Background

Bernoulli's Principle is used to help explain how planes fly. The shape of the wing (the "airfoil" when you look at it in cross section) causes air to flow quicker over the top of the wing. As the air flows faster over the top of the wing, the air pressure decreases above the wing. Because the air pressure below the wing remains the same and the air pressure above the wing is lowered, a force exerted upwards on the wing (a lift) that helps to push the plane upwards.



from NASA's **Principles of Flight: Bernoulli's Principle,** Museum in a Box curriculum

A Balloon Full of Flour

Activity 5: Experimenting with different strategies to complete a task. *(20 minutes)*

Materials & space needed

- A space outside or a room that can be easily cleaned when covered with flour.
- All-purpose baking flour, empty water bottles, balloons, small cups
- Spoons, straws, funnels, pens, paper, scissors, etc.

PROBLEM

Fill a balloon as full as possible with flour *(do not state this as the problem but simply present it as a challenge. As a reflection question, you will ask them to describe the challenge as a problem)*.

CONSTRAINTS

None.

A Balloon Full of Flour activity steps

1. Place materials in one common area without placing emphasis on any of the supplies available except the flour and the balloon.
2. Challenge every participant to experiment with ways to fill a balloon with flour.
3. As the activity continues encourage participants to experiment with other materials, collaborate with their efforts, and change their strategies.
4. When a participant believes they have filled it up completely, challenge them to fill it up with even more. How can they use a different strategy to fill it up with flour in the amounts of 1 tablespoon, ¼ cup, ½ cup, 1 cup or 2 cups?

An Eventual Strategy

1. Funnel flour into an empty dry water bottle using a funnel or a piece of paper.
2. Stretch opening of a balloon over the mouth of the bottle.
3. When balloon is secure over the bottle, squeeze bottle to force air into the balloon.
4. Turn bottle and balloon upside down and allow air to return into bottle. As the air goes into the bottle, the flour will go into the balloon.
5. Tie it off and enjoy the home-made stress ball or hacky sack!

Discussion (5 minutes)

1. Reflect:
   Ask youth to describe what the problem was that they were trying to solve (an example of the practice of defining a problem).
2. Reflect
   Ask youth to describe why they think their method was the best method to solve the problem. (This is an example of the practices of analyzing and interpreting data, engaging in argument from evidence and obtaining, evaluating and communicating information).
3. Apply
   Ask youth in what type of situation they will use the engineering design process to help them solve the problem in their everyday life.

A Tower of Cards

Activity 6: Experimenting with limited resources to create the highest structure. *(25 minutes)*

Materials for each group
- 10 playing cards or index cards
- 6 inches of masking tape and scissors
- 6 inches of ribbon, string or another similar item.

PROBLEM
Build a structure out of the cards that is as tall as possible.

CONSTRAINTS
1. If no tape is used the group is awarded a bonus 6 inches to their final height.
2. If no string, ribbon or similar item is used, the group is awarded a bonus 6 inches to their final height.
3. No additional materials will be provided.
4. Tape may only be placed on cards.
5. Structure may not be taped or lean on any wall, chair, desk or similar structure.

A Tower of Cards activity steps
1. Provide groups a set of materials. No additional materials may be provided.
2. Inform groups about the rules (constraints).
3. Inform groups that the structure will be measured at a 90 degree angle from the surface it is on.
4. Challenge every participant to build a structure out of the cards that is as tall as possible.

An Eventual Strategy
There is no eventual perfect strategy. The tower may be created in any number of ways. Youth may use materials in innovative ways, look for loop-holes in the rules, or develop a strategy that is unique to their group. Some groups may stack cards in a shape like a card

house, fold cards to increase strength, use tape sparingly at every connection, or cut cards to build strong connections without use of tape.

Discussion (5 minutes)

1. Reflect
    a. Ask if anyone first thought of a design in their head before building? (example of practice of developing and using models)
    b. How might it have been helpful to draw a design before building the tower? (example of practice of planning and carrying out an investigation)
2. Reflect
    a. Ask youth how they would break their tower into parts.
        i. Do they see any patterns in their tower?
        ii. Ask youth to describe how the different patterns or shapes in their tower relate or work together to hold up the tower.

These are examples of using the practices of mathematics to analyze characteristics and properties of geometric shapes and how they can relate to each other.

3. Apply
    Ask youth in what type of situation they will use the engineering design process to help them solve the problem in their everyday life.

Appendix

Science and engineering practices

The Next Generation Science Standards (NGSS) lay out a framework or guide to developing youth competencies in science and engineering by having youth engage in practices of inquiry and discussion while participating in science or engineering related activities. Many existing 4-H projects have a multitude of science and engineering components, providing an opportunity for 4-H members to improve their skills in the science and engineering practices. As 4-H volunteers and parents, you can help 4-H members improve their skills by highlighting and focusing on one, or several, or all of the science and engineering practices in the project(s) they are working on.

What is science?

Science is the study of how the world (or the universe) works. It is a systematic way of acquiring knowledge to understand how things work. it can be through observation or experimentation.

What is engineering?

Engineering is engaging in a systematic way to design a solution to a human problem.

The Eight Practices of Science and Engineering

These are practices that scientists and engineers use to do their work. You will notice that many of these practices overlap and connect to each other. A young person does not have to engage in all eight practices in a 4-H project to improve their skills in science and engineering practices. As a facilitator, you do not need to feel that you must incorporate every practice into each activity. However, the energy and enthusiasm youth have for their own project work (as opposed to doing assigned work) presents a special opportunity for you to point out when they are using science and engineering practices to complete a project. This encouragement can lead to youth considering areas or projects that they would not typically aim for, providing them with skills and confidence in those areas.

Asking questions and defining problems

- Science – asking questions that lead to inquiry with the goal of explaining how the world/ universe/phenomena work; we search for results that have quantifiable answers
- Engineering – defining a human problem that leads to designing a solution; there is not one correct solution so in defining the problem we must also know the constraints or limitations

Developing and using models

- Science- models are used to represent a system, or part of a system, to assist in developing questions and explanations
- Engineering – models can be used to analyze, study, or test a system to see where flaws may develop

Models can be drawings, analogies, physical replicas or prototypes and can be used to develop predictions or describe phenomena.

Planning and carrying out investigations

Whether the project is science or engineering related, youth should follow these steps (not unlike the steps in completing a 4-H project):

- State the goal of the investigation
- Predict the outcomes
- Plan a course of action to provide the best evidence to support conclusions

In controlled experiments, youth should be able to identify the independent variable (the variable they are changing) and the dependent variable (the variable that is being measured). Youth should also consider the sample size (when you increase the data, you get better data).

Analyzing and interpreting data

Data can be analyzed by organizing it in a manner that shows patterns or relationships (notes, tables, graphs).

- Science: Data is interpreted / analyzed by comparing and evaluating it as evidence to support or refute predictions or theories
- Engineering: Data is interpreted / analyzed to determine if the solution is optimal, or to suggest different designs or solutions to optimize (and then retest those new suggestions)

The limitations of the data analysis should be discussed (consider things such as causation versus correlation).

Using mathematics and computational thinking

Mathematics is used to represent variables and establish relationships (for example – area, volume, weight, time, ratio, percentage). These mathematical relationships can be used to describe, support or refute predictions, theories, phenomena or solutions.

Computational thinking involves strategies for organizing and searching data and using or creating simulations.

Constructing explanations and designing solutions

- Science: goal is to create explanations for the way the world (or universe) works using their own discoveries as well as others' discoveries

- Engineering: goal is to solve problems by designing, testing, evaluating, and improving solutions based on identified criteria and constraints

Engaging in argument from evidence

Goal is to construct arguments, critique arguments, and understand the importance of peer review in science and engineering. This practice relates to critical thinking by being able to explain and argue for the explanations constructed or the solution designed and defend that explanation with the interpretation of data (their own and others).

- Science: identifies the best explanation for how the world (or universe) works
- Engineering: identifies the best solution given the constraints and criteria

"Scientific argumentation" is a process for reaching agreements about explanations and design solutions. It is based on evidence and reasoning that lead to acceptance by the community.

Obtaining, evaluating, and communicating information

This practice also relates to critical thinking by developing abilities to read reports and identify important ideas, identify sources of error or flaws in designs, distinguish observations from inferences, and differentiate claims and evidence.

Also included in this practice is the ability to effectively communicate information and an understanding of the data, evidence, and explanation or solution.

Peer review of science explanations and engineering solutions is a fundamental component of science and engineering. Efforts to encourage in this practice develop competencies in reading and understanding scientific and technical text as well as critical thinking.