Engineering Post-Visit Resources for Educators

We are delighted to have spent time with you, your students, and their loved ones during our engineering program with your school. We hope you will use these resources to support you and your students to keep the engineering going in your classroom.

In early childhood, engineering is a design process that empowers children to be problem solvers by creating something that serves a specific purpose or solves a problem. Through the steps of the engineering design process, children express their creativity and collaborate in planning, use different materials to make something new, test out their ideas, and redesign.

This document contains the following:

- Overview of BADM's Engineering Design Process
- Think, Make, Try Poster
- Next Generation Science Standards Alignment
- Curriculum Integration
- Student Evaluations for Engineering
- Additional Resources

Thank you for working with us to facilitate your students' exploration of problem solving and the engineering design process. Have fun exploring with your budding engineers!

- School & Community Partnerships Team
Bay Area Discovery Museum

Overview of the Engineering Design Process

Engineering is how humans solve problems, by using science and math in an iterative process. Early engineering primarily focuses on introducing students to this engineering design process.

The engineering design process has many different interpretations; BADM's version is designed to be appropriate and accessible for young learners. Our engineering design process has three steps that occur in an ongoing cycle:

Think about the Problem

- Students start by identifying and articulating their understanding of a problem. Allowing students to be problem solvers develops their empathy and desire to be helpful, helps them learn responsibility, and shows that you value their ideas.
- Once students have built a solid understanding of a problem, they begin brainstorming solutions. Encourage students to imagine many different ways they can solve the problem, before selecting one solution to work on. Ask students to sketch their design to communicate their ideas.

Make a Prototype

- Making a prototype is a hands-on, child-directed opportunity for students to see their own ideas come to fruition. Students should compare and contrast their designs with other students, providing opportunities for language development and collaboration.
- This is also a space for students to explore and compare properties of many different materials. Having a variety of everyday and novel materials allows students to try many options and inspires their creativity. See the included list of suggested engineering materials for more ideas.

Try and Retry

- "Try and retry" means that students are able to test their hypotheses, make inferences, and compare and contrast their design solutions. Encourage students to iterate as many times as needed to continue improving their designs, even if their designs "succeed" on their first try.
- This step can be the most difficult for students, especially those who are not comfortable with the idea of failure. Encourage students to seek help from and support other students in improving their designs. You can also provide scaffolding for students by posing open-ended questions like "What worked or didn't work, and why?" or "How will you change your design to make it even better?"

The next page is a visual representation of our engineering design process. Please feel free to print out the page to use in your classroom.

ENGINEERING DESIGN PROCESS

THINK
ABOUT THE PROBLEM

MAKE
A PROTOTYPE

TRY
AND RETRY

Bay Area
Discovery
Museum

Next Generation Science Standards Alignment

The Next Generation Science Standards were created to shift science education from primarily focusing on content to also emphasizing process skills.

Below are the Engineering Design Performance Expectations for grades K - 2 and 3 – 5. We have also included notes on how to add intentional steps to deepen the engagement for older students.

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

3-5-ETS1-1: Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.

- Help older students dig deeper into defining problems by adding measurable ways to try their designs. For example, if the problem is creating something that floats, incorporate small weights so students can test the buoyancy of their designs. You can also include costs for different materials and implement a cost limit for designs – this is a great way to integrate math into the project!

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

3-5-ETS1-2: Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.

- For older students, work as a class to decide which plans will likely work the best and why, based on how you defined the problem. You can do this again after students have had time to create and test multiple prototypes. Encourage students to think creatively about how they can combine parts of different designs to create an even better solution.

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

3-5-ETS1-3: Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

- Give older students more autonomy to come up with a plan of how they will test their designs, based on how the problem is defined. As students try their designs out, have them identify areas for improvement in their original plan before drawing up a new plan to make their designs better.

Integrating Engineering into Your Curriculum

Because early engineering is focused on the process of designing, it naturally integrates with other subject areas. Interdisciplinary lessons are proven to increase student engagement with content and optimize learning opportunities. Below are suggestions for integrating the engineering design process into different subject areas.

Reading and Literature

The first steps of engineering - finding problems and building empathy with users – tie in well with ELA Reading:Literature standards around “Key Ideas and Details” and “Integration of Knowledge and Ideas”.

When reading stories with students, pause to help them identify key characters and the problems that they are experiencing. Instead of finishing the story immediately, encourage students to brainstorm designs that they can make to solve the problems. With some support and creativity, students can build prototypes and even find ways to try them out.

When you go back to finish the story, explain that this was just one way that the author chose to solve the problem. Encourage students to write and build their own endings to the story.

Social Studies

People around us have problems all the time. Whether it’s helping the school office manager with keeping track of keys or tackling big issues like food waste, giving students the opportunity to apply the engineering design process to real problems asks students to understand the points of view of people around them and empowers them to make changes in their lives and the lives of others.

Ask students to identify people at your school who might have problems. Work with your class to prepare questions that they can ask these people to find out more about their problems. Invite your special guests into your classroom, and give students a chance to interview and find out about the needs of their users. Help the students narrow down the problem to something manageable.

Brainstorm possible solutions with your students. With basic engineering materials, invite students to create prototypes of their ideas, so that they can try them out and improve them. Present these prototypes to your users and ask them for feedback, which students can bring back and incorporate into their designs. You may even be able to acquire more durable materials that students can use to make actual products.

Help students prepare a presentation to your users, including their process in creating their prototypes, and how they incorporated feedback into the final product.

Student Evaluations for Engineering

Engineering is an active, interdisciplinary learning process, which can make it hard to know what to look for and evaluate as evidence of student learning. The next two pages offer tools to guide your observations of student behaviors and engagement as you integrate engineering into your classroom.

The “**Think, Make, Try**” evaluation tool can be used in the moment as students are working on an engineering activity to guide your observations and to support you in noticing student behaviors that may be present in each phase of the engineering design process. As you incorporate engineering into your classroom activities and curriculum, think about how you can better support students to engage in these behaviors.

The longer “**Big Ideas of Early Engineering**” evaluation tool is better suited for long-term observation and evaluation of student learning over several engineering activities or an engineering unit. As you plan out your unit or class curriculum, think about ways you can support students in developing and reflecting on these skills and mindsets.

Think, Make, Try Evaluation Tool

Think	Make	Try
When students "Think about the problem," they should... ___ Ask questions. ___ Imagine solutions. They may also... ___ Explore materials. ___ Sketch their ideas. ___ Talk with others. ___ Make a plan. Notes:	When students "Make a prototype," they should... ___ Experiment with materials. ___ Look around for new materials. ___ Gather new ideas from the environment. ___ Make changes to their design as they go. Notes:	When students "Try and retry," they should... ___ Observe how their design works. ___ Share challenges and success. ___ Decide what to change. ___ Get help from others. Notes:

The Big Ideas of Early Engineering Evaluation Tool

•Students who engage in engineering are empowered by their ability to help others as they identify and solve problems in the world that matter to them.

Student behaviors to look for and cultivate:

___ Demonstrates empathy for others by showing a desire to understand their perspectives and by offering to help where needed.

___ Shows confidence in their ideas and has a positive attitude toward problem-solving.

___ Displays a willingness to approach new problems and activities and asks questions to help them understand the problem at hand.

•Students who engage in engineering build creative problem-solving skills and mindsets.

Student behaviors to look for and cultivate:

___ Able to collaborate with others in order to generate multiple solutions to a problem and then select one solution to try.

___ Sustains attention to challenging tasks, persisting in the face of mistakes, failures, and unexpected set-backs.

___ Adapts solutions to new constraints by changing his or her approach.

•Students who engage in engineering gain important interpersonal skills and executive function skills.

Student behaviors to look for and cultivate:

___ Plans out steps to problem solving.

___ Makes connections between previous experiences and the task at hand.

___ Invites others to join in and share their ideas .

•Students who engage in engineering learn a great deal about the physical world around them: that materials and tools matter, and some are better suited for certain solutions than others.

Student behaviors to look for and cultivate:

___ Manipulates and observes objects and materials and discusses their physical properties.

___ Applies growing knowledge of the physical world to their design and building.

___ Investigates solutions, comparing and contrasting them with attention to cause and effect.

Additional Resources: Materials List

This list includes some materials that might be helpful as you incorporate engineering activities into your classroom. These are simply suggestions, feel free to add or adapt as makes sense for you! Be sure to consider the age of your students to ensure that materials are safe for their use, and supervise as necessary.

Natural Materials:

- Bark
- Sticks
- Pebbles
- Dirt
- Sand
- Leaves
- Seeds/nuts

Craft Materials:

- Popsicle sticks
- Chenille stems/Pipe Cleaners
- Blocks
- Clay
- Aluminum foil
- Paper straws
- Tape
- Playdough
- Velcro
- Clothespins
- String
- Stapler

Recycled Materials:

- Cardboard
- Egg cartons
- Coffee stir sticks
- Packing peanuts/Styrofoam
- Shoeboxes

Tools:

- Scissors
- Glue sticks
- Hammers
- Mallets
- Screwdrivers
- Pliers
- Magnets
- Sandpaper or Rasps

Additional Resources: Reading List

These children's books all deal with various themes involved in engineering such as the engineering design process, specific projects such as building bridges or houses, and perseverance through failure. This is just one list – add your favorite books about thinking, making, and trying at the bottom as you find them!

- *Rosie Revere, Engineer* by Andrea Beaty
- *Iggy Peck, Architect* by Andrea Beaty
- *Ada Twist, Scientist* by Andrea Beaty
- *This Bridge Will Not Be Gray* by Dave Eggers
- *Cross a Bridge* by Ryan Ann Hunter
- *What To Do With an Idea?* by Kobi Yamada
- *Ish* by Peter H. Reynolds
- *The Dot* by Peter H. Reynolds
- *Stuck* by Oliver Jeffers
- *The Most Magnificent Thing* by Ashley Spires
- *How a House is Built* by Gail Gibbons

These resources can help you delve deeper into the research and best practices around early engineering.

- *Loose Parts* by Lisa Daly and Miriam Belogovsky
- *Mindset: the Psychology of Success* by Carol Dweck
- *Reimagining School Readiness* by the Center for Childhood Creativity
  https://centerforchildhoodcreativity.org/research/published/
- *The Roots of STEM Success* by the Center for Childhood Creativity
  https://centerforchildhoodcreativity.org/research/published/