SANTA FE ALLIANCE FOR SCIENCE

THE INVESTIGATION PROCESS

Inspiring the scientist in every student!

Children are born with all the traits of a good scientist or engineer. They are curious, are eager to investigate their surroundings, and happy to experiment. How best to harness this natural curiosity and energy? Hands-on STEM projects provide one answer! [1]

But where are good project ideas to be found? Baseball great Yogi Berra famously remarked: "You can observe a lot by just watching." The same can be said about successful science and engineering investigations. They often begin with simple observations about our surroundings. How are the eyes of various animals different and why? How is arroyo soil erosion affected by ground cover? Which model boat design allows for the fastest cargo loading? Which parachute design best protects an egg dropped from a height of six feet?

How do scientists come up with evidence and develop conclusions about such questions? How do engineers test and refine their solutions to real-world design problems? Here are some practical guidelines for STEM investigations.[2]

SCIENTIFIC RESEARCH DESIGN

Scientists observe phenomena, think about how their observations relate to what is already known, test their ideas in logical ways, and generate plausible explanations that integrate this new information into our understanding of the natural world. Here are the steps a student might follow in a scientific investigation:

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[1] Kristina Rizga, "Children Are Born Scientists. What if School Encouraged That?" *The Atlantic* online edition (September 21, 2020).

[2] Adapted from "STEM Fair Project Ideas," Whittier Elementary School, Seattle, WA.

1. **Make an Observation**. What phenomena do you notice in nature? What have you read about? What have you discussed in class? For example, perhaps you've noticed that mold sometimes grows on cheese stored in the refrigerator.
2. **Ask a Question**. Why does this pattern occur? What happens if I change this one thing? Does it always happen? Examples might include: What kind of cheese is most prone to mold? How do heat, light, and the absence of air affect cheese mold growth?
3. **Do Some Research**. Read to better understand what is already known about the answers to your questions. Write down what you've learned in your investigation notebook.
4. **Make a Prediction**. Predict what you think the answer will be. For example: Mold grows more quickly on cheddar cheese kept in a warm dark place. It's okay if the prediction ends up being wrong.
5. **Conduct an Experiment**. Write down your procedures and gather data. Change one thing at a time and measure the result. Test each change several times (multiple trials). Summarize your test results in a chart, graph, or table.
6. **Draw Conclusions**. Based on the data you gathered, what is the answer to your question? Do your results support your prediction? If not, then why? Make a claim and use evidence and reasoning.
7. **Share Your Findings**. Describe your research question, why it is important, what you predict will happen, the steps used in the experiment, and your conclusions. What did you learn, and what will you do next?

Six steps in the scientific research design process.

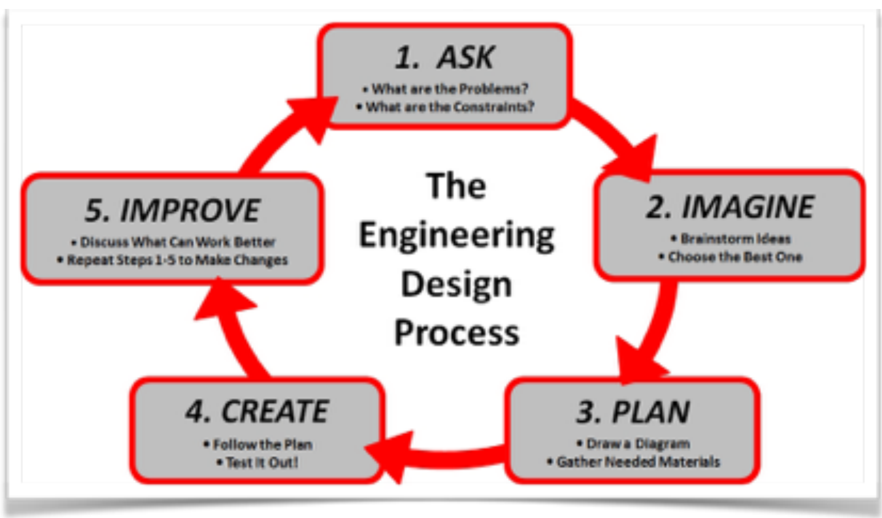
ENGINEERING DESIGN

Engineers use scientific knowledge and build something to test an idea or solve a real-world problem. Here are the steps a student might follow in an engineering investigation.

1. **Ask**. Brainstorm problems you want to try to solve. You can start by thinking of everyday problems you and others encounter, and possible solutions that might solve them. For example, plastic rings for six-packs of soda are inexpensive and convenient, but they can also be quite dangerous to animals in the environment. Can you find a better way to hold soda cans together in the store so that animals won't be harmed once the packaging is discarded?

2. **Imagine**. Brainstorm possible solutions and consider design options. Figure out how you will know if your solution solves the problem. For example, how and why are discarded beverage rings dangerous to animals? How can the rings be redesigned to reduce or eliminate this danger?

3. **Plan**. Choose the best design, draw a picture and identify the right materials to use.
4. **Create**. Build a solution based on your drawings and gather data on how well it works. Write down each step of the testing process. Change one thing at a time and measure the result. Test each change several times (multiple trials). Summarize your test results in a chart, graph, or table.
5. **Improve.** Based on the data you gathered, how well does the solution work? Can the design be modified to make it better? If so, change one thing at a time and measure the result of this modification several times.
6. **Share Your Findings.** Describe the engineering problem, why it is important, your initial solution, the steps used in testing the solution, any design improvements, and your conclusions. What did you learn, and what will you do next?



FIVE STEPS IN THE ENGINEERING DESIGN PROCESS.

Resources

The Alliance website offers an invaluable set of STEM project tools and tips that can be accessed here, everything from "*Choosing a Project,*" to "*Examples of Science Fair Projects,*" to "*Questions Judges May Ask*," and more.

Of course, there are many Internet web sites that have great STEM project ideas. In fact, a recent Google® search returned 2.830 billion hits. Here are a few of the most popular sites that have wizards and other tools to help narrow down the search:

- Science Buddies is a great place to start. Students can browse ideas that appeal to them personally. The site's Topic Selection Wizard is very helpful.

- From Astronomy to Zoology, students can explore over 500 project ideas using a keyword search at All Science Fair Projects.

- Science Fair Projects World has categories—Technology, Human Body, Physics, Math, Chemistry, Biology and Solar System—that students can search for ideas.

- The science fair project ideas page of education.com lets students browse by grade or by topic.

We don't recommend that students simply take a project description from the Internet and just follow the step-by-step instructions as though baking a cake. Instead, students should learn to use the ideas of others to come up with their own unique project. The key to successful STEM projects is to find something that really interests and excites the student investigator.

Contact: Diane Smogor, Executive Director info@sfafs.org