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**Science  
and  
Engineering  
Fair  
2017**

# Ask a question

- What do you want to investigate or figure out in the this lesson?
- What will be the main question that will guide what you do?

## Examples:

- **Not so great:**

- Which brand of battery is the best?
- Are mice smart?
- How do plants grow?

- **Much Better:**

- Can you estimate how high a tree is by measuring it's shadow?
- Which brand of battery lasts longer?
- Does a ball roll faster on grass or bare soil?

# Research

- Ask someone
- Think of past experiences
- Use text books
- Online sources – reference the source, not the URL
- Site the sources using MLA, APA format
- Summarize the research in three to five points:

# Hypothesis

Based on the research, write an answer/solution – your best educated guess – to the question/problem

Restate the problem in a declarative sentence that would answer the question/problem

# Hypothesis

- Do not begin with “I think” or “I predict”
- Your hypothesis should be something that you can actually test and measure both "what you do" and "what will happen."
- If fenders are put on a bicycle [having fenders is the independent variable], a rider will not get wet when riding through puddles [the dependent variable is how much water splashes on the rider]."

# Variables

- **Controlled variables:**  
kept the same throughout your experiment
- **Independent variable:**  
the one variable that is changed and tested
- **Dependent variable:** The measure of change observed because of the independent variable.
  - It is important to decide how you are going to measure the change. Use metrics.

## What Makes a Good Hypothesis?

Is the hypothesis based on information contained in my research?

Yes / No

Does the hypothesis include the independent and dependent variables?

Yes / No

Have you worded the hypothesis so that it can be tested in the experiment?

Yes / No

# Materials

- Make a detailed list of the items needed
  - Be specific about the amounts used.
  - Include quantity and size

## What Makes a Good Materials List?

Have you listed all necessary materials?

Yes / No

Have you described the materials in sufficient detail?

Yes / No

# Procedure

- List all of the steps used in the experiment.

# What Makes a Good Experimental Procedure?

• description and size for all experimental and control groups?	Yes / No
• step-by-step list of all procedures?	Yes / No
• description of how to change the independent variable and how to measure that change?	Yes / No
• an explanation of how to measure the resulting change in the dependent variable or variables?	Yes / No
• an explanation of how the controlled variables will be maintained at a constant value?	Yes / No
• how many times will the experiment be repeated (should be at least three times), and is that number of enough to give reliable data?	Yes / No
• the experiment can be duplicated based on the experimental procedure as written?	Yes / No
• With an engineering or programming project, several preliminary designs have been completed?	Yes / No

# Test

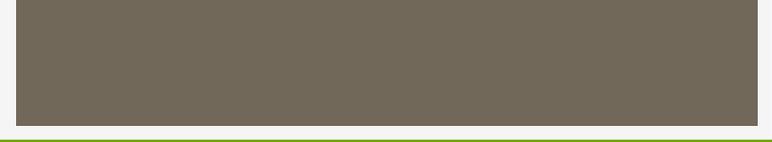
- Test the hypothesis
- Follow the procedures step by step
- Collect data
- Conduct experiment at least three times for accuracy – more data, more better!

# What Makes a Good Science Experiment?

Were detailed notes taken about observations and recorded in a laboratory notebook?	Yes / No
Was data collected using a data table?	Yes / No
Were consistent, careful, and accurate notes taken when measurements were made?	Yes / No
Did control variables remain constant so as not to affect the results?	Yes / No
If unexpected problems happened, was the experimental procedure changed?	Yes / No

# Variables

- **Controlled variables:**  
kept the same throughout your experiment
- **Independent variable:**  
the one variable that is changed and tested
- **Dependent variable:** The measure of change observed because of the independent variable.
  - It is important to decide how you are going to measure the change. Use metrics.



# What Makes for Good Variables?

Is the independent variable measurable?	Yes / No
Can you change the independent variable during the experiment?	Yes / No
Have all relevant dependent variables been identified and are they all caused by and dependent on the independent variable?	Yes / No
Are all dependent variable(s) measurable?	Yes / No
Have all relevant controlled variables been identified ?	Yes / No
Can all controlled variables be held at a steady value during the experiment?	Yes / No

# Data/Observations

- It is easier to understand the data if it is put into a table or graph.
- Make sure all data is clearly labeled.
- Add photos of the experiment

# Quantitative vs Qualitative Data



**BAR GRAPH** – most common type for science fair projects. A bar graph is chosen when the independent variable is qualitative (categories) or quantitative (numbers).

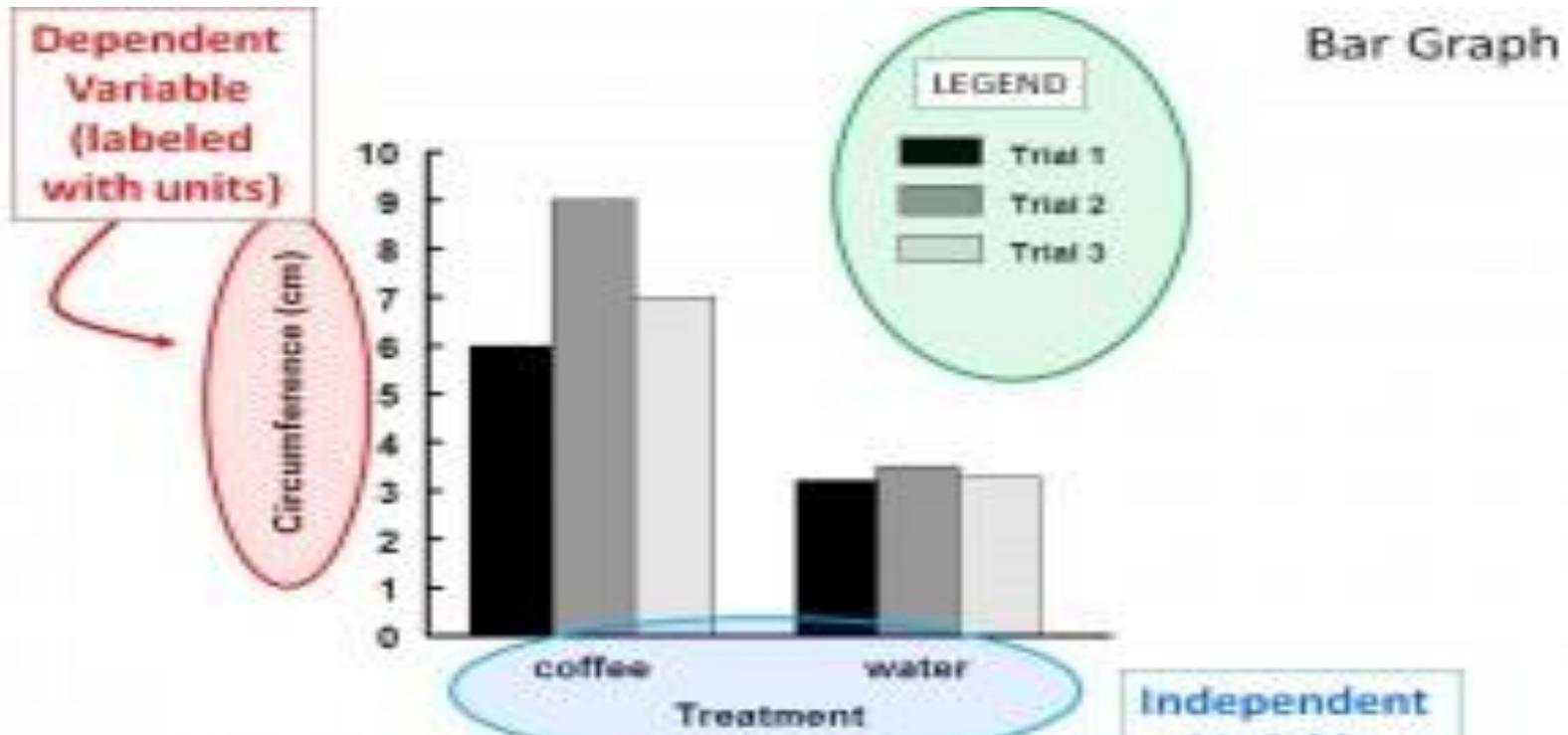


Figure 1. Text to describe the graph goes here (underneath example, the addition of coffee resulted in larger, but more sizes (measured by circumference) compared to the control

**Independent Variable (labeled with units)**

**LINE GRAPH** - are great for showing changes in the dependent variable over time or distance along a certain period.

## Line Graph

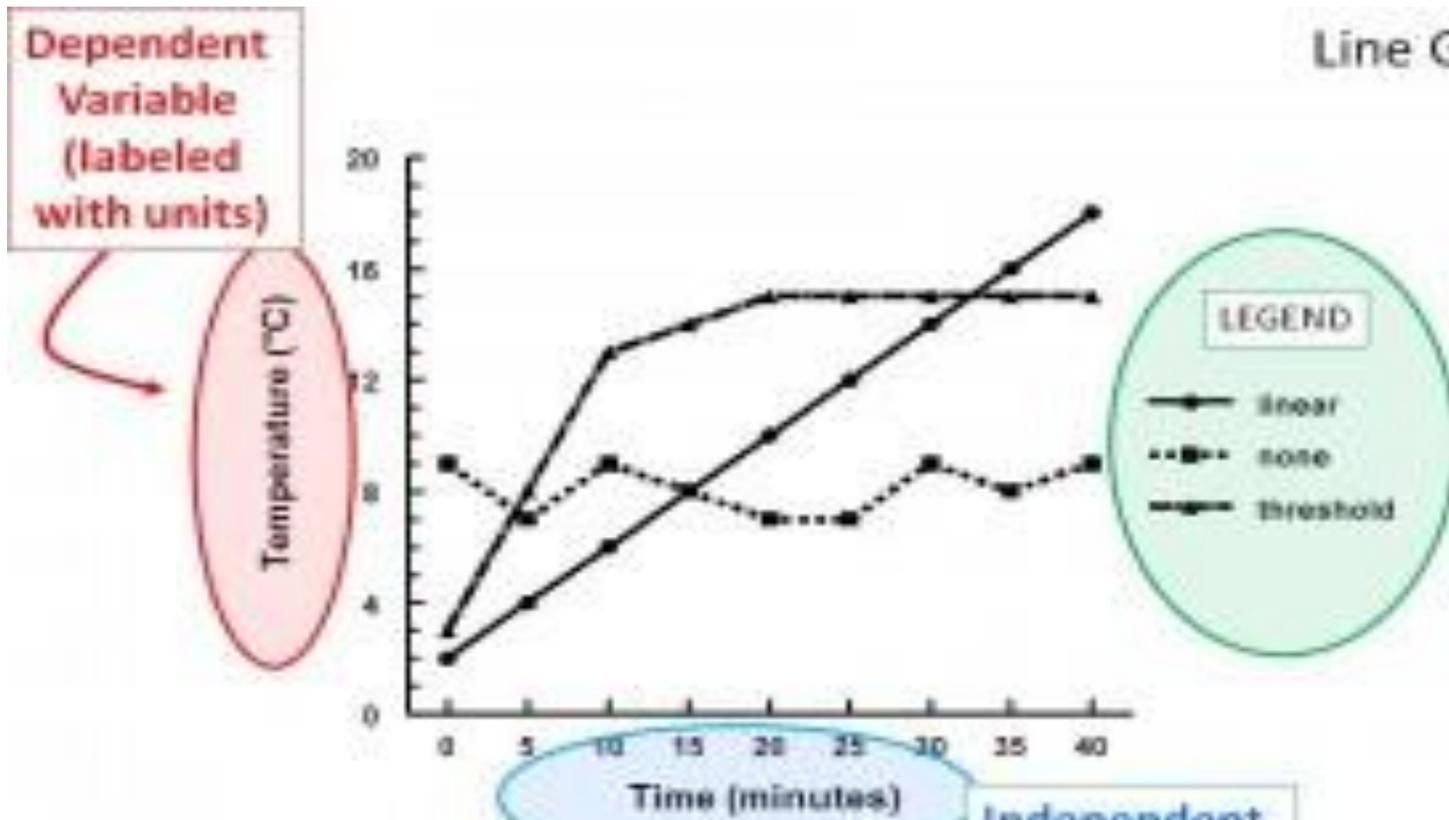


Figure 1. Test for line graph plots more directly and trend observed. Examples above include a linear response of temperature of an object (red line), no response of (green line), and a threshold response (blue line).

**PIE CHART** – Pie charts are good for projects that have qualitative independent variables and have generated data that can be expressed as percentages of the total.

Independent variable: color of feeder  
Dependent variable: number of visits  
(expressed as a percentage of total visits)

Pie Chart

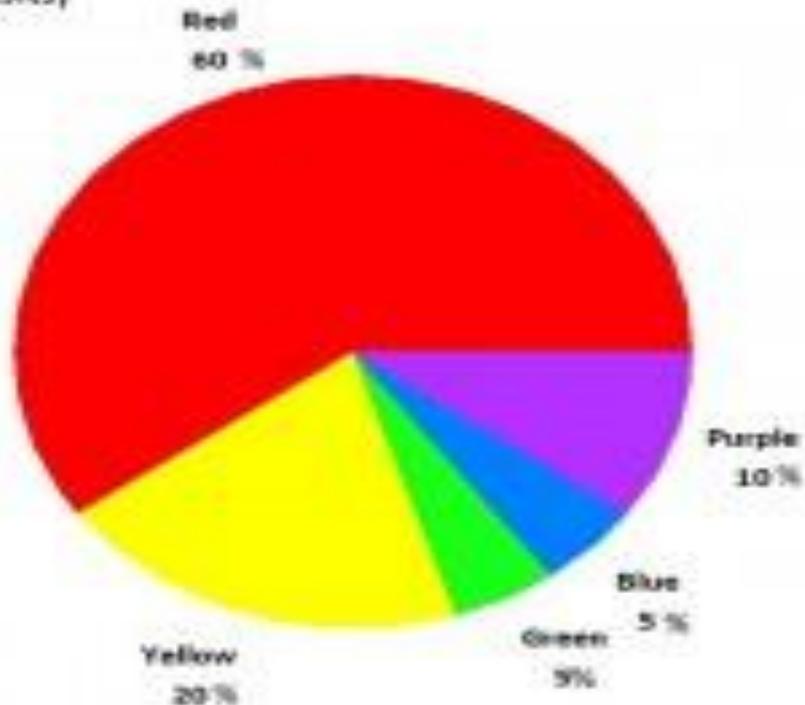


Figure 1. Text to describe the graph goes here (underneath graph).  
For example to describe the amount of time hummingbirds spent at  
feeders of different colors

# What Makes a Good Graph?

Have you selected the appropriate graph type for the data you are displaying?	Yes / No
Does your graph have a title?	Yes / No
Have you placed the independent variable on the x-axis and the dependent variable on the y-axis?	Yes / No
Have you labeled the axes correctly and specified the units of measurement?	Yes / No
Does your graph have the proper scale (the appropriate high and low values on the axes)?	Yes / No
Is your data plotted correctly and clearly?	Yes / No

# Conclusion

- Write a brief summary of what was discovered based on the results of experiment
- indicate whether or not the data supports the hypothesis and explain why or why not.
- Include what would you do, if you retested.

“The....data supports or does not support....”

## What Makes Good Conclusions?

Are the results summarized and used to support the findings?	Yes / No
Do the conclusions support or do not support the hypothesis? (Engineering & programming projects should state whether they met their design criteria.)	Yes / No
If appropriate, is the relationship between the independent and dependent variables stated?	Yes / No
Is the experimental procedure summarized and evaluated, with comments about its success and effectiveness?	Yes / No
Are changes in the experimental procedure and/or possibilities for further study suggested?	Yes / No

# Works Cited

Be sure to include sources and put them in alphabetical order.

**Google Scholar** <https://scholar.google.com/>

# Abstract

Type a brief overview or summary of the experiment.

Annotated example taken from *Nature* 435, 114–118 (5 May 2005).

One or two sentences providing a **basic introduction** to the field, comprehensible to a scientist in any discipline.

Two to three sentences of **more detailed background**, comprehensible to scientists in related disciplines.

One sentence clearly stating the **general problem** being addressed by this particular study.

One sentence summarizing the main result (with the words “**here we show**” or their equivalent).

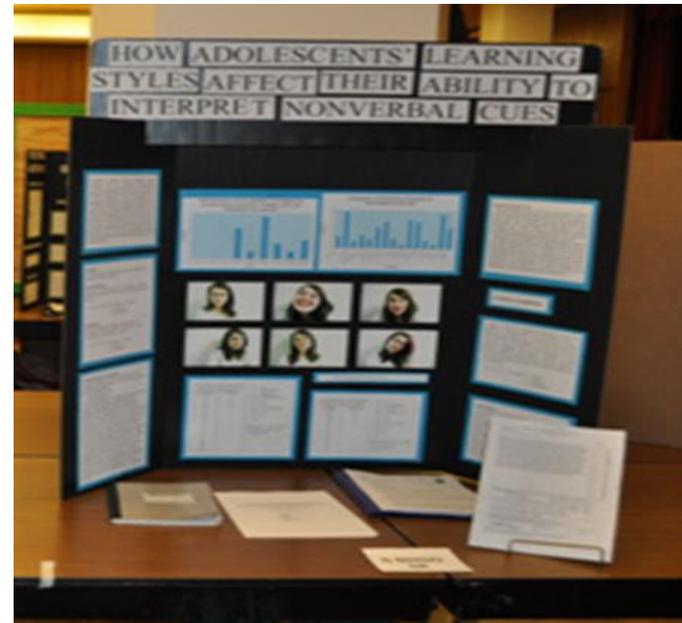
Two or three sentences explaining what the **main result** reveals in direct comparison to what was thought to be the case previously, or how the main result adds to previous knowledge.

One or two sentences to put the results into a more **general context**.

Two or three sentences to provide a **broader perspective**, readily comprehensible to a scientist in any discipline, may be included in the first paragraph if the editor considers that the accessibility of the paper is significantly enhanced by their inclusion. Under these circumstances, the length of the paragraph can be up to 300 words. (This example is 190 words without the final section, and 250 words with it).

During cell division, mitotic spindles are assembled by microtubule-based motor proteins<sup>1,2</sup>. The bipolar organization of spindles is essential for proper segregation of chromosomes, and requires plus-end-directed homotetrameric motor proteins of the widely conserved kinesin-5 (BimC) family<sup>3</sup>. Hypotheses for bipolar spindle formation include the ‘push–pull mitotic muscle’ model, in which kinesin-5 and opposing motor proteins act between overlapping microtubules<sup>2,4,5</sup>. However, the precise roles of kinesin-5 during this process are unknown. Here we show that the vertebrate kinesin-5 Eg5 drives the sliding of microtubules depending on their relative orientation. We found in controlled *in vitro* assays that Eg5 has the remarkable capability of simultaneously moving at  $\sim 20 \text{ nm s}^{-1}$  towards the plus-ends of each of the two microtubules it crosslinks. For anti-parallel microtubules, this results in relative sliding at  $\sim 40 \text{ nm s}^{-1}$ , comparable to spindle pole separation rates *in vivo*<sup>6</sup>. Furthermore, we found that Eg5 can tether microtubule plus-ends, suggesting an additional microtubule-binding mode for Eg5. Our results demonstrate how members of the kinesin-5 family are likely to function in mitosis, pushing apart interpolar microtubules as well as recruiting microtubules into bundles that are subsequently polarized by relative sliding. We anticipate our assay to be a starting point for more sophisticated *in vitro* models of mitotic spindles. For example, the individual and combined action of multiple mitotic motors could be tested, including minus-end-directed motors opposing Eg5 motility. Furthermore, Eg5 inhibition is a major target of anti-cancer drug development, and a well-defined and quantitative assay for motor function will be relevant for such developments.

# Communicate Results



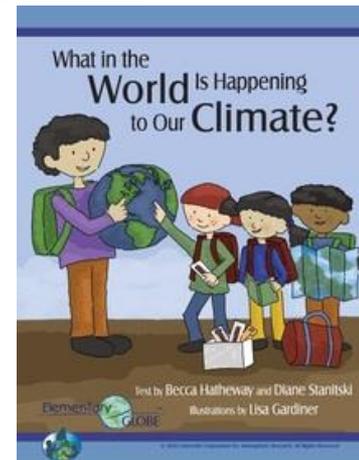
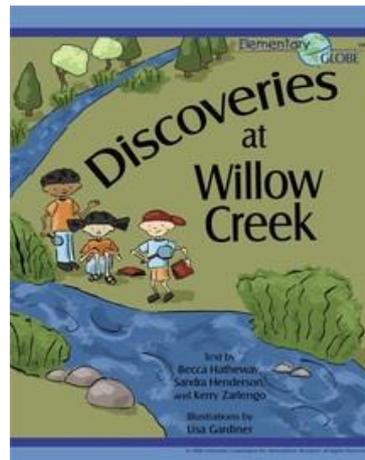
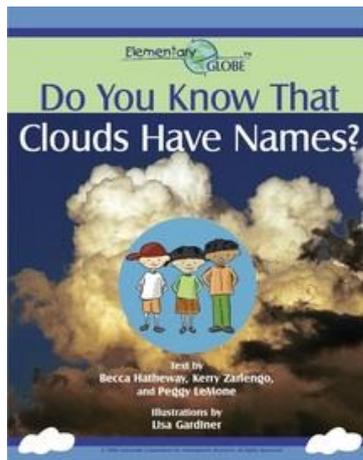
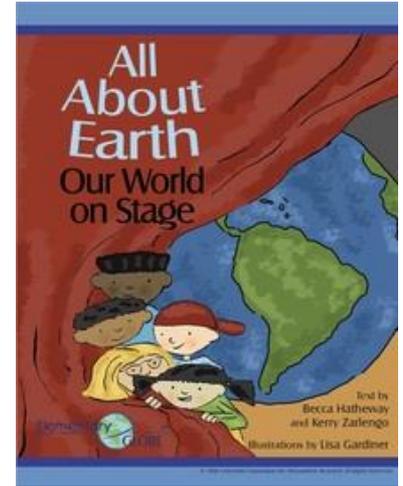
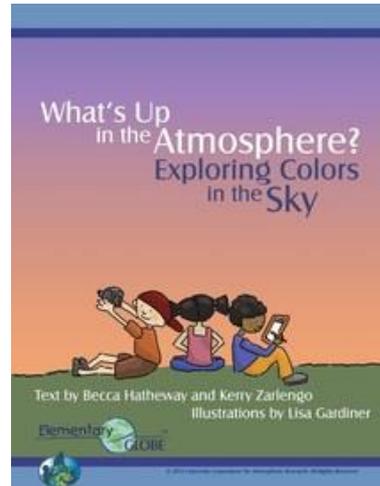
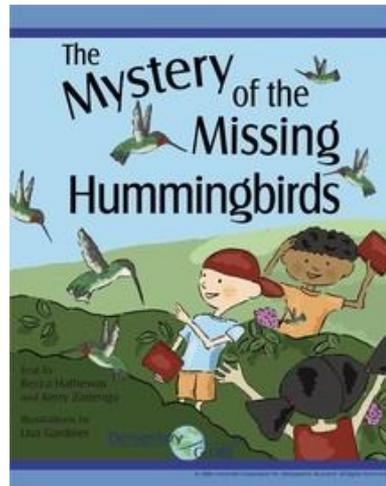
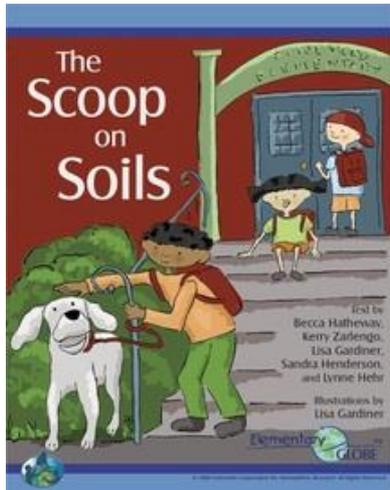
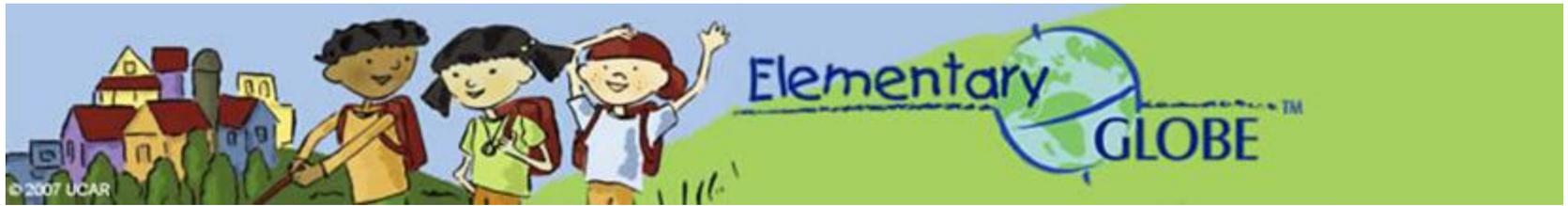
# The GLOBE Program

<https://www.globe.gov/>



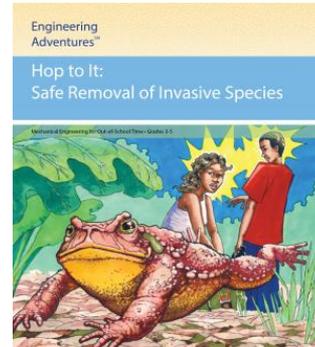
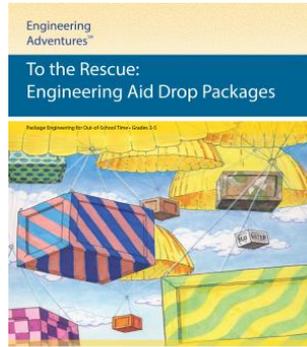
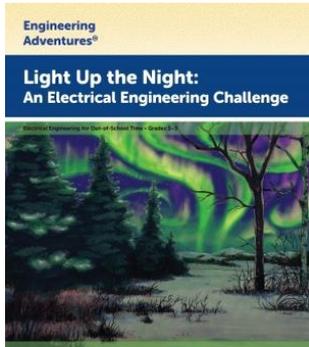
117	Countries
30,712	Schools
28,045	Teachers



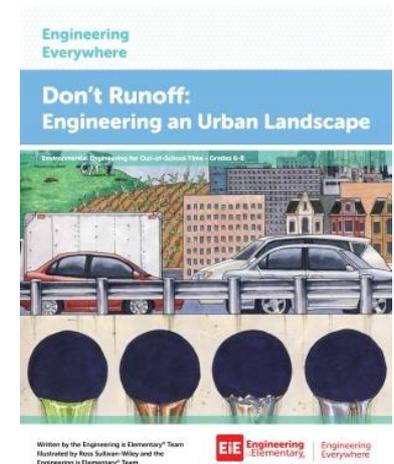
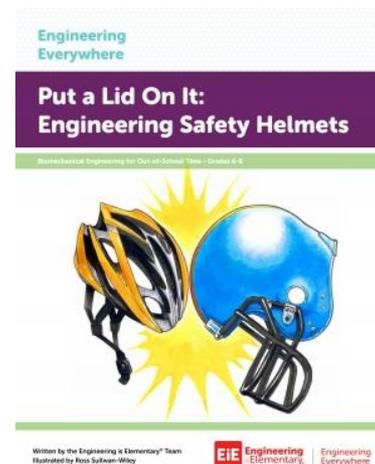
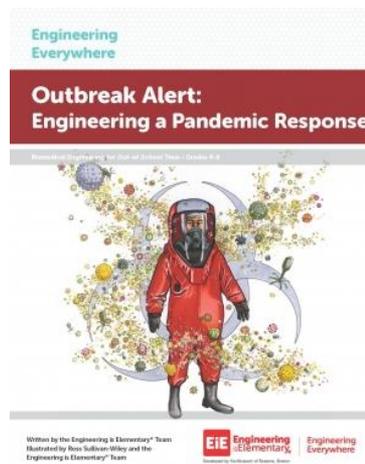
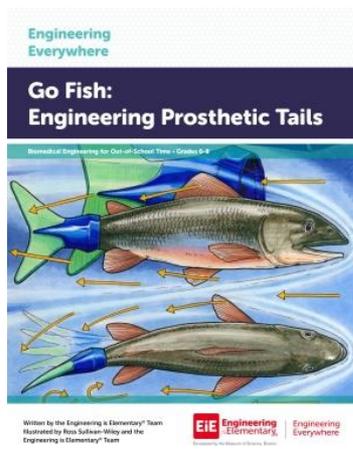


# Engineering is Elementary

## Engineering Adventures



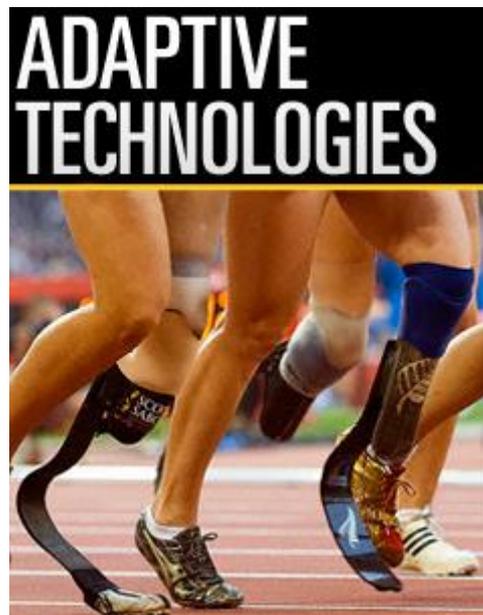
## Engineering Everywhere





# EiE Storybooks

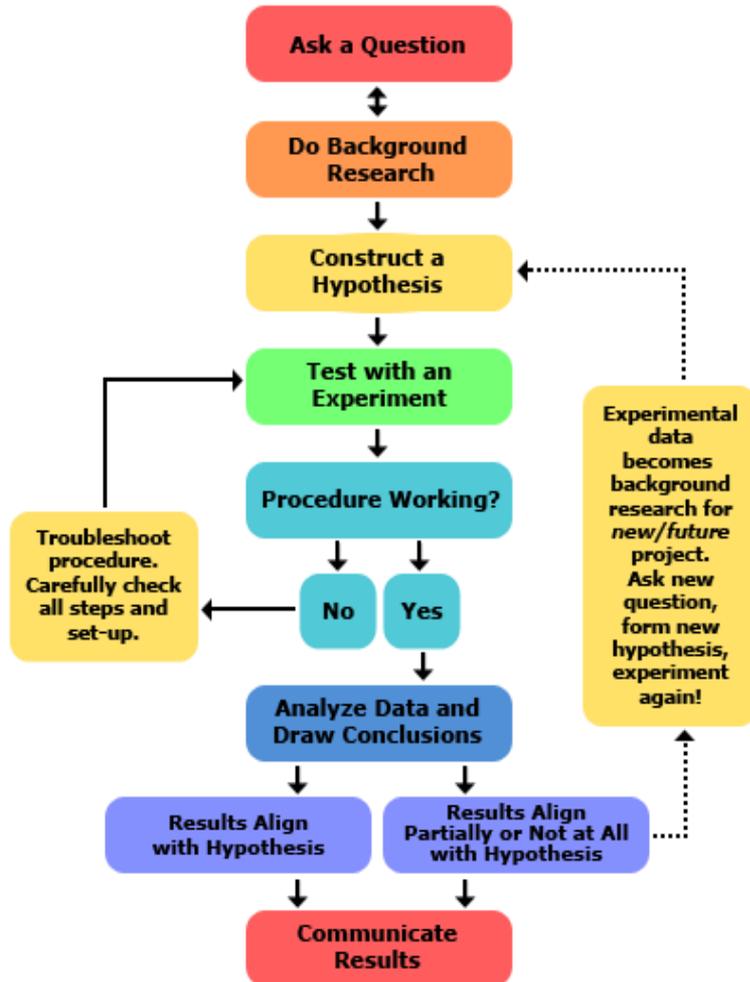
# NASA Design Squad Challenges



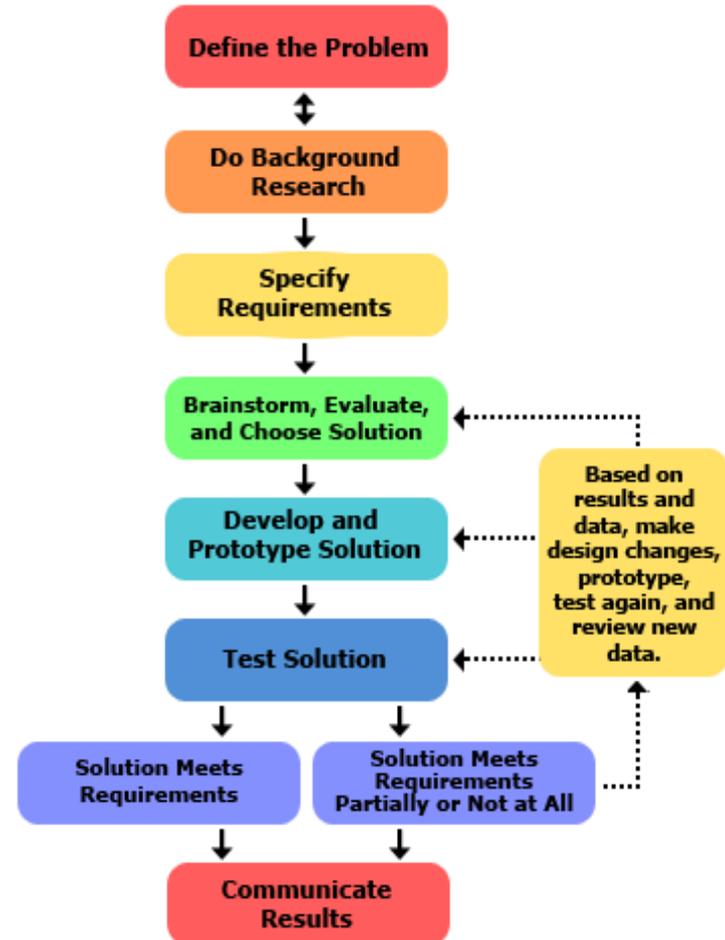
- **Science proposes** questions about the natural world and answers in the form of evidence-based explanation
- **Scientific inquiry** involves the formulation of a question that can be answered through investigation
- **Scientists investigate**
  
- **Engineering identifies** problems of human needs and aspirations and proposes solutions in the form of new products and processes
- **Engineering design**
- **Engineers create**

- Science is about *understanding* nature, **understanding what is.**
- Engineering is about *creating* what *has never been.*

## Scientific Method



## Engineering Design Process



# The Engineering Design Process

```
graph TD; 1[1. ASK] --> 2[2. IMAGINE]; 2 --> 3[3. PLAN]; 3 --> 4[4. CREATE]; 4 --> 5[5. IMPROVE]; 5 --> 1;
```

## 1. *ASK*

- What are the Problems?
- What are the Constraints?

## 2. *IMAGINE*

- Brainstorm Ideas
- Choose the Best One

## 3. *PLAN*

- Draw a Diagram
- Gather Needed Materials

## 4. *CREATE*

- Follow the Plan
- Test It Out!

## 5. *IMPROVE*

- Discuss What Can Work Better
- Repeat Steps 1-5 to Make Changes

"Scientists  
**DISCOVER** the world that  
exists;  
engineers  
**CREATE**  
the world that  
never was."

*Theodore Von Karmen*

~ aerospace engineer ~

## Example: EGG DROP!



### Using the scientific method, students

- may initially hypothesize that the egg will break!
- might think that x material will provide better shock absorption than y material
- An experimental procedure is then established to test.

### Using the engineering design process, students

- accept that the egg *will break* unless a solution is devised to protect it
- move on to brainstorming, prototyping, testing, and refining a solution created specifically to meet the need
- and protect the egg.

Home School. In accordance with ACT 1469 of 2013, a home school student shall be given the opportunity to try out for an athletic or non-athletic competitive activity or team in their resident public school district if the following criteria are met:

1. Inform the principal of the resident school district in writing of their request to participate in the interscholastic activity before the signup, tryout, or participation deadlines established for students enrolled in the resident school district.
2. Inform the principal in the request that the student has demonstrated academic eligibility by obtaining: a minimum test score of the thirtieth percentile on The Stanford Achievement Test Series, Tenth Edition, or another nationally recognized norm-referenced test in the previous (12) months, or a minimum score on a test approved by the State Board of Education.
3. In order to be eligible to participate, the student must be enrolled within the first (11) days of the fall or spring semester.
4. Meets the same requirements as enrolled students in regards to practice times, required drug testing, permission slips, waivers, physical exams, and participation fees.
5. The student cannot be required to be enrolled in more than (1) period per school day.
6. Be transported by the resident school district to and from interscholastic activities as the resident school district transports other students who are enrolled in the resident school district.
7. If the student withdraws from an Arkansas Activities Association member school to be home-schooled, the student shall not participate in an interscholastic activity in the resident school district for a minimum of (365) days after the student withdraws from the member school. Go to: <http://www.arkleg.state.ar.us/SearchCenter/Pages/historicalact.aspx> for a complete version of the ACT. Type in "1469" in the "Act Number" box and enter.

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