Using Engineering and Coding to Make Science Stick

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Pre-College Engineering Education

A division of the American Society for Engineering Education

Want to learn more about what ASEE has to offer? Come back here at 12:30 or attend our other fantastic sessions throughout the day.

Workshop Overview

1. Our teaching model
2. Let's try it - building a toy
3. How to incorporate arduinos
4. How we assess
5. How could YOU do this?

What will you get out of this workshop?

Understanding of what "engineering" means in schools

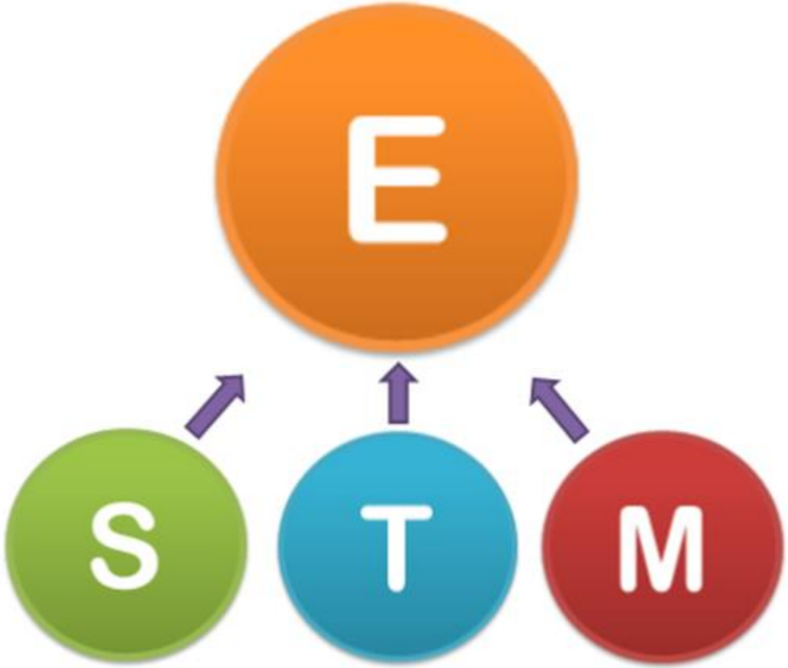
A ready to go lesson idea for teaching current electricity

A new approach to *teaching what you already teach*, but in a different context

A toy you can bring home to your kids or friends rather than buying that last minute gift in the airport!

Next Generation Science Standards – 3 Crosscutting Dimensions

1. Scientific and engineering practices
2. Crosscutting concepts that unify science
3. Core ideas in physical science, life science, earth/space science, engineering, and technology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Science and Engineering - What's the Difference?

Science

Focus is on studying the natural world to more deeply understand how things work.

Scientists ask questions, interpret data, and construct explanations.

Engineering

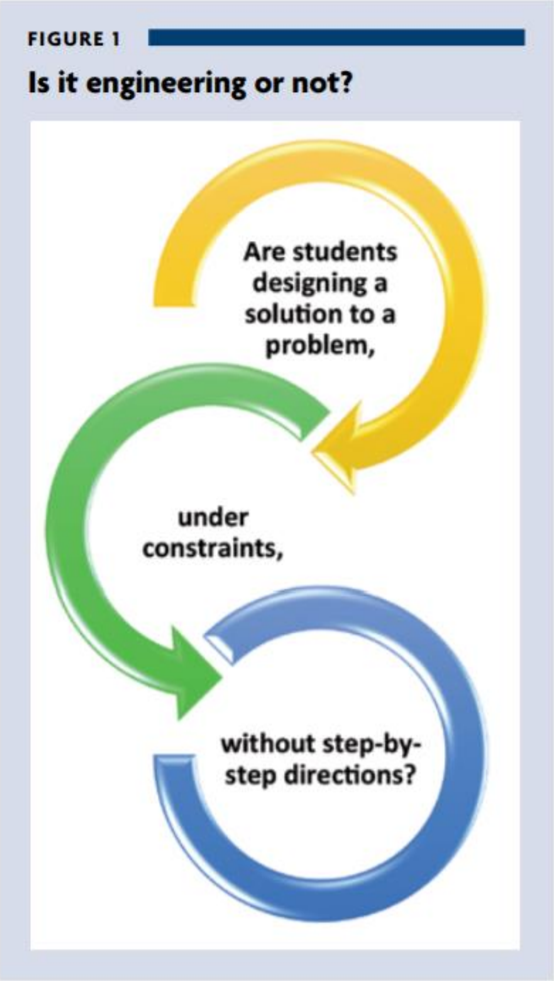
Focus is on modifying the world to solve problems and meet human needs and wants.

Engineers define problems and design solutions.

Overlapping Practices and Skills

Conducting research, using models, applying evidence to support design plans or ideas, using math, communicating with others

Is it engineering or not?

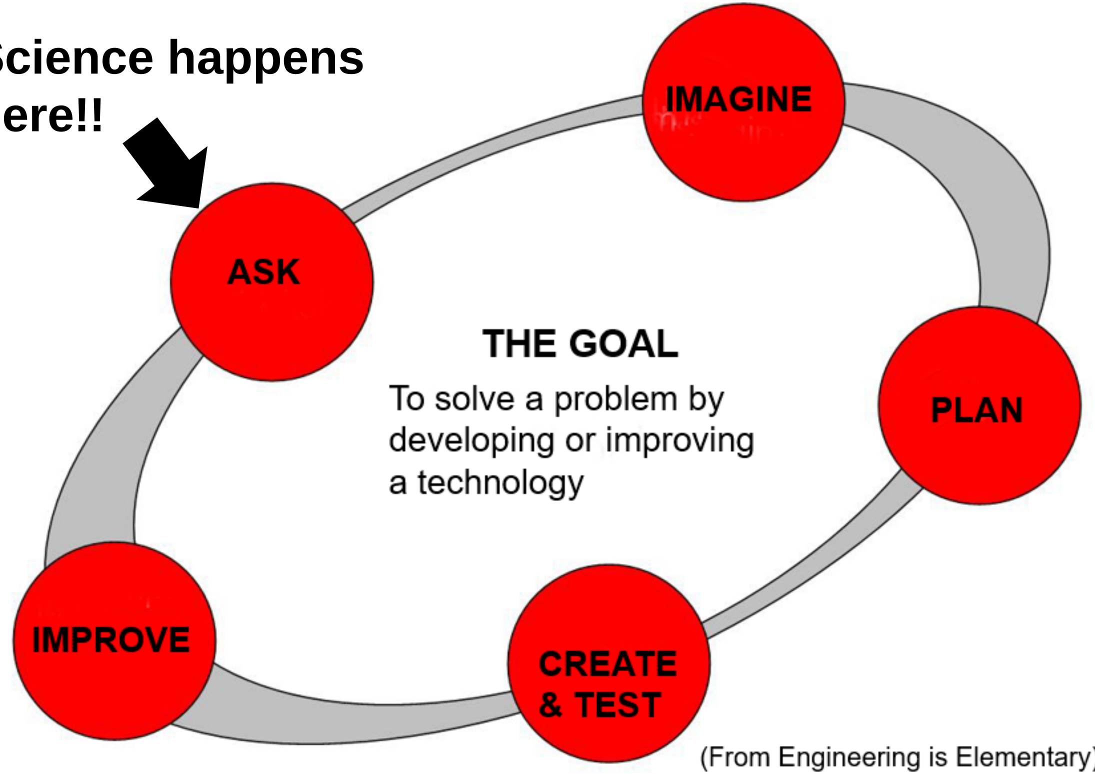


Whitworth, Brooke A., and Lindsay B. Wheeler. "Is It Engineering or Not?" *The Science Teacher* Summer (2017): 25-29. Web. 10 July 2017.

This is our goal!

The Engineering Design Process

Science happens here!!



(From Engineering is Elementary)

Science **before** the problem or science **after** the problem?

Advantages to Introducing the Problem First

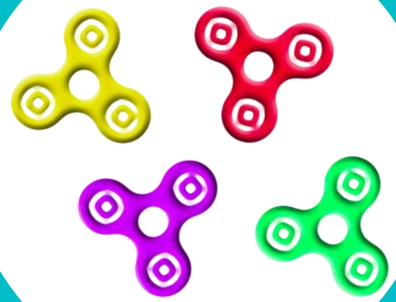
Big Picture - students always can see the forest through the trees

Buy in! Students learn the science for a purpose - better retention!

Advantages to Introducing the Science First

They ask better questions during the Ask phase

Faster movement from Introduction of the problem to brainstorming and designing the solution.



Let's Try it!

(Now you can wear your student hat)

THE PROBLEM

We’ve Been Hired!

We need to design a toy that will be entertaining enough that a panel of fifth graders will choose it on ABC’s The Toy Box.

Recent consumer research shows that kids like:

- electronic toys
- toys they can interact with

Constraints

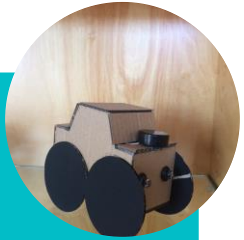
Materials - only what has been given to you

Time - 20 minutes

Criteria

Toy must incorporate a circuit

Toy must be interactive



ASK

What science background do you think will be helpful to keep in mind as we brainstorm solutions to this problem?

Example List from 7th Grade Class

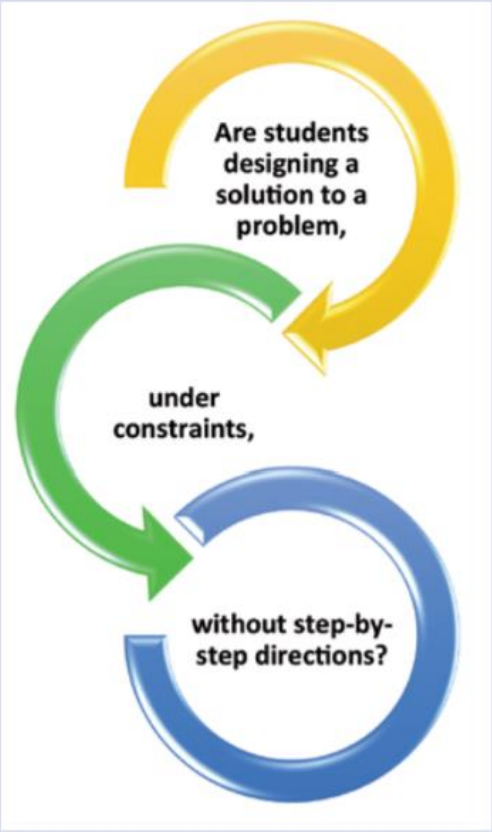
What "Science" Matters?

- LED's positive leg needs to connect to positive battery
- Only closed circuits will work
- parallel vs. series - there is a lot of info we know about why these might be important
- insulators have high resistance, conductors have low resistance
- electricity takes the path of least resistance - be careful about short circuits
- output devices, connectors and energy sources are required for a successful circuit
- Make sure you connect to both the positive and negative ends of energy source
- multiple loads increase resistance if wired in series

Get Brainstorming and Creating!

FIGURE 1

Is it engineering or not?



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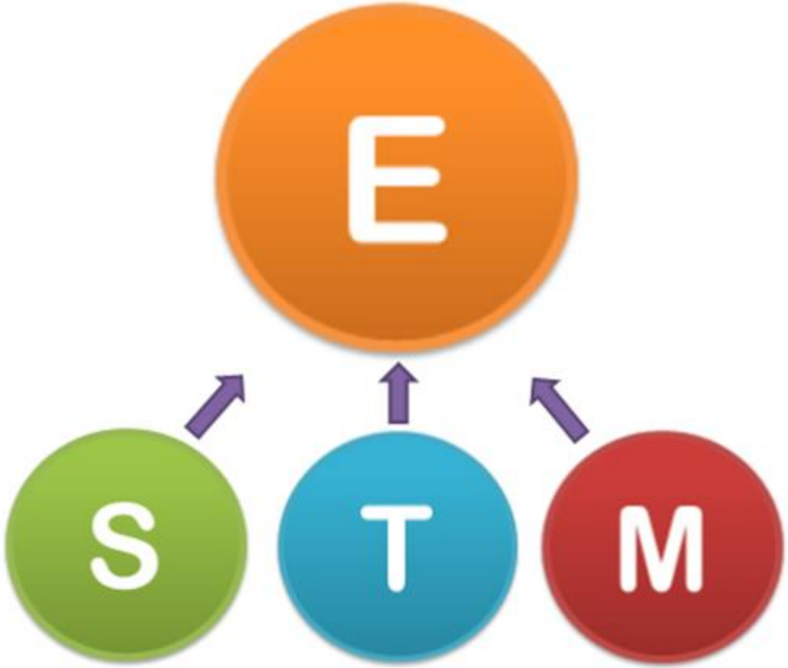
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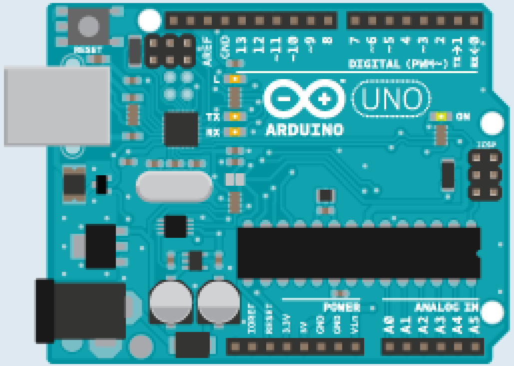
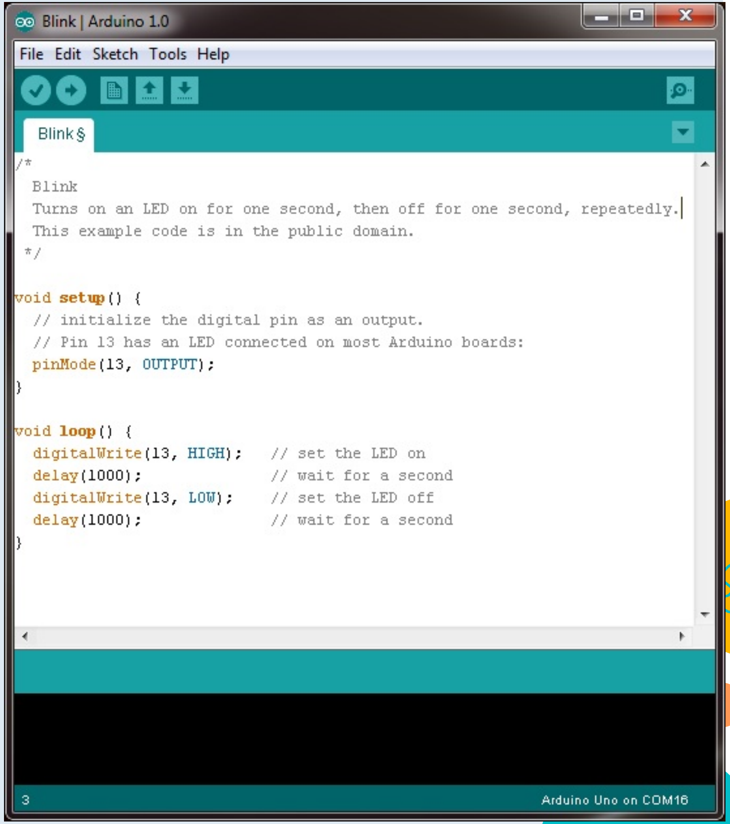
The Powerful Combination of Computer Progamming with Circuits

What is an Arduino?

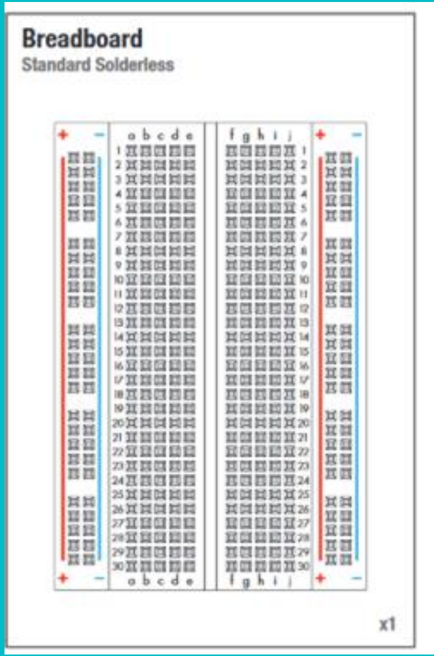
Small portable computer:

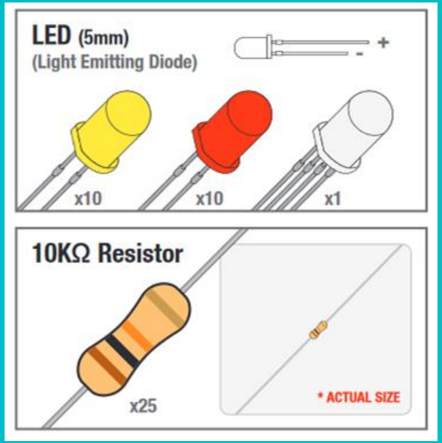
- interprets inputs to control outputs
- has its own simplified programming language

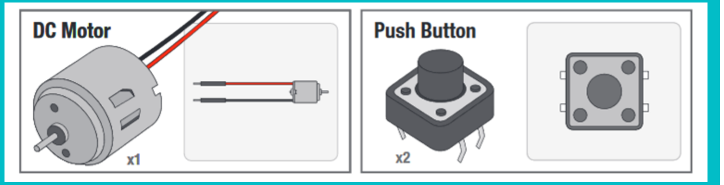


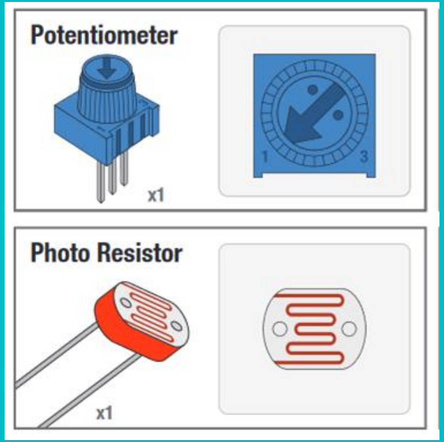


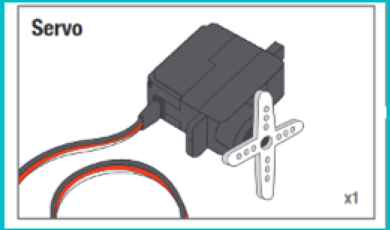
Options for the Toy/Arduino Combination











Inquiry Based Learning Using Arduinos

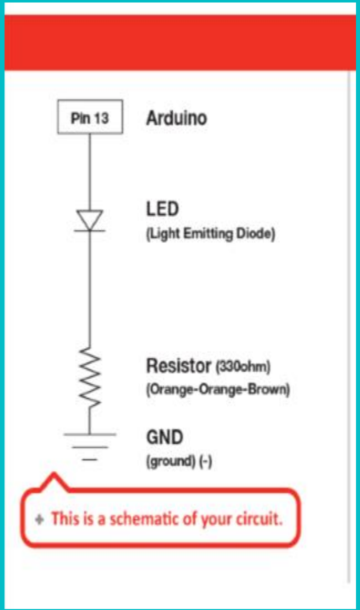
1. Begin with a block based Programming language to teach computational thinking and terminology. Examples: Scratch or Code.org

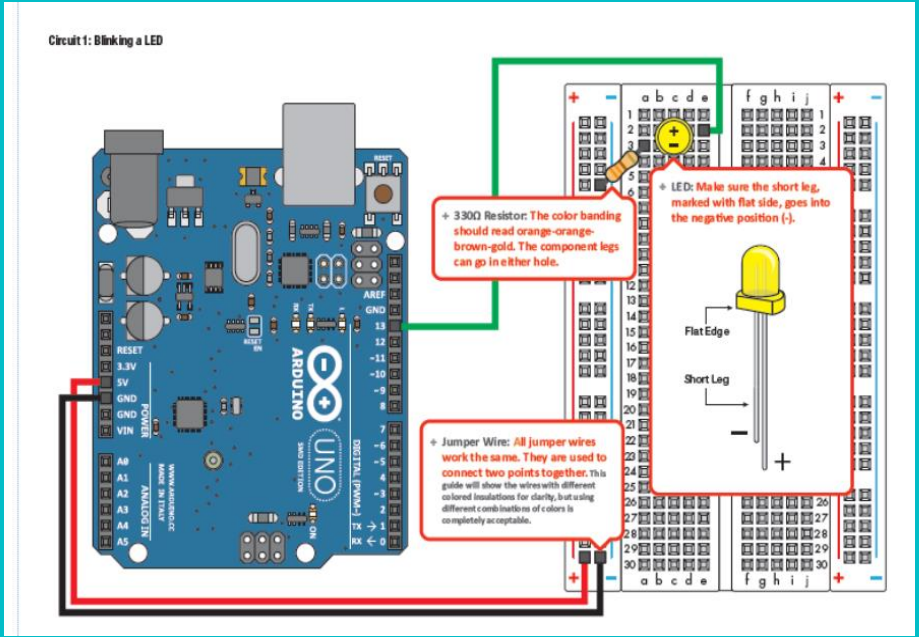
2. Students modify the input to get a different output using example Arduino programs! Make sure to have them document the input and corresponding output.

3. Take time to reinforce important programming concepts for each example and make sure to tie it back to the block based programming they did earlier.

4. Once they are comfortable, they can combine different example programs and find other programs online for their toy design!

Example 1: A Blinking LED





What is the **output** for this program?

What are the **input(s)** for this program?

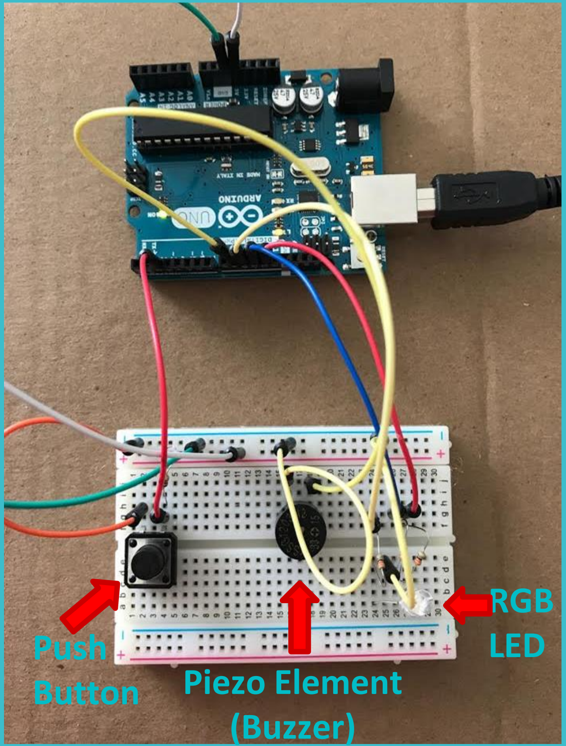
What are the key pieces of information in the **comments**?

Modify the program to make the LED blink faster or slower?

What did you change?

```
void loop()
{
  // The 13 digital pins on your Arduino are great at inputting
  // and outputting on/off, or "digital" signals. These signals
  // will always be either 5 Volts (which we call "HIGH"), or
  // 0 Volts (which we call "LOW").

  // Because we have an LED connected to pin 13, if we make that
  // output HIGH, the LED will get voltage and light up. If we make
  // that output LOW, the LED will have no voltage and turn off.

  // digitalWrite() is the built-in function we use to make an
  // output pin HIGH or LOW. It takes two values; a pin number,
  // followed by the word HIGH or LOW:

  digitalWrite(13, HIGH);   // Turn on the LED

  // delay() is a function that pauses for a given amount of time.
  // It takes one value, the amount of time to wait, measured in
  // milliseconds. There are 1000 milliseconds in a second, so if
  // you delay(1000), it will pause for exactly one second:

  delay(1000);              // Wait for one second

  digitalWrite(13, LOW);    // Turn off the LED

  delay(1000);              // Wait for one second

  // All together, the above code turns the LED on, waits one
  // second, turns it off, and waits another second.

  // When the computer gets to the end of the loop() function,
  // it starts loop() over again. So this program will continue
  // blinking the LED on and off!

  // Try changing the 1000 in the above delay() functions to
  // different numbers and see how it affects the timing. Smaller
  // values will make the loop run faster. (Why?)
}
```

The Positive Buddy is…



…never going to let you down.

How to Assess

Throughout the process and the final product

ASSESSMENT

- Require documentation of the process
- Consider individual reports even with group project
- Don’t emphasize success of the prototype

When it's real, students do real learning

Thank you!

Please find additional resources on the conference website including coding and project resources!

How can YOU do this?

1. Pick an Engineering Design Process and use it consistently
2. Pick a science topic you want to try this with and decide on a problem to solve (get insipiration from real life)
3. Put the science learning into the "Ask" phase of the EDP
4. Let students solve the problem – they will *naturally* use and apply the science you want them to learn