Engineering with Electromagnets

NSTA STEM Forum
San Francisco, CA
July 25, 2019

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UNIVERSITY OF CALIFORNIA, BERKELEY

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Session Goals

- Investigate a hands-on middle school physical science engineering activity aligned with NGSS.

- Reflect on how teachers can support classroom instruction of engineering and assess student ability to use an engineering design process.

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NGSS Performance Expectations

Engineering

MS-ETS1-4: Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

Physical Science

MS-PS2-3: Ask questions about data to determine the factors that affect the strength of electric and magnetic forces.

NGSS Science and Engineering Practices

Developing and Using Models (**ETS 1-4,** PS 3-2) Develop a model to generate data to test ideas about designed systems, including those representing inputs and outputs.

Asking Questions and Defining Problems (**PS 2-3,** ETS 1-1) Ask questions that can be investigated within the scope of the classroom, outdoor environment, and museums and other public facilities with available resources and, when appropriate, frame a hypothesis based on observations and scientific principles.

Engaging in Argument from Evidence (PS 2-4) Evaluate competing design solutions based on jointly developed and agreed-upon design criteria.

Analyze and Interpret Data (ETS 1-3) Analyze and interpret data to determine similarities and differences in findings.

NGSS Crosscutting Concepts

Cause and Effect (**PS 2-3**, 2-5) Cause and effect relationships may be used to predict phenomena in natural or designed systems.

Engaging in Argument from Evidence (PS 2-4) Evaluate competing design solutions based on jointly developed and agreed-upon design criteria

Engineering Design vs Scientific Inquiry

- A **scientist** pursues understanding of the natural world by using evidence to answer a question.
- An **engineer** uses science and tools to build a product that solves a practical problem.

NGSS Middle School Engineering Design

Defining the Problem

- How will end user decide whether or not the design is successful?
- How does the design effect the broader society and the environment?

Developing Possible Solutions

- address generating design solutions (elementary)
- evaluating using systematic method (middle)

Improving Designs

- An iterative process of test, re-design, re-test to optimize the solution

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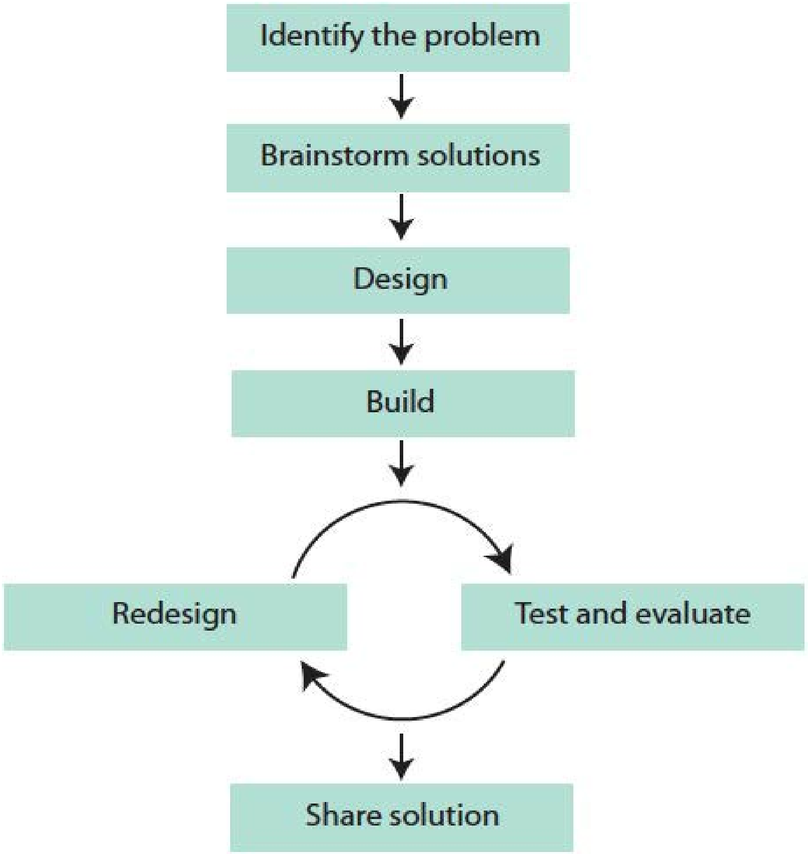
SEPUP's Engineering Design Process



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Electromagnets

Traditional Method:

- Battery (usually D-cell)
- Wire
- Iron Nail
- Paperclips

Pros:

- Relatively Simple
- Effective at showing electromagnetism

Cons:

- The circuit heats up quickly (Battery drains quickly)
- Not very powerful

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Electromagnets

Capacitor Method:

- Same as traditional with an added capacitor

Pros:

- Stronger magnetic field than traditional method
- Essentially no circuit heating (Batteries last longer)
- Allows for iterative designs

Cons:

- Less simple to use

What is a Capacitor?

A **capacitor** is a device that stores electric charge. When connected in a closed circuit, a charged capacitor will discharge its stored charge through the circuit. This creates a current in the circuit until the capacitor is discharged.

What does a capacitor do differently than a battery?

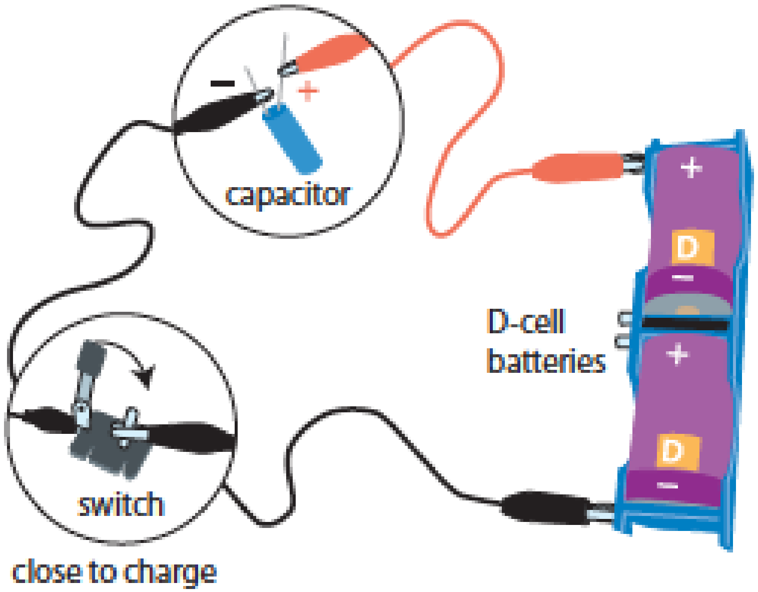
- The current it generates is higher than a battery of the same voltage because batteries have higher internal resistances.
- Once the capacitor is discharged, the current stops which prevents wires from over heating or batteries from draining

What Students Know

Going into this activity, students already know:

- Related to the materials:
    - How to charge the capacitor
    - Capacitors discharge quickly (less than 10 seconds)
    - How to wind the coils
- Electromagnetic properties:
    - Higher turn density = Higher magnetic field strength
    - Higher current = Higher magnetic field strength

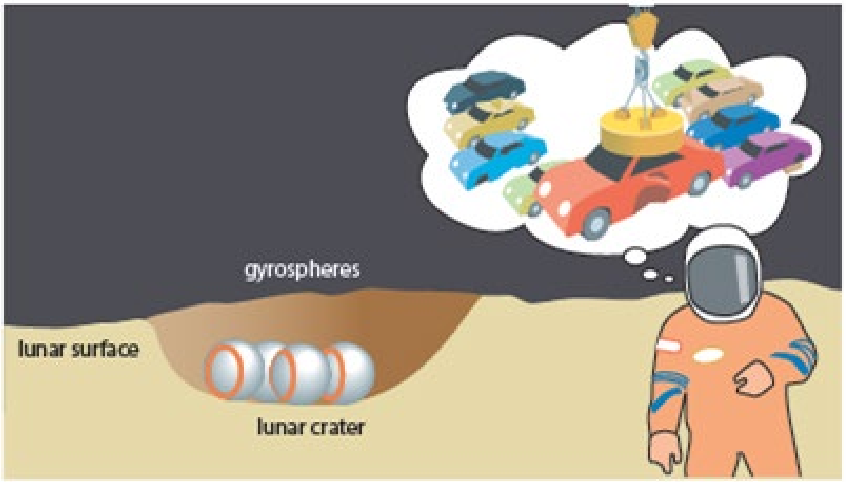
Charging the Capacitor



Identify the + and – wire leads on the capacitor. The + lead is longer. Connect – to – and + to +. Make sure that the the metal clips are not touching each other during charging or discharging.

Gyrosphere Rescue

- Students are revisiting a scenario but we'll just focus on the design criteria and constraints.
- Read through the Procedure and work with your team to come up with your design(s)
- Record your design process so that we can use the rubric.



Gyrosphere Rescue Assessments

- Procedure 1-3: Three-dimensional assessment of ETS1-4
- Analysis Items 1 and 2: Student reflection on Engineering Design Process
- Analysis Item 3: Three-diimensional assessment of PS2-3

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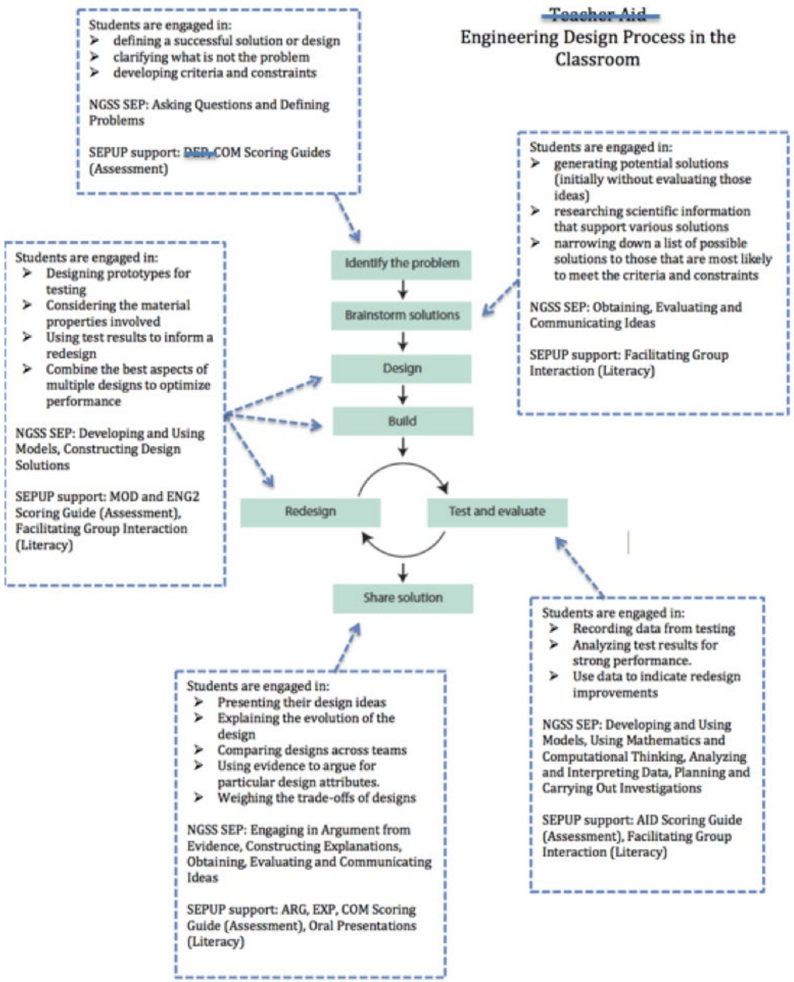
Implementing EDP in the Classroom

See handout



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Engineering Design Solutions assessment rubric

See handout

Level	Description
Level 4 *Complete and correct*	The student • uses all appropriate steps of the engineering design cycle, AND • meets all of the criteria within the defined constraints, AND • uses a combination of scientific concepts, data, and trial and error. • communicates the process followed to optimize the design.
Level 3 *Almost there*	The student • uses all appropriate steps of the engineering design cycle, AND • meets all of the criteria within the defined constraints, AND • uses a combination of scientific concepts, data, and trial and error.
Level 2 *On the way*	The student • uses some of steps of the engineering design cycle, AND • meets all of the criteria within the defined constraints, AND • uses a combination of scientific concepts, data, and trial and error.
Level 1 *Getting started*	The student uses some of the steps of the engineering design cycle, BUT the design does not meet any of the criteria.
Level 0	The student proposes no design or an irrelevant design.
x	The student has no opportunity to respond.

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Reflections

- Where was the NGSS engineering design present in the activity?
- How would you/your partner score on the engineering rubric?
- How could this approach for support and assessment be used on other engineering activities?

Wrapping up

Any questions?

Files can be found on NSTA website and *sepuplhs.org/news.html*