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BASIS Lesson Plan

Lesson Name: Turn It On, Turn It Off: Building An Electromagnet

Grade Level Connections:

Next Generation Science Standards: Grade 3, Physical Science (3-PS2)
Grade 4, Physical Science (4-PS3)
FOSS Next Generation Edition: Grade 3, Physical Science (Motion & Matter)
Grade 4, Physical Science (Energy)

**Note to teachers: Detailed standards connections can be found at the end of this lesson plan.*

Teaser/Overview

This hands-on lesson guides students to explore the relationship between magnetism and electricity. Students will first examine a variety of magnets to build an understanding that permanent magnets have some similar properties, but also that they can differ in their strengths. Students will then be introduced to the idea that electricity can be used to create a non-permanent electromagnet that can be turned on and off. They will make a hypothesis about how the voltage of a battery might affect the strength of a magnet. Students will work in pairs through all activities to emphasize the collaborative nature of science!

Lesson Objectives

- Students will understand that magnets have specific properties, such as their ability to push (repel) and pull (attraction) objects.
- Students will understand that magnets and electricity are connected and that you can use electricity to make a magnet.
- Students will make hypothesis about how the voltage of a battery may affect how powerful an electromagnet can be.
- Students will collect data in the form of the number of paperclips that can be picked up by an electromagnet. Students will also graph these results to look for patterns.

Vocabulary Words

Magnetism: an invisible force that pushes or pulls things towards a magnet without needing to touch. Magnetism cannot be seen, but the way it acts can be seen!
Attract: a magnet's pull

Repel: a magnet's push
Permanent Magnet: a magnet that is always in the "on" position
Electricity: a form of energy that results from charged particles (electrons)
Electromagnet: a magnet that is created using electricity. It can be turned "on" and "off" by turning electricity on and off.
Hypothesis: a guess based on things you already know and have previously observed

Materials

Scientist Volunteers will bring:

- Plastic baggies with a variety of magnets & objects (16)
  - Small disc magnets (2)
  - Small neodymium magnet (1)
  - Small flex magnet (1)
  - Paper clips (2)
  - Washers (2)
  - Foam blocks (2)
- Nail with copper wire coiled numerous times along the length (16)
- Paper clips (16 baggies with 50 paper clips each)
- AA 1-battery holders (1.5V) (16)
- AA 2-battery holders (3.0V) (16)
- AA (1.5 V) batteries (32 plus extra)
- Alligator clips (32 plus extra)
- Small magnets with pompom attached for graphing (32 blue, 32 red)

Materials teachers should provide:

Students should have pencils

Classroom Set-Up

We will start with a general introduction at the whiteboard and students will then be working together in pairs through several activities. Towards the end of the lesson, students will be creating a simple graph for their data and we will need a large section of magnetic white board space for this. If your whiteboard is NOT magnetic, please let us know beforehand. We will need access to a magnetic whiteboard and markers. Nametags for students are always very helpful!

Classroom Visit

1. Introduction (10 minutes)

Role Model Introduction:
Being a role model is an important part of being a BASIS volunteer! Begin your lesson by having each team member explain who they are and what they do as a scientist/engineer. Feel free to tell

your story as if giving an elevator pitch to elementary school students: Why did you become a scientist? What questions are you trying to figure out? What do you do in your job? Why should students relate to you? Feel free to bring in photos, specimens, and other props. Let your personality shine through!

Topic Introduction:
After you introduce yourselves as role models, take some time to introduce the topic of this lesson: permanent magnets and electromagnets. It may be helpful to keep the suggested take-away in the back of your mind throughout the lesson: **Magnets and electricity are connected – you can create a magnet (electromagnet) that you can turn on and off, using electricity.**

Your topic introduction should cover, at a minimum, the following information. As much as possible, try to frame this information as questions posed to the class, rather than as a lecture. This helps activate students' prior knowledge and facilitate student-guided conversation.

- Stick a magnet onto the white board behind you. "Who knows what this is?" [A magnet!] Today we're all going to be scientists and investigate how magnets work.
- Turn to the person sitting next to you and discuss three things you already know about magnets. And think of one thing you wonder about magnets. Have the students think-pair-share for a few minutes and then call their attention to the front again.
- Who here has used a magnet before? Where was it? On your refrigerator? What did you use the magnet for? What did you notice about the magnet? [Define **magnetism** and **force**]
- Do you think the magnet on your refrigerator is using a push or a pull to stay on there? [a pull] This pull is called **attraction** [define, write on board]. When magnets **repel** [define, write on board], the force they are using is a push.
- We're going to do some fun activities to explore magnets and understand their properties, and how you can use those properties of magnets to pull objects!

2. Learning Experience (45 minutes)

Students will work in pairs. Remember that all of these activities are designed to address the take-away in a particular way: **Magnets and electricity are connected – you can create a magnet (electromagnet) that you can turn on and off, using electricity.**

Activity 1: What Do Magnets Have In Common?

1. Engage students in a conversation about what properties magnets have.
    a. What kinds of things are magnetic? What kinds of things are not magnetic? How do magnets behave? In a moment, you and your partner are going to get a bag filled with objects. Some of these are magnets and some of them are not magnets. Try to figure out which ones are magnets and which ones are not. Make sure to explore the different properties of the magnets too!
2. Do the magnet sorting activity.
    a. Pass out bags of objects, one bag for each pair of students.

   b. Give the students a few minutes to play and explore with the objects. As you walk around and check in with students, provide some exploration prompts: "What are some similar things about the magnets that you notice? What are some differences?"
   c. Recollect the materials prior to wrap-up discussion for this activity.
3. Connect the activity to the big picture
   a. Invite students to reflect on the properties of the magnets. Did you notice any patterns about the objects that are magnets? How do they interact with each other? What about those objects that are not magnets? **Be sure to emphasize the difference between an object being magnetic versus it being a magnet. ** (e.g. a paper clip can be picked up by a magnet so it is **magnetic**, but it cannot pick up other paper clips by itself so it is not a **magnet**.
   b. Are there additional ideas that we can add to our list of properties of magnets?
   c. For those objects that were magnets, could you stop them from being magnetic? Were they always magnets? Or were they sometimes "on" and sometimes "off"?
   d. But what if we wanted to turn a magnet off? Is there a way to do that? Not with the magnets you examined. These are all called **permanent magnets** [Define, write on board]
   e. A nice real-world connection here are the magnets used to sort trash at waste management facilities.

Activity 2: Creating A Magnet Using Electricity

1. We can actually create a magnet using **electricity** [Define, write on board]. What do you know about electricity? Gather student ideas and write on board.
2. In a moment, we're going to work through an experiment together where we will use electricity to create a magnet. This is called an **electromagnet** [define, write on board]. This magnet is created using electricity and is different from our permanent magnets because we can actually turn them on and off.
3. Pass out worksheets to each pair of students. Instruct students to write their names at the top of the worksheet.
4. Show students a nail that has copper wire looped around it. This is what we will be usinig to create our electromagnet today. We're going to pass these out along with some paper clips. If the nail is a magnet, what will it be able to do with the paper clips? [Pick them up!]
5. Okay, when you get your materials, I want you to test it. Write down how many paper clips you're able to pick up with just the nail. [Pass out nail and bag of 50 paper clips to each pair of students.]
6. Did it work? [No!] That's because we need electricity!
7. In order to create electricity, we need a source of power and we need to create a circuit, which is essentially a circle. Draw a simple circuit on the board. For our experiment today, we're going to use batteries as our source of power.
8. We will be using batteries that are 1.5 volts (1.5V) and batteries that are 3 volts (3V). Do you think that the electromagnet we create with 1.5V versus 3V will differ in how many paper clips it will be able to pick up?

9. Before we pass out your other materials, talk with your partner and make a **hypothesis** (an educated guess) about what you think. Write it down now. Make sure all student pairs have written their hypothesis on their worksheet before proceeding to the next step.
10. Show students the first steps to set-up their electromagnet. Put the battery in the battery pack. Attach the alligator clips to the battery pack.
11. Pass out bags of other materials (batteries, battery packs, alligator clips). Make sure all student pairs have the correct set-up before proceeding to the next step.
12. The final step is for students to connect the alligator clips to the copper wire wrapped around the nail. Does the nail pick up any of the paper clips now? You just created an electromagnet! You are using electricity from the battery and that is creating the magnet!
13. Tell students that each person from the pair will have the chance to use the electromagnet. Place paper clips on the left side of the desk and see how many you can lift up and then drop on the right side of the desk. Repeat for each person. Record these numbers on the worksheet.
14. Undo the alligator clips from the 1.5V battery pack and from the copper wire.
15. Connect the alligator clips to the 3V battery. Connect the alligator clips to the copper wire. Repeat the experiment, moving as many paper clips as possible from the left side of the desk to the right side, using on the electromagnet. Repeat for each person. Record these numbers on the worksheet.
16. Have students clean up by placing the paper clips back into one bag. Keep the Nail out on the desk. And place all the other items back into the bigger bag.

Activity 3: Visualizing Data About Electromagnets

1. Now that you have all finished your experiments, we want to record your data (your numbers) and see what the class found. When we call your group, tell us the largest number of paper clips that you were able to pick up with the 1.5V and the 3V battery.
2. We will place a blue dot on the largest number of paper clips your magnet was able to pick up with a 1.5V battery and we will place a red dot on the largest number of paper clips your magnet was able to pick up with a 3V battery.
3. Model for students what this looks like. Call on each student pair to share their data. Place corresponding dots (data points) on the board.
4. Connect the activity to the big picture
    a. Discuss results with students. Do the data (numbers) support your **hypothesis**? Why or why not?
    b. Emphasize the overall takeaway of the lesson: **Magnets and electricity are connected – you can create a magnet (electromagnet) that you can turn on and off, using electricity.**

3. Wrap Up: Review and Discuss the Learning Experience (5 minutes)

It's important to leave time to **review** and **discuss** the learning experience at the end of the lesson. This might take the form of discussing conclusions from an experiment; or review of the take-away of the lesson

- Discuss the difference between a permanent magnet and an electromagnet
- Discuss how voltage affects the strength of an electromagnet

- Discuss the importance of repeating an experiment multiple times (trials) and the importance of visualizing our data using plots and graphs

4. Connections & Close (5 minutes)

Connections to the real world around students:
Magnets are also used in elevators, credit cards, electric toothbrushes, refrigerators, and your television! There are magnets just about everywhere, so keep exploring to see what you can do with magnets! Does anyone have any questions, about magnets, electricity, or being a scientist? Thanks and goodbye!

Follow Up: After the Presentation

Teachers who wish to extend the impact of this lesson may find the following CRS web pages useful:

- http://www.crscience.org/educators/helpfulreports
- http://www.crscience.org/educators/treasuretrove

Standards Connections

NGSS:

- Connections by topic
  - Physical Science: 3. Forces and Interactions
  - Physical Science: 4. Energy
- Connections by disciplinary core ideas
  - Physical Science: 3-PS2 Motion and Stability: Forces and Interactions
  - Physical Science: 4-PS3 Energy
- Connections by scientific & engineering practices
  - 3. Planning and carrying out investigations
  - 4. Analyzing and interpreting data
- Connections by crosscutting concepts
  - 2. Cause and effect: Mechanism and explanation
  - 5. Energy and matter: Flows, cycles, and conservation
- Connections by performance expectation
  - 3-PS2-3. Ask questions to determine cause and effect relationships of electric or magnetic interactions between two objects not in contact with each other.
  - 4-PS3-2. Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents.

FOSS Next Generation Edition:

Grade 3 Physical Science: Motion & Matter, Investigation 1 (Forces)
Grade 4 Physical Science: Energy, Investigation 3 (Electromagnets)