USE OR ABUSE: USING SCIENCE TO EVALUATE ELECTRICITY CONSUMPTION AT SCHOOL

Grade Level: Eighth Grade
Presented By: Tracy Ostrowski, Village Charter School, Chapel Hill, North Carolina
Length of Unit: Seven days, not including independent project time (7 lessons)

I. ABSTRACT

This unit provides students with background information about electricity and magnetism. The classroom lessons associated with the unit will prepare the students to conduct their own evaluation of electricity use (or abuse) at our school. The main goal of this unit is for the students to take the information they have learned about electricity and develop ways to encourage responsible production and use of energy at our current site and at our future school building. Students will have an opportunity to educate their schoolmates about electricity and to present an energy audit of the school to representatives from the school board.

II. OVERVIEW

A. Concept Objectives
   1. Students will understand characteristics of different types of magnets.
   2. Students will recognize that all magnets have certain characteristics in common regardless of shape, size, and strength.
   3. Students will review basic concepts of magnetism and electricity.
   4. Students will understand that there is a relationship between electricity and magnetism.
   5. Students will learn methods for calculating the rate of flow in an electric current.
   6. Students will understand that electricity is produced through a variety of methods.
   7. Students will be introduced to the concept of an electromagnet.
   8. Students will learn the concepts of electric potential and resistance.

B. Content from the *Core Knowledge Sequence* (197-198):
   1. Spinning electrons in an atom create a magnetic field around the atom.
   2. Unlike magnetic poles attract; like magnetic poles repel.
   3. Electricity and magnetism – Electricity as the flow of electrons.
   4. Flowing electricity.
      a. The total power of electric flow over time is measured in watts.
      b. Electric potential is measured in volts.
   5. Practical application of the connection between electricity and magnetism. **[North Carolina State Competency Goal 4.08]**

C. Skill Objectives:
   1. The student will conduct independent investigations to acquire knowledge about magnetism.
   2. The student will present information on magnetism and electricity to the class.
   3. The student will describe the shape and characteristics of a magnetic field.
   4. The student will use a compass as a tool to understand the relationship between electricity and magnetism.
   5. The student will construct a simple electrical circuit.
   6. The student will practice calculating resistance, voltage, and current.
   7. The student will develop a method for evaluating some aspect of energy production and use at our school.
   8. The student will make recommendations regarding plans for electricity use at our future school site.
   9. Students will build electromagnets and manipulate them to perform different tasks.

10. Students will evaluate each other's understanding of the relationship between electricity and magnetism.

III. BACKGROUND KNOWLEDGE

A. For Teachers:
   1. Wilson, Jerry D. *College Physics: Second Edition*. Englewood Cliffs, NJ: Prentice Hall, 1994. ISBN 0-13-145269-X.
   2. Griffiths, David J. *Introduction to Electrodynamics*. Englewood Cliffs, NJ: Prentice Hall, 1999. ISBN 0-13-805326-X
   3. Div, Grad. *Curl and All That*. W.W. Norton and Co., 1992. ISBN 0-393-96251-2.
   4. Miller, G. Tyler. *Sustaining the Earth: An Integrated Approach*. Wadsworth Publishing, 1999. ISBN 0534239226.

B. For Students:
   The students will have a background in basic electricity from classes taken in Grade 4.

IV. RESOURCES

A. Wainwright, Camille L, Ph.D. *Electricity and Magnetism.* Upper Saddle River, NJ: Prentice Hall, 2000. ISBN 0-13-434566-5.

B. *Science Insights: Exploring Matter and Energy*. Menlo Park, CA: Addison-Wesley Publishing Company, Inc, 1994. ISBN 0-201-81002-6.

V. LESSONS

Lesson One: What is a Magnet Anyway?

A. *Daily Objectives*
   1. Concept Objectives
      a. Students will understand characteristics of magnets.
      b. Students will recognize that all magnets have certain characteristics in common regardless of shape, size, and strength.
   2. Lesson Content
      a. Spinning electrons in an atom create a magnetic field around the atom.
      b. Unlike magnetic poles attract; like magnetic poles repel.
   3. Skill Objectives
      a. The student will conduct independent investigations to acquire knowledge about magnetism.
      b. The student will present information on magnetism and electricity to the class.
      c. The student will describe the shape and characteristics of a magnetic field.

B. *Materials*
   1. 8 circular magnets
   2. 2 horseshoe magnets
   3. 4 bar magnets
   4. 8 plastic-coated bar magnets w/ handles
   5. Paper and pencil
   6. Assorted nails, coins, staples, paper clips

C. *Key Vocabulary*
   1. Magnetic pole - the area of a magnet where the magnetic field is strongest.
   2. Magnetic field - the region of magnetic force around a magnet.

D. *Procedures/Activities*
   <u>DAY ONE</u>
   1. Teacher opens class discussion by asking the following questions:

a. What are magnets?
b. How do we use magnets?
c. How do magnets work?

2. Split class into 4 groups.
3. Assign each group a different type of magnet.
4. Instruct students to discuss their assigned magnet as a group and to develop 5 questions about the magnet that they could attempt to answer during the next 20 minutes. Ex: How many paper clips linked in a chain can a bar magnet hold? Where are the poles located on a circular magnet?
5. Review the questions for appropriateness prior to distributing equipment. Make sure that the questions can be answered through simple experimentation and observation in approximately 5 minutes apiece.
6. Students should keep a detailed record of their observations because they will be sharing their findings with the rest of the class at the conclusion of the independent exploration period.
7. Recap major points covered in presentations. Review questions discussed at the top of the class. Check choral response to see if students had their questions answered; use individual responses to gauge understanding of polarity, attraction, and repulsion.

DAY TWO

1. Write all directions on board prior to students' arrival in classroom.
2. Read pp. 14-21 of *Electricity and Magnetism* and complete review questions on additional handout (Appendix A).
3. Allow students to work independently for 20 minutes on questions.
4. Use this time to review their work and answer questions.
5. Select student to lead discussion of worksheet answers. Grade papers in class after 25 minutes.
6. Assign reading on pp. 24-29 for homework. Quiz (Appendix B) tomorrow.

E. *Assessment/Evaluation*

1. Each group must present a 3-5 minute summary of their questions and results to the entire class at the conclusion of day one.
2. Each student must contribute to the presentation or answer a question from the class or teacher.
3. Students are graded based on their participation and their ability to explain the concepts.
4. After the worksheets are graded in class on day two, the teacher will review the papers and record initial grades. The papers will be returned to the students for corrections and re-grading.

Lesson Two: Completing the Circuit

A. *Daily Objectives*

1. Concept Objectives
   a. Students will review basic concepts of magnetism and electricity.
   b. Students will understand that there is a relationship between electricity and magnetism.
2. Lesson Content
   a. Spinning electrons in an atom create a magnetic field around the atom.
   b. Unlike magnetic poles attract; like magnetic poles repel.
3. Skill Objectives
   a. The student will conduct independent investigations to acquire knowledge about magnetism.

b. The student will present information on magnetism and electricity to the class.
c. The student will describe the shape and characteristics of a magnetic field.

B. *Materials*
1. 8 D cell batteries
2. 4 flashlight bulbs
3. 10-20 20 cm pieces of coated copper wire
4. 4 light bulb holders
5. 8 battery carriers
6. 12 small circle compasses

C. *Key Vocabulary*
1. Electric circuit - a complete path through which electrical charges can flow
2. Electric current - the flow of charge through a material

D. Procedures/Activities

DAY ONE

1. Write review questions on board prior to start of class. Give the students 5 minutes to answer in complete sentences:
   Explain how your refrigerator can become magnetized by the earth.
   Why does the Earth have North and South poles like a magnet?
   What would happen to a bar magnet that is broken into two pieces? How would the domains of the two pieces be arranged?
2. Explain that we will be conducting an investigation on the interaction between compasses and electrical circuits. The first step is reviewing how to construct a simple circuit.
3. Ask class to explain electricity; how do we use it, how do we produce it, what is it? (they learn basic concepts of electricity in Grade 4, so this should be a review).
4. Before constructing circuits, students should understand that electricity is the flow of charged particles and a circuit is a path through which the particles move.
5. Divide class into four new groups and distribute materials. Draw diagram of a circuit using one D cell battery and a light bulb to demonstrate the flow of electricity.
6. Have students construct the circuit with teacher assistance.
7. After all of the students have constructed a simple circuit, introduce concept of a switch and have students try to figure out how to incorporate a switch into their circuits.
8. Allow the students the remaining time to experiment with multiple power sources, multiple switches, and any other configuration they can develop.
9. Write instructions for materials clean up on board. Give students 5 minutes to clean room, but tell them to keep a pencil and a piece of scrap paper on their desks.
10. Review workings of a simple circuit and electricity through individually answered questions.
11. Ask students to write down why they think we are studying electricity after spending two days on magnets. Collect their responses and review them before the next class.

DAY TWO

1. Before class, teacher places materials for constructing a simple circuit on students' desks.
2. Teacher writes instructions on board prior to start of class:

a. Sit with the same group you worked with yesterday.
b. Use the materials on your desk to construct a simple circuit with a switch.

3. Teacher distributes "Electricity and Magnetism Exploration" handout (*Electricity and Magnetism* p.30)
4. Students finish building circuits and turn their switches to the off position.
5. Students place small circular compasses at three points underneath the wire, the wire should not be touching the compasses, but the wire should be centered above the compass.
6. Students record the position of the compass arrows.
7. Students turn switches to "on" position and record position of the compass arrows when circuit is closed.
8. Students should repeat this trial 2-3 times.
9. Teacher instructs students to experiment with changing the direction of the current and moving the compasses and placing the compasses at different locations along the circuit.
10. Teacher collects all materials.
11. Students answer the following questions in writing:
    a. What happened to the compasses when you closed the circuit?
    b. What variations did you try on the experiment? Were your results different?
    c. What can you infer about electricity and magnetism?
12. Students present answers to questions a-c to entire class.
13. Students discuss review questions: ex. What is electricity? How does it relate to magnetism? Describe what causes magnetism.
14. Students use remaining class time to read through text pgs. 30-35; any unfinished reading is homework.
15. Ask review questions: ex. What is electricity? How does it relate to magnetism? Describe what causes magnetism.

E. *Assessment/Evaluation*

1. Teacher will review corrected quizzes for any gaps in information regarding magnetism.
2. Teacher will observe groups building simple circuits independently to check skills.
3. Teacher evaluates student participation in oral presentation of results on day two.

Lesson Three: Electromagnetism

A. *Daily Objectives*

1. Concept Objective
    a. Students will understand that there is a relationship between electricity and magnetism.
    b. Students will be introduced to the concept of an electromagnet.
2. Lesson Content
    a. Electricity and magnetism – Electricity as the flow of electrons.
    b. Practical application of the connection between electricity and magnetism. **[North Carolina State Competency Goal 4.08]**
3. Skill Objectives
    a. Students will build electromagnets and manipulate them to perform different tasks.
    b. The students will evaluate each other's understanding of the relationship between electricity and magnetism.

B. *Materials*
   1. 8 D cell batteries
   2. 10-20 20 cm pieces of coated copper wire
   3. 8 battery carriers
   4. 4-6 iron nails
   5. 12-20 paper clips
   6. 8 switches

C. *Key Vocabulary*
   1. solenoid – a current carrying coil of wire with many loops.
   2. electromagnet – a solenoid with a ferromagnetic core.

D. *Procedures/Activities*
   1. Distribute materials to each lab table.
   2. Draw diagram of electromagnet on the dry-erase board.
   3. Instruct students to follow diagram and build their own electromagnets.
   4. The students should demonstrate the electromagnet for the teacher using the paper clips.
   5. Each group of students must answer the following question in writing after discussing the answer:

      Using what you have learned about the production of electricity and the causes of magnetism, please explain why you are able to produce a magnet using an electric current.

   6. Challenge Activity: Construct a device that will allow you to accomplish the following tasks:
      a. Lift one paper clip from a container full of paper clips. You must complete this task with your hands at a height of 3 feet.
      b. Transport the paper clip 4 feet horizontally.
      c. Drop the paper clip into a second cup likewise from a height of 3 feet without touching the wires, battery, magnet, paper clip, or electrical clips.

E. *Assessment/Evaluation*
   1. Teacher will select one member of each group randomly and have that student give the group's answer for the question under procedure #5. The student should be able to explain the group's position thoroughly without the aid of written notes. Groups will be awarded points based on their correct use of the principles of electricity and magnetism in formulating their answers, not on whether they are absolutely correct.
   2. The teacher will observe the decisions students make while completing the challenge activity to note their understanding of how to increase magnet strength and how to cut the flow of a circuit.

Lesson Four: Calculating Electricity Usage

A. *Daily Objectives*
   1. Concept Objectives
      a. Students will learn methods for calculating the rate of flow in an electric current.
      b. Students will learn the concepts of electric potential and resistance.
   2. Lesson Content
      a. Flowing electricity.
         1. The total power of electric flow over time is measured in watts.
         2. Electric potential is measured in volts.
      b. Practical application of the connection between electricity and magnetism.

3. Skill Objectives
    a. The student will develop a method for evaluating some aspect of energy production and use at our school.
    b. The student will practice calculating resistance, voltage, and current.

B. *Materials*
1. Plastic tubing in various lengths and diameters.
2. Water.
3. Stopwatch.
4. Buckets (two for each group).

C. *Key Vocabulary*

D. *Procedures/Activities*
1. Students should retrieve jackets for this outdoor activity.
2. Divide students into groups of four.
3. Each group of students gets 4-5 different plastic tubes. Make sure that they have a variety of both lengths and widths.
4. Students should predict which tube will conduct a set volume of water in the shortest amount of time.
5. Teacher gives students 15 minutes to write a procedure.
6. Once all procedures are ready, the students and teacher go outside to complete the procedures. The teacher should allow the students between 10 and 15 minutes to complete their procedures.
7. At the conclusion of the activity, each group will present their findings regarding the rate of flow to the rest of the class.
8. Students will read chapter 2; section 2 from *Electricity and Magnetism* to connect the activity with concepts related to flow of electricity.

E. *Assessment/Evaluation*
1. The day following the activity, the students will write a short essay in class explaining the relationship between the activity and electricity and will have the option of reading their essays to the class. This type of reflection will allow the students time to focus their ideas about the activity and to refine their ideas by comparing them with the ideas proposed by class mates.
2. The teacher will also evaluate students based on their performance during the group activity. The teacher should ask questions to evaluate each group member's understanding of the procedure the group designed.

VI. CULMINATING ACTIVITY

A. At the conclusion of the in class portion of the unit, the students will have an opportunity to visit a local power plant to speak with the engineers responsible for its upkeep.

B. The students will be required to conduct an independent investigation of energy use practices at Village Charter School as part of this unit. They will work in groups of three or four. The project will take 5 weeks to complete, so the culminating activity (the project presentations) will occur 2 weeks after the conclusion of the in-class portion of the unit. Possible projects include, but are not limited to:

* How much electricity does each student use per day?
* How can we decrease electricity use per capita?
* Can alternative sources of energy production be utilized at our school?
* How can we educate people about the benefits of solar energy?
* Are we wasting electricity at school?
* What are the environmental impacts of the energy consumption at VCS?

The assignment for the project is as follows:

1. Students will be permitted one in-class work period per week and will get an additional work period during the week that presentations are due. The teacher should give each student a schedule of work periods and assignment deadlines prior to the start of the project.
2. Meet with your team members during the first in-class work period.
3. By the conclusion of the class period your team must develop a purpose and hypothesis for your investigation of electricity consumption at VCS. The teacher should evaluate questions carefully to insure that they are appropriate for the resources and time available.
4. Each student must bring a one-page summary of at least three sources of background information on energy use and/or production to work period two. Each student must also complete a bibliography for the sources. These reports should be collected at the beginning of the period.
5. At the conclusion of work period two, each group should have a rough draft of the experiment they will conduct for the remaining three weeks.
6. Each group should have preliminary results to share with the class at the beginning of work period three. At this point in the project, the work periods become an opportunity to meet with the teacher and analyze the data that the groups are collecting.
7. At the conclusion of work period four, the groups should have a rough outline of their presentation and an audio/visual needs list for the teacher.
8. Work period five should just be a dress rehearsal for the presentation later in the week.
9. In addition to presenting their project, the students must also turn in a complete bibliography for all sources they used to complete their project, including interview subjects.
10. The students are evaluated according to the rubric in Appendix C.

VII. HANDOUTS/STUDENT WORKSHEETS

A. Appendices A-D.

VIII. BIBLIOGRAPHY

Wilson, Jerry D. *College Physics: Second Edition*. Englewood Cliffs, NJ: Prentice Hall, 1994. ISBN 0-13-145269-X.

Griffiths, David J. *Introduction to Electrodynamics*. Englewood Cliffs, NJ: Prentice Hall, 1999. ISBN 0-13-805326-X

Div, Grad. *Curl and All That.* W.W. Norton and Co., 1992. ISBN 0-393-96251-2.

Miller, G. Tyler. *Sustaining the Earth: An Integrated Approach*. Wadsworth Publishing, 1999. ISBN 0534239226.

Wainwright, Camille L, Ph.D. *Electricity and Magnetism.* Upper Saddle River, NJ: Prentice Hall, 2000. ISBN 0-13-434566-5.

Science Insights: Exploring Matter and Energy. Menlo Park, CA: Addison-Wesley Publishing Company, Inc, 1994. ISBN 0-201-81002-6.

Appendix A – Use or Abuse?

Basic Concepts of Magnetism

Name: _____
Date: _____

Part I: Define the following terms.

1. Magnetic pole:
2. Magnetic field:
3. Electron spin:
4. Magnetic domain:

Part II: Answer the following questions in complete sentences.

1. How do magnetic domains differ between magnetized and non-magnetized materials?

2. How can you make a magnet?

3. What are two forces that can destroy a magnet? Why do these forces "un-magnetize" magnets?

4. What are three new pieces of information you learned about magnets? How can you use this new information?

Appendix B – Use or Abuse?

Magnetic Earth Quiz

Name: _____
Date: _____

Directions: Answer the following questions in complete sentences. You will have 5 minutes to complete the quiz.

1. Explain how your refrigerator can become magnetized by the earth.

2. Why does the Earth have North and South poles like a magnet?

3. What would happen to a bar magnet that is broken into two pieces? How would the domains of the two pieces be arranged?

Appendix C – Use or Abuse?

Electricity and Magnetism Lab

Name: _____
Date: _____

Directions: Complete the following tasks using the materials distributed by the teacher.

Purpose: To examine the relationship between electricity and magnetism.

Materials:

7. 8 D cell batteries
8. 4 flashlight bulbs
9. 10-20 20 cm pieces of coated copper wire
10. 4 light bulb holders
11. 8 battery carriers
12. 12 small circle compasses

Procedure:

3. Build a complete electrical circuit with a switch and turn your switch to the off position.
4. Place small circular compasses at three points underneath the wire, (the wire should not be touching the compasses, but the wire should be centered above the compass.)
5. Record the position of the compass arrows.
6. Turn switches to "on" position and record position of the compass arrows when circuit is closed.
7. Repeat this trial 2-3 times.
8. Change the direction of the current and move the compasses to different locations along the circuit.
9. Answer the following questions in complete sentences on a separate sheet of paper:
    a. What happened to the compasses when you closed the circuit?
    b. What variations did you try on the experiment? Were your results different?
    c. What can you infer about electricity and magnetism?

Appendix D – Use or Abuse?

Electricity and Magnetism Project Rubrics

One-page Background Information Summary

Appropriateness of Topic	/10 pts.
Grammar/Spelling	/10 pts.
Organization	/10 pts.

5 Source Bibliography

Used 5 sources	/10 pts.
Correct Format	/10 pts.

Final Presentation

Organization/Preparation	/10 pts.
Participation of Full Group	/10 pts.
Correct Information	/10 pts.
Visual Aids	/10 pts.
Methodology of Research	/10 pts.