Kay Kirman
IISME Veteran Teacher Fellow
Intel Corporation
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Charged Up! The Power of Magnetism & Electricity

The Intel Experience

Current chip manufacturing technology requires an abundance of chemicals combined with procedures that can create unsafe—even deadly—working conditions. Intel is an internationally recognized steward of the environment who is also at the forefront of creating the safest workplace possible. Intel's core values (*informed risk taking, commitment to quality, great place to work, disciplined conduct, results orientation,* and *focus on customers*) drive this process. Committed to *"do the right things right"* in an environment that *"foster(s) innovation and creative thinking"* while it strives to *"be an asset to its communities worldwide,"* Intel staffs an Environmental Health & Safety division responsible for insuring compliance with local, state, Federal, and international laws. But, the company doesn't stop at corporate practices. Intel takes the extra step by educating employees about how their individual actions affect the environment. For example, the company supports employee telecommuting (tele-computing) to reduce what is the greatest single factor in air and water pollution in the United States: automobile exhaust and related oil leakage.

Needs Assessment: Education Transfer Plan (ETP) Opportunity

I: The Students: Fostering Innovation and Creative Thinking

This ETP was inspired by three of my Grade 4 students who will be returning to my Grade 5 classroom in August 2005. The first, a gifted girl, loves to invent and once shared her personal philosophy: *"I believe in the impossible."* This is uncannily like the vision of Robert Noyce, Intel's co-founder, who said: "*Do not be encumbered by history. Go off and do something wonderful*." The second, an average male student, was frequently disengaged with the curriculum, but when study turned to magnets, circuits, and related matters he was positively electrified, pushing himself to determine how things worked and trying to make them perform better. The third, another male student, required frequent peer and teacher support to understand basic grade level concepts. However, he found his niche when he learned about the pollution potential of batteries during an Intel-inspired unit on the urban water cycle and waste water treatment. He returned to class after scouring his entire home for every dead battery (more than 60), which his friends helped sort into recyclable or rechargeable categories. He became an inspiration to others who then began bringing in their own non-rechargeable dead batteries for a spontaneous classroom recycling campaign.

II. The Standards: Doing the Right Things Right

In the late 1990s, California adopted state standards for the teaching of core subject matter (i.e., English language arts, mathematics, science, history-social science, and visual and performing arts). Organizing elementary study by grade and discipline gives individual districts, schools, and students a roadmap for a common framework of understanding. There is a catch, though. Like other pupils, California's Grade 5 students—regardless of their facility with English or individual learning modalities—take hours of written standardized tests in mathematics and language arts each spring. Fifth graders have an additional challenge: a 60-question test on science disciplines (physical science, life science, earth science, and experimentation and investigation). Forty percent of these questions ask students to evaluate relationships between chemistry and physics or interpret results of scientific experiments, a particular hurdle in schools where little to no science equipment exists. Teachers face another challenge: insuring key related physical science and earth science concepts from Grade 4 (magnetism and electricity) were understood while introducing new Grade 5 (periodic table) concepts.

ETP-RELATED CALIFORNIA CONTENT STANDARDS & TESTING ITEMS:

Physical Science

Grade 5 (11 Items Assessed)

- ✓ Elements and matter

Grade 4 (7 Items Assessed)

- ✓ Electricity and magnetism

Earth Science

Grade 4 (7 Items Assessed)

- ✓ Properties of rocks and minerals

Investigation and Experimentation

Grades 4 & 5 (6 Items Assessed)

- ✓ Scientific process

COMPLETE CALIFORNIA SCIENCE CONTENT STANDARDS

Grade 4 http://www.cde.ca.gov/be/st/ss/scgrade4.asp

Grade 5 http://www.cde.ca.gov/be/st/ss/scgrade5.asp

III. The Environment: Being an Asset to Our Community

Game boys and cubes, portable CD and DVD players, clocks and gadgets, small electronics and home computers. Today's students are surrounded by electronica. They are targeted by marketers and respond to those appeals to get the latest, greatest, newest thing that may ultimately—and quickly—end up in the garbage where it will be shipped off to take up increasingly precious landfill space. Worse, chemicals from this form of household waste may leach into the soil where they can contaminate both earth and groundwater. We can make every day *Earth Day* by guiding our students to become both responsible consumers and stewards of the planet they will soon inherit. Setting up an electronics recycling program may be too great a challenge for elementary school, but these students can still help their environment by recycling batteries and educating others about the importance of activities like this.

ETP Solution: The 5 E's Lesson Model for Inquiry-Based Learning

National Science Teaching Standards (NSTS) encourage inquiry-based learning in which teachers take on the role of guides as students construct their own hands-on understanding of the science topic under study. This ETP will be part of the 5 E's Lesson Design Pilot to be posted on-line in the fall of 2005 at www.iisme.org.

- *Engage*: Teacher captures student attention, stimulates thinking, and taps prior knowledge (including potential gaps in understanding).
- *Explore*: Students think, plan, investigate, collect, and organize information.
- *Explain*: Students analyze their own explorations then clarify and modify their understanding through the reflective nature of the process.
- *Extend*: Students expand and solidify their understanding by making real-world connections.
- *Evaluation*: Students create a performance-based activity that connects all the pieces of the process.

Charged Up! The Power of Magnetism & Electricity

The following inquiry-based lesson deepens student understanding of magnetism and electricity as it extends their knowledge to batteries. Students explore the history of battery development, impact on industry, and chemical and physical properties. Students learn that non-rechargeable batteries are a form of "universal waste" and undertake a service project to raise awareness of how to properly dispose of such materials.

Engage (Intel Core Value: *Risk Taking—Foster Innovation & Creative Thinking*)

Will It Work? Why?

Students investigate batteries and other components to find working combinations (e.g., light a bulb, ring a buzzer, run a motor). Through journaling, they describe and begin to process their discoveries.

Objectives

- Design a working circuit.
- Record parallel and series circuit connections.
- Explain how the circuit depends upon each of its components.

Materials (1 set for each group or station)

Batteries (AA or AAA)—min. 2/student
Battery holders
Paper clips—min. 4/student
Copper wire—6 strips, each approx. 2' long
Masking tape
Wood blocks
Buzzers
Small light bulbs (e.g. Christmas tree lights)
Optional:
Motors
Digital clock faces

Procedure

1. Set up the station or distribute the materials to small groups of no more than 6 students.
2. Demonstrate how to insert and extract batteries from their holders.
3. Discuss potential safety hazards and record group safety solutions.
4. After Instructing students to record (in words and pictures) each attempt they make to fulfill the challenge, provide time for them to explore how to use the materials to light the small bulb or ring the buzzer.
5. Introduce and discuss vocabulary (circuit, parallel, series, switch, open, closed) and ask students to record commonly agreed upon definitions.
6. Remind students to record each effort they make then give them the following challenge(s):
   a. Light 2 bulbs in a series circuit pattern.
   b. Light 2 bulbs in a parallel circuit pattern.
   c. Ring 1 buzzer and light 1 bulb in a series circuit.
   d. Ring 1 buzzer and light 1 bulb in a parallel circuit.
   e. Create and solve a challenge of your own.

References: SFUSD's Mission Science Center

Core Learning Goals (California Content Standards)

Grade 4 Physical Science: 1a. Design and build simple series and parallel circuits by using components such as wires, batteries, and bulbs.
1g. Electrical energy can be converted to heat, light, and motion.
Grade 5 Investigation & Experimentation: 6g. Record data using appropriate graphic representations (e.g. charts, graphs, and labeled diagrams) and make data-based inferences.

Lesson Resources

The Learning Circuit

Students draw a battery, label known parts, describe how they think it works, and list at least 2 questions they have about batteries. After sharing their drawings and ideas, information is compiled into a K (Know) – W (Want to Know) chart to guide their inquiry.

Objectives

- Outline battery anatomy.
- Discuss electrochemistry and determine flow of electrons in a circuit.

Materials

Chart paper divided into 3 columns labeled K (Know) – W (Want to Know)—L (Learned)
Venn Diagram
Various batteries

Procedure

1. Review student drawings from the *Will It Work? Why?* section.
2. Distribute various batteries (AA, AAA, C, D, 9-volt, etc.). Ask students to draw their samples.
3. Discuss battery design and create a Venn Diagram to compare similarities and differences among battery types (e.g., cylinder vs. rectangular prism).
4. Ask students to record the Venn Diagram.
5. In a "pair and share," instruct students to describe how they think batteries work. Students summarize and record what their partner said.
6. Guide students to create "K" statements and "W" questions (explain the "L" column will be completed later). Be sure they include suggested resources for answering their questions.

References

Battery Basics, http://electronics.howstuffworks.com/battery1.htm
Millenium Batteries, www.milleniumbatteries.com/Battery101/Science/anatomy.htm

Core Learning Goals

Grade 5 Investigation & Experimentation: 1a. Classify objects in accordance with appropriate criteria.

Lesson Resources

K-W-L Chart
Venn Diagram

Shocking Ideas

Students use a combination of metals and natural materials (e.g., their hands, lemons, potatoes, coins) to create working batteries.

Objectives

- Create a flow of electrical charge (current).
- Accurately take readings from electrical meters (e.g. voltmeter, microammeter).
- Define conductor and insulator.

Materials

Hand Battery:
DC microammeter
Aluminum plate (about the size of a hand)
Copper plate (same size)
2 electrical lead wires with alligator clips at both ends

Optional Hand Battery Materials:
Wood block
Nonmetallic plate
Galvanized steel plate
Voltmeter

Lemon Battery:
18 gauge insulated copper wire (ends stripped)
Paper clips
Lemons
Voltmeter (multi-tester)
Small light bulbs (e.g. Christmas tree lights)

Coin Battery:
Water
Glass(es)
Salt
Paper Towels
Pennies
Dimes
Plate
Voltmeter (multi-tester)

Potato Battery:
Potatoes
Plates
Pennies
Galvanized nails
DC microammeter
18-gauge insulated copper wire (ends stripped)

Optional Potato Battery Materials:
Aluminum foil
LED clocks
Copper electrodes (10 cm. thick CU ground wire)
Alligator clips

Procedures

1. Set up 4 stations: Hand Battery, Lemon Battery, Potato Battery, Coin Battery.
2. Place "guiding steps" pages for the challenges at each station (optional equipment is an extension for students without guiding steps).
3. Instruct students to record the materials they used and draw a picture of every attempt they make for each challenge. Be sure they include written statements outlining what they did and why they think it did/didn't work.
4. Rotate students through each station.
5. Share and compare results.
6. Pose guiding questions (e.g., Which materials were better conductors?). Record key learning points.
7. Discuss other common items that might work based on these investigations (e.g., tomatoes, oranges).

Core Learning Goals

Grade 5 Physical Science: 1c. Metals have properties in common, such as high electrical and thermal conductivity.

1i. Common properties of salts, such as sodium chloride (NaCl).

Grade 4 Physical Science: 1e. Electrically charged objects attract or repel each other.

Grade 5 Investigation & Experimentation: 6a. Classify objects by appropriate criteria.

6d. Identify the dependent and controlled variables in an investigation.

6e. Identify a single independent variable in a scientific investigation and explain how it can be used to collect information to answer a question about the results of the experiment.

6f. Select appropriate tools (e.g. microammeter) and make quantitative observations.

Grade 4 Investigation & Experimentation: 6c. Formulate and justify predictions based on cause-effect relationships.

References

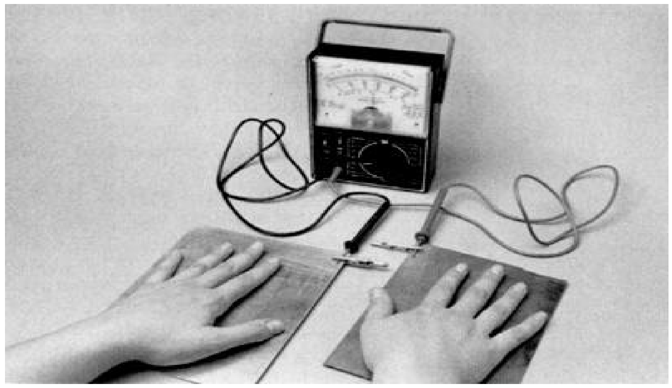
Exploratorium: www.exploratorium.edu/snacks/hand_battery.html
Oracle's Thinkquest site: http://library.thinkquest.org/6064/exper.html
PBS' Zoom site: http://pbskids.org/zoom/activities/phenom/potatobattery.html
Millenium Batteries: www.milleniumnatteries.com/Battery101/Science/make.htm

Lesson Resources

Guiding Steps pages (1/station)

Hand Battery

Can your skin and two different metals create a battery?



Thanks for the Snack, Exploratorium!

1. Lay each metal plate flat on the wooden desk.
2. Using the alligator clips, connect one end to the plate and the other to the microammeter.
3. Draw a picture of the arrangement. Label everything.
4. Place one hand on each plate. Take a reading and record it.
    a. If there is no reading just switch the connections.
    b. Still nothing? Check to make sure the clamp ends are touching the plates and that they're connected to the microammeter.
    c. What, still nothing? Try cleaning the metal plates with a pencil eraser or steel wool to remove oxidation.
5. Investigate. Predict what will happen if you:
    a. Press harder on the plates. Try it and record the results. Do they match your prediction(s)?
    b. Wet your hands and try again. What happens? Record your findings. Is it a match with your prediction(s).
    c. Have someone else put their hand on one plate while you put one hand on another then use your free hands to shake with the other person. What happens? Does it match your prediction(s).

Photo: *The Lemon Experiment* (library.thinkquest.org)

Lemon Battery

Is it a “lemon” or will it work?

1. Roll a lemon around on the table to soften the juices inside. Try not to split it open.
2. Straighten a paperclip. Insert it about an inch into the lemon.
3. Take a 6” piece of CU wire and insert it in a different place about 1” deep. (Be sure that the 2 metals don’t touch!)
4. Attach the ends of the lemon wires (the other end of the paper clip and the other end of the copper wire) to the microammeter and take a reading.
5. Draw a picture of your arrangement and include a description of what you think is happening.
6. Predict what would happen if you created a lemon series. Try it, draw it, write about it.
7. What are those light bulbs for?

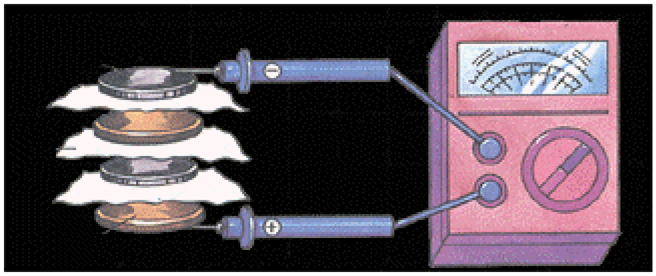


Illustration: Batteries 101/Weird Science

Coin Battery

Will a battery from 1800 work today?

1. Take a glass of water and dissolve some salt in it.
2. Take a paper towel and moisten it with salt water.
3. Place a penny on a plate, put a piece of paper towel on the penny, and place a dime on top of the paper towel. Make sure the paper towel separators don't touch one another yet cover the coin.
4. Take a reading from the voltmeter and draw a picture of your arrangement. Describe what you think is happening.
5. Predict what would happen if you added one more layer of coins. (Be sure to alternate a penny with a dime.) Try it, take a reading, and record the results. Do they match your prediction(s)?
6. Predict what would happen if you had a total of 5 layers of coins in the same pattern (penny, paper towel, dime, paper towel, etc.). Try it, take a reading, and record the results.

Potato Battery

How much power does a potato pack?

1. Cut a potato in half and put the two halves on plate (flat end down).
2. **2.** Wrap the end of one piece of wire around the nail and a second piece of wire around the penny.
3. **3.** Stick the nail and the penny into separate parts of one potato half. Be sure they don't touch.
4. **4.** Stick another nail (without wire) in the second potato half.
5. **5.** Wrap wire around the other penny and put it in the second potato half. Again, be sure the penny and the nail don't touch.
6. **6.** Connect the ends to the microammeter and take a reading. Draw the results and describe what you think is happening.

Hey, what's on TV? Check out: www.pbskids.org/zoom/activities/phenom/potatobattery.html

Explore (Intel Value: *Risk Taking--Learn from Our Successes & Failures*)

What Is It & How Does It Work?

Students read about batteries, magnetism, and electricity. After guided discussion, they create a triple Venn diagram organizing the connections they make.

Objectives

- Recognize all matter is electrical due to atomic structure.
- Describe a Voltaic pile, the first type of battery created by Alessandro Volta in 1800.
- Analyze Volta's experiments with both lemons and alternating metals.
- Identify electrodes and electrolytes.
- Compare magnetism to electricity, electricity to magnetism, batteries to electricity, and batteries to magnetism.

Materials

Computers with Internet access
Handouts or assigned reading lists
Flip chart or overhead for Venn Diagram
Chart markers or overhead pens

Procedures

1. Compile and assign student readings (e.g., textbook, online, school/public library).
2. Discuss vocabulary (e.g., conductor, insulator, charge, volt, electrochemical, electrode, electron, electrolyte, acid, circuit, current, flow, cell, battery, magnet, electricity).
3. Pair and share to discuss readings.
4. Create a Triple Venn Diagram. Label one circle "Batteries," another "Magnetism," and the remaining one "Electricity."
5. Compare and contrast then ask students to record the results.

References

Millenium Batteries: www.milleniumnatteries.com/Battery101/Science/make.htm
California Energy Commission: www.energyquest.ca.gov/story/index.html
Delta Science Readers: *Foss Science Stories: Magnetism & Electricity*
The Tech Museum of Innovation: *Welcome to Electricity!*
http://www.thetech.org/exhibits/online/topics/1xb_flash.html

Core Learning Goals

Grade 4 Physical Science: 1 c. Electric currents produce magnetic fields and students know how to build a simple electromagnet.
1e. Electrically charged objects attract or repel each other.
Grade 5 Investigation and Experimentation: 6h. Draw conclusions from scientific evidence and indicate whether further information is needed to support a specific conclusion.
Grade 4 Investigation and Experimentation: 6a. Differentiate observation from inference (interpretation) and know scientists' explanations come partly from what they observe and partly from how they interpret their observations.

Resources

Venn Diagram

Energizers

Students review a timeline of batteries and their development. They learn about the cultures and individuals essential to the development of this everyday electrochemical source of energy.

Objectives

- Summarize key developments that led to the invention of batteries.
- Diagram voltage in different circuit arrangements.

Materials

Flip chart
Markers
Computers with Internet access
Handouts or assigned reading lists

Procedure

1. Predict what led to the invention of batteries and when they were created. Share and record predictions.
2. Go to www.milleniumbatteries.com/Battery101/Sciencetimeline.htm.
3. Review the animated timeline without discussion.
4. Go back to the predictions and compare them with the timeline.
5. Review the html version of the timeline. (http://www.millenniumbatteries.com/Battery101/Science/timelinehtml.htm)
6. Review (or provide as handouts) pages 4 and 5 at the following link: http://www.chabotspace.org/visit/programs/techbridge/download/batteries_circuits.pdf
7. Draw the impact of batteries in series vs. parallel circuits. Which is more powerful? Why?
8. Update the "K" and "W" columns of the K-W-L chart.

References

Millennium Batteries, http://www.millenniumbatteries.com/Battery101/Science/timeline.htm
Chabot Space Center's Tech Bridge,
http://www.chabotspace.org/visit/programs/techbridge/download/batteries_circuits.pdf
Introduction to Batteries from howstuffworks, http://science.howstuffworks.com/battery1.htm

Core Learning Goals

Grade 5 Reading 1.2 Use word origins to determine the meaning of unknown words.
1.4 Know abstract, derived roots and affixes from Greek and Latin and use this knowledge to analyze the meaning of complex words (e.g., electrochemical)
Grade 5 Reading Comprehension (Focus on Instructional Materials) 2.1 Understand how text features (e.g. timelines, diagrams, charts) make information accessible and usable.
2.2 Analyze text that is organized in sequential or chronological order.
Grade 5 Listening and Speaking Strategies: 1.1 Ask questions that seek information not already discussed.

Resources

Timeline

E<u>xplain (Intel Value: *Discipline--Pay Attention to Detail*)</u>

Reflect & Connect

Students compare their initial thoughts with the results of their explorations. They begin to formulate concepts and definitions in their own words, using their recorded observations and summaries of their readings. They begin adding entries to the L (Learned) column of their initial K-W-L chart (they may also choose to add questions to the W [Want to Know] column).

Write to Know: Batteries 101

Students write and present step-by-step instructions for their favorite *Bright Ideas* activity/activities.

E<u>xtend (Intel Value: *Results Orientation--Assume Responsibility*)</u>

Science Fair

Students begin developing their question and investigation for presentation at the school science fair. They may participate individually or work with up to 4 students.

Recycling Campaign

Students partner with their lower grade buddies to create posters and other materials promoting what they have learned about battery recycling, energy conservation, and related topics. With the support of San Francisco's Department of the Environment, they launch a school-wide battery recycling campaign.

E<u>valuate (Intel Value: *Results Orientation--Focus on Output*)</u>

Closing the Loop

Students complete the L (Learned) section of their K-W-L charts and generate assessment questions to be included on their test.

Quiz Board

Students work in small groups to prepare questions/answers for an electronic game board. They design and test until they create a working version.

Objectives

- Apply electric circuit knowledge to build an electronic game board.
- Craft relevant game board questions from prior research.

Materials

References

Future Scientists and Engineers of America (FSEA), www.fsea.org

Core Learning Goals

Resources