5E STEM Battery Building Challenge

1.5 - 2 weeks

Authors

Abigayl Buida

Tiffany Dennis

Kristen Wilcox

SUBJECT/GRADE LEVEL

Subject Area: Science

Grade Level: 9th Grade Physical Science

Materials

- Alligator clips - Amazon Link ($5.99)
- Potato or Yam
- Lemon or Lime
- Gatorade or Powerade
- Apple or other fruit of your choice for testing
- Galvanized (Zinc) nails - Amazon Link ($5.94)
- Iron Nails - Amazon Link ($14.80)
- Aluminum Nails - Amazon Link ($2.39)
- Copper nails - Amazon Link ($8.99)
- Digital Multimeter- Amazon Link ($10.99)
- Salt
- Warm Tap Water
- Cups to test liquid electrolytes
- Snap Heat Packs (8 pack for $15)- Amazon Link
- Balloons - Amazon link ($6.85)
- Grocery Sacks (for plastic strips)



STANDARDS

Next Generation Science Standards

- HS-PS1-1: Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms.
- HS-PS1-2: Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.

- HS-PS3-3: Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.
- HS-ESS3-2: Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.

Mathematics Standards | Common Core State Standards

- CCSS.MATH.CONTENT.HSN.Q.A.1: Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.
- CCSS.MATH.CONTENT.HSN.Q.A.2: Define appropriate quantities for the purpose of descriptive modeling.
- CCSS.MATH.CONTENT.HSA.CED.A.2: Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales.
- CCSS.MATH.PRACTICE.MP1: Make sense of problems and persevere in solving them.
- CCSS.MATH.PRACTICE.MP2: Reason abstractly and quantitatively.
- CCSS.MATH.PRACTICE.MP4: Model with mathematics.
- CCSS.MATH.PRACTICE.MP5: Use appropriate tools strategically.
- CCSS.MATH.PRACTICE.MP6: Attend to precision.

English Language Arts Standards | Common Core State

- CCSS.ELA-LITERACY.SL.11-12.1.A: Come to discussions prepared, having read and researched material under study; explicitly draw on that preparation by referring to evidence from texts and other research on the topic or issue to stimulate a thoughtful, well-reasoned exchange of ideas.
- CCSS.ELA-LITERACY.RST.6-8.7: Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).
- CCSS.ELA-LITERACY.RST.6-8.8: Distinguish among facts, reasoned judgment based on research findings, and speculation in a text.
- CCSS.ELA-LITERACY.RST.6-8.9: Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic.

LESSON OBJECTIVE(S)

Students will be able to:

1. Describe how electrons move in an atom and how they relate to other subatomic particles (protons and neutrons).
2. Discuss how electronegativity varies across the periodic table and the reasons for these trends.
3. Differentiate between the anode and cathode in terms of electron flow and charge.
4. Describe how electrolytes are the chemical medium that allows the flow of ions between the cathode and anode and why this is important for conductivity.
5. Conduct an experiment to observe the conductivity of different electrolyte solutions.
6. Students will present their findings and propose a grant for future battery research based on their experiment from the Battery Building Challenge. This activity will assess their

understanding of the scientific method, data analysis, presentation skills, and ability to propose future research.

CAREER CONNECTION(S)

Mentor Background: Dr. Jan Allen, Senior Research Chemist at DEVCOM Army Research Laboratory

Dr. Allen is a senior research chemist at ARL with more than 20 years of experience, including a demonstrated history of working on novel materials. He is a strong research professional skilled in Lithium-ion Batteries, Thin Films, Materials Science, Nanomaterials, Spectroscopy, and X-ray diffraction. Experience in developing R&D topics and project management.

Mentor Background: Dr. Dat Tran, Senior Research Chemist at DEVCOM Army Research Laboratory

Dr. Dat T. Tran is a senior research chemist at ARL with more than 15 years of experience in the synthesis and characterization of inorganic materials and 10 years of experience in jet fuel analysis. His most recent research is focused on developing adsorbent materials for Army fuel cell applications. His other research interests include catalysts and materials related to fuel cell, battery, and combustion applications.

STEM Careers: Chemist, Electrical Engineer, Energy Research, Mechanical Engineer and Chemical Engineer, Army Lab Researcher, Mathematician, Data Scientist, Computer Science, STEM Educators, Professors

ENGAGEMENT

Brief Description: **Students will explore the phenomenon of exploding cell phone batteries and ponder questions about causes and potential solutions.**

Procedures:

1. **Hook Activity:** Show a brief video clip or images from news reports highlighting incidents where cell phone batteries have exploded or caught fire. Samsung Note 7 Explodes in Pocket
2. **Class Discussion:** Facilitate a class discussion to elicit students' initial thoughts, questions, and concerns about the topic. Encourage them to share any personal experiences or knowledge they have related to batteries or technology malfunctions.
3. **Safety Considerations:** Discuss the importance of safety when handling electronic devices and batteries.

4. **Prediction Exercise:** Pose the question, "What factors do you think might cause a cell phone battery to explode?" Students will then brainstorm in pairs or small groups and write down their initial thoughts on the whiteboard or if you want to be digital ion Canva Whiteboard.
5. **Concept Mapping:** Together as a class, we would create a concept map on the whiteboard (or digitally on Canva Whiteboard) to organize the factors that could contribute to battery explosions. Include terms like "overheating," "short circuit," "lithium-ion chemistry," and "manufacturing defects."
6. **Reflection/Reflective Questioning:** Students will watch a brief video explaining why the Samsung 7 Battery exploded. Explaining the Samsung 7 Battery Flaws with Cake. After students will be asked, “Why is it important for engineers and scientists to understand the causes of exploding batteries?” They will discuss in their groups and share out with the class.
7. **Closing:** Summarize key points from discussion and videos.

EXPLORATION

Brief Description:

Students will explore concepts of physical and chemical properties of a compound as an introduction to periodic Trends. Students will also explore static electricity on balloons to be introduced to electricity and current. The lesson plan includes links to the teacher resources below:

1. **Google Slides Presentation**
2. **Student Data Sheet (for exploration 1)**

Procedures:

Part 1: Slides 4-9

Students will examine the phenomenon of a reusable hot pack, first watching a video, then making observations about their own hot packs. As a class, the teacher will facilitate the creation of a driving question board. Students will then be walked through how these hot packs work. There is also a video mini lesson from Wonder of Science to help students in their identification of patterns.

Part 2: Slides 44-48

Students will watch a video of a strip of plastic that floats in the air. Students will then get to use balloons to make their own strips of plastic float. Then, after identifying the cause, effect, and mechanism of the phenomenon, students will see/use a PhET simulation to verify their mechanism. This will be followed up with a TED-Ed video about static electricity.

EXPLANATION

Brief Description: Following each of the exploration parts above, there will be an explanation section. These will simply be lecture slides that address the topics at hand. The lesson plan includes links to the teacher resources below:

1. **Google Slides Presentation**

Procedures:
Following each of the exploration sections, take students through the lecture slides to explain the material.

ELABORATE

Brief Description: Once students have been introduced to electrons, the periodic table, and electronegativity they will complete an experiment to build a battery and test different metals and electrolytes to try and build the best battery possible. After completing the Battery Building Challenge, students will present their findings and propose a grant for future battery research based on their experiment. This activity will assess their understanding of the scientific method, data analysis, presentation skills, and ability to propose future research. We recommend this activity & presentation be completed in groups instead of individually to minimize supply waste. This Lesson plan includes links to the following teacher resources:

1. Class powerpoint which includes an introductory review, connection to STEM careers for this activity, youtube videos, and tips for successful experiment. - CLICK HERE FOR LINK
2. Student Experiment Handout which includes powerpoint review, Lab Procedure, Data tables, and final questions. - CLICK HERE FOR LINK
3. Battery Building Challenge Handout Teacher Key which includes vocabulary review, youtube video answers, example data from experiment, and answers to final Lab questions. - CLICK HERE FOR LINK

Procedures:

1. Make sure you have all of your materials before you start the experiment. Completely read this procedure and make sure to ask if you have any questions after reading it.
2. Roll the lemon gently on a table to soften it without breaking the skin. This will help release the juice inside, improving conductivity.
3. Insert the Electrodes by iInserting the copper nail into the lemon about 1 inch deep. Then Insert the zinc nail into the lemon about 1-2 inches away from the copper nail. Make sure the nails do not touch each other inside the lemon.
4. Connect the Voltmeter by attaching the positive (red) probe of the voltmeter to the copper nail. Then attach the negative (black) probe of the voltmeter to the zinc nail.
5. Measure the Voltage by turning on the voltmeter and set it to measure DC voltage (if not already set).

6. Observe the reading on the voltmeter. It should show a small voltage, typically around 0.3 to 1 volt. Record the voltage on your data table.
7. Repeat steps 3-6 with the zinc nail and iron nail.
8. Repeat steps 3-6 with the aluminum and copper nail.
9. Repeat steps 3-6 with the aluminum and iron nail.
10. After finishing the experiment with the lemon, complete the experiment (steps 3-9) with each of the following electrolytes: apple, yam, gatorade, water, salt water.

EVALUATION

Brief Description: Students will present their findings and propose a grant for future battery research based on their experiment with lemon batteries. This activity will assess their understanding of the scientific method, data analysis, presentation skills, and ability to propose future research

Battery Building Challenge Presentation Evaluation Rubric - CLICK HERE FOR LINK

Google Form Assessment for Batteries & Electronegativity - CLICK FORM FOR LINK **(editable link)**- For any students who are struggling with their Presentations or require additional lessons to close comprehension gaps.

Procedures:

1. Battery Building Challenge - Students will need to complete the Battery Building Challenge & gather data. Remind students they can also utilize any detailed notes, photographs, and videos they created while they were completing the experiment in their presentation.
2. Data Analysis - Students should organize their data into tables and graphs. They should Analyze the effectiveness of their different batteries based on anode, cathode, and electrolyte used, including the voltage produced, factors affecting performance, and any anomalies observed.
3. Presentation Development - In groups students will create a shared powerpoint (teacher should be included as participant on shared powerpoint) so all parts of presentation can be delegated and assigned according to specific tasks. Each powerpoint should include the following slides:
    - Title Slide: Include the title of the project, student names, and date.
    - Introduction: Provide background information on batteries, the purpose of the experiment, and the hypothesis.
    - Materials and Methods: Describe the materials used and the steps taken to perform the experiment.
    - Results: Present data collected using charts, graphs, and photos.
    - Discussion: Analyze the results, explaining the findings and any unexpected outcomes.
    - Conclusion: Summarize the key findings of the experiment.
    - Future Research Proposal: Propose a grant for future battery research, explaining the significance of the research, objectives, methodology, expected outcomes, and budget.

4. Presentation Practice - Students practice their presentations in front of peers or Teacher (depending on the maturity level of the class). Teachers / students should provide constructive feedback to improve clarity, delivery, and content.
5. Presentation Day - Students present their findings and research proposal to the class, acting as a panel of potential grant reviewers. Each presentation should be followed by a Q&A session where students defend their proposal and answer questions.
6. Evaluation and Feedback - Use the rubric to evaluate presentations on various criteria such as content accuracy, data analysis, clarity, delivery, creativity, and feasibility of the future research proposal. Teachers will provide individual feedback to each student or group, highlighting strengths and areas for improvement.

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