Teaching Engineering Applications in Math and Science (TEAMS)
Template: Math/Science-Engineering connected Lesson Plan

Title of Lesson:	Energy Conversion – The Penny Battery
Date:	Summer 2009
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Grade level:	6 - 8
Content or Subject Area's:	Engineering, mathematics, chemistry, experimental techniques
Duration of lesson:	~45-60 minutes

General Objectives:	One clear sentence addressing the scope of the lesson and curricular goal as relates to engineering.	Students learn concepts of energy conversion and the law of conservation of energy by means of construction and testing of a simple battery
Learning Outcomes: (1-3 stated outcomes) After completion of the lessons, students will be able to: (use action verbs)	What do you want students to know and be able to do? What knowledge, skills, strategies, and attitudes do you expect students to gain? What important math/science and engineering applications will students learn?	1. Understand energy conversion and develop ideas for improving (engineering) the provided electro-chemical design concept. 2. Determine the single cell voltage and use simple algebra to predict how many series cells are required to make 9 volts. 3. Understand mechanisms why theoretical calculations (i.e. engineering predictions) do not always match experimental.

State Standards: (MT Math and/or Science Standards)	Grade 8: M1-1,2,3,4,5 M2-1,3 M3-1,4 M5-2,3 M6-1,2,5 M7-2,3,4 S1-2,3 S2-2,3,7 S5-2,3,4
National standards: (AAAS Benchmarks)	Grade 8: 2B/M1; 3A/M2; 3A/M3; 3B/M1; 3C/M4; 8B/M5; 8C/M1; 8C/M6; 8C/M7; 8C/M11

Materials and Resources:	Provide a list of materials, people, and references that 1) you used to create the lesson and 2) are required to teach the lesson, including all physical materials, sources and resources outside the classroom.	**per group:** 10 clean pennies (or copper sheet) 1 sheet aluminum foil (or aluminum or zinc sheet) Fine sandpaper (400grit or greater can be used to clean the surface of oxidized or dirty sheet) 1 heavy duty paper towel (blue shop towels are preferred, or even single layer cardboard) 1 volt meter (per group) 2-3 postal rubber bands Scissors (or craft punch) Distilled water, lemon juice, salt, vinegar Option 1: low voltage LEDs and motors which are cheap and easily obtained from Radio Shack Option 2: The natural succession to this lesson would be data acquisition to monitor how the voltage changes as a function of time. http://en.wikipedia.org/wiki/Voltaic_pile & **The Conservation of Energy Law states that energy cannot be created nor destroyed, it can only change forms.** (i.e.: Electrical Energy from your plug outlet to Thermal Energy from your heater.) The exchange of energy between the two types is the same. The amount of energy exchanged between the two will always be the same. Therefore, no energy was created nor destroyed, but changed. The same applies to the conversion of chemical energy to mechanical energy by means of combustion powering your automobile or the conversion of kinetic energy to heat for braking.

Instructional Procedures:	Focusing Event: Why would your students care or want to know about this topic?	Modern society is based upon the need for energy whether it be electrical energy to power your TV, Playstation,

(include time estimates where possible)	What "big" questions will generate discussion about this topic?	X-box, i-pod, or Nintendo DS or mechanical energy to get you to soccer practice, school, or across the continent. The future of our technological growth lies in the conversion of energy from one source to the next with a focus on clean/portable technologies. *(optionally there is also the security issue; not just any energy conversion device is allowed on airplanes or other sensitive transportation, this is what makes batteries so attractive)* What do you think the energy demands of the nation/world are? *As of 2005 the estimated energy usage is 1.6 x 10^{13} Watts (80-90% fossil fuel combustion)-this is enormous particularly when written with zeroes.* *http://www.energyque.com/site/energy-school/36-energy-facts/118-types-of-energy-use.html* *Compare to a light bulb (100 watts), microwave (1500 watts), etc….* Why is fossil fuel combustion such a problem? *Much of the energy of combustion is lost as waste heat (i.e. car radiator) and harmful emissions.* Solar and wind can address some need, but how else can we generate usable energy? *Nuclear, alternative energy (including electro-chemical methods)* No energy source is free, even solar and wind is bound by the law of conservation of energy, why?
	Teaching Methods and Student Activities: Sequentially list how you will carry out the various aspects of the	After discussing concepts of energy conversion in general and the law of the conservation of energy, the basic design of a battery will be explained

	lesson, including questions, examples, etc. What tasks will students complete? How will they build knowledge, skills, learn independently or with others? What instructional practices will you use with this lesson? How and where will your students work – labs, groups, stations?	showing the three main components: + electrode, - electrode, and electrolyte. Single cells are placed electrically in series such that the voltages of the cells are additive. This will be explained briefly, but electrical circuits, both series and parallel is a key concept that can be combined later in additional lessons. Students will be assigned to groups of 2, 3, or 4. The smaller the better to ensure each student gets hands on skills, but resources are sometimes limited. After the basic components of the battery are shown, the electro-chemical conversion process can be discussed in which we are converting the stored chemically energy of the solid metal electrodes directly into electrical energy. The goal of the laboratory project will be discussed: which is to determine the single cell voltage of the groups selected battery materials and electrolyte as well as their calculation of the number of cells required to fabricate a 9 volt battery. (a standard 9 volt battery will be disassembled to show the number of single cells required and thus how the battery is engineered-a high quality Energizer or Duracell battery will use 6 AAAA batteries in series and makes a better visual). Voltage measurements will be made for each cell and then plotted to observe the voltage trend (linear or non-linear) The battery will be fabricated with conventional pennies in addition to nickels or aluminum foil utilizing either NaCl, vinegar, or lemon juice as an

		electrolyte. The electrolyte cloth should be saturated, but not dripping wet! The students will be given the materials needed and work together to cut out the electrolyte cloths to the appropriate dimension, preparation of the electrolyte layers, and testing of the their single cell potential. They will then fabricate the number of cells needed to achieve their desired voltage and test their batteries. The more careful they are in cutting their components, the better the battery will work. Why is the penny battery limited-the electrolyte is limited in how many metals ions it can dissolve and transfer to the electrodes!
	Closure: To review what has been learned, to do a final check for understanding of the skill or concepts and to focus on the connection between previous, future and current lessons.	Discussions on improving performance, size, and weight will be addressed with the entire group after each group's results are put up for everyone to see and discuss. This will show that different configurations can yield different (sometimes quite dramatically) results. Simple volumetric calculations and concepts of density (g/cm^3) can be used for estimation. Students can describe why their calculations may not have yielded the desired result, hence experimental uncertainty. Students should be able to explain why electro-chemical energy conversion is more efficient than chemical combustion and why this area of alternative energy is such an

		exciting subject.

Evaluation procedures:	Describe your formative and/or summative assessment methods used in this lesson, your goals for using them, and how you will use the results. How will you know your students have reached the lesson goal? What assessment tools will you use? How will students be involved in ongoing assessment? How will students assess themselves?	The students' ability to propose new ideas to enhance to modify their battery will be a key indicator that they know what is going on: i.e. need a larger electrolyte reservoir, flatter electrodes, thinner electrodes, etc…