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Increasing K-12 Students' Understanding of Photovoltaics: Using Solar Energy to Engineer our Energy Future (Resource Exchange)

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Ms. Mia DeLaRosa

Mia DeLaRosa received her BA in in Elementary Education from Arizona State University in 2004. She went on to receive her Masters in Educational Leadership and Principal Certificate from Northern Arizona University in 2007. She is currently working on her EdD at Arizona State University. Mia is highly qualified to teach middle grades math, science, and language arts. Mia has taught middle school science in the Alhambra Elementary School District for nine years where she also leads after-school engineering clubs. Mia has been directly involved with district-wide initiatives including technology integration, Just In Time Assessments, curriculum pacing guides, and implementation of a research based, hands-on science and engineering curriculum. Mia has also worked closely with FOSS as a professional development facilitator. She also worked with Project WET at the University of Arizona Maricopa County Cooperative Extension as a curriculum developer and professional development faciltator.

Ms. Rebecca Hooper

Rebecca Hooper is currently working as the Science Department Chair at Laurel High School in Laurel, MS. She holds a M.A. in Curriculum & Instruction from University of Texas at Arlington and a B.S. in Biochemistry from California Polytechnic State University. In addition to serving as department chair she is also the Science Fair Coordinator and Beta Club Sponsor.

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Target Grades: 4th through 12th

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Background: Many of the pressing issues facing the world today are fundamentally intertwined with global energy needs. Thus, a defining challenge of the 21st century is meeting the world's demand for energy. Photovoltaic (PV) devices are a promising sustainable energy source. If the production and use of PV continues to grow at present rates, it can sustainably meet the world's total energy demand by 2050. However, committed engineers and knowledgeable citizen are needed to achieve this goal. Therefore, QESST, an Engineering Research Center for Quantum Energy and Sustainable Solar Technologies, aims to advance PV science, technology and education by supporting the ability of K-12 teachers and outreach coordinators to develop and implement lessons on PV research and engineering. To further these aims, we implemented a Research Experience for Teachers (RET) program that provides classroom teachers opportunities to develop connections between the lab and the classroom. Participants spent two weeks working in a Solar Power Lab, making and testing solar cells and modules before developing their PV engineering lessons. Each lesson went through multiple design cycles based on peer critique, expert feedback, and field testing with young students. The resulting set of lessons support K-12 students' understanding of how solar cells are made, how they work, and how engineering research is improving the potential of PV to address the world's energy needs. The purpose of the lessons is to help K-12 students learn about solar energy technologies and imagine how they might one day become innovators in this important field.

Lesson instructions are available on the QESST education website at www.qesst.asu.edu

Lesson Summaries

Lesson 1: Making a Solar Cell, Grades 4-6

Objectives: Students will demonstrate the steps involved in making a silicon solar cell and explain the purpose of each step for optimizing solar cell efficiency.
Lesson Description: After learning about how solar cells are made in a solar lab, students re-create the multistep process of making a silicon-based solar cell. Following a diagram with labels and a key of materials used in the manufacturing of solar cells, students use construction paper and other materials (e.g., silver pens, saran wrap) to represent the materials in each layer of a solar cell. Students then make connections between their PV cell and a real PV cell.
Curriculum Connections: This lesson is part of a unit on renewable and non-renewable natural resources. Following categorization exercises, students focus in on the process of converting specific natural resources into energy.

Lesson 2: Enacting a P-N Junction, Grades 4-9

Objectives: Students will enact the motion of electrons and photons to form a p-n junction.
Lesson Description: Students kinesthetically re-enact the motion of electrons and photons to form a p-n junction in a solar cell. They act out the process on a playing field with colored balls representing photons and positively and negatively charged electrons.
Outside on cement, the teacher draws a 10 ft. by 10 ft. box with chalk to represent a PV cell (See website for details and diagram. Students are assigned to represent the Sun, individual photons,

and a flashlight/lightbulb (to represent a completed circuit). The remainder of the students are divided into three groups to act as extra electrons, extra holes, and conductors. The students then act out the process of electrons filling holes in the P-N Junction.
Curriculum Connections: Students should come to this lesson with an understanding that a photon is energy and creates motion. Students identify and label the process of generating electricity using a solar cell before enacting the process in this kinesthetic activity. Following this lesson, students reinforce their new knowledge by creating a model of how a PV cell works.

Lesson 3: Watts Up?, Grades 6-8

Objectives: Students will analyze their personal use energy consumption, understand how their behaviors correlate to the costs involved with selected lifestyle choices, explain the benefits and drawbacks of using photovoltaic energy to power common everyday household items, and make recommendations for lifestyle changes to encourage responsible energy consumption.
Lesson Description: Students bring a self-selected powered device to class. Working in teams and drawing from the electrical grid, they plug their items into Kill-A-Watt device, take periodic readings, graph the data, report the average, and discuss how much power common electric devices require. Students are led to recognize that the graphed data is constant. They then repeat the experiments outside, using solar panels as the power source. Students are led to recognize the fluctuation in averages and discuss the need for reliable energy sources to power devices.
Background: This activity is part of a science unit in which students explore the focus question: What are the costs associated with your personal energy consumption habits? How could you be more environmentally responsible by reducing the use of just a couple electric devices?

Lesson 4: Designing a Solar Cell to Optimize Efficiency, Grades 7-12

Objectives: Students will examine the effects of one factor, shading, on solar cell efficiency.
Lesson Description: Students design the spacing of buss bars and fingers on a solar cell. Their goal is to optimize the front grid design of a solar cell to minimize power loss by drawing our own custom designs on a pre-drawn solar cell front panel grid. Students use a pre-determined formula to calculate the effects of shadowing on the cells' efficiency, estimating power loss associated with their design in order to compare and improve their designs.

Lesson 5: Ella the Electron, Grades 8-12

Objectives: Students will be able to explain how the electrons of an atom produce energy.
Lesson Description: Students interpret an original story of "Ella the Electron" through texts and pictures, engaging in substantive interaction with peers to negotiate their understanding and refine their knowledge of how charged electrons fill holes to form a p-n junction between semi-conductors in a solar cell. Students then connect the story to an actual solar cell given an overview of the cell's structure and vocabulary terms. Students can be assigned to groups, with each group assigned a scene from the story, following by whole-class discussion
Curriculum connections: This lesson pre-supposes that students have completed a unit on atomic structure. The lesson was an expansion of a unit on types of energy, as part of a sub-unit on solar.

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