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Graduate students help to create a discovery-based and cooperative learning experience about clean energy for high school students (curriculum exchange)

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Target Grade Level: 9-10th grade basic science and 11-12th grade advanced science classes.Authors' Names: Justin M. Hutchison, Alicia Burge, Katie M. Hutchison
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The clean energy engineering discovery-based and cooperative learning experiences were targeted at younger and older students in science classes with the final goal of bringing the two groups together for a student-led teaching and learning activity. Activities targeted engineering practices and principles related to clean energy including mass balance, fluid mechanics, electromagnetic force and biological processes. The activity involved collaboration between three Urbana High School teachers and three University of Illinois Civil and Environmental Engineering graduate students in Urbana, Illinois. While these activities were developed in conjunction with university graduate students, lesson plans were developed to be applicable in schools without access to university resources.

During the first semester and beginning of the second semester, graduate students led lessons for Advanced Placement Environmental Science (APES) students focusing on clean energy technologies including photovoltaic, solar thermal, wind, water and biological-based energy production. Discovery-based lessons for each clean energy technology were developed and presented by graduate students. The basic concepts for the energy production was explained in a lecture and field-trip format. For photovoltaic energy, lessons included explanation of the concept of photovoltaic cells and demonstration of actual cells. Solar thermal lessons included the concept of energy transfer including radiation and conduction. Wind and water lessons focused on concepts of aerodynamics and fluids, and energy produced from magnetic fields reinforced with field trips to a wind farm to observe harvesting wind power and to a local power plant to observe steam turbines. Finally, biological-based energy production lessons included basic concepts in microbiological methane production and thermochemical liquefaction processes. Biological-based energy production was demonstrated during a field trip to the local wastewater treatment facility. After completing introductory lessons for each clean energy technology led by the graduate students, discovery-based learning activities were performed.

For discovery-based learning, APES students were divided into small groups of 2 or 3 students. Students were directed to develop hypotheses followed by experimentation on clean energy. For photovoltaic cells, students were given solar cells and multi-meters to measure voltage and current. Students hypothesized on the optimal light source for producing energy and tested various light sources including indoor and outdoor lighting sources. Solar thermal experimentation involved hypothesizing on optimal fabrics for capturing heat. Students also experimented with developing optimal blade construction for wind mills and measured heat in composting bins to measure energy production due to biological activity.

Advanced Placement Environmental Science students were then tasked with internalizing the information and developing lesson plans, under guidance from the teacher and graduate students, on clean energy for an Integrated Physical Science (IPS) class comprised of Special Education students and English Language Learners. Following the presentations by APES students, the IPS students were divided into smaller working groups with an APES student acting as the group manager. The small groups were tasked with designing, building and testing inventions that improved upon or specifically used solar, wind, water or biologically-derived energy. As a culmination to the project, the high school students presented their inventions to a mock-investor panel which included faculty members and local entrepreneurs.

This activity-based, cooperative learning experience engaged high school students in engineering practices and principles while allowing the students the opportunity to develop communication skills necessary to explain engineering and science content to specific audiences.

For specific details and questions on the lesson plans, please contact the author.