Curriculum Exchange: Teaching Energy Concepts using Chain Reaction Machines

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Shakira McCall is a graduating Master's of Science student in Engineering at Arizona State University. She is also a recent recipient of the IGERT-SUN Traineeship funded by the National Science Foundation. Her PhD work will be continued in the School of Sustainable Engineering and the Built Environment beginning Fall 2014.

Dr. Odesma Onika Dalrymple, Arizona State University, Polytechnic campus

Dr. Odesma Dalrymple is an Assistant Professor in the Dept. of Engineering and Computing Systems at Arizona State University. She conducts research on tools and techniques that can be readily applied in real engineering learning environments to improve student learning and teaching. In this respect her two prominent research contributions are with: 1) artefact-inspired discovery–based pedagogy, i.e., learning activities where students' exploration of STEM knowledge is self-directed and motivated by interactions or manipulations of artefacts; and 2) the development of faculty expertise in outcomes-based course design through the use of the Instructional Module Development (IMOD) system, a self-guided web-based training tool.

Dr. Shawn S Jordan, Arizona State University, Polytechnic campus

Shawn Jordan, Ph.D.is an Assistant Professor in theDepartment of Engineering atArizona State University. He is the PI on three NSF-funded projects: CAREER: Engineering Design Across Navajo Culture, Community, and Society (EEC 1351728), Might Young Makers be the Engineers of the Future?(EEC 1329321), and Broadening the Reach of Engineering through Community Engagement (BRECE)(DUE 1259356). He is also Co-PI on one NSF-funded project: Should Makers be the Engineers of the Future?(EEC 1232772), and is senior personnel on an NSF-funded grant entitled Workshop: I-Corps for Learning (i-Corps-L). He received his Ph.D. in Engineering Education (2010)and M.S./B.S. in Electrical and Computer Engineeringfrom Purdue University,and as a qualitative researcher studies both STEM and informal engineering education. As an educator, he foundedandled a team to two collegiate National Rube Goldberg Machine Contestchampionships, and has co-developed theSTEAMMachines™ /"Rube Goldbergineering" program over the past 6 years to exposemiddle and high school students to the engineering design process.

Teaching Energy Concepts using Chain Reaction Machines (Curriculum Exchange)

The STEAM Machines™ programs challenge teams of middle and high school-aged students to learn and apply the engineering design process to build Rube Goldberg-style chain reaction machines. These summer camp programs teach real-world engineering skills, provide experience with systems thinking and multi-team collaboration, integrate arts and STEM, and create a pathway for student to better understand careers in engineering and other science, technology, and math fields.

For the Summer 2013 implementation of the summer camp programs, new content modules on energy and anaerobic digestion were integrated into the curriculum and introduced at three high school sites, i.e.; two in Arizona and one in Trinidad and Tobago. A total of 65 students ranging from ages 13 to 18 participated in the experience. With the addition of the energy content and related activities students learned to:

- Identify the different states and forms of energy
- Describe the Law of Conservation of Energy
- Describe the difference between renewable and non-renewable sources of energy
- Describe things that can be done on a national and individual level to use energy sustainably
- Design chain reaction machines with constraints related to forms of energy
- Describe the process of anaerobic digestion
- Describe how biogas is created and its applications
- Create biogas and use the resulting energy to power a stem in a chain reaction machine

Although the energy and anaerobic digester modules were designed to align with the Next Generation Science Standards (NGSS), the presented concepts were covered in greater depth than what is specified in the standards. Using a combination of interactive presentations and hands-on activities, the modules appealed to visual, auditory, and kinesthetic learning styles.

For the curriculum exchange the following resources related to the energy and anaerobic digestion module will be shared: a) lesson plans with instructor notes; b) presentations and worksheets; and c) assessments.