Energizing Engineering Students with Hydrogen Fuel Cell Project

PHOTO BY RACHEL BINI, GRAPHIC COMMUNICATIONS STUDENT AT DESERT VISTA HS

BY NORI CANNELL AND DAN ZAVALETA

As you enter Dan Zavaleta's automotive and engineering classroom and lab at Desert Vista High School, you can feel the energy—not as a result of the hydrogen fuel cell power students are generating, but because of the intense learning students experience in his classroom. A continuous flow of planning, creating, building, testing and competing through teamwork and collaboration is always under way among his students.

Located in the East Valley Ahwatukee Foothills area of Phoenix, Arizona, Desert Vista is one of seven high schools in the Tempe Union High School District. When Zavaleta began teaching at Desert Vista 17 years ago, he focused on automotive technology while creatively integrating computer manufacturing and Cisco classes into the program. In 2008 he began working with professors from Arizona State University (ASU) to expand the program to include mechanical engineering. That year an application was submitted to and approved by the Arizona Department of Education's Career and Technical Education Division to fund the Hydrogen Fuel Cell Project at Desert Vista for two years. The division has supported green program growth with funding through the Perkins Innovation Grant. The purpose of that grant is to encourage development in the areas of science, technology, engineering and math.

This project is one of many in Zavaleta's engineering and automotive classes in which students develop the knowledge and skills they must acquire to work in the automotive industry, and/or continue on to postsecondary education in the automotive and engineering fields. One hundred and thirty-four students, juniors and seniors, are now enrolled in the automotive and engineering classes at the school. During the first year of the project, students:

- built a small fuel cell vehicle prototype;
- learned to generate hydrogen and produce, store and utilize the hydrogen in fuel cells;
- demonstrated alternative fuel sources to harness energy to run vehicles;
- applied concepts and principles learned in chemistry, physics and math classes to expand their knowledge of and familiarity with hydrogen; and
- researched manufacturing processes and examined them as a fuel source.

Student Engineers in the Making

Using two models—hydrogen generation and fuel cell utilization—students observed how water was split into H2/O2, the amount generated, and the path to the fuel cell where power was created. An example of a math application that accompanied generation was determining the amount of power required to split water. The students experimented to see if increased power would increase the split, and were able to determine the amount of current and voltage created by the fuel cell dependent upon the demand of the electric motor. From there, students were able to see how much power from a fuel cell was required to run a small and then a full-sized car. Students used two test engines in the automotive area that were modified to run on hydrogen. They studied the amount of fuel needed and worked with hydrogen to set pressures for various RPM ranges. Students utilized various compression ratios to determine how much hydrogen was needed to run the engine at different RPMs.

The current and second year of the project provides students with experience in the latest engineering technologies and a greater understanding of the past, present and future of automotive engineering. The students are currently researching how hydrogen engines operate, how computers can control the injection system and types of systems, as well as storage. Students study the plumbing needed to move from the fuel tank to the engine, and are experiencing how computers control the injection system. They are focused on understanding how hydrogen works as a fuel and why special applications are necessary for certain engines. For the capstone achievement, students will create, test and demonstrate a full-size working model of the hydrogen fuel-cell vehicle.

Engineering Student Success

The project is preparing students at Desert Vista for a career in engineering by having them work alongside professors who are partnering with both local and international companies. The students have explored ASU's automotive engineering program at the ASU Polytechnic Campus and they have created career plans. Zavaleta collaborates with professors to ensure the curriculum aligns with ASU standards and remains up-to-date in technological development. ASU and industry have provided students with specialized equipment, and computer and industry software (Solidworks and CAD Programs) to support this program. Industry partnerships for this project include the American Hydrogen Energy Association, Intel, Motorola, Honeywell, Salt River Project, General Motors, U.S. FIRST Robotics Competition, and the Society of Automotive Engineering.

The young engineers designed the Aquarius Underwater Project and placed first at the 2009 National Underwater Robotics Challenge. The students built working underwater recovery vehicles they nicknamed "Whale" and "Octopus" made with PVC pipe, tape, flashlights, small electric motors attached to propellers, miniature television cameras, and several feet of electrical wiring. The students also plan to travel to San Diego to the U.S. Naval Underwater Training Development Center to tour the facility and interact with engineers and others who are researching sources of alternative energy. Students are members of SkillsUSA and participate in engineering competitions such as rocket launching, wind generation, robotics, bridge building, and trebuchets. In addition, Zavaleta's classes have partnered with Salt River Project to design and develop electric conversions of full-size vehicles and competed in the solar boat competitions.

The engineering classes offer students broad exposure to many different engineering concepts. They have acquired knowledge and skills related to these concepts through project-based learning. The lab is designed to develop problem solving, critical thinking, research and documentation skills. The courses prepare students for further study in engineering careers, encompassing pre-calculus, calculus and applied physics, while developing their team-building, presentation skills, and technical reading and writing. The one-year dual credit program with ASU enables students to receive credit for two semester classes for Engineering 101 and 102.

Engineering Academy Set to Open

Desert Vista is also developing an engineering academy. A team of teachers are working together to design a program of study that includes math, science, foreign language (Chinese, Spanish and German), software application, programming, entrepreneurship and economics. The academy will begin in August and will be open to freshmen; students will follow a coherent sequence of courses that will ultimately lead to the mechanical engineering class that is offered for concurrent credit with ASU for Engineering 101 and 102.

Pursuing a Future in Engineering

Each of the students in the program plans to pursue an engineering degree in aerophysics, aeronautical, mechanical, computer or electrical engineering. Students especially enjoy analyzing data to formulate new designs and designing then building the projects. When asked what she plans to do after high school, engineering student Elaine Rhoades said she plans to major in aerophysics. The program is helping her to learn to use tools and giving her instructional time and experience with a college professor. Another student Brian Boehringer said that the class greatly promotes teamwork because each project is team-based and students depend on each other to improve and complete the project. Student Anuras Gupta summarized one of the most valuable lessons learned, "If one mind is not working, the whole group suffers." T

Nori Cannell
is director of guidance and career and technical education of the Tempe Union High School District. She can be contacted at ncannell@tuhsd.k12.az.us.

Dan Zavaleta
is a teacher and engineering and technology department chairman at Desert Vista High School in Phoenix, Arizona. He can be contacted at dzavaleta@tuhsd.k12.az.us.

ACTE Interested in exploring this topic further? Discuss it with your colleagues on the ACTE forums at www.acteonline.org/forum.aspx.