ATTRACTING YOUNG MINDS TO ENGINEERING TECHNOLOGY FIELDS WITH MOBILE RENEWABLE ENERGY EDUCATION

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Abstract

Various ways to attract young minds to STEM fields have been implemented by non-profit organizations and institutions through volunteer work or funding. Mobile Renewable Energy Education (MREE) is a long term project aimed to provide area (especially rural) K-12 students and teachers with an applied mathematics, engineering and science curriculum package based on Photovoltaic (PV), wind power, energy conversion and conservation, energy safety and awareness, human power, and global warming. The MREE project has established a partnership between the university and selected area schools to improve students' mathematical and scientific skill sets and to improve their technological literacy by creating an environment where they must understand and figure out relationships in basic mathematics, science, and engineering technology. The students can then apply their new-found skills to study renewable energy fields, to mentor others and manage their studies effectively, and to gain a professional skill-set for successfully applying mathematics and science to technical projects with diverse teams throughout their careers. The use of a number of renewable energy and energy efficiency based hands-on projects such as a nationwide solar electric project promotes mathematics and science for teachers and students. In this paper, all the information about the successful mobile outreach program will be shared with academia including data, feedback, description of materials used, demographics, funding, results etc.

Keywords: stem, renewable energy, engineering technology, mobile education, outreach, energy conservation

Introduction

Recently, there have been academia- and industry-supported events and outreach programs to attract young minds to engineering technology fields using a variety of different methods [1-12]. The student interest in STEM (Science, Technology, Engineering, and Math) fields has been low due to issues encountered in K-12 education system. Science and math classes affect students' future career decisions based on the recent studies [13-16]. There are numerous investments at state and federal government levels to increase interest in STEM fields. One of these fields is engineering technology, which can attract young minds to engineering fields through applied activities.

The Mobile Renewable Energy Education (MREE) program is a three year project for K-12 education which was developed to increase student interest in STEM careers. A team consisting of faculty and students offer a series of educational activities since 2010 to promote science and engineering education through applied Renewable Energy (RE) workshops in East Texas rural school districts. A mobile unit (an enclosed and retrofitted trailer) is used to solve the transportation issues of the students in rural school districts by taking all the equipment to directly school districts instead of having students come to the college campus.

This project was initially sponsored by the Entergy Charitable Foundation and Sam Houston State University (SHSU). It established a partnership in Science and Engineering Technology in East Texas related to applied RE areas between SHSU, seven school districts, and Houston Community College. First, workshops were conducted at the SHSU campus; these workshops received very positive feedback from the participants and school administrators. However, rural school districts could not participate due to scheduling and transportation issues. Project principals wrote another grant to buy a mobile unit to reach rural school districts instead of requiring the students to come to the SHSU campus. The Entergy Charitable Foundation funded the project a second time to purchase an enclosed 22ft. trailer.

Renewable energy applications such as wind power, solar energy, energy conservation, global warming, hydrogen fuel-cell theory and applications are covered in the curriculum. The immediate goals of the project include development of partnerships with area schools to improve students' mathematical and scientific skills as well as their technological literacy by creating an environment where they can understand relationships among basic mathematics, science, and engineering technology as applied to renewable energy fields. This is done in order to mentor and present educational programs to students in an effective manner and to give them a professional skill set for successfully applying mathematics and science to technical projects via diverse teams throughout their careers.

From May 2010 to May 2013, the MREE project reached out to East Texas high school students, middle school students, elementary students, and high school agriculture and science teachers. Over 300 students were directly influenced by the project when the SHSU mobile energy laboratory visited their school districts to conduct renewable energy workshops, typically from 8 a.m. to 3 p.m. These workshops consisted of short lectures and hands-on training activities using renewable energy training units developed at SHSU by undergraduate students in the Agricultural and Industrial Sciences Department. In addition, opportunities for professional studies and STEM careers were discussed.

Mobile Unit

A 22ft. V-nose enclosed trailer was purchased and modified to house various renewable energy equipment, tools, and materials. This trailer was modified only to transport necessary platforms for workshops. It was not intended as a classroom or demonstration unit. All the platforms are unloaded in an outdoor environment for experiments after the trailer, hauled by a department truck, arrives at the school district. After completion of the workshops, all the platforms are loaded on the trailer to transport the equipment back to campus. To hold the training boards and other equipment, cabinets with shelves were built by construction management students as class projects. Volunteer students and faculty travel in a department van to school districts. Figure 1 shows a photograph of the modified trailer.

Figure 1. Workshop Trailer

Graphic design as well as design and development student major accomplished the design work for the project logo and motto (Figure 2). A design and development student major designed several cabinets that built inside the trailer to hold materials and tools. Construction student majors built the cabinets for the tools and equipment inside the trailer. Students commented that this project gave them a real life experience for their future career. The project team wanted to make a wrap outside the trailer to promote and advertise the project when the trailer was in motion. However, due to high cost of the wrap quoted by several of local companies, The University Sign shop offered to make a simple decal at an inexpensive price.

Figure 2. Project logo and motto

Equipment and Materials

In the product category of instruments or equipment, the project team has produced 10 mobile training units for hands-on instruction in basic electronics, solar and wind energy. The training units were designed and developed with the help of SHSU undergraduate students in the Agricultural and Industrial Sciences Department. Two designs, shown in Figure 3, are currently available to conduct renewable energy workshops on the road. The large-sized training units on wheels are for outdoor experiments, and the small-sized training units can be used outdoors or can be used indoors by with light (light bulb) and wind (fan) when weather conditions are not favorable. Prior to the period of performance, five of the large training units had already been built for the mobile energy laboratory. During the period of performance, five more large training units were built along with 10 small-sized training units. For wind energy experiments, the large training units connect to a portable commercial wind turbine. Similarly, the small-sized training units connect to peripheral components, such as a 10-inch by 10-inch photovoltaic module. Using worksheets, students learn about the function of each electrical component and how to connect the components to harness sun or wind energy and convert the energy into electricity to power a device such as a light bulb, an LED, or an electrical motor. Since they cost significantly less than commercially available training units, the project training units have been found to be cost-effective and efficient for teaching about renewable energy technology.

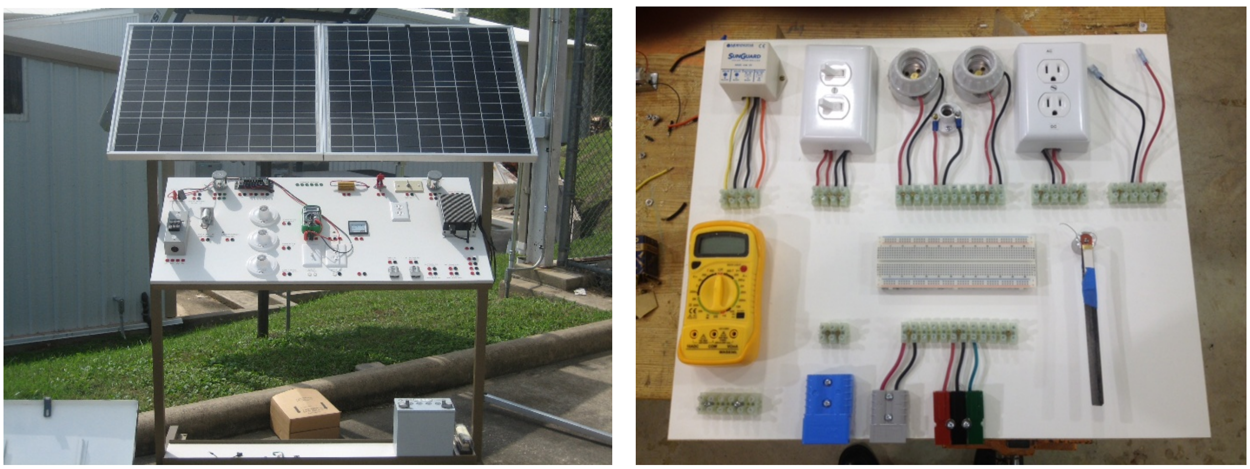

Figure 3. Mobile Training Units

For science, agriculture, and technology education teachers, a portable mini-lab training unit was custom built. This training unit is also used for high school student experiments. The system has the capability to accept several different renewable energy sources at a time and convert these intermittent voltage sources to constant voltage to charge a battery. The charge controllers handle the charging process of the battery at different input voltages that vary by intensity of light energy, wind speed, or human kinetic energy. The modules and sub-modules of power generation from ambient energy sources using the Alternative Energy training unit are detailed for each energy source (Table 1).

Table 1. Components used for hands-on experiments of the workshops

Photovoltaic System	*Wind System*	*Human Power*
PV modules light and charge controller lightning arrestor circuit breakers and fuses	wind turbine charge controller lightning arrestor start/stop switch	electric bike bike power generator portable power pack and power monitor

solar pathfinder	circuit breaker/fuse	bridge rectifier
battery	amp-meter	DC/AC light bulbs
amp-meter	DMM & precision resistor	fuses
digital multimeter (DMM)	anemometer	hand-held power analyzer
temperature sensor	wind vane	tachometer
irradiation sensor	battery	hand-crank generator
General Components		
DC loads (DC receptacles, DC motor, LED light bulbs, windshield heater, resistors) AC loads (AC receptacles, LED light bulbs, heater, AC motor) power inverter and step-down transformer battery (with protection fuse) solar thermal air heating system solar thermal water heating system DMMs and amp-meters temperature, light, sound, mass, rotary, force, VI, rainfall, humidity sensors barometric pressure, heat index, wind chill, dew point sensors piezoelectric materials friction, thermoelectric, and flywheel kits		

Various renewable energy kits were purchased or built for the K-12 grade level students. These kits are usually accompanied with lab manuals which are more simplified and in greater detail to offer more experiments and demonstrations. The units are a) Power House Green Essentials Edition, b) Solar Super Racing Car, c) 6 in 1 Educational Solar Kit, d) Intelligent Fuel Cell Car Lab, e) Alternative Energy Lab, f) Wind Power Educational Kit, g) Hand-Crank Generator, and h) Kinetic Energy (E-Bike). The kinetic energy E-Bike demonstrates the power of energy generation through a generator by pedaling. Students learn how power is being generated by pedaling and can visualize the voltage, power, current, total power generated. Students also monitor and visualize lighting through the intensity of various light bulbs with LED lights as they pedal.

Project Facts

Fifteen renewable energy workshops and two summer camps were held to attract young minds to engineering technology fields through the alternative energy activities offered in K-12 schools since May 2010. Two week-long summer camps were offered with a variety of energy activities (hands-on, lectures, and demonstrations) to thirty female high school students and twenty-two high school teachers. Among the fifteen workshops and two summer camps, only one workshop and a summer camp were offered to teachers. The school districts where workshops were offered had a very limited number of STEM teachers. Usually there are one or two science and vocational education teachers per school, except in the Conroe ISD High School. Unfortunately, it was not possible to invite teachers from several school districts for one day at one location. The project team has been trying to determine a school district which is close enough to other school districts to schedule a STEM teacher workshop. This way, teachers may travel to the closest school district for a workshop. A summary of participants and instructor numbers is given in Table 2.

A series of workshops were held on and off campus with participation from local area schools. The statistical information in Table 2 includes registration and attendance rosters. This table gives a summary of facts based on numbers of K-12 students and teachers. Student teachers, especially, were involved and were very helpful to workshop instructors. The hands-on sections of the workshops were conducted by student teachers under the supervision of the instructors. Student teachers were trained by the project investigators before the workshops to help students and teachers during the applied sections of the workshops. All the materials applying to workshops including design work, surveys, forms, workshop workbooks, web site, building affordable educational equipment, etc., were prepared with the help of the Industrial Technology program students and faculty.

Table 2: Workshop Facts

Number of students workshops offered (Boys and Girls Club of Walker County)	12
Number of teachers (Science and Vocational – including those teachers who participated as mentors for the student workshops)	52
Number of students (9-12 Grades)	225
Number of students (6-8 Grades)	54
Number of students (4-5 Grades)	86
The number of SHSU student teachers (who helped to conduct workshops)	24
The number of SHSU faculty and graduate students helped to conduct workshops	7

Activities

There are 34 experiments that present comprise the workshop curriculum. Experiments are divided into four categories based on the knowledge level of participants. These types of experiments are conducted using custom built training equipment in the program, which are designed to offer a variety of experiments at several levels.

- Overview to Experiments
- Introduction to the Training Unit - Training Unit Guide
- Overview of Equipment and Materials
    - Exp. 1 Basic Electricity & Measurements (Voltage, Current, Resistance, and Power)
    - Exp. 2 Overview to Photovoltaic Technology
    - Exp. 3 Solar Panel Output Measurements (Voltage, Current, Power, Temperature)
    - Exp. 4 Series-Parallel Connections of Solar Modules
    - Exp.5 Effects of Temperature, Irradiation, Humidity, Wind to Solar Module Output
    - Exp. 6 Solar Panel Efficiency – Shading Effects
    - Exp. 7 Solar Path Finder - Side Shading Analysis and Solar Tracking
    - Exp. 8 Overview to Wind Power Technology
    - Exp. 9 Wind Turbine Output Measurements (Voltage, Current, Resistance, and Power)
    - Exp. 10 Series-Parallel Connections of Wind Turbines
    - Exp. 11 Wind Power Efficiency – Wind Speed vs. Turbine Efficiency
    - Exp. 12 Wind Speed and Direction Measurements
    - Exp. 13 Battery Charging & Protection

- Exp. 14 AC/DC Load Characteristics and AC/DC Conversions
- Exp. 15 Hybrid Systems - Wind and Photovoltaic
- Exp. 16 Energy Generation from Human Power; Electric Bike and Hand Crank Generators
- Exp. 17 LED (Light Emitting Diode) Technology and Comparison to Traditional Lighting
- Exp. 18 Energy Harvesting from Piezoelectric Materials
- Exp. 19 Flywheel Energy Harvesting and Storage
- Exp. 20 Energy Harvesting from Friction Technology
- Exp. 21 Thermoelectric Energy Harvesting Technology
- Exp. 22 Energy Harvesting from Hydrogen Fuel Cell
- Exp. 23 Hydrogen Generation – Electrolysis
- Exp. 24 Measurements I – Light, Temperature, VI
- Exp. 25 Measurements II – Sound, Mass, Rotary, Force, Rainfall
- Exp. 26 Measurements II – Humidity, Barometric Pressure, Heat Index, Wind Chill
- Exp. 27 Alternative Energy Laboratory Experiments Kit
- Exp. 28 6-in-1 Solar Educational Kit
- Exp. 29 Wind Power Science Kit
- Exp. 30 Power House Green Essentials
- Exp. 31 Measuring Wind Speed with Anemometer
- Exp. 32 Solar Super Racing Car
- Exp. 33 DIY. Solar Electric Boat
- Exp. 34 Human Power Lab (Energy Bike)

Several selected photographs of learning activities are shown in Figure 3. There are more activity pictures by the school districts provided on the web site.

 

Feedback

To evaluate the effectiveness of the workshops, students were asked to fill out a brief survey after completing the workshop. Pre- and post-tests were not conducted. Students verbally shared their feedback about the workshop content and wrote their comments on the survey sheets. Surveys were conducted for each group who participated in the workshop to determine how satisfied participants were at the end of the workshops. The feedback from the student and teachers is very positive. The major feedback was the request that we conduct more experiments by having the workshop on several days instead of covering all topics in a single day workshop. Another feedback was to provide more information specific to renewable energy resources and engineering fields by providing flyers, brochures, and posters.

Conclusion

A successful partnership between the Agricultural and Industrial Sciences Department at Sam Houston State University and Entergy Inc. has focused on providing educators and students with exciting, hands-on, unique learning tools that will initiate discussions about renewable energy applications, energy efficiency, and energy conservation in their lives. Though still in its infancy, there is an emerging movement in engineering education across the country, as evidenced by the growth in Science, Technology, Engineering, and Mathematics (STEM) academia and programs in secondary schools as well as the development and deployment of engineering and science curricula. However, rural school districts are often at a disadvantage; there are neither sufficient student populations, resources, nor qualified teachers necessary to implement these specialized programs. Research suggests rural students are less likely to pursue engineering careers due in part to the lack of exposure to or unfamiliarity with the field. Collaboration between schools and institutions is an efficient way to promote engineering education by integrating renewable energy systems into coursework which can generate more student interest than providing equation-based curriculum. Renewable energy-related summer camps and workshops have proven to generate more student interest and promote STEM education, especially in rural areas where there is a lack of teaching tools and equipment. Teachers who have completed the workshop are then able to implement the energy concepts in their classrooms with renewable energy projects and to create an environment where students will understand basic relationships among mathematics, science, and engineering technology applied to renewable energy fields.

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