AC 2011-270: EMERGING TECHNOLOGY INSTITUTE - TRAINING MIDDLE AND HIGH SCHOOL TEACHERS IN ALTERNATIVE ENERGY

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Emerging Technology Institute - Training Middle and High School Teachers in Alternative Energy

Abstract:

Making the nation's energy system greener and smarter will benefit the environment, the economy, and the workforce. Yet, a critical national shortage of skilled electric power professionals is expected in the next five years. This deficit could be stemmed if talented middle school and high school students considered such careers. Middle and high school teachers can play a key role in encouraging students to pursue careers in green energy. To be effective advocates, teachers need training to bring motivating green energy lessons to their own classrooms, sustain student interest with inquiry-based problem solving experiences, and assess the effectiveness of their efforts using valid research methods.

The Emerging Technology Institute (ETI) is a collaborative project of Northern Illinois University, Rockford Public School District, West Aurora Unit School District, Rich Township High School District, and Harlem Consolidated School District supported by the Illinois State Board of Education. The main focus of the project is to provide middle school and high school science, math and technology teachers with hands-on interdisciplinary experience with faculty in state-of-the-art laboratories of alternative energy, nanotechnology, fuel cell, and modern manufacturing. The goal of the institute is to improve teachers' content knowledge and teaching practices in ways that increase the academic performance of their students and in ways that build capacity within their schools for continued, sustained student learning.

This paper describes the alternative energy section in the ETI project. Fundamental concepts of electricity and alternative energy systems were taught using a green energy trainer. Topics include energy review, introduction to electricity, electrical circuits, solar energy, study of characteristics of photovoltaic cells, study of characteristics of wind turbines, data acquisition system to obtain data of voltage, current and power, electric power distribution and smart grid. Next, participants are formed into group of two to design and build a solar powered flashing light. Through the group design project, participants demonstrate understanding of relevant electric safety issues and increase their ability to design and implement alternative energy systems. Towards the end of the workshop, each participant was given a topic to research on and they made an oral presentation to the class.

Problem-based, inquiry learning using authentic problems in alternative energy technology is applied to increase content knowledge of alternative energy and increase interest and awareness of alternative energy. Participants will become community leaders promoting alternative energy technology.

Introduction

A conceptual framework has been provided to show that professional development of quality can lead to increases in educators' knowledge and skills, which in turn leads to changes in instruction and ultimately improves student learning [1]. The Emerging Technology Institute incorporates the professional development context, process, and content standards of the National Staff Development Council [2]. The context standards are met by the learning community approach and involvement of academic leaders in ways that can lead to improved instruction based on action research.

A critical aspect of ETI is its approach to teaching advanced technology. The goal is to have engineering educators communicate directly to the teachers about both fundamental and emerging concepts [3-5]. This allows the teachers to collaborate to format this newly-acquired engineering knowledge into a portable format. This project provides middle school and high school science, math and technology teachers with hands-on interdisciplinary experience with faculty in state-of-the-art laboratories of alternative energy, nanotechnology, fuel cell, and modern manufacturing. The ETI started in summer 2010, and has a period of three years. This paper is mainly focused on the subject of alternative energy within the ETI.

Fundamental Concepts of Electricity and Power

Fundamental concepts of electricity and alternative energy systems were taught to the participants using a green energy trainer. The trainer is a GREEnNtech energy efficiency & renewable energy training lab from Graymark. Topics include energy review, introduction to electricity, electrical circuits, solar energy, study of characteristics of photovoltaic cells, study of characteristics of wind turbines, data acquisition system to obtain data of voltage, current and power, electric power distribution and smart grid.

Fundamentals of electricity were introduced to the teachers first. Concepts of voltage, current, power and energy were defined. Main types of circuits include series circuit, parallel circuit and series-parallel circuit. After the basic concepts of electric circuit were studied, the participants examine the basic characteristics of solar power and wind power. The ETI participants conducted the following experiments. In the mean time, participants were given the web site of National Renewable Energy Laboratory [6] to research on solar power and wind power. The experiments built a solid foundation for the participants to conduct more advanced study on solar and wind power system.

1. Connect a DC voltage source to a DC motor in series.
2. Examine and test an insulated conductor.
3. Verify a DC voltage source has polarities.
4. Measure DC voltage of a battery pack with a digital multi-meter.
5. Measure DC current using a digital multi-meter.
6. Measure resistance using a digital multi-meter.
7. Gather voltage, current and power data of a circuit using data acquisition software.
8. Measure output of a solar panel using data acquisition software. Capture and plot the data.
9. Power a DC motor with solar panels.
10. Observe effect of various light levels on solar panels.
11. Observe effect of heat on a solar panel.
12. Observe effect of tilt on a solar panel.
13. Observe effect of shade on a solar panel.
14. Assemble small wind turbines.
15. Test wind turbines.
16. Change wind turbine blades and measure results.

Group Design Project

Participants were formed into group of two to design and build a solar powered flashing light. The following parts were provided to each design group.

1. Solar panel
2. Solar charge controller
3. 1.2 Ah sealed lead acid battery
4. High brightness light emission diode (LED)
5. 555 timer
6. Capacitors
7. Resistors

Requirements for the design project are as follows.

1. Address safety issues.
2. The solar panel and rechargeable battery should provide all the power for the flashing light circuit.
3. Use 555 timers to control the frequency of the flashing light. The light should flash every second.
4. Current through the LED should not exceed 70 mA when it is forward biased.

Through the group design project, participants demonstrate understanding of relevant electric safety issues and increase their ability to design and implement alternative energy systems.

Oral Presentation

Towards the end of the workshop, each participant was given a topic to research on and they made an oral presentation to the class. Some of the topics are "Application of solar power", "Application of wind power", "Electric safety", "History of solar power and wind power", "Solar and wind power hybrid systems" and "Helpful websites for experiments and lesson plans related to solar and wind technology".

Lesson Plans

Each participant wrote an inquiry-based lesson plan in solar and wind power technology, and electricity after attending the ETI institute. Inquiry-based learning incorporates interdisciplinary study, critical thinking skills, and structured research considering the students as individual learning styles to produce a student-centered instructional method. An example of inquiry-based lesson plans is included in the appendix.

Conclusion

The ultimate outcome of the project is an increase in the number of teachers with alternative energy knowledge and skills. Additional expected outcomes are: each participant will discuss the key facts and engineering applications related to solar and wind power; demonstrate understanding of the relevant electric safety when working with solar and wind power system; demonstrate understanding of basic concepts of electric voltage, current, resistance, power and energy; demonstrate understanding of correct procedure to measure voltage, current and power;

competently research and discuss other experiments and lessons using web-based tools; have increased ability to design alternative energy systems; and write solar and wind technology-based lesson plans to use in his or her classroom.

Problem-based, inquiry learning using authentic problems in alternative energy technology is applied to increase content knowledge of alternative energy and increase interest and awareness of alternative energy. Participants become community leaders promoting alternative energy technology. Each participant writes an inquiry-based lesson plan in solar and wind power technology after attending the ETI institute. Inquiry-based learning incorporates interdisciplinary study, critical thinking skills, and structured research considering the students as individual learning styles to produce a student-centered instructional method. The lesson plans focus students' inquiry on questions that are challenging, debatable and difficult to solve, and structure lessons so that students have opportunities to work with peers and apply concepts to new situations. An example of the lesson plans was included in this paper.

Appendix

Circuit Lesson Plan

TITLE: Brown Bag Science

GRADE LEVEL: Appropriate for grade 5

OVERVIEW: This is a hands-on science investigation on electricity. Students learn through the discovery method how electricity works. The student's natural curiosity and sense of exploration will enable them to explore and learn on their own with little input from the teacher.

PURPOSE: The purpose of this investigation is to introduce students to the concept of electricity and dispel any fears they may have that they don't understand the concept. This is excellent for girls, who often feel that they don't or shouldn't understand electricity as well as boys.

OBJECTIVES: As a result of this activity, the students will:

1. Be able to draw and explain how an electrical circuit works.

2. Be able to define and use vocabulary associated with electricity. Vocabulary: circuits, electrons, force, conductors, switch, insulation

3. Be able to construct a simple circuit and a parallel circuit.

4. Be able to make an electrical motor work and add a switch to turn it on and off.

RESOURCES/MATERIALS: All items can be bought very inexpensively at Radio Shack or from Edmond Scientific Elementary Catalogue.

ACTIVITIES AND PROCEDURES:

1. The teacher will prepare ahead of time a kit for each two or three students. If students work in larger groups, some will not get hands on experience. Each kit will include a brown lunch sack, one C cell battery, two insulated copper wires, one battery holder and two brass battery clips, one small flashlight bulb and socket. All these items must be separate and in random order in the bag. The bag must be closed, sometimes I close it with one of the copper wires like a twisty.

2. Give each pair of students a bag and allow 10 minutes for exploration. During this time the teacher must remain quiet unless asked a question. The students will be very busy trying to find out what to do with the contents of the bag. Do not give any clues as to use of contents. This is exploration time.

3. Before the 10 minutes are up some students will have undoubtedly have made a simple circuit with the contents of the bag. At this time you can stop for discussion. Have the students explain what they did so others can follow. You can now talk about the concept of electricity, the flow of electrons through a conductor, discuss what things are conductors, etc. Discuss where the electricity comes from and where it goes, how does it make the light bulb light. Discuss how the battery stores electricity. How do we know that electrons are flowing?

4. After all students have been successful with the simple circuit, each pair must draw what they have done in their science log or on a piece of paper. Older kids will label all the parts of the circuit, etc.

5. At this time, I give each pair of students a second battery and let them experiment. Does the second battery change anything? Does the light get brighter or dimmer? Does the way the batteries are connected make any difference in the way the light works. Try different ways of connecting the batteries. Some students will make a parallel circuit. At this time stop and have the students tell what they did. Discuss the concept of parallel circuits. Each pair of students draw what they have done.

6. A follow up activity if you have time is to have switches available. For those students that finish quickly, they get a switch. See if they can connect it into the circuit to make the light come on and off. Discuss how electricity flows. Why does the electricity not cross over the switch when it is open? Does electricity jump? Again, each pair must draw what they have done. This completes the thinking process and makes the learning more personal.

7. Electrical motors can also be added. Students enjoy making small fans out of the motors. Each pair of students can exchange their light bulb and socket for a small electric motor and try to connect it into the circuit. Torn or cut paper makes great fan blades. Let the students experiment to find the best size and shape to make the fan go very fast.

8. The role of the teacher in this activity is to be a facilitator. Please refrain from your urge to teach. In this activity, students discover the concept of electricity. The less you show and tell the better.

TYING IT ALL TOGETHER:

1. Check each pair of students diagrams and leave small personal messages so they will know that you have looked at what they have done.

2. Encourage all students to share what they have learned with other students and parents.

Reference

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