
AC 2012-3075: PROBLEM-BASED LEARNING IN THE TRAINING OF MIDDLE AND HIGH SCHOOL TEACHERS IN ALTERNATIVE ENERGY

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Problem-Based Learning in the Training of Middle and High School Teachers in Alternative Energy

Abstract:

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.

Problem-based learning is a student-centered pedagogy in which students learn about a subject in the context of complex and real problems. The problem drives the learning, as students need to acquire new knowledge and integrate with existing knowledge to solve the problem. In the recent years, problem-based learning (PBL) has seen significant development in engineering and technology education. Compared to the traditional lecturing that is instructor-centered, the PBL approach is an active, student-centered, and problem-centered method. Problem-based learning was first applied in medical science education at medical schools. Recently, PBL approach is used for computer network design, electronics circuit design, biomedical engineering, chemical engineering and physics. The approach has mostly been used for university students. but has not been applied adequately to train middle and high school teachers.

This paper describes the alternative energy section in the ETI project. In particular, the paper presents the experience of a structured problem-based learning approach to teach alternative energy to middle and high school teachers. First, the learning objectives were identified. Each participant will discuss the key facts and engineering applications related to solar power; demonstrate understanding of the relevant electric safety when working with solar 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 in solar and wind power systems; have increased ability to design alternative energy systems; and write solar and wind technology-based lesson plans to use in his or her classroom. Second, a problem is defined based on the learning objectives. A problem of solar powered flashing light was given to the teacher participants. Small groups of two teacher participants worked collaboratively. The team brainstormed and discussed methods to solve the problem. The faculty member facilitated the learning process and provided consulting to the teacher groups when necessary. Through the group design project, participants demonstrate understanding of relevant electric safety issues and increase their ability to design and implement alternative energy systems.

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.

Problem-based learning is a student-centered pedagogy in which students learn about a subject in the context of complex and real problems. Problem-based learning was first applied in medical science education at medical schools. Recently, PBL approach is used for computer network design [6], electronics circuit design [7, 8], biomedical engineering [9], chemical engineering [10] and physics [11]. Most of the research has been focused on PBL approach for graduate students and junior/senior level undergraduate students.

Learning Goal and Objectives

The goal is to enhance participant awareness of the many aspects of solar and wind technology as taught from electrical engineering technology approach. Based on the Illinois professional teaching standards and the National Science Teachers Association professional standards, the following objectives have been defined.

Each participant will

1. Discuss the key facts and engineering applications related to solar and wind power.
2. Demonstrate understanding of the relevant electric safety when working with solar and wind power systems.
3. Demonstrate understanding of basic concepts of electric voltage, current, resistance, power and energy.
4. Demonstrate understanding of correct procedures to measure voltage, current and power in solar and wind power systems.
5. Competently research and discuss other experiments and lessons using web-based tools.
6. Have increased ability to design renewable energy systems
7. Write solar and wind technology-based lesson plans to use in his or her classroom.

Fundamental Concepts of Electricity and Power

The teacher participants were recruited from the school districts in the northern Illinois region including the Rockford, DeKalb, Ridgeland, Rich Township, Harlem, and West Aurora School Districts. The teachers have background in mathematics, physics, chemistry, biology, environmental science, and industrial technology. With such a diverse background, it is important to prepare the participants with necessary knowledge and skills to embark on the problem based learning. Therefore, fundamental concepts of electricity and alternative energy systems were first taught using a green energy trainer. The trainer is a GREENtech 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. Main types of circuits include

series circuit, parallel circuit and series-parallel circuit were introduced. After the basic concepts of electric circuit were studied, the participants examine the basic characteristics of solar power and wind power.

Problem Based Learning

Based on the goal and objectives, a problem is defined. Two participants formed a group to work collaboratively. Each group designed and implemented a solar powered warning light.

The following parts were provided:

1. Solar energy kit
 - a. solar panel
 - b. solar charge controller
 - c. rechargeable battery
 - d. Cables and socket
2. Light emission diode (LED)
3. 555 timer
4. Capacitors
5. Resistors

Following are the requirements of the project.

1. Address safety issues.
2. The solar energy kit provides all the power for the flashing light circuit.
3. Use 555 timers to control the frequency of the flashing light. The light should flash at a frequency of 1 Hz. The 555 timer has astable operation. The frequency is determined by the values of the selected resistors and capacitor.
4. Current through the LED should not exceed 70 mA when it is forward biased.

The teacher participants first designed the circuits using the provided parts and datasheet. Next the participants discussed their designs with the faculty member and teaching assistants. The Participants then conducted a Multisim simulation. Figure 1 shows the simulation. Figure 2 shows the simulation results of channel A and B. The 555 timer controls the frequency to turn on and off the LED. The simulation helps identify problems in the design, and verify the design. The participants need to connect a solar panel to a charge controller, and then connect the charge controller to a rechargeable battery. The battery provides all the power for the flashing light circuit. This practice helps the participants with wiring and connections. The participants then build the system based on the simulation, and finally test the system outdoors. The hands-on experience helps emphasize the practical safety issues when working with electrical circuits. Through the problem based learning, participants increased their ability to design and implement alternative energy systems.

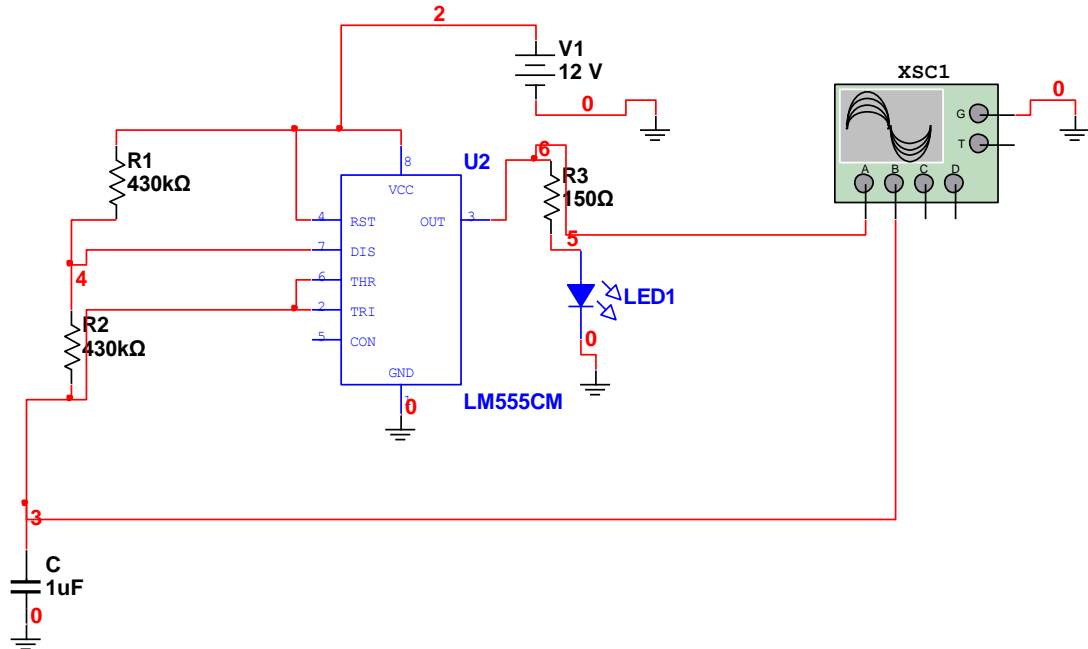


Figure 1. Multisim Simulation of Solar Powered Warning Light

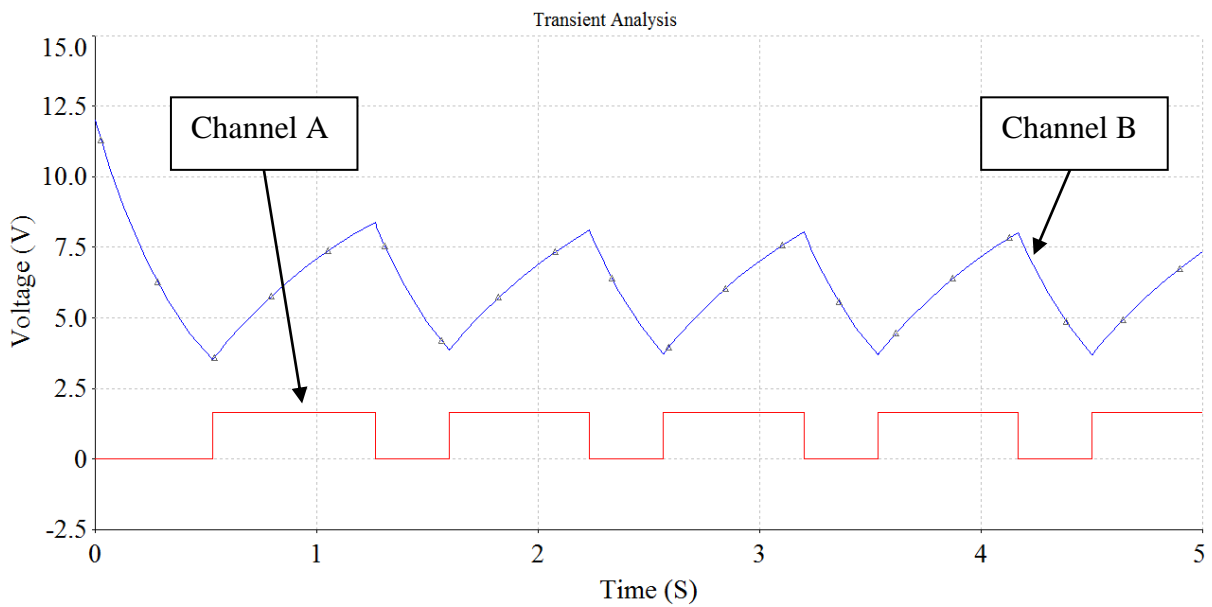


Figure 2. Simulation Results

Conclusion

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 will write 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.

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