Enhance the Student Learning Outcome in Green Energy Engineering using Combined Lecture and Seminar

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Abstract

There is an increasing trend in promoting green energy to replace fossil energy in both academia and industry due to the significant impact in environment and economy. Major investments are being made by the federal government and industry in clean energy technologies that will create entirely new industries, expand markets for solar, wind, and other clean energy sources. Therefore, in order to meet the demand in green energy, the training and education of the next generation workforce is critical to success of green energy industry and the nation’s economy growth and prosperity. Traditional engineering education seldom covers any content related to green energy engineering. To address this gap, we will investigate the use of combined learning activates such as special topic summer course and regional student seminar to enhance the student awareness in green energy engineering. The learning outcomes include fundamentals of green energy materials, design and manufacturing of green energy devices, and management of green energy systems. Assessment tools used in assessing student learning outcomes include quiz, exam, project, and survey. In conclusion, it is found that student’s knowledge in green energy engineering has been significantly increase after the combined lecture and seminar activities.

Keywords: Green Energy, Lecture, Seminar, Learning effectiveness

Introduction

Mills & Treagust identified the critical problems in how engineering courses are delivered. This issues arises because engineering courses rely on traditional lecture-based approach. Additionally, engineering curricula focuses on engineering science without incorporating practices that will be helpful to the student once he graduates. Another issue identified, is the lack of teamwork and design experience. In lecture-based approach, students selectively learn from the instructor while dismissing the rest. To address this problem, several solutions have been proposed such as flipped classroom and project-based learning. The former consists of using video content for lectures and take-home problems in order for the student to learn the theory at home. Additionally, flipped classroom dedicates most of the lecture time on problem-solving session in groups, or other interactive activities. This methodology has received an overall positive response from students. However, it still under development so it has not been widely implemented in college. On the other hand, project-based learning has been broadly executed. Project-based learning enhances knowledge retention in students since they acquire the fundamental principles by solving a problem, which provides context to the theory learned while making it more relevant. Additionally, it prepares students for industries as it enhances team working and soft skills.
Special Topic: Green Energy Materials and Engineering (*MECH 4395/5390 and IE 4395/5390*)

Green energy materials and engineering is a special topic course that focuses on combining renewable energy design and manufacturing while incorporating cyber-infrastructure issues which provides diverse content on how to conduct research in areas of nano-material, manufacturing, evaluation of green energy materials found in practice and their performance, green engineering storage devices and harvesting materials and devices, and nano-materials and their manufacturing. In order to achieve said objectives, the class was divided into three modules while integrating the concept of flipped classroom.

In Module 1 fundamental concepts of conscious (benign) manufacturing were introduce to familiarize students with energy and environmental issues that need to be taken into account for product and process design. Life cycle assessment (LCA) is implemented with Green manufacturing software package (LCA), GaBi, and case studies. LCA will teach students to identify and develop strategies, techniques, and methods to assess environmental concerns by making environmentally responsible decisions. In this module, students had a project were they had to recognize a problem and utilize GaBi to propose a solution. This project provided the students with the opportunity to learn to analyze and interpret data collected from LCA, and the impact this data has in decision making. An active lecture session can be seen in Figure 2.
Module 2 discussed green energy technologies and their commercial and industrial application. Students engaged in discussions of the performance of green energy such as thermoelectrics, solar photovoltaic panels, and composite material wind turbine systems. These fundamental discussions focused on financial considerations and an efficiency perspective. Additionally, students achieved hands-on experience by conducting experiments to measure the efficiency of energy devices previously mentioned. This module focused on team-based projects, while both the quiz and exam were individually assessed.

Module 3 exposed students on modern fabrication techniques that are being used for green energy devices such as solar cells, advanced lithium-ion-batteries, vibration energy harvesters, pyroelectric energy harvesters, super capacitors, and electrochromic coatings. Fundamentals of energy harvesting and storage energy devices were covered in class. Additionally, future development trends were introduced by giving students an investigation assignment on energy harvesting and energy storage devices such as dye-synthetized solar cell, super capacitors, lithium-ion batteries. At the end of the module student were expected to do a fifteen-minute presentation on the research they conducted on the design of energy devices.

Implementation of Project-Based Learning

During the third module students were assigned projects designed to expand knowledge on pyroelectric materials and their applications; a subject covered as part of Green Energy Materials and Engineering. The experimental setup consisted on either a piece of Lithium Niobate (LiNbO$_3$) or Lead zirconate titanate (PZT) placed on top of a heating pad, which was connected to a power supply. Additionally, a surface thermocouple will be placed on top of the sample to read its temperature. A picoammeter was connected to the sample to measure the current it generates when it is subjected to a temperature difference over time. The students’ objective was to use the current readings to back calculate the sample’s temperature, showing them the feasibility of developing a temperature sensor based on the pyroelectric principle.

For the experiment and data gathering, teams of five members were randomly formed. Each team had to conduct the experiment, collect data and analyze it. Then wrote a report explaining the pyroelectric concept, the methodology and apparatus used. Additionally, they had
to interpret the data and discuss their results of the experiment. The experimental setup and data gathering procedure are illustrated in Figure 3.

Figure 3: Experimental setup: A) Experimental apparatus, B) shows student using LabView for data gathering

Survey

A survey was conducted at the beginning of the first module to understand how familiar students were with topics covered in the Green Energy Materials course. From the survey, only 27% preferred project-based learning (flipped classroom) over face to face learning. However, many stated that mixing both teaching styles would be the better solution, as they augment each other. Moreover, they discussed that the problems often encountered with flipped classroom setting is not being able to ask question or engage in discussions. When asked if they have had some experience working with energy materials, only 35% had worked with energy materials. Students were also asked to rate their knowledge on energy materials, and smart materials before the course began. Only 6.3% considered themselves able to assemble and balance facts, and ideas while making informed decisions on both energy materials and smart materials. For energy materials, 12.5% considered themselves capable of performing task related to the topic by using fundamental skills, while for smart materials was 6.3%. 25% Students considered familiar with topics and being capable of dealing with specific definition with of smart materials, and 37.5% for energy materials. However, 50% students were only familiar with terms and language used in
energy materials, while for smart materials it was a 56.3%. Both graphs of the pre-course survey, energy materials and smart materials, can be found in figure.

Figure 5: Graphs showing student’s response when asked to rate their level of knowledge on A) energy materials and B) smart materials.

A survey was also conducted at the end of course, during the third module. Students were asked the same question, to rate their level of knowledge in smart materials and energy materials. However, by the time of the post-course survey, the students had already researched about the subject and achieved hands-on experience conducting experiments with green energy materials. None of the student assessed their knowledge as aware for neither of the two subjects. The percentage of students considering themselves capable of performing task related to both smart materials and energy materials increased to 43.8%. The percentage of students assessing themselves as familiar with definition decrease to 31.3% for energy materials, while increasing to 37.5% for smart materials. The percentage of students considering themselves make informed decisions and recommendations also increased to 25% in energy materials and to 18.8% in smart materials. Both graphs of the post-course survey, energy materials and smart materials, can be found in figure.

Figure 6: Graphs showing student’s response when asked to rate their level of knowledge on A) energy materials and B) smart materials.

Conclusion

This paper provides an overview of the course Green Energy Materials & Engineering that was offered in the term of summer 2016 at the University of Texas at El Paso. This courses focuses
on Green Manufacturing and Green Energy devices. Additionally, it emphasizes on students achieving hands-on experience through laboratory experiments. The laboratory setting associated with the class is also described. Students also learned how to conduct research in areas of nanomaterials and nano-manufacturing. In order to quantify the success of the course, students were handed a short questionnaire before and after the course. In this survey, students were asked to assess their knowledge on the different topics covered in the class. It was found that students before taking the class, lacked the understanding of Green Energy engineering needed for industry. This is due to the engineering curricula not covering content relating to Green Energy engineering. However, students after taking the course were knowledgeable enough to discuss subjects or perform tasks related to Green Energy. This was achieved by implementing both flipped classroom and project-based learning approaches.

References


Appendix:

1. Sample slides used for teaching
2. Sample slides developed by students in flipped classroom learning activities
Solar Thermal Energy Storage

What is it Solar Thermal Energy?

Solar thermal technology uses the sun’s energy, rather than fossil fuels, to generate low-cost, environmentally friendly thermal energy. This energy is used to heat water or other fluids, and can also power solar cooling systems. Water is then used to generate steam and passed through a turbine to change this thermal energy into electricity.

Storage

Energy collected by the sun in the fluid needs a place for storage. There is different types of storages that serve different functions and are for different type of purposes.

These storages are:
- Water tanks
- Borehole Storage
- Aquifer Storage
- Cavern Storage and Pit Storage (under development)

Water tank

This type of storage is normally used in houses or for large apartment complexes. It is a good solution because it can serve for various utilities like electricity and hot water.

Once heated water from the solar collector is stored it can be passed through a set of filters which can clean the water for domestic use instead of using a normal water heater which uses fossil fuels to heat water. From the same storage tank water can be passed through a steam turbine which in turn produces electricity.

Borehole Storage

Borehole storage is normally used in places where there is cold climates and keeping the water hot in the storage is a problem.

This type of storage is based on vertical heat exchangers installed underground which ensure the transfer of thermal energy to and from the ground layers. The ground helps in this type of storage since low temperature heat is extracted from the soil to keep water hot.

Aquifer Storage

Aquifer storage uses natural aquifers for this application. The greatest limiting factor is that there has to be an aquifer close by the construction site.

This type of storage pumps water from and to another one adding thermal solar energy to heat it. The water is stored and used and in the opposing season this same energy can be extracted by pumping out the water for cooling. This type of system is basically used for very large constructions like tall buildings.

Cavern Storage and Pit Storage (under development)

Cavern storage are based on large underground water reservoirs created in the subsol to serve as thermal energy storage systems. These storage options are technically feasible, but applications are limited because of the high investment costs.

This type of storage follows the same principle as the aquifer storage, but these are man made aquifers which imply high costs and are normally used with state of the art edifications.