Training Renewable Education Systems to Midwestern College Students for Engineering Education and Improved Retention Rates

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Abstract

Energy education, especially alternative energy, is a broad field with many disciplines, including engineering, physics, chemistry, biology, mathematics, and others. One of the major challenges of energy related education is to provide students in this field with the ability to understand the fundamental concepts. Another is to be able to retain students' interest in the field, especially in the discipline of engineering, at both the college and high school levels. In the present study, a first year college student from a previous study was given the opportunity to, with guidance, improve upon a project related to the field of energy. The opportunity provided the ability to enhance the level of education and interest in engineering, as well as informing the student on the social, economic, and educational implications of the engineering field. Opportunities of this nature could help to retain students in engineering education and complete the degree on time.

Keywords: Science Project, Energy Harvesting, Engineering Education, Student Retention.

1. Introduction

1.1 Motivation

This study is a continuation of a study done in the Spring and Summer of 2014[1] by this group that was related to a study done in the Spring of 2013, of which one of the members of this group was involved[2]. The results of the 2013 study show that high school students involved in the technology training program showed increased interest in enrolling in the College of Engineering (CoE) at Wichita State University (WSU). This promoted interest amongst the authors to further study methods to recruit and or retain students, thus sparking the 2014 study. The 2014 study did issue some positive results, but it was felt that it could be taken further. The current study is intended to do that. While the 2013 study focused on promoting nanotechnology education to high school students, the 2014 study focused on promoting energy education to high school students, and it utilized the same scientific approach to a different engineering subject. While the 2013 study utilized many separate experiments, the 2014 study utilized a single project. The current study is an improvement upon the 2014 study. This study relies on the further improvement of the project from the 2014 study. While both previous studies showed an overall interest of the students in studying engineering, gaining the initial interest only goes so far. When classes, such as the calculus series, begin to become difficult, the interest can dwindle, and lead to students choosing to abandon engineering education for education in other fields. For the

study, while a first year college student was the participant, could be applied to the high school level as well. The goals of the current study are:

- To educate a college student using a hands-on experience by improving a single project in the field of energy involving research
- To maintain interest in the field of energy, especially alternative energy sources
- To further improve the awareness of some applications of alternative energy sources
- To further improve the basic knowledge of energy sources, as well as associated technologies and ideas.

And, finally,

- To maintain interest in the field of engineering.

1.2 Energy and Education

Energy is the ability to do work. In this study, energy is redefined as the storage potential of work and the ability to use it at a later time. Alternative energy refers to energy sources that are renewable, such as wind, solar, biomass, and hydroelectric[3]. One of the most commonly used forms of energy in the world is electricity. However, other energy sources must be used in order to produce electrical energy. About 68% of all electricity generated in the United States is generated from the fossil fuels, such as coal, natural gas, and petroleum[4]. This leaves only 32% of the electricity generated by non-fossil fuel sources. Extensive research in the area of renewable energy sources is ongoing, and relates to many fields, such as engineering, mathematics, physics, chemistry, education, business, and so on.

There is both public and private interest in developing new technologies for alternative energy sources. Due to this, there is a need for highly talented engineers to analyze and design new and innovative technologies and ideas for harnessing alternative energy sources[5-6]. However, if future engineers lose interest in their studies into engineering education, there will be significantly fewer engineers to perform those duties. The Midwest has a historical relationship to energy production, and today especially renewable energy sources. Midwestern agriculture provides biomass for ethanol energy production, and the Midwest is home to several electricity generating “wind farms”. Therefore, new engineers interested in renewable energy will be a valuable asset to the Kansas and other Midwestern states.

2. Methodology

2.1 Hands-on Experience

In this study, a first year college student was trained in the Spring and Summer of 2015. The plan was to have the college student, the high school student in the 2014 study, improve upon and gather data for the project that he completed as part of the 2014 study. An engineering faculty member in the Department of Mechanical Engineering at WSU was available as a resource guide to the high school student for the project improvements. The project was to

utilize the waste heat in a Natural Gas or Propane Gas barbecue (BBQ) grill to charge the battery for an electric igniter for the grill. The project required the high school student to do research as to the best method for harnessing the waste heat, and it also required the high school student to run experiments to verify the methods chosen. However, as part of retaining the student's interest in engineering, the student was to improve upon this project, and gather data related to the function of the device.

2.2 Project Description

This section provides a brief description of the student's project, as well as improvements. Even though the project has been continuing, this report generally delivers a summary of work that is finished up to now. A Thermo-Electric Generator (TEGs) was selected as the source of power. Figure 1 shows the photograph of the thermo-electric generator used in the present study.

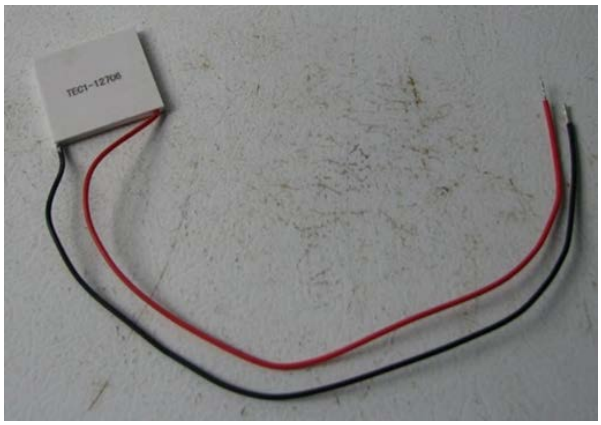

Figure 1: The photograph showing the example of thermo-electric generator which was attached to the hot surface of the BBQ grill during the cooking.

A Nickel-metal hydride (NiMH) battery was used in the project. The original basic circuit relied on several different parts, including a power circuit, temperature circuit, control circuit, charge circuit, and ignition circuit. Figure 2 shows the general layout of the basic circuit diagram.

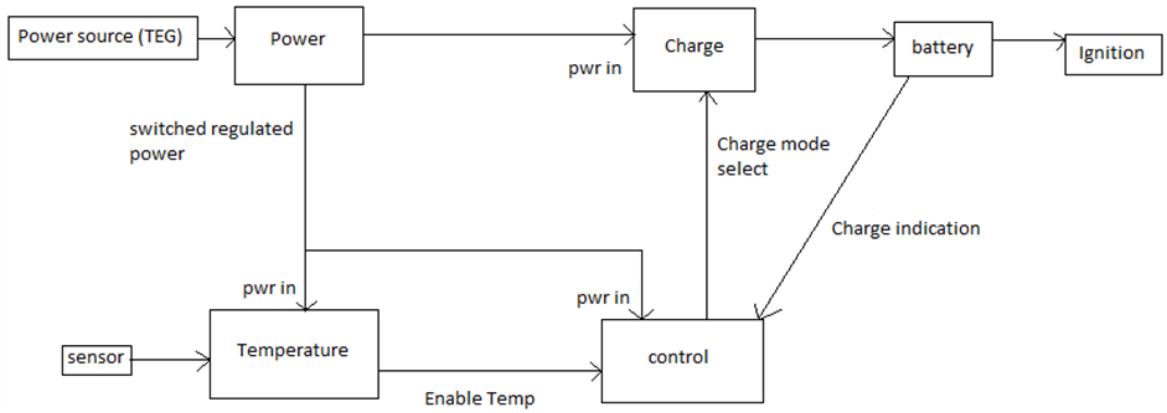

Figure 2: General layout of the basic circuit diagram for energy systems.

The ignition circuit is a standard electric igniter for a grill, shown in Figure 3, with some modifications. For more information on the original project, please see the 2014 study, as the modifications are more relevant to the current study.

Figure 3: The ignition system used during the experiment.

While the current study is ongoing, with some elements still in progress, the most major improvement is to the circuit design. An improvement to the sub-circuits allows for the combination of the analog Temperature and Control sub-circuits into a single programmable integrated circuit (IC) sub-circuit that fulfills both functions, which allows for simplification of the overall circuit, as seen in Figure 4.

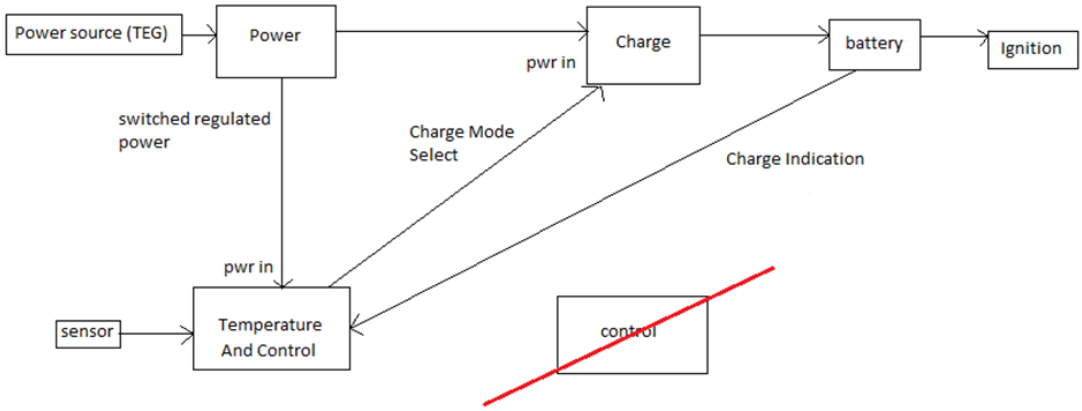

Figure 4: The improved basic circuit diagram for this study.

3. Results and Discussion

3.1 Test Results

Due to the complexity and power requirements of the analog circuitry, an efficient programmable IC was implemented. The implementation of the programmable IC significantly reduced the number of components necessary for the circuit. The simplification of the circuit will also decrease the amount of energy lost. It does so by decreasing the power demand of the

circuit. This will increase the amount of energy that is available to charge the battery, which will result in faster, more efficient, charging.

The power the circuit will be supplied by TEGs. The TEGs are generally used to generate a heat differential from electrical potential rather than electrical potential from a heat differential. Due to this, there was no data available for this application. Therefore, it was required to gather data through experimentation. In order to identify the number of TEGs needed to power the circuit and charge the battery, it was necessary to identify power output per heat differential per TEG. Electrical potential was the only parameter that could be measured from the TEG (Figure 5). Using Ohm's Law, it was possible to calculate power output by measuring electrical potential over a known resistance, as seen in Figure 6. Based on the data collected, it is estimated that six TEG units will be needed to adequately power the circuitry and charge the battery.

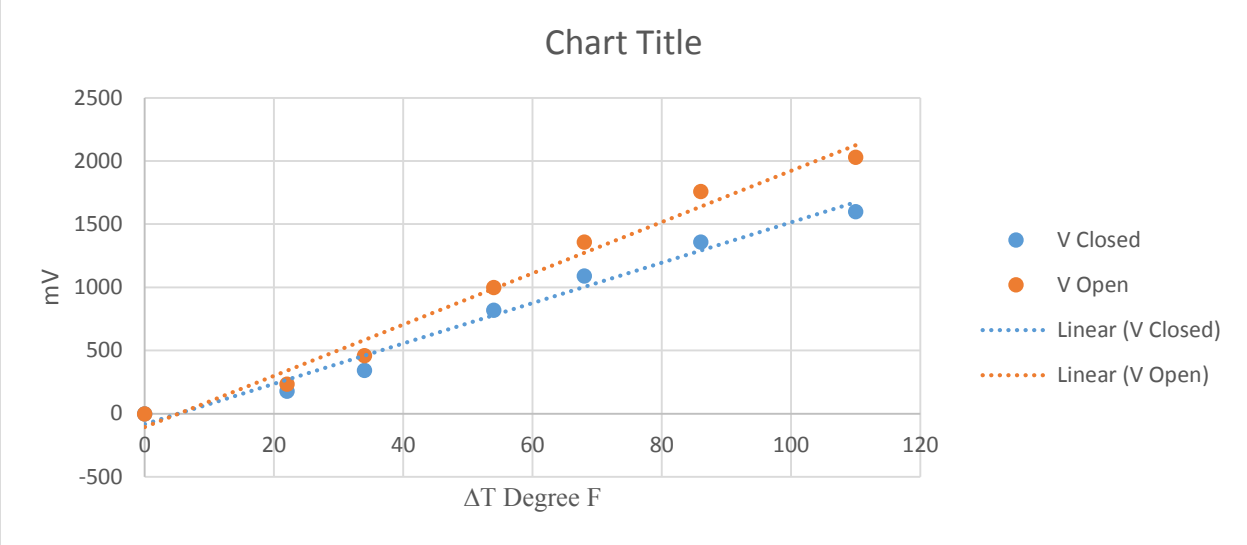

Figure 5: Voltages measured from the TEG without load (open circuit) and with load (closed circuit).

This project, despite small scope, reaches further. While it proves that it is possible to charge a battery used in the operation of the grill, thus the grill is more self-sustaining, by scaling up, it could be possible to charge not only the grill battery, but an external battery as well. This would capture and store more of the otherwise wasted energy. It could also be possible to use similar technologies for larger applications, such as capturing waste heat from sources such as automobile exhaust, power or other industrial plants, high-use electrical devices such as air conditioning compressors, and others.

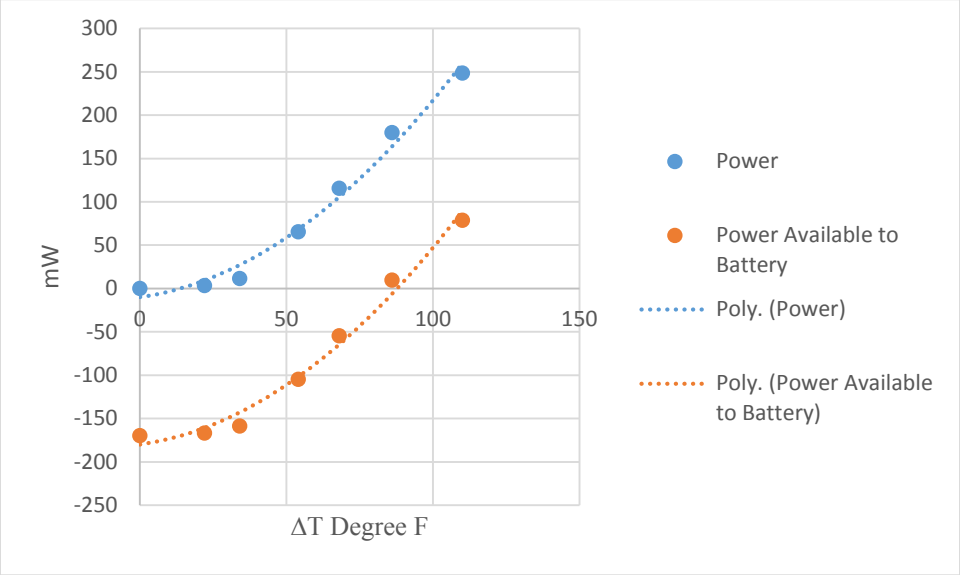

Figure 6: Power calculated during the experimental studies.

3.2 Evaluation of Study

There is potential for several outputs to be drawn from the present studies in terms of design, manufacturing, concept, energy efficiency, and future trends in the energy fields. As an evaluation of the overall study, the college student, Erik Mallonee – first author of the paper, was asked these questions:

- What did you like about this experience?
- What were your thoughts on continuing engineering education before this experience?
- What did you learn from this experience?
- What can be improved?
- How can these improvements be made?
- Do you plan to continue engineering education at one of the Engineering Collages in the Midwest area or other part of the country?

Erik responded to all of these questions properly and clearly, some of which are summarized below. He responded saying that the best part of the project was the experience in design improvement, research, experimentation, and manufacturing. He felt that the problem solving process is an important part of being an engineer. He also stated that the continuing work on the project has helped to maintain his interest in engineering. Erik said that he learned even more from this experience about energy efficiency and conversion, since that was what the major area of improvement to the project was. He stated that the most important thing he learned is that one of the major tasks of an engineer is to look for and solve the problems when designing

something, no matter how small. He felt that even though something an engineer designed meets the what is required, there is always room for improvement upon the design.

Erik stated that there were no major improvements to be made to the program used for the study. He believed that the problems from the 2014 study had been resolved, and that no new problems had arisen. This experience changed the way that Erik viewed renewable energy and future energy sources. He plans to continue education in engineering at one of the Midwestern Universities and study further in these fields.

3.2 Comments from Student

As stated in the previous section, Erik has maintained his views of engineering education, due in part to this project. "I've had a pretty strong resolve to remain in engineering education, and part of that is due to the opportunity I have been given. Especially since I have recently taken some difficult classes required for engineering, I have questioned my choice of engineering as opposed to other areas of study. But I have always remembered what engineering is, and why I want to study it. The project has helped with that. I want to create things. I want to solve problems. I want to solve problems that I have created. "

Erik also had some comments about the experience overall. "I am incredibly lucky to have been offered the previous opportunity by the engineering faculty member (last author of the paper) at WSU in the first place. I am extremely lucky to have been offered the current opportunity, and I am very glad that I have been a part of this project. Not everyone is given one opportunity like I have. Fewer still are offered two. I feel very fortunate to have been offered these great opportunities. This recent opportunity has served to strengthen my future plans. Even though I chose engineering as a major, I had always considered other areas of study as well. As I mentioned before, I have questioned my decision few times. After this experience, however, I am even more committed to engineering at WSU than ever before."

4. Conclusions

The project was involved in illustrating the concept, design, manufacturing, research, development and experimentation, and improvement aspects of engineering to retain student interest in engineering education. The college student learned about how engineering is always open for improvement, and that future engineers can make that improvement. Review by the student of the process shows that he is highly interested in continuing his studies in engineering education, despite suitable other alternatives. Overall, this study indicates that renewable energy education and education on the further improvement of technology is an option to retain students in the CoE at WSU by furthering student interest.

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Erik Mallonee

Mr. Mallonee is a first year college student at Butler Community College planning to transfer to Wichita State University, and is interested in learning the renewable energy and biotechnology related fields. He has authored one paper.

John Barkley

Mr. Barkley is a technical fellow and interested in designing and manufacturing of energy systems and devices.

Ramazan Asmatulu

Dr. Asmatulu received his Ph.D. degree in March 2001 from the Department of Materials Science and Engineering at Virginia Tech. After having the postdoc experiences, he joined the Department of Mechanical Engineering at Wichita State University (WSU) in August 2006 as an assistant professor, and received his tenure and promotion to be associate processor in July, 2012. He is currently working with 13 M.S. and 8 Ph.D. students in the same department. Throughout his studies, he has published 78 journal papers and 166 conference proceedings, edited two books, authored 34 book chapters and 4 laboratory manuals, received 35 funded proposals, 15 patents and 34 honors/awards, presented 91 presentations, chaired many international conferences and reviewed several manuscripts in international journals and conference proceedings. To date, his scholarly activities have been cited more than 1050 times, according to the web of science.