Robert Fletcher, Lawrence Technological University

Robert W. Fletcher joined the faculty of the Mechanical Engineering Department at Lawrence Technological University in the summer of 2003, after two decades of continuous industrial research, product development and manufacturing experience.

Dr. Fletcher earned his Bachelor of Science Degree in Chemical Engineering from the University of Washington, in Seattle, Washington, a Master of Engineering in Manufacturing Systems from Lawrence Technological University, in Southfield, Michigan, and the Master of Science and Ph.D. degrees in Chemical Engineering focusing on Electrochemical Engineering, both from the University of Michigan, in Ann Arbor.

He teaches a number of alternative energy courses and is leading LTU's efforts to establish a full energy engineering program that addresses both alternative and renewable energy systems, as well as energy conservation and optimization of traditional energy systems. He also is the Director of the Alternative Energy program at Lawrence Tech. Dr. Fletcher and his student research teams are currently conducting long-term performance durability and reliability on multiple PEM fuel cell research used under a wide range of operational conditions for the US Army, as well as battery research, and the implementation of alternative energy power sources in autonomous ground vehicle robots. He is also working with his students supporting DTE Energy in the operation and optimization of their Hydrogen Power Park in Southfield, Michigan, a photovoltaic, biomass, water electrolysis, hydrogen storage, hydrogen vehicle fueling station and fuel cell power demonstration project, funded by the Department of Energy. He has also established an alternative energy laboratory at LTU that contains integrated fuel cell and hydrogen generation systems, as well as equipment for solar (thermal and photovoltaic), biomass, wind and other alternative and renewable energy generation equipment.
Using an Alternative Energy Summer Camp for High School Students as a University Outreach Program for the Recruitment of Future Engineering Students: A Two Year Study

Abstract

Lawrence Technological University (LTU) in 2007 and 2008 conducted a one week long Alternative Energy Summer Camp for high school students. This summer camp is one of several on-campus camps at Lawrence Tech that give high school students the opportunity to learn about specific technologies and to interact with full-time university science and engineering faculty. The Alternative Energy Summer Camp focuses on the major technologies in this field, including solar heating, solar photovoltaics, wind energy, geothermal systems, and fuel cell and hydrogen technologies. This camp was held with a limited enrollment to help assure close faculty contact and to give the students maximum opportunities to obtain hands-on experiences with the major associated equipment in our university’s Alternative Energy Laboratory. This paper evaluates the evolution of the summer camp structure, as well as assesses and reviews the feasibility, benefits, and value of conducting this summer camp over two summer sessions. Detailed assessment data obtained from the student participants (by survey and interviews), as well as feedback from participating faculty from both summer sessions that augment the understanding and value of such work to both student and institution are provided and reviewed. We have found that students not only gained a significant understanding of the Alternative Energy technologies, but also increased their desire to pursue the study of such technologies when they enrolled in college. Students also indicated an increased interest in pursuing an engineering degree in general. The results of this effort at LTU strongly support the value and benefits of holding such summer camps for the recruitment and expansion of student appreciation of the Alternative Energy field.

1) Introduction

The recruitment, enrollment and retention of students are major areas of attention for colleges and universities across the country. This is especially true for academic programs in the sciences and engineering. In addition, major efforts in Science, Technology, Engineering, and Mathematics (STEM) education programs have now been on-going for several years to help assure an adequate supply of future engineering and technical talent.\textsuperscript{1, 2} Many universities and their and their respective colleges have, over the years, developed summer camp programs for students from all ages of the K-12 spectrum to help meet these goals of recruitment and enrollment. This is especially true for colleges of engineering and the departments within those universities.

A quick review of the ASEE literature alone documents and reviews numerous summer camp programs with a broad array of scope and emphasis. The literature typically indicates four types of summer camp programs. These are loosely grouped here as:

a) Introduction to Engineering programs that expose the student to the broad and many aspects of engineering, while hoping to kindle interest and enthusiasm in these students
to become engineers, and try to help them understand the value and importance of engineering.\textsuperscript{3,7}

b) Topical programs that concentrate on a specific technical area or field. These can range from robotics to computer programming, and can include specific engineering disciplines. These are typically the types of summer camp programs offered by Lawrence Technological University.\textsuperscript{8-13}

c) Programs that target specific segments of the population that may be underrepresented in the engineering disciplines, or at universities, in general. These include summer camps for example that concentrate on teenage girls, minorities, or inner city youth.\textsuperscript{14-22}

d) Summer camps that focus on teaching public school teachers about engineering and can give those teachers new skills or insights that, in-turn, can be given to their students.\textsuperscript{5,23}

In some cases, these programs run throughout the year.\textsuperscript{24}

Accompanying these summer camp programs are well documented efforts to assess and evaluate the effectiveness of enhanced student knowledge and learning about engineering, as well as their ability to recruit and enhance enrollment at the institutions where they are implemented. In most cases these summer programs are helpful in both areas.\textsuperscript{10,19,25-29} There are, however, financial costs incurred to the institution. There are also significant time commitments required of those teaching in these programs. These will be discussed later in this paper.\textsuperscript{9}

Lawrence technological University (LTU) has had various summer outreach programs for several years. These have included the Summer Science Institute for high school juniors and seniors, and the Summer Odyssey for middle school students. LTU found that these, and other programs, have successfully recruited new students, and have helped women and minorities improve their attitude toward math and science.\textsuperscript{2,30} In 2007 LTU transitioned from the previous format they had for summer outreach programs to more focused and topic specific summer camps. The 2007 summer camp topics included Autonomous Robotics Camp, Alternative Energy Power and Generation Camp, Telecommunications/Communication Systems Camp, Gaming Camp, Biotechnology Camp, Biomedical Engineering Camp, and an Introduction to Engineering Camp. In the summer of 2008 some modifications were made and the summer camp roster included Biomedical Engineering Camp, Entrepreneurial Discovery Business Camp, Forensic Summer Science Institute Camp, Autonomous Robotics Camp, Alternative Energy Power and Generation Camp, Automotive Design Camp, Gaming Camp, and the Biotechnology Camp.

This paper reviews the Alternative Energy Power and Generation Camp offered over the two summers of 2007 and 2008. The Alternative Energy camp was proposed in 2006 as a possible summer camp option. LTU has been developing an Alternative Energy engineering program since 2003 and has built up a range of technologies in its Alternative Energy lab. These include fuel cells, full-scale photovoltaic systems, full-scale solar water heating systems, a small on-campus wind turbine and a low-velocity wind tunnel designed and built by faculty and students to study airfoil designs for wind turbines, biofuel production systems such as biodiesel and ethanol on small laboratory and semi-plant production rates, oxygen bomb calorimetry for liquid fuel (and some solid fuel energy content analysis), a geothermal heated and cooled building on campus with data collection and system tracking, solar insolation meters, and many other
instrumentation and measurement systems. As a result it was thought that these fully operating systems could be beneficial when utilized as teaching tools for such a summer program.

Lawrence Technological University is a private, fully accredited university located in Southfield, Michigan. LTU has approximately 5,000 students in more than 60 degree programs at the associate, bachelor’s, master’s, and doctoral levels through the Colleges of Architecture and Design, Arts and Sciences, Engineering, and Management. The College of Engineering is comprised of a Mechanical Engineering Department, an Electrical and Computer Science Engineering Department and a Civil Engineering Department. Historically, the College of Engineering was focused on teaching, but a growing number of full-time faculty members are now undertaking research programs to supplement their teaching efforts. The college of engineering student base is predominantly undergraduates. The college’s graduate programs are growing, thought still primarily teaching based. Research is required at the doctorate degree level.

2) Program Structure and Content

During the development phase of the Alternative Energy summer program there were concerns regarding which students should be allowed to enroll in the program. The author of this paper, who directs the Alternative Energy lab, and who was the primary instructor for the summer camp, had concerns about the safety of the students and the well-being of the equipment while used by summer camp students. Some of the equipment in the lab is custom built and some is research-grade worth many thousands of dollars. Due to these issues it was felt that there had to be a head-count limit and an age limit for the students for lab activities. The school administration wanted to allow all high school students to be able to attend. The author questioned who is a high school student? The LTU summer camp program coordinator, (a non-faculty member) believed that someone entering the 9th grade (just out of 8th grade) could be viable high school students to admit to the program. The author wanted only students who were going into grade 11 and grade 12 to attend the summer camp assuring attendees had an adequate level of maturity in the lab and around the equipment. School systems are not the same, even for neighboring school districts. Often student academic performance and maturity at the same grade level can vary widely. It was thought that these older high school students would also have a greater academic capability from possible having taken high school chemistry and/or high school physics so that they would understand the basic science behind the alternative energy systems scheduled to be covered in the camp. In 2007 students who were entering 9th grade up to entering 12th grade were admitted. The author’s concerns regarding 9th graders, and in some cases regarding 10th graders, were validated in 2007. So in 2008 the minimum age level was changed to admitting only students going into grade 10 through grade 12. No 9th graders were accepted in 2008 because it was clear that their maturity and science background was not adequate for the program. This change was very beneficial. Table 1 below lists the major criteria for each of the two years the camp was offered.

Another area of concern was the motivation of why students had enrolled in the summer camp. The author had been involved in summer educational programs several years prior and was well aware that some parents use a summer camp program as an opportunity to put kids someplace for several hours a day and to “just get them out of the house”. The developers of this summer
program did not want it to be perceived as a summer “edutainment” program for bored high school students. It was well understood that the students enrolled would need to be engaged and active throughout the program, and that the students needed to be dynamic participants in the daily sessions. To help assure that these concerns where addressed a set of student conduct expectations where sent to parents a week before the camp began. These expectations included points regarding attendance, overall student conduct and behavior, student maturity, and the following safety note:

“Safety Tips for the Camp: Just some safety tips prior to the camp beginning. The Professor will go over these and additional safety rules for work within the laboratory on the first day of the camp. Safely glasses or lab goggles will be given to participants in this camp. If you have your own or access to a pair, please bring them to wear. No open-toe shoes, sandals or slippers are acceptable. Only close-toe shoes such as tennis shoes, boots, or leather shoes are allowed in the lab. If you have long hair it should be combed back into a pony tail or gathered behind the head so as to not be caught in any lab equipment. A safety review will be held before each experiment or class project. Anyone not participating in the safety review will not be allowed to take part in the activity planned.”

Fortunately, major disciplinary action was never required in any of the session, although some immature behaviors had to be addressed and corrected. But these were minimal. It is believed that once the expectations were set and understood by the students that they would comply, and generally this was indeed born out. The effort each day was to affirm the learning aspect of the sessions, to keep the sessions flowing and moving, and to strive to keep the students engaged at all times. Lectures were lively and short – 45 minutes maximum. Lab time and projects were longer, typically 60 to 90 minutes. Having the students move around, interact with each other, and to physically do things was a goal from the outset and deemed critical. Projects, called Learning Activities, were well-defined structured tasks given to small student sub-groups typically comprised of two or three students.

Table 1: Criteria for the Alternative Energy Summer Camp at LTU

<table>
<thead>
<tr>
<th>Camp Criteria</th>
<th>2007</th>
<th>2008</th>
</tr>
</thead>
<tbody>
<tr>
<td>Academic level of students admitted</td>
<td>Grades 9 through 12</td>
<td>Grades 10 through 12</td>
</tr>
<tr>
<td>Residency</td>
<td>Day camp/commuter only</td>
<td>Commuter and on-campus residence in dormitories</td>
</tr>
<tr>
<td>Daily duration</td>
<td>9:00 am to 3:00 pm</td>
<td>9:00 am to 4:00 pm</td>
</tr>
<tr>
<td>Days of week</td>
<td>Monday through Thursday</td>
<td>Monday through Friday</td>
</tr>
<tr>
<td>Learning sessions approach</td>
<td>Lectures, labs, projects and tours</td>
<td>Lectures, labs, projects and tours</td>
</tr>
<tr>
<td>Lunch meals</td>
<td>Up to student, brown bag – 30 minutes</td>
<td>Provided – 60 minutes</td>
</tr>
<tr>
<td>Special lunch-time presentations</td>
<td>15 minutes total</td>
<td>None</td>
</tr>
<tr>
<td>Breaks - 15 minutes each</td>
<td>One in mid-morning and one in early afternoon</td>
<td>One in mid-morning and one in mid-afternoon</td>
</tr>
<tr>
<td>Cost</td>
<td>$125</td>
<td>$450 commuter, $550 in-residence</td>
</tr>
<tr>
<td>Maximum student enrollment</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td>Session offerings in summer</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>
2.1) Goals of Program

The goals set for this program were multifaceted and remained essentially unchanged for each year’s session. These included:

a) Provide students an opportunity to learn both the basic science and engineering theory of alternative energy systems.

b) Give students a hands-on experience through “you build-it” projects and by using alternative energy systems.

c) Educate students about career opportunities and the diversity of skills that can be utilized in the alternative energy field.

d) Expose students to the LTU campus and to create institutional and departmental awareness within the university environment with the objective that LTU would be a university that they would both apply to and attend, once they completed their high school education.

e) Provide a safe and enjoyable summer camp learning environment for students.

2.2) Organization and Schedule

As is noted in Table 1 above, the summer camp was expanded from four days and six hours per day in 2007, to a 2008 schedule of five days and seven hours per day. The general schedule for each year is given in Table 2 (for 2007) and Table 3 (for 2008).

Table 2: The general schedule for the Alternative Energy summer camp for 2007

<table>
<thead>
<tr>
<th>Time</th>
<th>Mon 7/9</th>
<th>Tues 7/10</th>
<th>Wed 7/11</th>
<th>Thurs 7/12</th>
</tr>
</thead>
<tbody>
<tr>
<td>9:00</td>
<td>Introductions</td>
<td>Review</td>
<td>Review</td>
<td>Review</td>
</tr>
<tr>
<td>9:15</td>
<td>Orientation to lab</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9:30</td>
<td>Introduction to energy and Power</td>
<td>Solar PV II</td>
<td>Wind I</td>
<td>FC and H2 Intro</td>
</tr>
<tr>
<td>9:45</td>
<td>Alt E I</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10:00</td>
<td>Break</td>
<td>Break</td>
<td>Break</td>
<td>Break</td>
</tr>
<tr>
<td>10:15</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>10:30</td>
<td>Alt E II</td>
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<td></td>
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<tr>
<td>10:45</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11:00</td>
<td>Project I</td>
<td>Solar PV II</td>
<td>Wind II</td>
<td>FC and H2 Intro</td>
</tr>
<tr>
<td>11:15</td>
<td></td>
<td></td>
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<tr>
<td>11:30</td>
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<td>11:45</td>
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</tr>
<tr>
<td>12:00</td>
<td>Lunch ***</td>
<td>Lunch ***</td>
<td>Lunch ***</td>
<td>Lunch</td>
</tr>
<tr>
<td>12:15</td>
<td>&quot;Presentation&quot;</td>
<td>&quot;Presentation&quot;</td>
<td>&quot;Presentation&quot;</td>
<td>Break</td>
</tr>
<tr>
<td>12:30</td>
<td>Break</td>
<td>Break</td>
<td>Break</td>
<td>Break</td>
</tr>
<tr>
<td>12:45</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>1:00</td>
<td>Solar Energy</td>
<td>Solar Heating</td>
<td>Wind III</td>
<td>DTE Energy Park Tour</td>
</tr>
<tr>
<td>1:15</td>
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<tr>
<td>3:00</td>
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The presentations given during the 2007 lunch session on Monday, Tuesday, and Wednesday involved guest speakers from the various departments in the college of engineering, representatives from the LTU admissions office who explained the typical application process to...
universities in general and to LTU specifically, and a representative from the LTU Office of Career Services who spoke about the prospects for employment and job opportunities of college graduates and of career opportunities in the alternative energy field.

Table 3 shows the expanded time in 2008 and added day to the summer camp. Two major topics were added in 2008, with these being geothermal and biomass energy. A minor topic was added, heat exchangers, which helped expand and clarify some of the capabilities of solar water heating. Such additional topics allowed the expansion to a 5 day format. This expansion had its drawbacks, such as more teaching time, and more preparation by the course instructor. These are discussed in the Overall Program Evaluation below.

### Table 3: The general schedule for the Alternative Energy summer camp for 2008

<table>
<thead>
<tr>
<th>M</th>
<th>T</th>
<th>W</th>
<th>Th</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>9:00 AM</td>
<td>Introduction</td>
<td>Review</td>
<td>Review</td>
<td>Review</td>
</tr>
<tr>
<td>9:15 AM</td>
<td>Lab tour</td>
<td>Alt E</td>
<td>Introduction to Photovoltaics</td>
<td>Biomass #2</td>
</tr>
<tr>
<td>9:30 AM</td>
<td>Learning Activity #1 - What is energy?</td>
<td>Finish solar Ovens</td>
<td>PV tour</td>
<td></td>
</tr>
<tr>
<td>10:00 AM</td>
<td>Solar water testing</td>
<td>Solar Oven Testing</td>
<td>Learning Activity #3 - PV</td>
<td>Wind #1</td>
</tr>
<tr>
<td>10:15 AM</td>
<td>Therm Sci lab power plant demo</td>
<td>Solar Oven Testing</td>
<td>Learning Activity #3 - PV</td>
<td>Wind #1</td>
</tr>
<tr>
<td>10:30 AM</td>
<td>Break</td>
<td>Break</td>
<td>Break</td>
<td>Break</td>
</tr>
<tr>
<td>10:45 AM</td>
<td>Campus power tour</td>
<td>Solar Oven Testing</td>
<td>Learning Activity #3 - PV</td>
<td>Wind #1</td>
</tr>
<tr>
<td>11:00 AM</td>
<td>Therm Sci lab power plant demo</td>
<td>Solar Oven Testing</td>
<td>Learning Activity #3 - PV</td>
<td>Wind #1</td>
</tr>
<tr>
<td>11:15 AM</td>
<td>Therm Sci lab power plant demo</td>
<td>Solar Oven Testing</td>
<td>Learning Activity #3 - PV</td>
<td>Wind #1</td>
</tr>
<tr>
<td>11:30 AM</td>
<td>Therm Sci lab power plant demo</td>
<td>Solar Oven Testing</td>
<td>Learning Activity #3 - PV</td>
<td>Wind #1</td>
</tr>
<tr>
<td>11:45 AM</td>
<td>Therm Sci lab power plant demo</td>
<td>Solar Oven Testing</td>
<td>Learning Activity #3 - PV</td>
<td>Wind #1</td>
</tr>
<tr>
<td>12:00 PM</td>
<td>Lunch</td>
<td>Lunch</td>
<td>Lunch</td>
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<tr>
<td>12:15 PM</td>
<td>Lunch</td>
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<tr>
<td>12:30 PM</td>
<td>Lunch</td>
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<td>Lunch</td>
<td>Lunch</td>
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<tr>
<td>12:45 PM</td>
<td>Lunch</td>
<td>Lunch</td>
<td>Lunch</td>
<td>Lunch</td>
</tr>
<tr>
<td>1:00 PM</td>
<td>Solar Energy</td>
<td>Solar oven review</td>
<td>Geothermal</td>
<td>Wind #2</td>
</tr>
<tr>
<td>1:15 PM</td>
<td>Solar Energy</td>
<td>Solar oven review</td>
<td>Geothermal</td>
<td>Wind #2</td>
</tr>
<tr>
<td>1:30 PM</td>
<td>Solar Energy</td>
<td>Solar oven review</td>
<td>Geothermal</td>
<td>Wind #2</td>
</tr>
<tr>
<td>1:45 PM</td>
<td>Solar Energy</td>
<td>Solar oven review</td>
<td>Geothermal</td>
<td>Wind #2</td>
</tr>
<tr>
<td>2:00 PM</td>
<td>Solar Energy</td>
<td>Solar oven review</td>
<td>Geothermal</td>
<td>Wind #2</td>
</tr>
<tr>
<td>2:15 PM</td>
<td>Solar Energy</td>
<td>Solar oven review</td>
<td>Geothermal</td>
<td>Wind #2</td>
</tr>
<tr>
<td>2:30 PM</td>
<td>Solar Energy</td>
<td>Solar oven review</td>
<td>Geothermal</td>
<td>Wind #2</td>
</tr>
<tr>
<td>2:45 PM</td>
<td>Solar Energy</td>
<td>Solar oven review</td>
<td>Geothermal</td>
<td>Wind #2</td>
</tr>
<tr>
<td>3:00 PM</td>
<td>Solar Energy</td>
<td>Solar oven review</td>
<td>Geothermal</td>
<td>Wind #2</td>
</tr>
<tr>
<td>3:15 PM</td>
<td>Solar Energy</td>
<td>Solar oven review</td>
<td>Geothermal</td>
<td>Wind #2</td>
</tr>
<tr>
<td>3:30 PM</td>
<td>Solar Energy</td>
<td>Solar oven review</td>
<td>Geothermal</td>
<td>Wind #2</td>
</tr>
<tr>
<td>3:45 PM</td>
<td>Solar Energy</td>
<td>Solar oven review</td>
<td>Geothermal</td>
<td>Wind #2</td>
</tr>
</tbody>
</table>

#### 2.3) Topics Covered and Activities

The topics covered in the 2008 summer camp were the same as those covered in the 2007 camp with the previously mentioned added topics of geothermal, biomass energy and heat exchangers. Therefore, the discussion here will mainly focus on the topics covered in the 2008 camp as they were the more comprehensive list of topics.
A major challenge with Alternative Energy engineering for high school students (and with many undergraduate college students) is to appreciate the capabilities of these new and emerging energy technologies. They need a working understanding of fundamental energy units such as a joule, a watt and a kilowatt. These high school students also generally lack an appreciation of the nature and capabilities of traditional energy systems and power plants. As a result they typically do not understand something as basic the scaling of a 10 kW photovoltaic system to a 1,000 megawatt coal-fired power plant.

Day#1:
The lack of basic energy understanding is not unusual with undergraduate engineering students, so it was deemed safe to assume that this would be the case with the summer camp high school students. Therefore, on the morning of the first day after an overall introduction to the summer camp, to the Alternative Energy laboratory, and to safety requirements, the students were given a survey which assessed their knowledge of basic energy concepts and gathered information about their enrollment in the Alternative Energy summer camp. They were also given a three-ring binder for course notes and lab activities, a “lab notebook” to record data, a low-cost photovoltaic powered calculator, and a pen.

Students were then given Learning Activity #1: The difference between energy and power. The purpose of this learning activity was to help them understand the nature of energy and how to calculate the quantity of energy expend for basic human physical activities. Students were required to weigh themselves to determine their mass, and then to walk a specified distance (400 yards) at a give speed, and then to ride a simple instrumented stationary bicycle at various speeds and Calorie per minute rates. Using the data they had just collected they were required to calculate the rate of energy expended to determine power. Once students compute the power and energy they had physically expended, they then computed kilowatt-hours. These values were then correlated to common energy and power quantities used in everyday systems. Students were stunned to learn that after they were winded, and in some cases tired, that they did so little work and expend such small amounts of energy compared to well-known energy consuming technologies such as a 5 hp lawn mower or a small automobile.

The students were then given a tour of the main on-campus power plant, boilers and the on-campus electrical utility transformer step-down station. In each of these the students were able to compute the power levels involved and gain a strong reference for how much power and energy these systems transformed versus the small amounts of energy and power they expended and produced in their walk and stationary bicycle ride. Students were then given a tour of the LTU mechanical engineering thermal science laboratory which has a small Rankine cycle educational bench-top steam power plant. This was helpful because students could reference the energy they expended to that of the lab’s mini-power plant. See Figure 2 below, which shows the small lab-scale power plant.

After lunch students were given a short lecture on the nature of solar energy with photocopied handouts of all PowerPoint slides as reference for their 3-ring binder. (These PowerPoint presentations were highly abbreviated and simplified presentations extracted from our EGE3903 undergraduate Alternative Energy Fundamentals course, which is a survey course of the most common, various Alternative Energy technologies currently available.)
The students were then assigned **Learning Activity #2: Build a Solar Oven.** The purpose of this project was to provide the students an opportunity to work in a small team to fabricate a solar oven. The solar oven is made from cardboard, aluminum foil, foil pans, and duck tape. It also gives the student an opportunity to understand the three standard modes of heat transfer so critical to Alternative Energy. Weather permitting (and fortunately each year it was sunny) the next day the solar ovens were completed and taken outside to evaluate their performance just before lunch. See Figure 2 that shows students with their solar ovens. On a sunny summer day a well-built solar oven can easily reach 450°F. Biscuits or muffins were then cooked in the ovens and eaten by the students to give them a clear demonstration of the capabilities of their working solar ovens. The basic solar oven design used for this project can be found on the internet (at [http://www.re-energy.ca/t-i_solarheatbuild-1.shtml](http://www.re-energy.ca/t-i_solarheatbuild-1.shtml)) and has been used in the LTU 1st year Introduction to Engineering course, with great success. It should be noted that gathering and preparing all of the materials for this project can take significant time for the instructor.

**Day #2**

After a short lecture covering an overview of all of the various major forms of Alternative Energy systems the solar ovens were completed and, as stated earlier, were tested outside. Figure 3 below shows a photograph of students enjoying biscuits that they baked in their solar ovens. After lunch students were then shown an evacuated tube solar water hating system that can easily boil 5 gallons of water within 90 minutes on a clear sunny day. Figure 4 shows a photograph of that lab system.
A data acquisition system is used to track ambient air and water temperatures for the duration of the water heating example test. These data were immediately downloaded and shown to the students. Once students saw the capabilities of the evacuated tube water heating system and the solar ovens they begin to get a better understanding of heat transfer, and could then appreciate the need for heat exchangers and what heat exchangers are designed to do. This is critical for students as it allows them to appreciate how the hot water can be utilized in radiant floor heating or for hot water storage within a home. A short lecture was then given to conclude the afternoon with overall solar heating systems and various solar heating technologies, both small and large scale.
Day #3
The previous day’s activities introduced several important concepts regarding solar energy which were then developed into the 3rd day’s topic of photovoltaic systems. A sort lecture introducing the basic science of band gaps and semiconductors was given. It then quickly went into the basic physics of photovoltaic (PV) cells and then the nature and design of PV systems. Students were then given Learning Activity #3: Solar Photovoltaics and Solar Powered Car. The purpose of this activity was to give small groups of students each the opportunity to understand the way solar photovoltaic panels work and how they can power a small electric car. This learning activity uses a model toy car powered by a combination of small PV panel and a simple PEM fuel cell. Figure 5 below illustrates the commercially available educational kit used in this module of the summer camp.

Figure 4: The author with the evacuated tube solar water heating system.

The kit illustrated in Figure 5 comes with a reasonably well-written instruction manual that provides instructions on how to assemble the cars and provides several learning experiments that are easily completed by the students. The students are given specific sections of the manual to complete relating to PV, and then are allowed to run their toy cars in the open central “quad” of the campus. The teams were entered into simple races with their toy cars against each other, and were also allowed to “go have some fun”. This portion of the summer camp was frequently listed by students as their favorite activity.
Figure 5: The simple solar and fuel cell powered toy car used in the summer camp to demonstrate both PV and fuel cell technology.

After lunch students were given a quick tour of the LTU 10 kW PV system on top of the College of Engineering building, a grid-tied PV system along with a detailed description of the inverters that convert the DC power from the PV panels to AC used by the building. See Figure 6 below that illustrates the LTU 10 kW PV system. After this the students were introduced to geothermal systems in a short lecture. They were then given a short tour of the LTU Student Services Center building that is geothermally heated and cooled. Students got to see the location of the geothermal wells and see the geothermal pumping and heat exchanger system on the ground floor of the Student Services Center. Figure 7 below shows a photograph of the LTU Student Services Center.

Figure 6: A photo of the 10 kW PV system on top of the Engineering Building.
A very short lecture introducing biomass and biomass energy was then given, followed by a break. By this point the students were starting to reach “informational overload”, so it was important to be sensitive to their fatigue and ability to concentrate. After the break students were divided into groups of two and given the simple lab task of making biodiesel using vegetable corn-oil and a pre-mix of methanol and sodium hydroxide. Some premixing was done for safety purposes. The students mixed the liquids together to observe the transesterification process from corn oil to biodiesel. Each group made approximately 200 ml of biodiesel. A simple demonstration was also given about the drying of biomass materials and the weight losses associated with such drying. Students then calculated an estimation of energy lost to compensate for the heating and vaporization of water if the biomass material were to be combusted.

Day #4
After a short review the students were returned to the lab to evaluate their biodiesel production. All samples were separated from the glycerin, also a product of the transesterification process and collected.

The collected biodiesel was then placed into the fuel tank of a small 5 kW diesel electric generator used in the LTU Alternative Energy lab for various biodiesel testing experiments. The operating generator gave the students the opportunity to see the biodiesel they produced actually fueling a diesel electric generator system providing power to a work-lamp electric load. Current and voltage measurements were taken at various loads by turning on or off different numbers of lights to give the students the ability to see the power output of the generator. Figure 8 below shows an example of this test setup.
A short lecture on wind energy was given, and then following lunch, they took a tour of the small wind turbine system installed by engineering students on the roof of the engineering building. It is a simple tip-up 400 watt DC generator turbine that can be lowered to let student see the blade configuration and the basic operation of the turbine. This system’s 24 volt power output is routed to a small lab rack that houses four lead acid batteries, with two in parallel and two in series. These are then connected to a 24 volt (input) inverter that outputs 120 volts AC. Seeing this gives the students an opportunity to understand the need for various electrical interfaces with power generation systems. After lunch the students were given Learning Activity #4: Building a simple electric AC generator, which had them build a simple electric generator from folded cardboard, a wire wrap and magnets all connected to a small electric light. All components for this simple generator can be purchased from Radio Shack. The design was found on a website: (http://amasci.com/coilgen/generator_1.html)

Once the students understood the basic aspects of electric generators, then a short lecture was given explaining the major components of a wind turbine. This was then followed by a short demonstration of the low velocity wind tunnel in the Alternative Energy Lab. This system uses a simple electric generator and model airplane propeller to produce power outputs at various wind velocities in the wind tunnel. Students collect data and then plot the power output. This is a helpful experiment for students to gain understanding regarding “cut-in” wind speeds and the effect of blade pitch on generator power output at various wind speeds.

The end of this day’s session concluded with a very brief introduction to fuel cells. This was done so not to overwhelm the students with information on the last day of the summer camp, which focuses on fuel cells.
Day #5
By this point in the summer camp the students had reached a saturation point and were very tired. Therefore, it was important to keep things moving and to not give too lengthy of lectures. Class sessions were kept to 30 minutes when possible, and more time was given to lab activities. The day started with a short review of the previous day’s activities and then a lecture on fuel cell systems. **Learning Activity #5: Fuel Cells and Hydrogen,** was given with the purpose of showing how fuel cells work and how to generate hydrogen. This was accomplished using the toy solar and fuel cell cars the students were familiar with from sessions on day #3. They were required to generate hydrogen using simple electrolysis and the PV panel of the toy car to provide enough voltage and current to split water into hydrogen and oxygen. There is a small gas collection system for both the H\textsubscript{2} and the O\textsubscript{2} gas in the toy car kits. Once collected these gasses were then used to feed the simple PEM fuel cell that, in-turn, produces the electricity that drives the small electric motor that propels the wheels on the toy car. The students enjoyed this activity immensely and they were able to spend well over an hour working with these toy fuel cell cars. Since they had already been exposed to the concept of hydrogen generation using the toy cars for electrolysis a very short lecture on hydrogen generation was given with a short lab demonstration using a Hoffman Electrolysis Apparatus that produces oxygen and hydrogen at different electrodes from a water electrolyte when connected to a voltage/current source. In this lab we used a simple 18-volt, 8-amp power supply. Running at various currents and voltages the students were able to collect data and determine that hydrogen and oxygen are generated at the 2:1 ratio.

After lunch a field trip was schedule where the students were taken to the DTE Energy Hydrogen Technology Park located 3.5 miles from LTU. This Hydrogen Technology Park is a joint venture demonstration between the US Department of Energy and the local utility company DTE Energy. It has 26 kW of PV power production, ten 5-kW Plug power fuel cells, a water electrolysis system to produce hydrogen, a 5,300 psi hydrogen storage system and a hydrogen vehicle refueling dispenser. LTU has served as the data analysis partner on this project since before it was built in 2004, and the school has a very strong working relationship with DTE Energy. See Figure 9 for an aerial view of the Power Park.

Students were returned to the school after the power park tour and given time to discuss and reflect upon the week’s events and activities. They were then given a survey to gather their assessment of the summer camp. These assessments comprise the remainder of this paper.

3) Program Assessment and Evaluations

A critical aspect of any academic undertaking is its assessment. It was believed critical for this summer camp that participating students be surveyed both at the start of the camp and at its conclusion. The program leaders needed to understand the scope and level of knowledge students gained, and how they viewed the summer camp.
The surveys for 2007 and 2008 had some common questions, but the surveys were not identical for each year. Some questions were different between the two. Surveys from 2007 were not well constructed, so they contain less information. But they still provided valuable insights to the first camp session, so the worthwhile portions of those surveys are presented and reviewed here. The 2008 surveys were better constructed and had more focused questions. Their results are more comprehensively reviewed in this section.

3.1) Student Surveys

The survey questions given to the students at the start of the summer camp and at the end of each year’s summer camp are included in the Appendix of this paper. A few questions were removed from those listed here because those questions asked were either not relevant to this paper, or the questions were not well written and were misunderstood by the students, resulting in some convoluted answers. Because of these issues they were dropped from the survey results. Also, due to the relatively small sample size, n = 10 for the initial survey of 2007 and n = 11 for the final 2007 survey (an additional student showed up on the second day of the 2007 session) and n = 11 for both 2008 surveys, only averages and general interpretation of the data are made here.

3.2) Results of surveys

The participant demographics for both years’ summer camps are listed in Table 4 below.

<table>
<thead>
<tr>
<th>Year</th>
<th>Grade 9</th>
<th>Grade 10</th>
<th>Grade 11</th>
<th>Grade 12</th>
<th>Male</th>
<th>Female</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>2007</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>7</td>
<td>3</td>
<td>10/11</td>
</tr>
<tr>
<td>2008</td>
<td>0</td>
<td>2</td>
<td>3</td>
<td>6</td>
<td>8</td>
<td>3</td>
<td>11</td>
</tr>
</tbody>
</table>
Several questions common to both years’ surveys were asked to assess the academic background of the students attending. These are summarized here where a “no” was given a score of zero – 0, and a yes was given a score of 1. An average of “1.0” meant that all participants said yes to that question, and alternatively an average of “0” meant they all answered no. The average was then computed for each question as indicated in Table 5.

Table 5: Academic background for attending students

<table>
<thead>
<tr>
<th>Question</th>
<th>Average 2007</th>
<th>Average 2008</th>
</tr>
</thead>
<tbody>
<tr>
<td>Have you taken a math course with trigonometry?</td>
<td>0.70</td>
<td>0.55</td>
</tr>
<tr>
<td>Have you taken a physics course?</td>
<td>0.40</td>
<td>0.27</td>
</tr>
<tr>
<td>Have you taken a chemistry course?</td>
<td>0.30</td>
<td>0.64</td>
</tr>
<tr>
<td>Have you taken a calculus course?</td>
<td>0.20</td>
<td>0.18</td>
</tr>
<tr>
<td>Have you taken a course with a “laboratory” component?</td>
<td>0.60</td>
<td>0.81</td>
</tr>
</tbody>
</table>

To understand how student heard about, or came to learn about the Alternative Energy summer camp the students gave the following responses indicated in Table 6.

Table 6: How students came to learn about each summer camp session

<table>
<thead>
<tr>
<th>Method</th>
<th>2007</th>
<th>2008</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parent</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Other family member or friend</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>LTU website</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Other</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

We found the reason why students were attending the camps for both years was predominantly because they were interested the topic, and specifically they wanted to learn about fuel cells. About 30% said they were interested in pursuing an engineering career in this field. Only two from 2007 had attended other LTU summer camps and four from 2008 had attended other LTU summer camps. All the students attending both years planned on going to college, but only about half knew which college they planned to attend. This would make sense since such a large number of students were not entering their senior year of high school and would probably not have made any formal decision regarding college. Two student from each year stated they were already interested in attending LTU before the summer camp session started.

Basic technical questions relating to electrical energy were asked both at the beginning and end of each session. For the 2007 session only 27.5% initially answered the questions correctly, but at the end of the session they were able to answer those same questions correctly 80% of the time. Clearly, the students had learned. For the 2008 session only 23.6% answered these questions correctly, and at the end they answered 43% of these questions correctly. But one must remember that the 2008 session was five days long and discussion relating to these points was held the first day, so there may be a time factor limiting retention evident here. This is especially true since fewer of the 2008 students had taken physics, but more of them had taken chemistry.
Students in 2007 saw a dramatic increase in confidence of their understanding of how the various alternative energy systems worked. They were asked if they could generally explain how these technologies worked. Table 7 reviews their responses. A “yes” answer was rated as 1 point where a “somewhat” or partially correct answer was rated at 0.5. A “no” or an incorrect answer was given a zero. So if all answered the question correctly it would be scored as 1.0 and 0.0 for all wrong. For “2008 After” students were asked a slightly different question on these. They were asked to briefly describe how these systems worked; as opposed to if they thought they could explain how these systems worked. Their answer scores are included here, with 1 point for a correct answer, 0.5 for a partially correct answer and zero for an incorrect answer. Lastly, there was an overall assessment of each summer camp session. The results of those questions are provided in Table 8.

### Table 7: Knowledge of subject confidence

<table>
<thead>
<tr>
<th>Question</th>
<th>2007 Before</th>
<th>2007 After</th>
<th>2008 Before</th>
<th>2008 After</th>
</tr>
</thead>
<tbody>
<tr>
<td>Can you explain in technical terms how a solar hot water heater works?</td>
<td>0.25</td>
<td>0.77</td>
<td>0.41</td>
<td>0.55</td>
</tr>
<tr>
<td>Can you explain in technical terms how a photovoltaic panel works?</td>
<td>0.30</td>
<td>0.86</td>
<td>0.36</td>
<td>0.55</td>
</tr>
<tr>
<td>Can you explain in technical terms how a wind turbine works?</td>
<td>0.50</td>
<td>1.0</td>
<td>0.50</td>
<td>0.80</td>
</tr>
<tr>
<td>Can you explain in technical terms how geothermal energy works</td>
<td>na</td>
<td>na</td>
<td>0.23</td>
<td>0.45</td>
</tr>
<tr>
<td>Can you explain in technical terms how a fuel cell works</td>
<td>na</td>
<td>0.95</td>
<td>0.27</td>
<td>0.65</td>
</tr>
</tbody>
</table>

### Table 8: Overall assessment of this summer camp session

<table>
<thead>
<tr>
<th>Question</th>
<th>2007 After</th>
<th>2008 After</th>
</tr>
</thead>
<tbody>
<tr>
<td>Did you enjoy attending the Alternative Energy Summer Camp?</td>
<td>0.82</td>
<td>0.9</td>
</tr>
<tr>
<td>Do you feel that you learned something new about Alternative Energy?</td>
<td>0.95</td>
<td>1.0</td>
</tr>
<tr>
<td>Do you feel that the lab sessions helped you understand the Alternative Energy technologies that were covered in the camp?</td>
<td>1.0</td>
<td>0.95</td>
</tr>
<tr>
<td>Do you feel that the lab sessions were well organized?</td>
<td>0.90</td>
<td>0.90</td>
</tr>
<tr>
<td>Was the instructor interesting to listen to?</td>
<td>0.86</td>
<td>0.95</td>
</tr>
<tr>
<td>Did the instructor present the information in an organized and clear way?</td>
<td>0.91</td>
<td>0.95</td>
</tr>
<tr>
<td>Did the instructor explain technical topics well?</td>
<td>0.91</td>
<td>0.95</td>
</tr>
<tr>
<td>Did the instructor answer your questions adequately?</td>
<td>0.86</td>
<td>1.0</td>
</tr>
<tr>
<td>Rate the Civil Engineering speaker</td>
<td>0.54</td>
<td>na</td>
</tr>
<tr>
<td>Rate the Electrical Engineering speaker</td>
<td>0.54</td>
<td>na</td>
</tr>
<tr>
<td>Rate the Admission Office speaker</td>
<td>0.72</td>
<td>na</td>
</tr>
<tr>
<td>Rate the Career Services Speaker</td>
<td>0.95</td>
<td>na</td>
</tr>
</tbody>
</table>
4) Overall Program Evaluation and Lessons Learned

A good way to evaluate any program is to compare the results of the program to its original goals. The goals set for this program included:

a) Provide students an opportunity to learn both the basic science and engineering theory of alternative energy systems.

b) Give students a hands-on experience through “you build-it” projects and by using alternative energy systems.

c) Educate students about career opportunities and the diversity of skills that can be utilized in the alternative energy field.

d) Expose students to the LTU campus and to create institutional and departmental awareness within the university environment with the objective that LTU would be a university that they would both apply to, and attend, once they completed their high school education.

e) Provide a safe and enjoyable summer camp for students.

The qualitative and quantitative data from the student surveys show that students enrolled in these summer camp sessions definitely felt that they both learned and had valuable hands-on experiences. Several students expressed genuine gratitude and stated that they had learned a great deal about the field of alternative energy. Not one student in either year expressed any negative aspects regarding the things they learned or their summer camp experience. There were some comments about the length of the lectures. In all fairness, the 2007 summer camp was held during a very hot spell in Michigan and on a few occasions the room air conditioning system was adequate, so one can appreciate their desire for “shorter lectures”. In most cases students expressed that the summer camp met or exceeded their expectations for learning. Several preferred the hands-on sessions and thought they should be expanded.

One of the pleasant surprises was the ability to meet goal “c”, and the very high evaluation of the career services speaker in 2007. These same types of presentations occurred in the 2008 summer camp session, but under a very different format which was difficult to evaluate by this author, so it was not assessed for the 2008 session. The LTU career services speaker addressed career opportunities and was able to answer many of the student’s questions. This is unquestionably an important component of any career-related summer camp program and is now part of all LTU summer camp sessions, regardless of the topic.

Goal “d” was definitely met. Of the 10 eligible high school seniors attending over the two years this program was offered, the author was informed that 4 students enrolled in LTU the next fall and several more applied, but those exact numbers were not available at the time of this writing.

The emphasis on safety throughout the camp paid off as no students were hurt or injured during these sessions. This was a great relief considering that students were climbing ladders up on the roof, operating expensive equipment and using sharp cutting knives to make their solar ovens.

There were several lessons learned from these sessions. These are listed below in no particular order. Some commentary is provided with each point as to why they were listed.
1) Older and more mature high school students are better equipped to concentrate and focus on the tasks at hand. At these ages a year makes a great difference in a student’s view and approach to challenges encountered in a summer camp such as this.

2) One should not underestimate the time and effort required to prepare these sessions, projects and labs. If something can go wrong, it usually will go wrong. It took approximately two to three weeks lead-time to acquire all items needed per each one-week session. Also, if the program is presented as the LTU 2008 program was, the instructor is going to be spending 35 hours with these students during the instruction week. It is critical to get help and support for these activities. Use graduate and undergraduate students when possible. The time demand on the instructional faculty to organize and prepare for these summer camp sessions is significant, and is often not appreciated nor respected as valued service or worthwhile scholarly activity by department chairs, deans, or other administration staff. Anyone intending to take on such a summer session should plan on four to five weeks of total commitment for a one week session. This includes clean up and paperwork after a session is over each day, and once the week’s session is over.

3) Having extra backup items for every lab or project was critical. In some cases it was necessary to have two or three backups, as with the required quantity of cardboard for solar ovens. One of the solar cars worked fine the week prior during our preparation time, but would not work properly during the 2008 session. A backup was available, and that saved the day.

4) Tell students to turn off their cell phones and i-Phones while in class and labs. The reasons for this are obvious. If possible, have student leave them at home.

5) A few students attended these sessions because they had nothing to do in the summer. Identify these students a soon as possible and try to get them engaged early. Otherwise they can distract and bother the other students.

6) Do not allow “helicopter parents” to hang around during classes or labs. They are an annoying and unacceptable distraction.

7) If there are some slow data collection periods try to have other tasks or readings for the students not immediately, or directly involved in the data collection. This can be challenging, because when the students are formed into small teams, ideally each of the students should be involved with and understand where the data came from, and how they were generated. Side tasks to keep them occupied could impede this.

8) Schedule guest speakers well before the summer camp sessions and then follow up with them a few days prior to their presentation. People’s summer schedules can get complicated, so be sure to help them remember their commitments.

9) Be prepared for rain, especially for solar related projects. Have video and data as backup just in case inclement weather hits. LTU was fortunate during both of these summer sessions to have sunny weather. Michigan is known for its unpredictable weather. This program was
scheduled for a week in July of 2009 but was cancelled due to low enrollment. An interesting side note is that it rained, sometimes quite heavily the entire week that the 2009 session was scheduled, but not held.

10) If possible keep enrollment low, especially if single-use or expensive equipment is involved. Students need hands-on time with the equipment and waiting in line to use equipment reduces enthusiasm.

11) Stress safety throughout the sessions. Many of these students have never worked around equipment or have been in a laboratory. They often don’t know the issues, the rules, or safe laboratory practices.

12) Find out if any of the students have special needs. These can include medical or physical issues. Are any students allergic to bee stings or do they have acrophobia? Being out-of-doors and going up on the roof to see the LTU PV system required checks on such things.

13) Remember that these students are usually under-age and must be accounted for at all times. University professors who typically only work with college students who are over 18 years of age can forget this.

14) Be careful on pricing of the program. The 2009 Alternative Energy summer session was given a major price hike for tuition and its enrollment plummeted. This came at the peak of the recession in the Detroit Metro Area, already hard hit by the major employment losses in the auto industry. As a result the 2009 session was canceled.

5) Conclusions and Acknowledgements

Lawrence Technological University offered an Alternative Energy summer camp to high school students in 2007 and 2008. These sessions met the program goals and directly resulted in outreach to potential engineering students and resulted in 40% enrollment of eligible students who were high school seniors. These programs, though enjoyable for faculty to participate in, were very time consuming and seriously pulled one away from other critical summer tasks such as research activities. Students who attended gained documented understanding of the technology and had hands-on opportunities to directly work with the equipment of interest. Older high school students have greater maturity, generally have taken more academic science courses that help them understand the technical topics better, and overall helps them grasp the engineering principles required.

These Alternative Energy summer camp sessions were deemed successful and were valuable to the outreach and recruitment of students to the university.

The author would like to thank Lisa Kujawa, the LTU Assistant Provost for Enrollment Management, for all of her support and efforts to help make these summer camp sessions both a reality and a success. Lisa was one who did understand the time demands on faculty and provided the unwavering support that was absolutely critical for these summer camp sessions.
References

Alternative Energy and Power Generation Summer Camp
- 2007 -

Participant Initial survey – 1st class session

1) General questions:
   1.a) This coming fall I will be entering grade – 9 10 11 12
   1.b) Have you taken a math course with trigonometry? Yes No
   1.c) Have you taken a physics course? Yes No
   1.d) Have you taken a chemistry course? Yes No
   1.e) Have you taken a calculus course? Yes No
   1.f) Have you taken a course with a “laboratory” component? Yes No
   1.g) How did you hear about this summer camp?
   1.h) In a few sentences explain why you are attending this summer camp and what you hope to learn about Alternative Energy.
   1.i) Have you attended other LTU summer camps? Yes No
   1.j) Do you plan to go to college when you graduate? Yes No
   1.k) If you answered yes to question 1.j, do you know where you plan to go to college?

2) Energy questions:
   2.a) Define a volt.
   2.b) Define an ampere.
   2.c) Define a watt.
   2.d) Define a kilowatt-hour.

3) Solar energy questions
   3.a) Have you ever used solar energy technology before? Yes No
   3.b) If you answered yes to question “3.a” please list those technologies.
3.c) Can you explain in technical terms how a solar hot water heater works?
   Yes  Somewhat  No

3.d) Can you explain in technical terms how a solar photovoltaic panel works?
   Yes  Somewhat  No

4) Wind energy questions
4.a) Have you ever seen or used wind energy technology before?  Yes  No

4.b) If you answered yes to question “4.a” please list when or where.

4.c) Can you explain in technical terms how a wind turbine works?
   Yes  Somewhat  No

5) Fuel cell and hydrogen questions
5.a) Have you ever seen or used a fuel cell before?  Yes  No

5.b) If you answered yes to question “5.a” please list when or where.

5.c) Can you explain in technical terms how a fuel cell works?
   Yes  Somewhat  No

5.d) Do you know where hydrogen typically comes from?
   Yes  Somewhat  No

   If so, where?

6) Lab questions
6.a) How do you think the Alternative Energy lab equipment examples will help you learn these technologies?

6.b) Do you like to be shown how the lab equipment works or do you like to use it yourself?

6.c) What Alternative Energy equipment do you think would be the most interesting to use?
Alternative Energy and Power Generation Summer Camp
- 2007 -

Participant survey – Last class session

1) Energy questions:
   1.a) Define a volt.

   1.b) Define an ampere.

   1.c) Define a watt.

   1.d) Define a kilowatt-hour.

2) Solar energy questions
   2.a) Have you ever used solar energy technology before? Yes No

   2.b) If you answered yes to question “3.a” please list those technologies.

   2.c) Can you explain in technical terms how a solar hot water heater works?

       Yes Somewhat No

   2.d) Can you explain in technical terms how a solar photovoltaic panel works?

       Yes Somewhat No

3) Wind energy questions
   3.a) Have you ever seen or used wind energy technology before? Yes No

   3.b) If you answered yes to question “4.a” please list when or where.

   3.c) Can you explain in technical terms how a wind turbine works?

       Yes Somewhat No

4) Fuel cell and hydrogen questions
   4.a) Have you ever seen or used a fuel cell before? Yes No

   4.b) If you answered yes to question “5.a” please list when or where.

   4.c) Can you explain in technical terms how a fuel cell works?

       Yes Somewhat No

   4.d) Do you know where hydrogen typically comes from?

       Yes Somewhat No

       If so, where?
5) Lab questions

5.a) How do you think the Alternative Energy lab equipment examples will help you learn these technologies?

5.b) Do you like to be shown how the lab equipment works or do you like to use it yourself?

5.c) What Alternative Energy equipment do you think would be the most interesting to use?

6) Alternative Energy Summer Camp Evaluation

6.a) Did you enjoy attending the Alternative Energy Summer Camp?
Yes  Somewhat  No

6.b) Do you feel that you learned something new about Alternative Energy?
Yes  Somewhat  No

6.c) What parts of the Alternative Energy Summer Camp were most interesting to you?

6.d) What parts of the Alternative Energy Summer Camp were least interesting to you?

6.e) What would you suggest we do differently for the next time we offer the Alternative Energy Summer Camp?

6.f) Do you feel that the lab sessions helped you understand the Alternative Energy technologies that we covered in the camp?
Yes, well organized  Somewhat organized  No, they were confusing

6.g) Do you feel that the lab sessions were well organized?

6.h) What do you think was the best lab session?

6.i) What do you think was the worst lab session?

6.j) What should we do with the lab sessions to improve them?

7) Instructor evaluation

7.a) Was the instructor interesting to listen to and to follow?
Yes  Somewhat  No

7.b) Did the instructor present the information in an organized and clear way?
Yes  Somewhat  No
7.c) Did the instructor explain technical topics well?
    Yes  Somewhat  No

7.d) Did the instructor answer your questions adequately?
    Yes  Somewhat  No

7.e) Rate the guest speakers we had in class each day:
    Dr. Jensen (Civil Engineering)  Informative  Ok  Not interesting
    Dr. Farrah (Electrical Engineering)  Informative  Ok  Not interesting
    Art Michalski (Admissions)  Informative  Ok  Not interesting
    Jennifer Cunningham (Career Services)
    Informative  Ok  Not interesting
    Mike Samaroo (Formula Zero racing)
    Informative  Ok  Not interesting
Alternatives Energy and Power Generation Summer Camp
- 2008 -
Participant Initial survey – 1st class session

1) General questions:
   1.a) This coming fall I will be entering grade – 9 10 11 12
   1.b) Have you taken a math course with trigonometry? Yes No
   1.c) Have you taken a physics course? Yes No
   1.d) Have you taken a chemistry course? Yes No
   1.e) Have you taken a calculus course? Yes No
   1.f) Have you taken a course with a “laboratory” component? Yes No
   1.g) How did you hear about this summer camp?
   1.h) In a few sentences explain why you are attending this summer camp and what you hope to learn about Alternative Energy.
   1.i) Have you attended other LTU summer camps? Yes No
   1.j) If yes to question 1.i, which camps?
   1.k) Do you plan to go to college when you graduate? Yes No
   1.l) If you answered yes to question 1.k, do you know where you plan to go to college?

2) Energy questions:
   2.a) Define a volt.
   2.b) Define an ampere.
   2.c) Define a watt.
   2.d) Define a kilowatt-hour.
   2.e) What is the difference between energy and work?

3) Solar energy questions
   3.a) Have you ever used solar energy technology before? Yes No
   3.b) If you answered yes to question “3.a” please list those technologies.
3.c) Can you explain in technical terms how a solar hot water heater works?  
Yes  Somewhat  No

3.d) Can you explain in technical terms how a solar photovoltaic panel works?  
Yes  Somewhat  No

4) Wind energy questions
4.a) Have you ever seen or used wind energy technology before?  Yes  No

4.b) If you answered yes to question “4.a” please list when or where.

4.c) Can you explain in technical terms how a wind turbine works?  
Yes  Somewhat  No

5) Geothermal energy questions
5.a) What is geothermal energy?

5.b) Have you ever seen a geothermal energy system before?  Yes  No

5.c) If you answered yes to question “5.c” please list when and where.

5.d) Can you explain in technical terms how geothermal energy works?  
Yes  Somewhat  No

6) Fuel cell and hydrogen questions
6.a) Have you ever seen or used a fuel cell before?  Yes  No

6.b) If you answered yes to question “6.a” please list when and where.

6.c) Can you explain in technical terms how a fuel cell works?  
Yes  Somewhat  No

6.d) Do you know where hydrogen typically comes from?  
Yes  Somewhat  No

If you answered yes, where does it come from?

7) Lab questions
7.a) How do you think the Alternative Energy lab equipment examples will help you learn these technologies?

7.b) Do you like to be shown how the lab equipment works or do you like to use it yourself?

7.c) What Alternative Energy equipment do you think would be the most interesting to use?
Alternative Energy and Power Generation Summer Camp
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Participant survey – Last class session

1) Energy questions:
   1.a) Define a volt.
   1.b) Define an ampere.
   1.c) Define a watt.
   1.d) Define a kilowatt-hour.

2) Solar energy questions
   2.a) Explain in technical terms how a solar hot water heater works.
   2.d) Explain in technical terms how a solar photovoltaic panel works.

3) Wind energy questions
   3.a) Describe the various components of a wind turbine.
   3.c) Explain in technical terms how a wind turbine works.

4) Geothermal energy questions
   4.a) Describe a few types of geothermal energy systems.
   4.c) Explain in technical terms how a geothermal energy system works.

4.1) Fuel cell and hydrogen questions
   4.1.a) Explain in technical terms how a fuel cell works.
   4.1.d) Where does hydrogen typically comes from?

5) Lab questions
   5.a) How did the Alternative Energy lab equipment examples help you learn these technologies?
   5.b) Do you like to be shown how the lab equipment works or do you like to use it yourself?
   5.c) What Alternative Energy equipment do you would you like to use more in the future?
6) Alternative Energy Summer Camp Evaluation
   6.a) Did you enjoy attending the Alternative Energy Summer Camp?
       Yes  Somewhat  No

   6.b) Do you feel that you learned something new about Alternative Energy?
       Yes  Somewhat  No

   6.c) What parts of the Alternative Energy Summer Camp were most interesting to you?

   6.d) What parts of the Alternative Energy Summer Camp were least interesting to you?

   6.e) What would you suggest we do differently for the next time we offer the Alternative Energy Summer Camp?

   6.f) Do you feel that the lab sessions helped you understand the Alternative Energy technologies that we covered in the camp?

   6.g) Do you feel that the lab sessions were well organized?
       Yes, well organized  Somewhat organized  No, they were confusing

   6.h) What do you think was the best lab session?

   6.i) What do you think was the worst lab session?

   6.j) What should we do with the lab sessions to improve them?

7) Instructor evaluation
   7.a) Was the instructor interesting to listen to and to follow?
       Yes  Somewhat  No

   7.b) Did the instructor present the information in an organized and clear way?
       Yes  Somewhat  No

   7.c) Did the instructor explain technical topics well?
       Yes  Somewhat  No

   7.d) Did the instructor answer your questions adequately?
       Yes  Somewhat  No