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Development of a Workshop for Camp REACH Alumni

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1. Camp REACH
2. education
3. workshop

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Abstract

This Interactive Qualifying Project deals with the creation of a workshop that stimulates the interests of adolescent females in engineering and technology fields. Background information needed to properly evaluate the statistical, social and psychological issues of female involvement in mathematics and science, as well as information on creating an effective workshop, are documented. Project development is described and a final curriculum is included. Activities included in the workshop are the creation of an anemometer and radiometer.

1.1 Introduction

According to the National Science Foundation[1], as elementary school students, girls possess similar knowledge and interests in math and science as boys of the same age. However, as they approach and enter adolescence their interests and grades in science and mathematics decrease tremendously as compared to their male counterparts. To address this issue, there is already a WPI program (Camp REACH) in effect for girls entering the 7th grade to pique their interests in math, science, and engineering throughout high school and college. Unfortunately, there is a gap of six years between the target ages of Camp REACH and when girls will begin to make college decisions.

In order to reinforce the interest in science in engineering that Camp REACH has instilled in its campers, a new workshop is needed for older girls. By allowing previous Camp REACH campers to attend a workshop between the actual camp and their college decision making process, we hope to once again boost their interests in math and science related tasks and to steer them towards majors and careers in this area.

The goals of this IQP are to:

- Develop a one-day workshop for girls about to enter ninth grade.
- Hold a test workshop with previous Camp REACH campers.
- Use the girls' reactions during the workshop to analyze the effectiveness of our workshop and to alter our workshop curriculum as appropriate.
- Determine what the girls' parents are willing to pay for this workshop and balance our budget accordingly, resulting in a workshop that will pay for itself.

The goals of the workshop are:

- To take into account the current school curriculum in order to make the workshop challenging, but not too difficult, for the girls.
- To be interesting enough to pique the interest in related engineering fields.
- To boost the girls' self-confidence by showing them that math and science can be fun and educational.

To fulfill these goals, we have studied the background of Camp REACH, the development of adolescent girls, and also studied the curriculum of the public school system in Massachusetts. We used this background material to evaluate several possible workshops. Once the two most appropriate workshops had been chosen, a pilot test was run that provided more data with which to fine-tune our workshop and turn it into an end product that meets our goals.

2.1 Literature Review

In order to create an effective workshop, it is important to gather background information regarding Camp REACH, past IQPs that have worked with Camp REACH, the educational abilities and experiences of girls in our targeted age group, and their cognitive and social abilities.

2.2 Camp REACH Background

Camp REACH is a summer camp that takes place at the WPI campus [2]. Its purpose is to give girls who will be entering 7th grade exposure to mathematical and engineering situations in hopes of stimulating their interest in these fields. The maximum enrollment of girls for the camp is 30 to comply with organizational and financial needs. During the camp activities for the girls include a community oriented design project that runs for the length of the camp, field trips oriented toward a community design project and various, smaller-scale discovery projects. The discovery projects are one-day events that are designed to show the girls that engineering and science are both enjoyable and within their means to pursue. Aside from academic activities, the girls also participate in various recreational activities. In the past there have been reunions for past campers with recreational activities, but no real follow-up to the camp has ever been performed.

2.3 Women in Science and Engineering

The number of women in the fields of science and engineering has been rising over the past twenty years. Despite this growth, however, women still trail men in most fields of comparison involving science and engineering education and employment.

Much statistical analysis has been performed comparing women to men in this regard in an attempt to gain insight into the nature of the problem of few women participating in science and engineering. Some heartening evidence is seen among the large amount of statistical data taken on this subject. For example, a study performed by the National Science Foundation for the year 2000 concerning women, minorities and disabled persons in science and engineering, has shown that women are more likely to graduate from high school and enroll in college than men and equally likely to graduate from college. Nearly half (47 percent) of all science and engineering bachelor's degrees awarded went to women and instances are rising of women achieving degrees in most science and engineering fields except mathematics and computer science[4]. Also, younger women are as likely to report management duties among their major job roles in science and engineering employment.

While signs of progress are shown there still exists alarming information as evidence of the disparities that exist for women in technical fields. As of 1994 only 16% of scientists in the U.S. are women as well as only 6% of engineers and 4% of computer scientists. According to a 1995 survey of public high school students 10% of boys and only 3% of girls expressed interest in the pursuit of a career in engineering, math or science. Alarmingly, 34% of high school aged girls reported being advised by a faculty member not to take senior math compared to 26% of boys with similar results for senior science courses[4]. These numbers show that there is still work to be done both to interest girls in math and science and to change the common perception that girls are not suited for technical careers.

2.4 Development of Adolescent Girls

Through the elementary school years, girls possess the same interests and skills in mathematics and scientific subjects as do their male counterparts, however, as these girls approach middle school and beyond, both their interests and aptitude wanes dramatically[5]. This lack of interest and lower grades is believed not to be a result of lack of mental ability, but rather the result of psychological and social factors.

In the few years before and during adolescence, girls experience a dramatic drop in self-esteem that is not observed equally in boys. This plunge in self worth leads girls towards reduced involvement and interest in mathematical and scientific subjects, loss of dreams for the future, and leads girls to slowly conform to the soft-spoken unassertive stereotypes that have been created for females throughout the ages. Patricia Freedman, who runs a program called Girls' Group, feels that the way to "immunize girls with empowerment" is to help them find their inner voices helping them identify their true talents and values[6].

As girls and boys approach adolescence, boys are being prepared for a technological society with computer games and the Internet. The majority of games are aimed towards male values, such as speed, violence, danger, and destruction. The majority of games geared towards girls, however, are often too over-simplified to assist girls in becoming motivated towards technological futures. While girls have a tendency to prefer less violence and destruction in their games, items such as the Barbie's Fashion Design program are not adequate substitutes[7]. Psychologist Sandra Calvert, PhD, believes that these two extremes in the computer technology aimed at young people are "inadvertently steering young women away from computer technology". She explains that computer games are often "gateways" for young adults to technology and technological careers. One possible solution to this problem is to allow girls to use technology for what appeals to their personal values. According to Lisa Rabasca, girls view technology as a tool to create, to share ideas, and to improve life[8]. If girls are given chances to use technology and computers to concentrate on these values, then perhaps they will be given the same motivation towards technological careers that boys are given by their computer games

2.5 Current Massachusetts Curriculum

To design an effective workshop, the scientific and mathematical background knowledge of the camper must be fully understood. To gain this understanding, we studied the mathematical and the scientific curriculum frameworks of the state of Massachusetts provided to us by the Massachusetts Department of Education. The workshop has been designed for girls about to enter the ninth grade. We focused on what was taught in both eighth and ninth grades so that the workshop material would draw on subjects they are familiar with but also give them a head start on what subject material will be taught in high school.

2.5.1 Mathematics

Listed in the sections below is an overview of the learning standards for grades 5th-9th put forth in the Mathematics Curriculum Framework. "The learning standards specify what students should know and be able to do as learners of mathematics at the end of each grade span or course. Students are held responsible for learning standards listed at earlier grades as well as their current grade."[9] The mathematics curriculum focuses on developing problem solving, communicating, reasoning, connecting, and representing skills through several topics of math, Number sense and Operations, Patterns, Relations, and Algebra skills, Geometry, Measurement, and Data Analysis, Statistics, and Probability.

Number sense and Operations deals with the understanding of number systems and how they work in different operations. Integer exponents, fraction and ratio, and order of operations of just a few of the topics covered in grades five and six. Scientific notation, roots, powers and rational numbers are seen in the seventh and eight grade. Subjects like numerical expression simplification and properties of real number operations identification are incorporated into the ninth and tenth grade learning standards.

Patterns, relations, and algebra skills deals "extending, representing, analyzing, and generalizing a variety of patterns with tables, graphs, words, and possibly, symbolic expressions." [10] By seventh and eighth grade, students should be able to evaluate simple algebraic expressions, such as linear equations and inequalities for one or two given variables.

Geometry topics for fifth and sixth grades have to deal with Cartesian graphs, polynomial identification, and 3D shape analysis and symmetry types. In seventh and eighth grade students acquire an understanding of the Pythagorean theorem, angle relationships, and 2D-3D interaction and representation. In ninth grade the geometric properties of angles and shapes are taught.

Measurement encompasses the idea of using "modes, graphs, and formulas to solve simple problems involving rates, such as those including velocity and density."[11] Students are taught how to apply formulas and procedures to taking measurements. The recording of measurements ties nicely into the next topic of study, data analysis, statistics, and probability. A specification under this topic deals with representing possible outcomes of trials through previous data. Seventh and eighth graders are expected to find, describe, and interpret the mean, median, mode, and range for various sets of data.

A full list of the Massachusetts Department of Education's mathematical learning standards can be seen in Appendix A. This material will aid us in deciding if the workshop topic is appropriate for the knowledge of the participant.

2.5.2 Science

"Significant science and technology learning builds on students' curiosity and intuitions."[12] Through the study of technology students develop problem solving skills as well as practical ways to use their knowledge of math and science. Massachusetts' science curriculum is broken up in to four major premises: inquiry, domains of science, technology, and science, technology, and human affairs. Below are some topics and specifics of the curriculum requirements set forth by the Department of Education. Inquiry is the basis for scientific and technological problem solving. This includes creating an ability to observe relevant details, patterns and relationships when performing tests or experiments helps the students to ask relevant questions and identify the problem at hand and ways to solve it. Inquiry is basically the ability to solve a particular problem by experimentation, observation, and asking the write questions.

The domains of science curriculum specifications deal with three major topics, physical science, life science, and earth and space science. Through the study of physical science students learn the properties of matter, position and motion of objects, the forms and transformations of energy, and motion and its charges. In grades nine and ten, the structure of matter, interaction of substances, forces and motion, and conservation and transmission of energy are taught. Life science encompasses the characteristics, diversity and adaptation of organisms, heredity, reproduction and development, organisms and environment, ecosystem and the matter and energy in it, as well as the evolution of life. Lastly earth and space science covers the properties and changes of earth's materials, objects in the sky, interactions and cycles in the earth system, earth history, earth and space, matter and energy in the earth system, and the evolution of the universe.

Technology has become a big part of everyday life, and therefore it is not a surprise that children today are learning about it as early as kindergarten. Schools strive to give students an understanding of the uses of technology in society by teaching them about the nature and impact, history, tools and machines, and resources of technology, as well as technological areas of communications, construction, manufacturing, transportation, power, and bio-related technologies.

The final topic of the Massachusetts science curriculum deals with the interactions between science, technology, and society. Students explore the history and the way the implementation and advancement of science and technology influenced the lifestyles of people of the time.[13]

Once again, a full list of the science and technology learning standards can be seen in Appendix A. The curriculum material will aid us in deciding the appropriateness of the workshop topics.

2.6 The Style of Teaching

2.6.1 Underlying Problems in Teaching Methods

Studies have shows that by the time adolescent girls reach middle school their interest in math and science begin to dwindle[14]. This lack of interest is clearly seen when looking at the percentage of women that pursue undergraduate degrees in math and physical science. To discover the reasons for this decline in interest one must explore the way that math and science is taught to children before college, going back as early as kindergarten.

Moulton and Ransome wrote an article in *Education Week* magazine in which they purposed that mathematics and science tended to be dominated by the white male. Both math and science are "frequently defined by the way men learn and practice these subjects."[15] Sue Rosser also discusses male dominance in math and science in her book *Teaching the Majority*. She points out the absence of recognition given to women scientist in the early days. Showing that not until the early twentieth century did women like Christine Pizan (1405) and Giovanni Boccaccio (1355-1359) get recognition for their past achievements in science.[16]

Post-secondary education of math and science history lacks the names and achievements of early women scientists and mathematicians, creating an absence of female role modes. The lack of a role model has a negatives effect on young girls, causing them to shy away from the fields of math and science.[17] Project PRISM also accounts that a lack of women role models in science and math careers as a reason for why it is hard for girls to get a good science and math education.[18]

Aside from the male dominated history of science and math, studies have also show that girls think, learn and interact with equipment in a totally different manner then boys. When looking at how math and science is taught today it can be shown that it is geared to the way males learn and think. Understanding gender-learning differences becomes a major key in finding the proper ways to educate girls in math, science, and technological fields.[19]

Elizabeth Valentine establishes these female differences in her paper *Gender Differences in Learning and Achievement in Mathematics, Science, and Technology and Strategies for Equity*. Some of the things pointed out are that girls are more passive and willing to please others than males of the same age. Valentine points out that these traits cause girls to be "overlooked and ignored by their teachers."[20] Katherine Hanson reinforces this issue in her online *Education Development Center* publication. Saying that "Throughout their learning girls are encouraged to be passive, caring, to take no risks, and to defer to male voices in the public discussion. They are also given the message that math is for males. Such an orientation obviously has an impact on how they learn and behave in school."[21]

Fennema and Carpenter in 1998 found that there were definite gender differences in problem solution strategies.[22] Boys' solution strategies are inclined to be more abstract. The Boys solution strategies differed from those introduced by the teacher, suggesting that: "boys were able to more readily adapt and develop a new technique to solve a problem that went beyond the techniques learned." [23]

Although the idea of gender learning differences has to be more deeply investigated, it is safe to say that problems do exist in teaching styles. The lacking interest in math and science seen in girls can exist for many reasons. Whether it is an emotional, motivational or educational reason, something needs to be done to let girls know that not just boys are good in math and science.

2.6.2 Fixing the Problem

Although much more research has to be done in the exploration of gender learning differences and teaching equality, there are things that we can do now to try and fix the problems that we do know of. Gender Gaps' executive summary, *Where school Still Fails Our Children*, offers some recommendations that should decrease the gender gaps the exist in schools today. They tell use that teachers and counselors should give encouragement to girls as much as possible, persuading them to take higher-level math and science courses. Valentine emphasizes this point by considering that women need to be encouraged to reach their potential in the technical areas and to pursue further study as well as careers in math and technology.[24]

Rosser points out that the positive social benefits of science and technology should be presented in schooling. Studies show that a majority of females that pursue scientific and technological careers do so because of the important social implementation.[25]

Moulton and Ransome offer a list of steps that they feel will help lessen the negative feeling that girls have towards math and science. First, positive role models in the classroom must be provided. Inspirational female teachers will help in showing that girls that they can be leaders in fields long dominated by males. Second, the use of smaller group dialogues and hands-on learning experiences in the classroom have proved to be a more effective way of teaching. Third, interactions and expectations must be equalized between the sexes, providing equal opportunities for class participation. Fourth, relating topics to real life examples and useful gender-friendly metaphors help girls relate better to the topic a hand. Giving all students a chance to reflect on the question asked before responding is also a good method in getting girls involved in class discussions. "Research shows that girls like to ponder questions longer than their male peers, so a waiting period of 30 seconds would equalize responses." [26]

Probably the most important thing for a teacher is to realize is that "the way females learn and interact can be different from males, but not better or worse. A collaborative and cooperative teaching style, rather than a competitive one, will engage all students more. Teaching girls to learn like boys is not the answer."[27]

2.6.3 Creating an Effective Workshop

Those behind Project PRISM propose that enrolling girls in out-of-school activities maybe one of the most important things to get girls involved and interested in math and science.[28] Therefore by creating a science and engineering based workshop for adolescent girls we are joining in the fight against gender gaps. This poses yet other question: what should such a workshop consist of? To answer such a question we must look to the information present.

Women learn more easily when cooperative rather then competitive pedagogical methods are used.[29] Therefore the workshop should not be designed with competition in mind. Moulton and Ransome support a hands-on approach to teaching, saying that it will improve "understanding, increasing curiosity, and promoting involvement and cooperation."[30]

Sandra Campo stated during a personal interview that the workshop should have a definite goal to start with and a clearly defined end product. At the start the girls should be presented with a background for what they will be doing and how this project relates to helping people. Women of varying ages, some close and others older should run the workshop, giving the girls positive role models to look up to during the program. Lastly the workshop should be closed with a discussion of what they did and observed through out the day. Ms. Campo suggests that this should be done in stages, starting in small groups of discussion and concluding in a group discussion so that the less outgoing girls get a chance to share. Aside from a final discussion of there activities for the day, a sheet of questions should be given to the girls. This will help them better understand the things they did thorough the workshop. A journal could also be kept, having them record any observations, question and answers in them, and allowing them to take them home at the end of the day.[31]

A successful engineering workshop must model what engineering is at a level that the age group participating can find it fun and intriguing. The material cannot be too difficult but must be challenging enough so not to be considered too easy. While the workshop must have a distinct goal in mind, it must remain fun for the participants and not to math intensive. Because only girls will be attending this event, it should be designed with their interest and ways of thinking in mind. A fun, hands-on activity that can be applied to real life situations, while teaching them teamwork and science skills, stimulating their interest will fulfill the goal intended for this workshop.

3.1 Methodology

This section details the steps that we took in our project. In summary: we held a brainstorming session in which we shared various ideas. After this session, we compared each suggested project with our workshop goals and evaluated them based on a series of criteria. Having decided upon two projects to base our workshop on, we invited former Camp REACH campers to attend our pilot test, which was held on March 25, 2001. Based on the reactions the girls gave during the test workshop and their written responses to a survey given, we revised certain aspects of the workshop to better meet our goals.

To satisfy our financial goals, we paired with a second IQP group to survey parents on how much money they would be willing to pay for the workshop. After analyzing our data, we compared the average price parents were willing to pay with the cost of our workshop in order to determine if we had met the goal of having the workshop "pay for itself."

3.2 Brainstorming

The first step we took in determining which project we would use during our workshop was to brainstorm our ideas so that we had a large list of possible projects to discuss and choose from. These projects are described in this section along with reasons why many were eliminated.

We first drew upon projects and variations of projects we have personally done in high school and camp situations for ideas. Building bridges was one of the first ideas to make it on to the list, as it is a fun, hands-on experience which can convey principles of physics and civil engineering, however because it is such a typical project for high school physics classes, we decided to not use it. Also, it is most often in our experiences made into a competition of whose bridge can hold the most weight, and we are trying to avoid creating competition between the girls. A variation of an air pressure rocket-building project was added to the list as well, but because this is a weather dependent activity we decided against it.

Other projects we brainstormed were eliminated due to having too much similarity to past IQPs and Camp REACH workshops. We had considered having the girls build a crystal radio, however a similar project was done in the past. We had also considered adapting a project using solar power to cook hotdogs, however this was eliminated because there was a similar project done at the camp and it had failed due to being weather dependent.

We had selected some projects that had at first seemed interesting ideas, but later seemed to hold too little substance in terms of engineering principles. Building lamps was one idea that was too simple and not substantial enough for a daylong workshop. Optical illusions were also eliminated because of their lack of relevance to engineering.

The last project we eliminated in the initial stage was a project to determine how oil could be cleaned from water. This would be weather dependent and involve adding chemicals to water that may be environmentally unfriendly.

Six potential workshop topics remained after our initial elimination: Peanut Power, Making a Thermometer, Steam Powered Rocket Boat, Electrostatic Generator, Anemometer, and LED Radiometer. These workshops were worthy and diverse enough to be run through the workshop evaluation form we created. Also, all these projects were inexpensive enough to allow the girls to work in pairs, which is desirable because it allows for teamwork while making sure that each girl gets the chance to work on the project instead of just watching her partners.

In Peanut Power, the girls would learn about chemical energy by burning peanuts and determining the energy released by the peanut molecules. In the Making a Thermometer workshop, the girls would create a thermometer out of rubbing alcohol and bottles, which would demonstrate chemical properties of liquids and the effects of changes of temperature on them, a vital knowledge base for chemical engineering. In the Steam Powered Rocket Boat workshop, the girls would build small boats propelled by steam power. In the Electrostatic Generator, the girls would be able to generate electrostatic energy with tin cans and water. In the Anemometer workshop, the girls would learn to measure wind speed using a self-made Anemometer as well as investigate the many applications in engineering. In the LED Radiometer workshop, the girls would build their own radiometers, which are devices that measure energy reflected from various objects, as well as it's engineering applications.

Our evaluation of each workshop can be found in Appendix B and are discussed in Section 3.3.

3.3 Analysis of Evaluation Forms

The evaluation forms helped us to narrow our decision down from six possible workshops to two workshops that will be run through pilot testing. One or both of the workshops run through the pilot test will be selected as the topic for the final event. Below is an analysis of the evaluation forms, a description of the elimination process, as well as specific reasons for the decisions made.

Peanut Power was the first topic to be evaluated, ranking well in cost effectiveness, hands on ability, and success. However, it lagged in fun level and teamwork. Though the material knowledge was well in accordance to what the girls should know, the experiment lacked a major topic for discussion and expansion during a final workshop curriculum. This lack of expandability and practical social relations resulted in our rejection of peanut power as a final workshop topic.

The second idea examined was the making of a thermometer. Scoring high in cost range and hands on ability, and having a low likely hood to fail; thermometer construction looked like a good topic. Upon further inspection, we came to see that this topic might not be all that fun to 14-year-old girls, and that if used as a workshop topic we would need to perhaps join it with anther experiment to make it last a full day. These facts led to our rejection of thermometer construction as a final workshop topic.

Building a steam powered rocket boat as a workshop ranked well in all categories. The material was well in the knowledge range of the girls, and the fun, teamwork and hands on rating were all high. The facility needed was readily available and the cost was well in range. This topic did offer some forms of expansion but the biggest reason for rejection was the probability that someone could get hurt and because of a high level of competition.

Fourth, we explored the idea of constructing an electrostatic generator using metal cans and drops of water. Cost was well in the estimated range and all other ratings ranked high. Being fun, hands on, cheap and teamwork oriented, this experiment was a definite candidate for our final workshop. Unfortunately we were uncertain of the project working the way it was said to, so we decided that we would reject this topic idea and go for one with more validity.

With four workshop topics eliminated from the choices, only two potential workshops remained: the anemometer and the LED radiometer. Both topics categorized under an environmental/ physics theme. An anemometer is a device that measures wind speed in revolutions per minute, while a radiometer measures energy reflected from different portions of the earth. Both workshops rated high in all categories and seemed very diverse from past projects done during Camp REACH. We decided to pilot test both projects and based on our observations during the test, either choose one or implement both into the final workshop.

4.1 Workshop Creation

To conduct the pilot test, each workshop topic needed to have a lesson plan that followed the guidelines we set forth in Section 2.6.3 of the literature review. Significant background was gathered on both topics. The handouts contained systematic instructions for the building of each device. To get an idea of what knowledge the girls have and how they perceived the workshops that they would be participating in, we created handouts with various questions related to the workshop. Copies of the workshop handouts are located in Appendix C.

4.2 Anemometer Lesson

Looking back on our literature review, Section 2.6.3, we see the course of action that we wanted to take in creating an effective and fun workshop for the girls. The first point we wanted to cover was presenting them with a background of what they would be doing and why it would be useful in helping people. We researched background information on the topics of energy, power, wind energy, and anemometer use. We concluded that breaking the material up into a question-and-answer type format would be appropriate.

Section one of the anemometer handout explains what energy is. Giving definitions for several energy forms and an example of how energy gets from one form to another gives the girls a solid starting point.

Section two describes the difference between power and energy. Explaining the precise difference in the forms of measurement allowed the girls to better understand the terminologies used when referring to electricity.

Sections three and four deal with the origin of wind energy and the way in which it converts to electricity. This section begins to touch on some of the things that wind energy is useful for while explaining in engineering aspects of a wind turbine. Several visual aids were used in this section, which gives the girls a clear picture of what they are studying and mechanically how it operates.

Section six gives a definition of an anemometer and how it is used. Illuminating the uses and the way the anemometer measures wind speed prepares the girls for the experiment they are about to perform. Pictures of several types of anemometers are also inserted here so that participants have a visual idea of what they are about to build.

In section seven the steps for making the anemometer are shown along with the method in which they will be tested. Diagrams, formulas, and examples are shown to add in the creation and testing phase. Once the anemometer is built the girls are asked to test their devices. This is done using a three-speed fan, first measuring the revolutions per minute of the medium setting and comparing them to a reading taken from another type of anemometer called a pressure probe, which we borrowed from the mechanical engineering department.

The pressure probe is much more accurate in measuring wind speed then the anemometer built in the project. Using the pressure probe reading and the revolutions per minute taken by the anemometer a ratio is calculated and than used in predicting the miles per hour speed at the other fan speed levels. After the predictions are made the girls are then given the readings from the pressure probe for the other fan settings. The two measurements are compared and they are asked to compute the percent error of their anemometer. Lastly, the girls are taken outside to measure the wind speed that day using the ratio and error range they calculated in lab testing.

The last section of the handouts goes over the uses of wind energy. Once again touching on how this type of engineering and technology is useful in everyday life. A focus in this lesson is how wind energy is environmentally friendly. After a wrap-up discussion, the girls are given a set of questions that focus on things they liked and learned during this project.

4.3 Radiometer Lesson

A major concern about the radiometer project was the difficulty and time expense of teaching the girls how to solder their components together. Because of this concern the amount of background information included in the handout material was kept concise. The project handout was modeled after the type of laboratory handouts given by college professors, but effort was made to keep the girls' level of experience in mind. An introductory paragraph helps to acquaint the reader with the uses of radiometers in science and engineering and leads into the purpose statement which explains the goal of the laboratory.

The procedure section outlines the basic steps needed to be performed in order to complete the lab project. A list of materials, circuit diagram and list of important tips are given for the girls to refer to during the building process. The last section is entitled "Once your radiometer is assembled…" and discusses how the radiometer can be used to measure red and green light with the aid of a voltmeter.

The handout was created with the intention that the instructors would be helping the girls throughout the course of the laboratory by offering supplementary information about radiometers, the soldering process, physical circuit design and a final explanation that accompanies the girls' use of the "testing station" described in the handout.

4.4 Materials

Materials needed for each workshop were purchased prior to the scheduled date of our trial run. Both the radiometer and the anemometer were built by our team ahead of time to get the specific details about what type of materials we needed and what steps would have to be taken to construct each device.

Our testing came to show that for the construction of each anemometer we would need two evenly cut pieces of cardboard, one pushpin, a pencil, clay, and for paper cups. A ruler, scissors, and a stapler are needed put together all the pieces.

For the radiometer portion of the workshop the following materials are required per group of girls: one small prototype board, one red and one green jumbo (10mm) light emitting diode (LED), one 3 contact, 2 position switch, one of each 5.1 Mohm and 10 Mohm resistors and a small coil of solder. A soldering station with soldering irons is required to assemble the circuit.

4.5 Invitation Process

In order to have a sample of girls to attend our pilot test workshop, we sent invitations to all previous Camp REACH campers via email and through the postal service. We had originally planned to accept 16 girls into the workshop; however, the invitation did not explain what the workshop was specifically about and apparently did not generate the amount of interest that we had intended.

5.1 Pilot Testing

Pilot testing was held on March 25th, 2001. The six girls the attended arrived at a 12:30 in front of Atwater Kent (AK). AK room 317a was used for our event because the radiometer testing required the use of a multimeter to measure voltage. We allotted ourselves a three and a half hour period to complete both workshops and allowing for a short snack break in-between. For the pilot test, Jodi Campo was to instruct the anemometer lesson, Kevin Candiloro was to instruct the radiometer lesson and Gillian Orlik observed the workshop and took notes on what transpired.

Everything got underway at approximately 1:00 PM. Prior to starting; the girls were given the handouts for both projects to read thought while waiting. We started with a short icebreaker and then proceeded to teach the lesson. Figuring that the anemometer would be less time consuming, we started with it. A brief discussion was held on the underlying topics of the anemometer, but not as in depth as one would have hoped. We were pressed for time so explanations and background discussion were kept to a minimum.

Materials were passed out and the girls we left to assemble their anemometers. They were paired in groups of two, which we hoped would stimulate non-competitive hands-on teamwork environment. Following the step-by-step process given to them in the handouts all three groups successfully erected their anemometers and prepared to test their creation.

Each anemometer was tested with the same three setting fan, which was placed approximately two feet from the device. The fan was set to medium, one girl keep track of time while the other girl counted the number of revolutions. Pressure probe readings were given for the medium setting so that a ratio could be determined. Revolutions per minute measurements were then taken for the two remaining fan speeds. Mile per hour estimations we mad using the previously found ratio and percent error calculations were computed using the pressure probe readings for the additional speeds. Now that lab testing was complete each group had the specifics for their device. It was now time to go outside and test the wind that day. Seeing that time was an issue we decided that we would wait to see if after the completion of the radiometer lesion there was any time left to continue the testing of our anemometers. A brief snack break was taken, after which the radiometer lesion was started.

In the interest of time the radiometer lesson was aimed to give the girls the most time possible for soldering their circuits together. Since there was no basis to decide how long this process might take or how effectively the girls would be able to solder their components together, some time that could have been used for explanation of the circuit design was allocated to soldering time. The radiometer portion of the workshop began by asking the girls to read their handouts and indicating the most important information that they should be aware of concerning the lab. A brief description was given of each section of the handout to supplement the information there. The girls were told that help would be given during the soldering process and an example of an already built circuit was made available to them. They seemed quite cautious about the prospect of having to solder, but started building their circuits quickly despite their apprehension. Some groups went right to the pre-built circuit and saw how it was laid out on the board and others figured out their own layout using the circuit diagram.

Once each group was confident with their component layout the workshop coordinator in charge of the radiometer lab checked it over and brought them to the soldering station. Each group was shown how to solder by the coordinator who demonstrated by soldering one connection on their prototype board. The girls took to soldering quite readily and there were no mistakes made.

After each group felt confident that their circuit was correctly soldered together the lab coordinator began to explain more about how radiometers were used and brought them to the testing station. The testing station consisted of a couple of desk lamps, a multimeter and colored "terrain" patterns that were printed out. The terrain patterns were meant to be held up to the desk lamps so that the radiometers could be held up to the colors and readings could be taken in a similar fashion to how a satellite might look at the earth. This technique worked to a moderate degree, but greater color density was needed on the terrain patterns to receive clearer results. A last minute addition to the testing station was a red laser pointer that worked extremely well to illustrate that the radiometer LED's only detected their respective colors. When the laser was shone upon the red LED the voltage displayed by the multimeter had risen significantly, but when it shone on the green LED no change in voltage was seen at all. The addition of a green laser pointer, if financially possible, would have helped to strengthen this concept.

5.2 Notes from the Pilot Test

I. The girls seemed excited as they arrived. Two girls came by themselves, and two brought friends, giving us a total of six girls for the workshop. We were expecting two more who never showed up. As they arrived, they filled out a survey about themselves (name, grade, favorite subjects, possible career choices, hobbies). After everyone had arrived, we did a short icebreaker so everyone could introduce herself.

II. The Anemometer:

A) Jodi handed out a packet of information that included questions to be answered before the workshop began, information on building the anemometer, and background info. The girls filled these sheets out before the workshop actually began.

B) Jodi went over the information in the packet, such as what anemometers are for and what we would be doing. The girls paid close attention to Jodi.

C) After Jodi was finished speaking, the girls went to get supplies. They worked in pairs & all of the girls went to the table to get the right supplies. They were talking to each other about building the anemometer and laughing. One girl told her partner that she was probably going to screw it up and that the partner should do the cutting.

D) As they worked, the girls asked questions to Jodi & Kevin to make sure they were doing it right. They were focused on the task at hand. In each group, both of the girls split up the amount of work evenly and certain supplies were shared between the groups without any problems (stapler, scissors, etc). There was not much talking within the groups except about the task at hand at this point.

E) The girls finished building their anemometers at different times. The first group to finish came up to the table where the fan was set up in order to test it. They laughed about how there was no way their anemometer was going to stay together, and then listened to Jodi's explanation of the testing procedure. It took them a few tries to get a hang of the test without having their anemometer fall over, but not too long. The other two groups came over as they finished and watched. They laughed a lot saying how their own anemometers weren't going to stay together. The next two groups had less trouble than the first because they had had an opportunity to watch the testing in action.

F) As each group finished, they were given some formulae to use in order to calculate the "wind speed" of the fan. The girls grabbed calculators and sat down in their groups to finish the work. Kevin and Jodi helped them with the calculations as needed, but the girls were pretty secure on their own.

G) At the very end of the workshop, we took the girls to a windy area outside to test their anemometers again, however it was not windy enough and the sporadic gusts of wind made it very difficult for them to get an accurate wind speed. They saw the actual anemometer that is on the side of Higgins Labs and thought it was interesting to see a real life example of what they were doing.

III. The Radiometer

A) Kevin passed out a packet of information regarding the radiometer to each of the girls. Most of the girls looked a little confused and some were laughing nervously.

B) Kevin began to talk about what a radiometer is and how they would be building it. He gave them instructions on putting it together and told them to let him or Jodi look at what they built before they began to solder. Some of the girls seemed very excited about getting to solder. He explained the parts of the radiometer and drew a diagram on the whiteboard that seemed to confuse the girls.

C) He passed around a pre-built radiometer as an example. The reactions of the girls were very different: two of the girls seemed excited and said "Cool!" One girl raised her eyebrows at it, one girl looked quite intimidated by the radiometer, and the last group laughed nervously.

D) Girls seemed a bit reluctant to get the parts for the radiometer, needed help from Kevin to determine what they actually needed.

E) Two of the groups were almost silent as they put the radiometers together. One group was laughing about it as they put it together. They all used the pre-build radiometer as a reference as they worked and asked Jodi and Kevin questions. Jodi and Kevin spent a lot of time talking with the girls on putting the radiometer together.

F) As they finished putting the radiometer together, they showed it to Kevin before they started to solder. After getting an OK to solder it together, Kevin showed them how to use the soldering irons. A couple of the girls did not want to solder or seemed afraid of the soldering irons, but the rest of them were very excited to get to solder. They laughed a lot as they soldered their radiometers together, even the girls who did not want to solder helped by holding the device still.

G) Once they began to solder the girls seemed a lot more confident and less nervous about whether what they were doing was right or wrong. They began to ask each other for OK's rather than Jodi and Kevin.

H) Once they began to test the radiometer, Kevin gave them an explanation of the testing procedure in terms of a real-life situation. The girls all seemed to think it was cool & enjoyed playing with the various different sample "terrains" and other light sources with their radiometers. As they were testing their radiometers they all seemed extremely proud of themselves.

5.3 Questionnaires

The girls had pre and post-experiment questions to answer as part of the anemometer activity as well as a final workshop evaluation that covered the entire pilot testing experience. Each sheet was given in hopes to provide use with a better knowledge of what background the girls already had as well as how the girls felt about the materials and methods of the projects. The evaluation for the entire workshop was based upon a similar survey given by another IQP group. The scale of the evaluation form was left without a neutral answer so that it can be accurately used for comparison with the results of previous Camp REACH workshops. Photocopies of the questionnaires collected in the workshops can be seen in Appendix D.

5.3.1 Pre-workshop Data Collection

Pre workshop questions were pasted out for the anemometer project, it consisted of four simple questions. Questions were intended to get the girls to think about topics of the project they were about to do, and to also give us insight on what knowledge they already possess.

Through the questions asked we found that most girls knew that there were different kinds of energy and that it is defined as the ability of an object to do work. Some went on to state the different types and one girl knew that energy could not be created or destroyed. In addition, every participant knew that kinetic energy comes from the motion of participles. Half of the group new what an anemometer was and that it measured wind speed. A few of the girls had a general idea of wind turning a device, such as a windmill, to create electricity, but only on that basic of a level.

These results tell us that a brief background on concepts of energy would be sufficient. Definition and uses of an anemometer as well as information on wind energy, its origins and uses should undeniably be a part of the discussion and handouts of this project according to these results.

5.3.2 Post-workshop Data Collection and General Results

End questionnaires were given to the girls at the completion of each project; input given here will help in revising the workshop to be most enjoyable and educational for the participants.

Responses to the anemometer project were generally good. The girls felt that they learned how to construct a wind measuring device with everyday items, some felt that they needed to know more about how the device was used. Suggestions were for longer pushpins, a fan with more speed settings and something a bit sturdier then the clay used in the pilot testing.

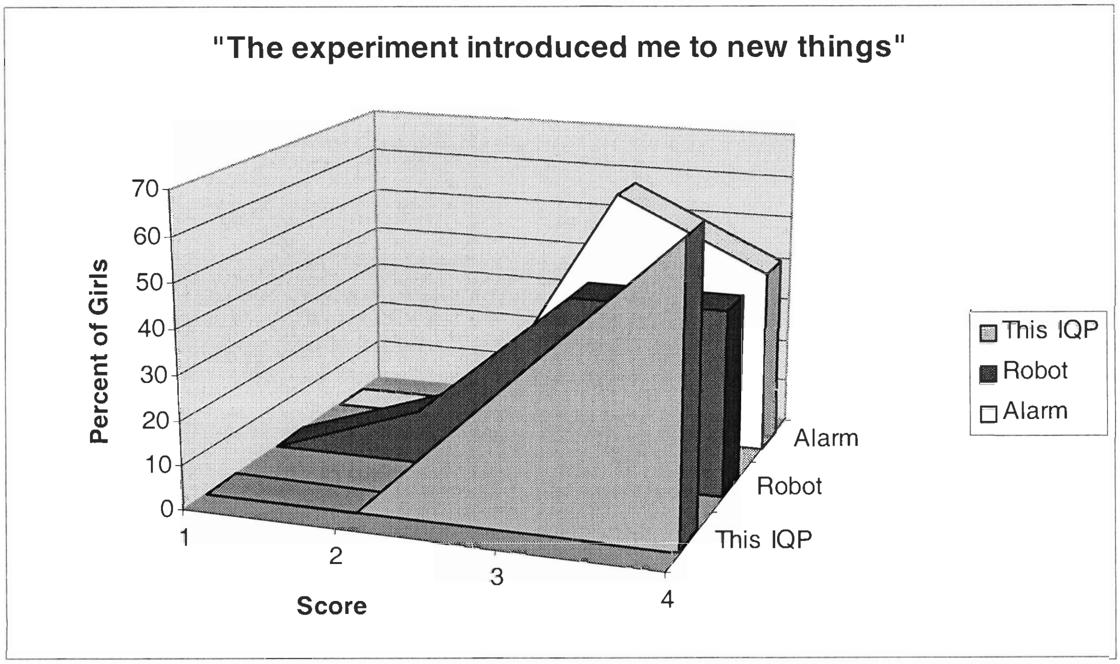
The radiometer project received high praise from the girls on a fun and interesting level. It was a new experience for most of them, soldering and testing the device was a very hand on experience that produced results that they could clearly see. The only complaints were that the diagram of the device was very confusing and not clear to them with out in-depth explanations.

Suggestions and recommendations given have been considered in the creation of the final workshop curriculum in hopes that all participants will find the day even fun filled and educational.

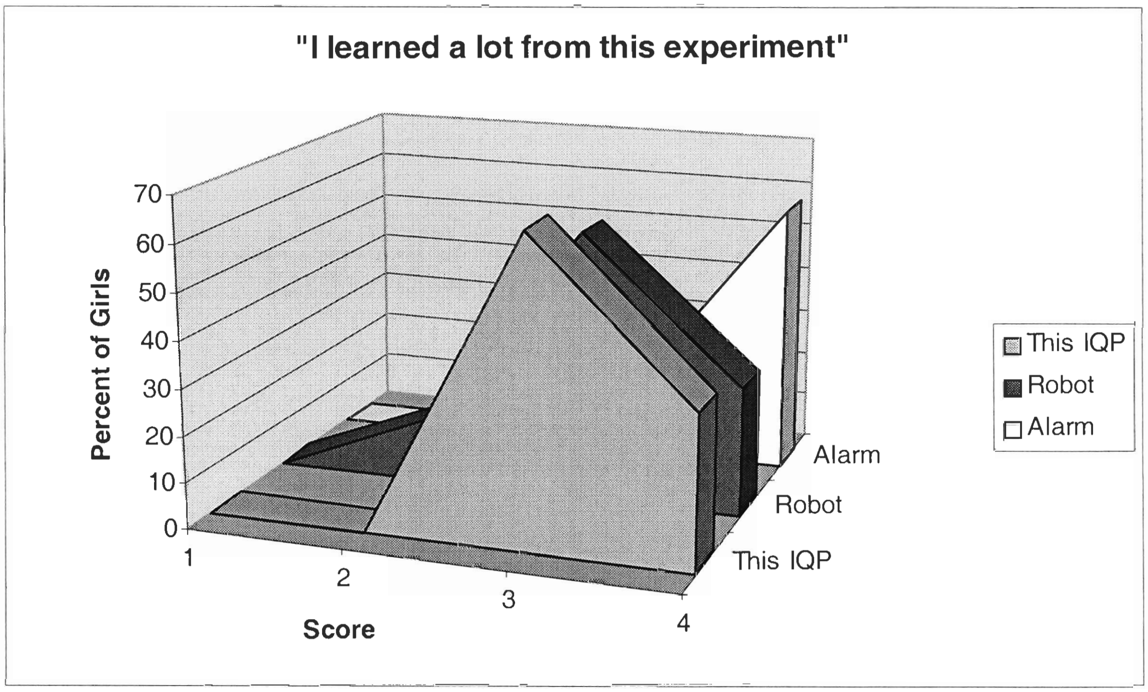
5.4 Statistical Analysis

At the completion of the two projects, a specific perception questionnaire was passed out. With questions relating to the experiments, processes, and content as well as reactions to the days event's and working in groups, this survey will gave us statistical ratings and show us where our event was strong and where it lacked. Below are the questions asked and the statistics (Mean = average, Median = number in middle of set given, and Mode = most frequently occurring number) calculated for each question fallowed by our comments on the results. Actual surveys can be viewed in Appendix D.

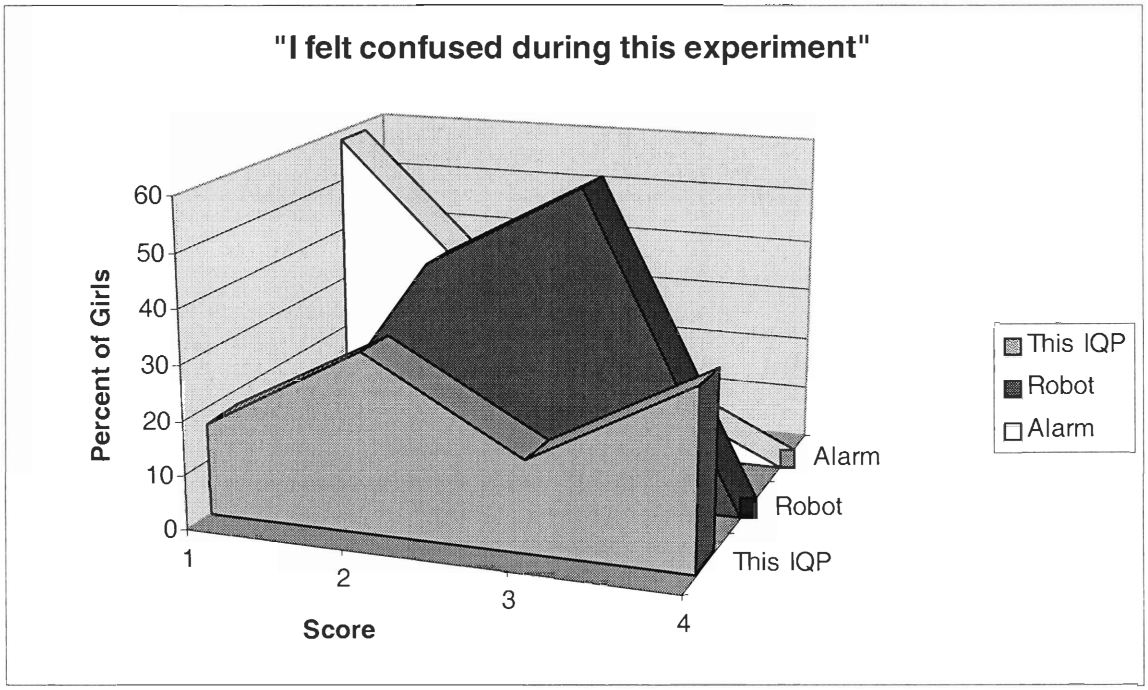
Another project group that finished their IQP in C term of 2001 also used Camp REACH alumni as their test audience for a camp workshop. The general workshop surveys found in Appendix D are taken from this previous IQP project so that we could evaluate our own workshop on the same basis that others employed. In their workshop, the other project group evaluated two possible workshop experiences: one involving the assembly of a robot kit and the other the assembly of an electronic alarm kit. They then rated both of these activities using the data that they received from the girls' completed surveys. In order to rate our own workshop success and compare our activities with those of previous attempts, the following graphical analyses were made using four key survey questions that cover a broad range of success measurement. While our project is based upon two workshop activities, it is meant to be administered as a single experience and is rated accordingly. The reason that the previous IQP group rated multiple activities was in order to choose the best one out of the two that they tested.



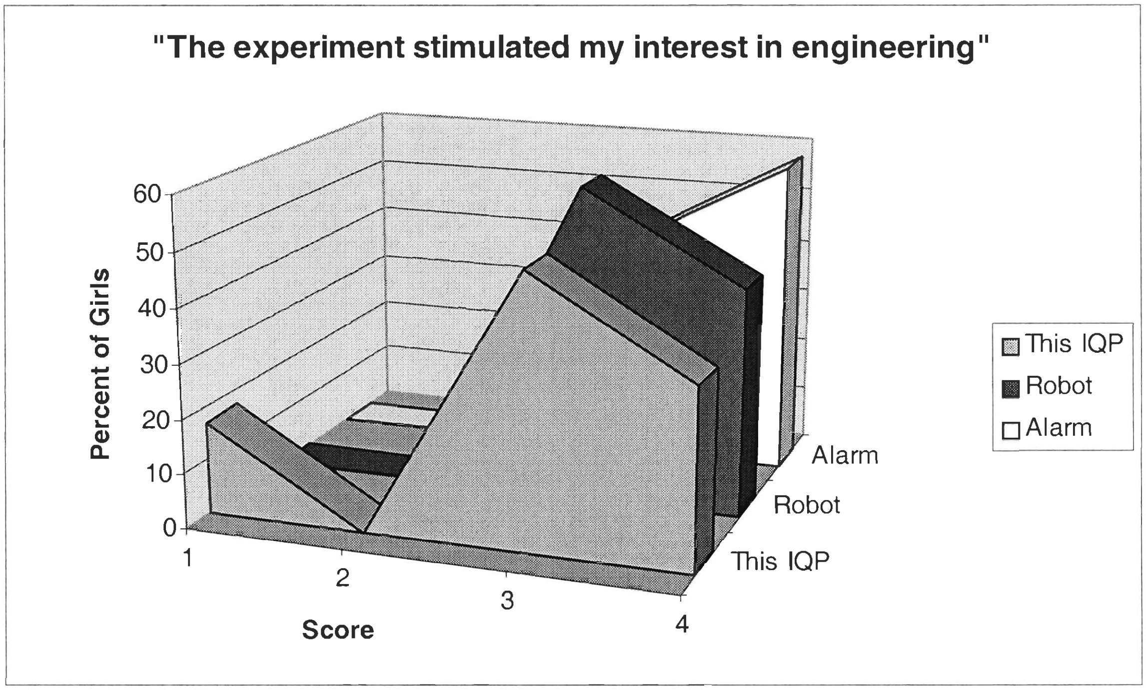
This graph shows that while generally similar to the other two activities, our workshop did exhibit a greater tendency to deal with topics and materials that the girls had not yet been exposed to. One reason that this may be true is because our activities both involved the total creation of a product and were not kit-based projects that can be found in stores.



It is evident from this chart that our workshop was similar to the robot building activity in that both had a high educational value for most of the girls. Compared to the alarm building activity, our workshop rates slightly lower on this scale, but the absence of any negative comments is convincing that our workshop was successful overall. It is our hope that the revisions made to the workshop will increase its intellectual worth.



In this case, a neutral to slightly negative rating is most desirable. It is obvious that the alarm building activity of the previous IQP pilot test was easily understood and would be the best choice based on ease of understanding. The robot activity scored poorly in this field due to the high percentage of girls who clearly felt confused. Our workshop shows a fairly even distribution of results with an average skew toward being more challenging than intended. This is most likely due to the state of the radiometer activity where some small misconceptions occurred. The revision of the radiometer handout should clear this problem up and smooth out the average challenge level to tend more toward a neutral state. The balance of the workshop being challenging, but not too difficult, was close in the pilot test, but modifications were necessary.



Our workshop scored similarly to the robot building activity and generally showed a high amount of interest in engineering generated. The absence of the small amount of negative feedback would have made it equally, or better rated than the robot experience. Interest in the alarm kit project was slightly higher. This may be due to the ease of understanding that this project showed. This rating is, perhaps, one of the most important overall since it is the generation of interest in engineering that motivates Camp REACH and programs like it. Overall, each of these activities was successful in this category to a significant degree.

What follows is that actual statistical breakdown of each question along with a conclusive comment:

Question 1

The experimentation process was well organized.

Mean $\rightarrow$ 3.333333

Median$\rightarrow$ 4

Mode $\rightarrow$ 4

Comment:

Strong agreement to our experimental process is good this means we really do not need to revise the organization of our curriculum.

Question 2

The instructions were clear and informative.

Mean $\rightarrow$ 2.833333

Median$\rightarrow$ 3

Mode $\rightarrow$ 3

Comment:

A majority of the participants felt the instructions were clear and informative. For the questioner we know that they wanted more of a step-by-step process for the construction of the radiometer, this will be revised in the final curriculum. This revision should cause the mode to increase to a rating of four instead of three. By creating clearer instructions, the girls will feel more confident approaching the project.

Question 3

The experiment was within my abilities.

Mean $\rightarrow$ 3.166667

Median$\rightarrow$ 3

Mode $\rightarrow$ 3

Comment:

The participants found that the experiments were in the in range of their capabilities. They were able to complete both projects with little problems. This indicates that the girls felt relatively confident of their abilities.

Question 4

The experiment stimulated my interest in engineering.

Mean $\rightarrow$ 3

Median$\rightarrow$ 3

Mode $\rightarrow$ 3

Comment:

Practically every participant felt that their interest in engineering was stimulated by their involvement in this workshop.

Question 5

I learned a lot from the experiment.

Mean $\rightarrow$ 3.333333

Median$\rightarrow$ 3

Mode $\rightarrow$ 3

Comment:

Everyone felt that they learned something from this experience.

Question 6

The experiment was interesting.

Mean $\rightarrow$ 3.333333

Median$\rightarrow$ 3.5

Mode $\rightarrow$ 4

Comment:

Only one girl found the experiments uninteresting. Majority found it interesting therefore nothing really needs to be changed.

Question 7

The experiment introduced me to new things.

Mean $\rightarrow$ 3.666667

Median$\rightarrow$ 4

Mode $\rightarrow$ 4

Comment:

All participants felt that new things were introduced to then in this workshop.

Question 8

The experiment was fun.

Mean $\rightarrow$ 3.5

Median$\rightarrow$ 3.5

Mode $\rightarrow$ 3

Comment:

Every girl found the day's events to be fun and entertaining.

Question 9

The experiment was pointless and boring.

Mean $\rightarrow$ 1.5

Median$\rightarrow$ 1.5

Mode $\rightarrow$ 1

Comment:

No one found the experiments to be pointless or boring.

Question 10

The experiment was a good group project.

Mean $\rightarrow$ 2.833333

Median$\rightarrow$ 3

Mode $\rightarrow$ 3

Comment:

One girl felt that the experiments performed were not good group projects. Seeing that the other five girls felt that it was, we did not feel that anything need to be revised due to this result.

Question 11

I worked well in my group.

Mean $\rightarrow$ 3.666667

Median$\rightarrow$ 4

Mode $\rightarrow$ 4

Comment:

Everyone worked well in the groups they were placed in.

Question 12

I enjoyed working in my group.

Mean $\rightarrow$ 3.5

Median$\rightarrow$ 3.5

Mode $\rightarrow$ 3

Comment:

Group work was enjoyed but all the participants.

Question 13

My group members had equal participation.

Mean $\rightarrow$ 3.5

Median$\rightarrow$ 3.5

Mode $\rightarrow$ 3

Comment:

Group members found that they worked well and that tasked we distributed evenly.

Question 14

I felt confused during the experiment.

Mean $\rightarrow$ 2.666667

Median$\rightarrow$ 2.5

Mode $\rightarrow$ 2

Comment:

The responses to this question were split. Three girls felt that they were confused at some point during the workshop will the other three said that no confusion existed. Through inspection of questionnaire answers we came to conclude that the confusion came from the diagram give in the radiometer lesson handouts. This issue has been addressed in the revision of the lessons and handouts.

Question 15

I would like to participate in this experiment again.

Mean $\rightarrow$ 2.833333

Median$\rightarrow$ 3

Mode $\rightarrow$ 3

Comment:

67% of the participants said that they would participate the experiment again.

Question 16

I would like to learn more about this subject.

Mean $\rightarrow$ 3.166667

Median$\rightarrow$ 3

Mode $\rightarrow$ 3

Comment:

83% said they would be interested in learning more about this subject.

Question 17

This experiment helped me see the importance of engineering.

Mean $\rightarrow$ 2.5

Median$\rightarrow$ 3

Mode $\rightarrow$ 3

Comment:

Only 67% of the girls found that the material presented helped them see the importance of engineering. Though this means that only two girls did not, we still feel that this issue should be addressed.

Question 18

The experiment was a good hands-on experience.

Mean $\rightarrow$ 3.166667

Median$\rightarrow$ 3.5

Mode $\rightarrow$ 4

Comment:

One girl strongly disagreed on the hands-on rating of this workshop, but all the others found that the experiments were good hands-on experiments.

6.1 Revisions

Results from data take from the pilot testing were used to aid us in our revisions. Suggestions were taken in to account, workshop lessons were made more descriptive and reader friendly, and problems that occurred were prevented with new materials and diagrams.

6.2 Anemometer Workshop Revisions

Few revisions were made to the anemometer lesson handouts. Question 2 in the pre workshop questions was changes from "Do you know what kinetic energy is?" to the more general question "Do you know any of the different forms of energy? If so state any that you know and a give a brief description." In doing this we hope to get the participants to think more in depth about energy and about the different forms that exists. The section titled "What are some of its uses of wind energy?" was re-worded and more information about uses and environmental issues pertaining to the anemometer was added.

A materials section was also added to the "Making you anemometer" section of the handouts. For the workshop long pin thumbtacks and firm clay should be used. In the trial there were problems with sturdiness and one groups cardboard and cup creation would come unattached from the pencil in high winds.

6.3 Radiometer Workshop Revisions

The handout for the radiometer lesson was changed slightly to mirror the concerns voiced by the girls who participated in the trial workshop. A listing of how the components need to be connected now accompanies the circuit diagram, which has been augmented with correlating connection number markers. The decision to leave the actual physical layout of the circuit ambiguous was made to maintain similarity to an actual electrical engineering laboratory where physical placement is left up to the builder. Another addition to the handout is an explanatory paragraph about how the device actually works. After the trial workshop, the girls expressed their excitement about the radiometer, but also said that they felt unfamiliar with exactly how the circuit operated.

6.4 General Workshop Revisions

Several things were done to the handouts and the workshop schedule. Since we decided to keep both lesson plans, we needed to find a way of incorporating them together into one lesson.

The decision to keep both activities as pieces of the entire workshop was based in the fact that each experience lent its own merits to the overall program. While building the anemometer is a simple and fun task, creating the radiometer was daunting to the girls at first, but rewarding in the end. Alone, neither experiment uses sufficient time to warrant its own full workshop. It is felt that incorporating both activities into the same workshop serves to balance the overall challenge of the experience. It also shows evidence of the broad range of engineering activities that exist.

A workshop introduction page was created. Starting with a brief description of the devices the participants will be assembling, followed by how the two devices related to each other. The projects were categorizing under an environmental theme, and both fell under the subject areas of earth science and physics. Section two of the introduction page explains how the anemometer and the radiometer relate to environmental topics and issues.

To conclude the workshop, a wrap-up section was created. This section just summarized the important issues learned during the workshop, focusing on the useful functions of the anemometer and radiometer.

To aid in the implementation of our workshop we prepared a timeline and itinerary for the instructor of the event to follow. We hope this form assures that the workshop will run smoothly and that all the things intended to do during the even take place, going in to such detail as what topics should be discussed.

An aspect we found to be problematic was the low response to our invitations to the pilot test. In order to gain the girls' interest, we have created a more interesting flier, which better describes the workshop and its projects. This flier can be seen in Appendix E.

7.1 Budget Expectations

In order to determine what we could reasonably expect parents to pay for their child to attend our workshop, we conducted a survey of 60 parents. Through a telephone interview conducted in collaboration with another IQP group also involved with Camp REACH, we asked each parent what he or she would be willing to pay. The average price suggested was thirty dollars. Knowing this, our goal is to run the workshop for less than $30 for each girl, allowing for some financial aid for some students.

7.2 Expected Workshop Costs

To determine the actual cost, we summed the cost of supplies and other possible workshop expenses. The total cost of supplies per girl came to $6.06 for both the anemometer and radiometer projects. Since the workshop would last a significant amount of time, snacks should be provided midway through the program. The estimated cost per girl for snacks is $2.75.

In order to save costs on workshop instruction, we have asked the members of WPI's Society of Women Engineers if there would be an active interest in recruiting some volunteer workshop instructors. The response was that with adequate notice they would be glad to provide volunteers. This correspondence may be viewed in Appendix F. Our suggestion is to request two volunteer instructors per every ten girls. There are costs with regard to mailing the invitations to the girls, the estimated cost of photocopying or printing, envelopes, and postage totaling under one dollar per girl.

7.3 Budget Analysis

The following is a list of the materials purchased for the workshop. All prices are based upon groups of two and calculations are done for a total of 16 girls:

- **Radiometer supplies**
  - Order of 40 Jumbo 10mm LED's (20 red and 20 green) $8.80
  - Wire available at ECE shop ($.50 per 5 feet x 16 girls) $8.00
  - Prototyping board priced from Radio Shack ($1.49 x 16) $23.84
  - Price per girl (this experiment) <u>$2.54</u>

- **Snacks:**
  - Cookies
    - 44 cookies $13.20
    - Price per girl $0.83
  - Drinks
    - 22 cans of soda $19.80
    - 12 bottles of water $10.80
    - Price per girl $1.92
  - Price per girl (entire snack menu) <u>$2.75</u>
- **Anemometer supplies:**
  - Scissors $3- $4 (x 8) $28.00
  - Paper Cups (40 pack enough for 8 groups) $1.97
  - Markers (only one pack needed) $1.18
  - Cardboard $0.97 x 4 (small box will supply 2 groups) $3.88

- Ruler $0.68 x 8 (one per group) $5.44
- Stapler (one can be shared) $3.99
- Push Pin (one large pack) $0.99
- Pencil (20 pack enough for 20 groups) $0.97
- Modeling Clay (enough for several groups) $4.97
- Stopwatch ~$5.00
- Price per girl (this experiment) $3.52

- Volunteer instructors from SWE FREE

Total workshop cost **$140.96**

TOTAL PER GIRL (Price for all workshop materials) **$8.81**

Because the parents were, on average, willing to pay $30 for their daughters to attend this workshop, we consider our budget to be a success. The workshop can pay for itself and for a few financially strained students if the girls were charged $12.00 each to attend the program.

8.1 Running the Workshop

The materials to create the workshop include the instructor worksheets, the student worksheets and the workshop itinerary. Based upon the feedback that was received from the pilot testing, revisions were made to the student worksheets. These are all included in Appendix G.

8.2 Itinerary / Timeline

The workshop will be run as follows:

10 minutes – Introductions and Icebreaker

15 minutes – Anemometer & Wind Energy lesson and question session

30 minutes – Anemometer building

30 minutes – Anemometer testing

15 minutes – Break for snacks & discussion

15 minutes – Electrical Engineering and Radiometer discussion

40 minutes – Radiometer building

20 minutes – Radiometer testing

15 minutes – Discussion

Total Workshop Time: 3 hours and 10 minutes

We suggest that the existing staff allot an extra half hour to allow for differences in working with a larger group of girls.

9.0 Conclusion

Faced with the task of creating a workshop that would excite adolescent female students' interest in engineering and technical fields, preliminary research had to be done. Background research regarding statistics of women in science and engineering careers, social and physiological development of females, problems in teaching styles and ways to fix them, as well as tips on producing an effective workshop. Aside from motivating females to pursue technical careers, this workshop has hopes of creating a hands-on teamwork environment that is not only educational but also fun.

With the foundation of information in place, the search for a project topic that best fit our needs began. A variety of projects were considered, many were eliminated because of similarities to previously done projects or validity of content. An evaluation form containing goals and specifics we researched was created to aid in the choosing of the final workshop topic. Anemometer and LED Radiometer were the two projects that ranked highest. The two remaining topic ideas were expanded into workshop lessons that would be taught during a pilot testing of Camp REACH alumni. Surveys and questionnaires were distributed and collected during pilot testing, responses were used to further evaluate the projects and aid in the revisions process.

Both topics were approved for final a workshop; they are related through an environmental theme and allow participant to explore and better understand two devices used in predicting environmental conditions. Improvements to the workshop were made in accordance to comments we received from the girls as well as things that we observed during pilot testing. Introduction and wrap-up handouts were created as a way to show the relationship of the two projects. A teacher's guide was also written to insure that the instructor would be aware of how the workshop was anticipated to run, and important points that should be discussed.

Workshop implementation through pilot testing showed the goals in place for this workshop were met. Reviewing the response received, the girls found the workshops enjoyable and educational, as well as stimulating. Group work proved to be successful and introduction of new topics was present. The soldering of LED Radiometer was a new hands-on experience for most of the participants.

Creating a successful and appealing workshop for Camp REACH requires a lot of feedback from past campers and girls of the appropriate target age. It is recommended that feedback be taken from these people prior to the selecting and creation of a workshop topic. This information will assure that your topic is interesting to the girls that will be participating. It is also very important that the topic relates to real world issues, and that the advertising for the event will catch attention, spark interest, and attract more girls to the program.

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[24] Ibid.
[25] Rosser op. cit. pp13
[26] Moulton and Ransome op. cit
[27] Ibid.
[28] Project PRISM op. cit.
[29] Rosser op. cit. pp11.
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Appendix A

Massachusetts Curriculum

Mathematics

The mathematics curriculum focuses on developing problem solving, communicating, reasoning, connecting, and representing skills through several topics of math, Number sense and Operations, Patterns, Relations, and Algebra skills, Geometry, Measurement, and Data Analysis, Statistics, and Probability.

Number sense and Operations deals with the understanding of number systems and how they work in different operations. Integer exponents, fraction and ratio, and order of operations of just a few of the topics covered in grades five and six. Scientific notation, roots, powers and rational numbers are seen in the seventh and eight grade. Subjects like numerical expression simplification and properties of real number operations identification are incorporated into the ninth and tenth grade learning standards.

Patterns, relations, and algebra skills deals "extending, representing, analyzing, and generalizing a variety of patterns with tables, graphs, words, and possibly, symbolic expressions." By seventh and eighth grade, students should be able to evaluate simple algebraic expressions, such as linear equations and inequalities for one or two given variables.

Geometry topics for fifth and sixth grades have to deal with Cartesian graphs, polynomial identification, and 3D shape analysis and symmetry types. In seventh and eighth grade, students acquire an understanding of the Pythagorean theorem, angle relationships, and 2D-3D interaction and representation. In ninth grade, the geometric properties of angles and shapes are taught.

Measurement encompasses the idea of using "modes, graphs, and formulas to solve simple problems involving rates, such as those including velocity and density." Students are taught how to apply formulas and procedures to taking measurements. The recording of measurements ties nicely into the next topic of study, data analysis, statistics, and probability. A specification under this topic deals with representing possible outcomes of trials through previous data. Seventh and eighth graders are expected to find, describe, and interpret the mean, median, mode, and range for various sets of data.

Science

Through the study of technology, students develop problem solving skills as well as practical ways to use their knowledge of math and science. Massachusetts' science curriculum is broken up in to four major premises: inquiry, domains of science, technology, and science, technology, and human affairs. Below are some topics and specifics of the curriculum requirements set forth by the Department of Education. Inquiry is the basis for scientific and technological problem solving. This includes creating an ability to observe relevant details, patterns and relationships when performing tests or experiments helps the students to ask relevant questions and identify the problem at hand and ways to solve it. Inquiry is the ability to solve a particular problem by experimentation, observation, and asking the write questions.

The domains of science curriculum specifications deal with three major topics, physical science, life science, and earth and space science. Through the study of physical science, students learn the properties of matter, position and motion of objects, the forms and transformations of energy, and motion and its charges. In grades nine and ten, the structure of matter, interaction of substances, forces and motion, and conservation and transmission of energy are taught. Life science encompasses the characteristics, diversity and adaptation of organisms, heredity, reproduction and development, organisms and environment, ecosystem and the matter and energy in it, as well as the evolution of life. Lastly earth and space science covers the properties and changes of earth's materials, objects in the sky, interactions and cycles in the earth system, earth history, earth and space, matter and energy in the earth system, and the evolution of the universe.

Technology has become a big part of everyday life and, therefore, is not a surprise that children today are learning about it as early as kindergarten. Schools strive to give students an understanding of the uses of technology in society by teaching them about the nature and impact, history, tools and machines, and resources of technology, as well as technological areas of communications, construction, manufacturing, transportation, power, and bio-related technologies.

The final topic of the Massachusetts science curriculum deals with the interactions between science, technology, and society. Students explore the history and the way the implementation and advancement of science and technology influenced the lifestyles of people of the time.

Appendix B

Workshop Evaluation Forms

Workshop evaluation form

Title: **Peanut Power**
Area of study: Chemistry/ Physics

The questions below are intended to help us pick the workshop that best fulfills our goals, while being most appropriate for the age group being dealt with. **(Based on very low = VL, low = L, moderate = M, high = H, very high = VH, scale)**

Diversity:
Yes, diverse from workshops done in the past.

Previous knowledge required for workshop:
Basic knowledge of heat and energy

Accordance with the Massachusetts curriculum learning standards pre 9th grade: VL L M H **VH**

Topics to be taught in workshop:
Potential energy -> kinetic energy, calories

Fun level for camper: VL L **M** H VH

Hands on rating: VL L M **H** VH

Teamwork needed to complete project: VL L **M** H VH

Facilities needed:
lab area, ventilation, and running water

Availability of facilities:
On campus: **Yes** or No
Weather dependent: Yes or **No**
What could go wrong:
Peanuts could not ignite, fire safety issues.

Likelihood for project to fail: VL **L** M H VH

Supplies needed:
Peanuts, corks, needles, large and small metal cans, can opener, hammer, large nail, BBQ skewer, thermometer, matches

Cost estimate: about $10 to $20

Cost for camper: $10 -$12

Accordance with price willing to pay: VL L M **H** VH

Material Appropriateness:	1 2 3 **4** 5
Cost Appropriateness:	1 2 3 **4** 5
Even Appropriateness:	1 2 **3** 4 5

Workshop evaluation form

Title: **Making a Thermometer**
Area of study: Physics/chemistry

The questions below are intended to help us pick the workshop that best fulfills our goals, while being most appropriate for the age group being dealt with. **(Based on very low = VL, low = L, moderate = M, high = H, very high = VH, scale)**

Diversity:
Yes

Previous knowledge required for workshop:
Temperature and reaction to heat

Accordance with the Massachusetts curriculum learning standards pre 9th grade: VL L M **H** VH

Topics to be taught in workshop:
Chemical reaction to heating

Fun level for camper: VL L **M** H VH

Hands on rating: VL L M **H** VH

Teamwork needed to complete project: VL L **M** H VH

Facilities needed:
lab area

Availability of facilities:
On campus: **Yes** or No
Weather dependent: Yes or **No**

What could go wrong:
Mix wrong.

Likelihood for project to fail: **VL** L M H VH

Supplies needed:
Rubbing alcohol, water, bottles, food coloring, straw, modeling clay, heat sources

Cost estimate: $15 - $20

Cost for camper: $7 - $10

Accordance with price willing to pay: VL L M H **VH**

Material Appropriateness:	1 2 3 **4** 5
Cost Appropriateness:	1 2 3 4 **5**
Even Appropriateness:	1 2 **3** 4 5

Workshop evaluation form

Title: **Steam Powered Rocket Boat**
Area of study: Chemistry

The questions below are intended to help us pick the workshop that best fulfills our goals, while being most appropriate for the age group being dealt with. **(Based on very low = VL, low = L, moderate = M, high = H, very high = VH, scale)**

Diversity:
Yes

Previous knowledge required for workshop:
Heat and expansion

Accordance with the Massachusetts curriculum learning standards pre 9th grade: VL L M H **VH**

Topics to be taught in workshop:
Heat Reactions

Fun level for camper: VL L M **H** VH

Hands on rating: VL L M **H** VH

Teamwork needed to complete project: VL L M **H** VH

Facilities needed:
Sinks, basin or wading pool

Availability of facilities:
On campus: **Yes** or No
Weather dependent: Yes or **No**
What could go wrong:
Potential to get hurt or burnt if done incorrectly

Likely hood for project to fail: **VL** L M H VH

Supplies needed:
metal Tube, strong wire, cork, food warmer candles, balsa wood, masking tape, hammer, nails, matches, and hot water.

Cost estimate: $ 20

Cost for camper: $10

Accordance with price willing to pay: VL L M **H** VH

Material Appropriateness: 1 2 3 4 **5**
Cost Appropriateness: 1 2 3 **4** 5
Even Appropriateness: 1 2 3 **4** 5

Workshop evaluation form

Title: **Electrostatic Generator**
Area of study: Physics/Electricity

The questions below are intended to help us pick the workshop that best fulfills our goals, while being most appropriate for the age group being dealt with. **(Based on very low = VL, low = L, moderate = M, high = H, very high = VH, scale)**

Diversity:
Medium

Previous knowledge required for workshop:
Charges, magnets, electricity

Accordance with the Massachusetts curriculum learning standards pre 9th grade: VL L M **H** VH

Topics to be taught in workshop:
Electrostatic energy

Fun level for camper: VL L M **H** VH

Hands on rating: VL L M **H** VH

Teamwork needed to complete project: VL L M **H** VH

Facilities needed:
lab area, and running water

Availability of facilities:
On campus: **Yes** or No
Weather dependent: Yes or **No**
What could go wrong:
Uncertain if it will work the way it is said to??

Likelihood for project to fail: VL L M H VH **?**

Supplies needed:
metal cans, water, something to create a charge

Cost estimate: $10 (if that)

Cost for camper: $5

Accordance with price willing to pay: VL L M H **VH**

Material Appropriateness: 1 2 3 **4** 5
Cost Appropriateness: 1 2 3 4 **5**
Even Appropriateness: 1 2 3 **4** 5

Workshop evaluation form

Title: **Anemometer**
Area of study: Environmental/ Physics

The questions below are intended to help us pick that workshop the best fulfills our goals, while being most appropriate for the age group being dealt with. **(Based on very low = VL, low = L, moderate = M, high = H, very high = VH, scale)**

Diversity:
Yes diverse from workshops done in the past.

Previous knowledge required for workshop:
Ratios and proportion, theories of energy and wind power generation.

Accordance with the Massachusetts curriculum learning standards pre 9th grade: VL L M H **VH**

Topics to be taught in workshop:
Calculation of wind speed, % accuracy

Fun level for camper: VL L M **H** VH

Hands on rating: VL L M **H** VH

Teamwork needed to complete project: VL L M **H** VH

Facilities needed: Lab area

Availability of facilities:
On campus: **Yes** or No
Weather dependent: Yes or **No** windy day would be good but not needed

What could go wrong:
could fall apart if wind is to strong but very easy to fix

Likelihood for project to fail: **VL** L M H VH

Supplies needed:
Scissors, cups, markers, stiff cardboard, modeling clay, stopwatch and fan.

Cost estimate: $20

Cost for camper: $10

Accordance with price willing to pay: VL L M **H** VH

Material Appropriateness: 1 2 3 **4** 5
Cost Appropriateness: 1 2 3 **4** 5
Even Appropriateness: 1 2 3 4 **5**

Workshop evaluation form

Title: **LED Radiometer**
Area of study: Environmental/ Physics/ Electronics

The questions below are intended to help us pick the workshop that best fulfills our goals, while being most appropriate for the age group being dealt with. **(Based on very low = VL, low = L, moderate = M, high = H, very high = VH, scale)**

Diversity:
Yes diverse from workshops done in the past.

Previous knowledge required for workshop:
Energy, voltage

Accordance with the Massachusetts curriculum learning standards pre 9th grade: VL L M **H** VH

Topics to be taught in workshop:
Electromagnetic spectrum

Fun level for camper: VL L M **H** VH

Hands on rating: VL L M **H** VH

Teamwork needed to complete project: VL L M **H** VH

Facilities needed:
EE lab

Availability of facilities:
On campus: **Yes** or No
Weather dependent: Yes or **No**
What could go wrong:
N/A

Likely hood for project to fail: VL **L** M H VH

Supplies needed:
LED's, digital multimeter

Cost estimate: $10 (if that)

Cost for camper: $5

Accordance with price willing to pay: VL L M H **VH**

Material Appropriateness:	1 2 3 **4** 5
Cost Appropriateness:	1 2 3 4 **5**
Even Appropriateness:	1 2 3 4 **5**

Appendix C

Pilot Test Worksheets

Pre workshop questions

1) What do you know about energy?

2) do you know what kinetic energy is?

3) Do you know what an anemometer does? (see picture if you are not sure what exactly an anemometer does.)

4) Do you know wind how wind energy works? If so explain? If not please tell use any knowledge that you do have about wind energy.

What exactly is energy?

Energy is defined by the amount of work a physical system is capable of performing. Energy can neither be created, consumed nor destroyed, but it can be converted to different forms of energy.

For example the kinetic energy of moving air molecules may be converted to rotational energy by the rotor of a wind turbine, which in turn may be converted to electrical energy by the wind turbine generator. During each conversion some part of the source energy is converted in to heat energy.

Some Definitions:

Kinetic energy – energy possessed by an object, resulting from the motion of that object.
Rotational energy – The work that a rotating body does.
Electrical energy – The ability of an electrical source to carry out useful work, this energy can be used to drive an electrical motor and carry out some mechanical work. The electrical energy is usually expressed in units of watt-hour
Heat energy – a form of energy that is transferred by a change in temperature

So what the difference between energy and power?

To decipher the difference between energy and power we look to the units that both are measured in. Energy has the units of kilowatt hours (a *kilowatt is equal to 1000 watts*), where as power units are kilowatts. Knowing this we can conclude that power is the amount of energy transferred per unit of time. Power may be measured at any point in time whereas energy has to be measured during a period of time.

You might be familiar with the term "horsepower," which is used when referring to automobile engines. If we think about power and energy in terms of a car engine, **power** defines how much "muscle" a generator or motor has, whereas **energy** tells you how much "work" a generator or motor performs during a certain period of time.

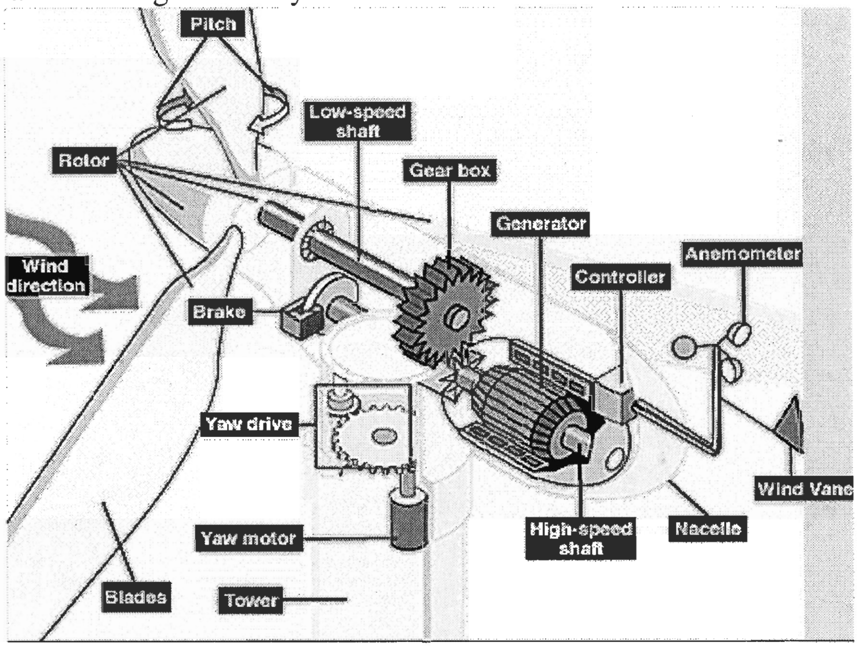
1kw (or 1000 watts) = 1.359 HP

Where does wind energy come from?

Ultimately comes from the sun. The sun radiates 100,000,000,000,000-kilowatt hours of energy to the earth per hour. In other words, the earth receives 10 ^18th watts of power. About 1 to 2 per cent of the energy coming from the sun is converted into wind energy.

How is wind energy converted in to electricity?

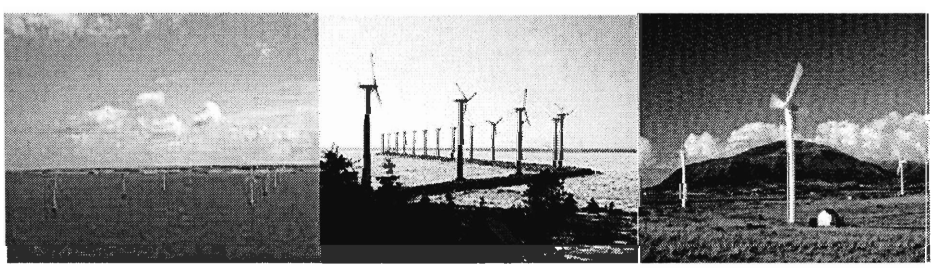
One of the devices uses to convert wind energy to electricity is the wind turbine. The blades if the turbine spins with the wind, similar to large toy pinwheel. The blades are attached to a hub that is mounted on a turning shaft. The shaft goes through a gear transmission box where the turning speed is increased. The transmission is attached to a high-speed shaft, which turns a generator that makes electricity. The diagram below may make these processes a bit clearer. But simply the tuning blade turns the inner workings of the generator and creating electricity.



Wind turbine inner workings

Winds must be at speeds about 12 or 14 miles per hour for the turbines to turn fast enough to generate electricity. A signal turbine will produce about 50 to 300 kilowatts of electricity. So at most the electricity of one turbine can light 3,000 100watt light bulbs.

Turbines are grouped together in what are called wind "farms." Theses wind farms are located mostly in the three windiest areas of the state. The three wind farms in California make enough electricity to supply an entire city the size of San Francisco with power.

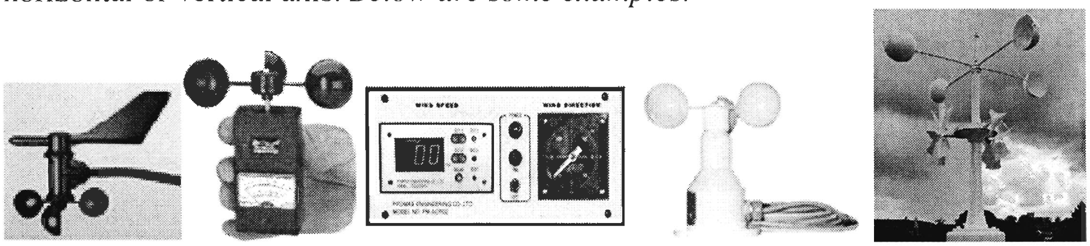


Above are some of the different types of wind farms seen around the world

What is an anemometer and how is it used?

An Anemometer is a weather instrument that measures the speed of wind. This instrument is useful because it rotates at the same speed as the wind and quite helpful in accurately determining wind speeds because it gives a direct measure of the speed of the wind.

There are many varieties of anemometers that have been developed since the fifteenth century. The one that we will be building is the rotational, it is a freely rotating device that has cups or vanes to capture the wind and rotate allow it to rotate about a horizontal or vertical axis. *Below are some examples:*



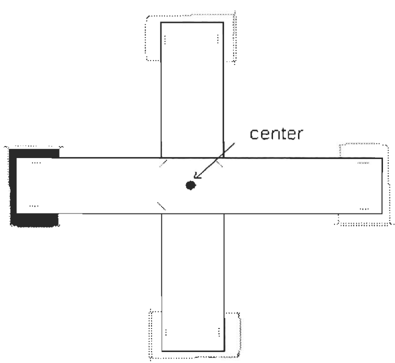
An anemometer measures wind seed by counting the number of full rotations during a period of time. They are most useful in weather predictions and wind speed patterns.

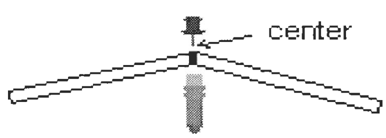
Making you anemometer

Step one: Take the four cups in your anemometer building kit and cut the rolled edges off to make them lighter. The lighter the less resistance and higher accuracy. After all edges are cut talk on cup and color the outside with a marker enough so that you can tell it apart from the other cups.

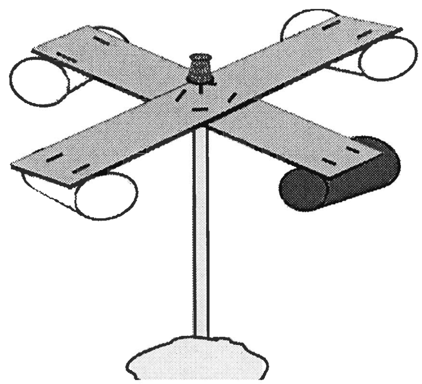
Step two: Cross the two cardboard strips so that they make a plus sign (+) and staple them together. With a ruler and pencil find the exact center of the crossed boards. (Must have the center or your anemometer will be off balance)

Step three: Staple the cups to the ends of the cardboard strips making sure they are all facing the same direction. Next take a pushpin and put it through the center that you previously found then attach the crossed cardboard and cups to the eraser of your pencil.





Step four: Use the clay as a base so that the device and stand on it's own, then test to see if the cardboard strips spin by bowing in to the cups. (Loosen the push pin if no spinning occurs.



Now where ready to test it out!

Using the fan provided place your anemometer in front of the fan turn the fan to the medium setting and count the number of times the colored cup comes around in 1 minute. (Use a stop watch to keep track of time and make sure before starting the fan the colored cup in directly in from of the person counting the rotations.) This measurement will give you the rotations per min at that fan setting.

We know from using the pressure probe that the speed of the fan at medium setting is 10.9 miles per hour. Therefore:

_____ revolutions/minute = 10.9 miles/hour

Now turn the fan to its low setting and measure the number of revolutions per minute. Repeat this for the high fan setting as well

_____ revolutions/minute (low setting)

_____ revolutions/minute (high setting)

Now find the miles per hour speed using the ratio we found above.

Example:

$$\frac{\text{Know miles/hour}}{\text{Know rev/minute}} = \frac{\mathbf{X}}{\text{new rev/minute}}$$

Solve for **X**

Now we want to find the accuracy of our anemometer. To do this we will use the error equation to find **error**.

Error equation:

$$\frac{\text{Actual} - \text{Measured}}{\text{Actual}} = \text{error}$$

Knowing the %error and ratio of your anemometer you can calculate the speed of any wind with in a certain range of accuracy.

Approximate wind speed:

X ± **error** miles per hour

Now that we have all the variables needed we will take our anemometer out side and calculate the wind speed today.

Today's wind speed:

_____ revolutions/minute

So what did you calculate the wind speed to be outside today? Make sure the specify the error range of your measuring device.

What are some of its uses of wind energy?

Boat use wind energy to push it through the water by lifting a sail. Farmers have been using wind energy for many years to pump water from wells using windmills like the one pictured here. Wind is also used to turn large grinding stones to grind wheat or corn, just like a water wheel is turned by waterpower.

Aside from aiding humans in the things above wind energy is efficient in creating electricity. Wind energy is a free, renewable resource, so no matter how much is used today, there will still be the same supply in the future. Wind energy is also a source of clean, non-polluting, electricity. Unlike conventional power plants, wind plants emit no air pollutants. California's wind power plants make up for the emission of more than 2.5 billion pounds of carbon dioxide, and 15 million pounds of other pollutants that would have otherwise been produced.

End Question

What do you fell you leaned?

What, if any, question do you still have?

What did you like and dislike? What would you suggest for us to change or expand on?

Build a Simple Radiometer

Introduction

In order to collect important data about the earth NASA uses satellites equipped with highly sensitive instruments called **radiometers**. A radiometer measures the amounts of different types of light energy that are given off by the earth and its atmosphere. One way scientists and engineers can collect important data is by looking at what colors of light are present in a certain area. The color of light can tell them if plant life is healthy, how much water vapor is present in the air or even the temperature of the earth. By analyzing color information the computers in contact with these satellites can "see" what's going with our environment and help researchers collect important data.

Purpose

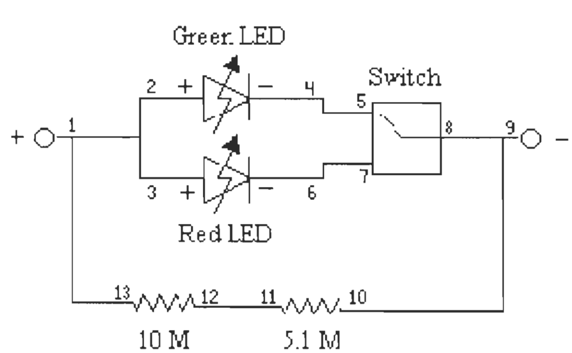
The objective of this experiment is to build your own simple radiometer that measures amounts of red and green light. The radiometer will be built using red and green LEDs (light emitting diodes) which will be used in reverse to create voltage rather than to create light. The voltage created by the LEDs will be measured using a volt meter to show how much red and green light is present at a test point.

Procedure

First, identify that you have all the parts necessary to build your radiometer. You should have:

1 - prototyping board (fiberglass board with holes and copper pads on it)
5 - short pieces of connection wire (ask for more if you need them)
1 - red LED
1 - green LED
1 - two position, 3 contact switch
1 - small coil of solder
1 - 5.1 Mohm resistor (stripe pattern: gold, green, brown, green. Some also have a yellow stripe at the beginning)
1 - 10 Mohm resistor (stripe pattern: gold, blue, black, brown)

Circuit Diagram



Some things to remember:

The "free wires" shown in the circuit diagram are where readings will be taken by connecting them to a volt meter.

Place your components on the side of the prototype board that does not have the copper pads on it. Push them through the board so that the metal ends stick up through the copper pads on the board. This is important since you will be soldering the components from the back of the circuit.

If you place two components next to each other on the prototype board you do not need a wire between them. They can be connected with a neat blob of solder.

Some more things to remember:

The short lead wire on the LEDs is the negative side. It is important to connect your LEDs correctly or else you will get negative readings from your radiometer.

The switch must be connected so that the center terminal is connected to the resistors and the negative lead from an LED is connected to one of the outer terminals. It doesn't matter which LED goes on which outer terminal.

Be sure to show your circuit to one of the instructors before you begin to solder the components! Components are hard to remove once they have been soldered on!

After your radiometer circuit has been checked by an instructor you may begin to solder the components together at one of the soldering stations. If you need any help doing this please ask an instructor.

Once your radiometer is assembled…

Your radiometer is actually working already, but you can't see any results yet! The radiometer must be attached to the volt meter at your workstation so you can start measuring light. Instructions will be given on how to do this. The switch on your radiometer determines which color light you are measuring, red or green. The number you see on the volt meter is not any specific type of measurement, but you will be able to see the difference between how much red and green light exists at your test area.

A testing site will be available for you to see how your radiometer can be used to "look" at different kinds of land area so you can begin to understand how scientists and engineers use these instruments to look at the earth. At the testing area hold a terrain sample up to the lamp and place your radiometer on the other side. You should be able to distinguish the different colors of terrain by the numbers you see that indicate amounts of red and green light.

Workshop References

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http://www.airflow.co.uk/glossary.htm
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http://www.uswcl.ars.ag.gov/exper/led.htm
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http://www.measureanything.com/products/94545-2778/datasheet_anemometer_94545-2778-7911.asp
http://www.instruments.co.za/catalog/anemometer.htm

Appendix D

Questionnaires and Responses

Camp REACH Evaluation
March 25, 2001

Name:

PART I – Your Specific Perceptions
Please circle the number that indicates your feelings towards each statement.
1 – Strongly Disagree   2 – Disagree   3 – Agree   4 – Strongly Agree

1. The experimentation process was well organized.	1 2 3 4
2. The instructions were clear and informative.	1 2 3 4
3. The experiment was within my abilities.	1 2 3 4
4. The experiment stimulated my interest in engineering.	1 2 3 4
5. I learned a lot from the experiment.	1 2 3 4
6. The experiment was interesting.	1 2 3 4
7. The experiment introduced me to new things.	1 2 3 4
8. The experiment was fun.	1 2 3 4
9. The experiment was pointless and boring.	1 2 3 4
10. The experiment was a good group project.	1 2 3 4
11. I worked well in my group.	1 2 3 4
12. I enjoyed working in my group.	1 2 3 4
13. My group members had equal participation.	1 2 3 4
14. I felt confused during the experiment.	1 2 3 4
15. I would like to participate in this experiment again.	1 2 3 4
16. I would like to learn more about this subject.	1 2 3 4
17. This experiment helped me see the importance of engineering.	1 2 3 4
18. The experiment was good hands-on experience.	1 2 3 4

Camp REACH Evaluation

March 25, 2001

Name:

PART I – Your Specific Perceptions

Please circle the number that indicates your feelings towards each statement.

1 – Strongly Disagree   2 – Disagree   3 – Agree   4 – Strongly Agree

1. The experimentation process was well organized. 1 2 3 4
2. The instructions were clear and informative. 1 2 3 4
3. The experiment was within my abilities. 1 2 3 4
4. The experiment stimulated my interest in engineering. 1 2 3 4
5. I learned a lot from the experiment. 1 2 3 4
6. The experiment was interesting. 1 2 3 4
7. The experiment introduced me to new things. 1 2 3 4
8. The experiment was fun. 1 2 3 4
9. The experiment was pointless and boring. 1 2 3 4
10. The experiment was a good group project. 1 2 3 4
11. I worked well in my group. 1 2 3 4
12. I enjoyed working in my group. 1 2 3 4
13. My group members had equal participation. 1 2 3 4
14. I felt confused during the experiment. 1 2 3 4
15. I would like to participate in this experiment again. 1 2 3 4
16. I would like to learn more about this subject. 1 2 3 4
17. This experiment helped me see the importance of engineering. 1 2 3 4
18. The experiment was good hands-on experience. 1 2 3 4

Camp REACH Evaluation

March 25, 2001

Name: Carrie Croucher

PART I – Your Specific Perceptions

Please circle the number that indicates your feelings towards each statement.
1 – Strongly Disagree 2 – Disagree 3 – Agree 4 – Strongly Agree

1. The experimentation process was well organized.	1	2	3	**(4)**
2. The instructions were clear and informative.	1	2	**(3)**	4
3. The experiment was within my abilities.	1	2	3	**(4)**
4. The experiment stimulated my interest in engineering.	1	2	3	**(4)**
5. I learned a lot from the experiment.	1	2	3	**(4)**
6. The experiment was interesting.	1	2	3	**(4)**
7. The experiment introduced me to new things.	1	2	3	**(4)**
8. The experiment was fun.	1	2	3	**(4)**
9. The experiment was pointless and boring.	**(1)**	2	3	4
10. The experiment was a good group project.	1	2	**(3)**	4
11. I worked well in my group.	1	2	3	**(4)**
12. I enjoyed working in my group.	1	2	3	**(4)**
13. My group members had equal participation.	1	2	3	**(4)**
14. I felt confused during the experiment.	1	**(2)**	3	4
15. I would like to participate in this experiment again.	1	2	**(3)**	4
16. I would like to learn more about this subject.	1	2	**(3)**	4
17. This experiment helped me see the importance of engineering.	1	2	**(3)**	4
18. The experiment was good hands-on experience.	1	2	3	**(4)**

Camp REACH Evaluation

March 25, 2001

Name: Nicolette Schlichting

PART I – Your Specific Perceptions

Please circle the number that indicates your feelings towards each statement.
1 – Strongly Disagree 2 – Disagree 3 – Agree 4 – Strongly Agree

1. The experimentation process was well organized.	1 2 3 (4)
2. The instructions were clear and informative.	1 2 (3) 4
3. The experiment was within my abilities.	1 2 3 (4)
4. The experiment stimulated my interest in engineering.	1 2 3 (4)
5. I learned a lot from the experiment.	1 2 3 (4)
6. The experiment was interesting.	1 2 3 (4)
7. The experiment introduced me to new things.	1 2 3 (4)
8. The experiment was fun.	1 2 3 (4)
9. The experiment was pointless and boring.	(1) 2 3 4
10. The experiment was a good group project.	1 2 (3) 4
11. I worked well in my group.	1 2 3 (4)
12. I enjoyed working in my group.	1 2 3 (4)
13. My group members had equal participation.	1 2 3 (4)
14. I felt confused during the experiment.	1 (2) 3 4
15. I would like to participate in this experiment again.	1 2 (3) 4
16. I would like to learn more about this subject.	1 2 3 (4)
17. This experiment helped me see the importance of engineering.	1 2 (3) 4
18. The experiment was good hands-on experience.	1 2 3 (4)

Camp REACH Evaluation

March 25, 2001

Name:

PART I – Your Specific Perceptions

Please circle the number that indicates your feelings towards each statement.

1 – Strongly Disagree 2 – Disagree 3 – Agree 4 – Strongly Agree

1. The experimentation process was well organized.	1 **(2)** 3 4
2. The instructions were clear and informative.	1 2 **(3)** 4
3. The experiment was within my abilities.	1 2 **(3)** 4
4. The experiment stimulated my interest in engineering.	1 2 **(3)** 4
5. I learned a lot from the experiment.	1 2 **(3)** 4
6. The experiment was interesting.	1 2 **(3)** 4
7. The experiment introduced me to new things.	1 2 3 **(4)**
8. The experiment was fun.	1 2 **(3)** 4
9. The experiment was pointless and boring.	1 **(2)** 3 4
10. The experiment was a good group project.	1 2 **(3)** 4
11. I worked well in my group.	1 2 3 **(4)**
12. I enjoyed working in my group.	1 2 **(3)** 4
13. My group members had equal participation.	1 2 **(3)** 4
14. I felt confused during the experiment.	1 2 3 **(4)**
15. I would like to participate in this experiment again.	1 2 **(3)** 4
16. I would like to learn more about this subject.	1 2 **(3)** 4
17. This experiment helped me see the importance of engineering.	1 2 **(3)** 4
18. The experiment was good hands-on experience.	1 2 3 **(4)**

Camp REACH Evaluation

March 25, 2001

Name: Aimee Hart

PART I – Your Specific Perceptions

Please circle the number that indicates your feelings towards each statement.

1 – Strongly Disagree   2 – Disagree   3 – Agree   4 – Strongly Agree

1. The experimentation process was well organized.	1 (2) 3 4
2. The instructions were clear and informative.	1 (2) 3 4
3. The experiment was within my abilities.	1 (2) 3 4
4. The experiment stimulated my interest in engineering.	(1) 2 3 4
5. I learned a lot from the experiment.	1 2 (3) 4
6. The experiment was interesting.	1 (2) 3 4
7. The experiment introduced me to new things.	1 2 (3) 4
8. The experiment was fun.	1 2 (3) 4
9. The experiment was pointless and boring.	1 (2) 3 4
10. The experiment was a good group project.	1 (2) 3 4
11. I worked well in my group.	1 2 (3) 4
12. I enjoyed working in my group.	1 2 (3) 4
13. My group members had equal participation.	1 2 (3) 4
14. I felt confused during the experiment.	1 2 3 (4)
15. I would like to participate in this experiment again.	1 (2) 3 4
16. I would like to learn more about this subject.	1 2 (3) 4
17. This experiment helped me see the importance of engineering.	(1) 2 3 4
18. The experiment was good hands-on experience.	(1) 2 3 4

PART II – Written Comments
Please answer following questions.

1. What did you particularly like about this experiment?

   I got to solder things together

2. What did you particularly dislike about this experiment?

   ~~[illegible]~~ I didn't understand the directions.

3. Can you suggest anything to improve the experiment?

   put more lights ~~[illegible]~~

4. What were the pros and cons for working your group?

5. Other Comments?

PART II – Written Comments
Please answer following questions.

1. What did you particularly like about this experiment?

2. What did you particularly dislike about this experiment?

The diagram was not very clear.

3. Can you suggest anything to improve the experiment?

Make the diagram clearer.

4. What were the pros and cons for working your group?

It was kind of fun
didn't understand.

5. Other Comments?

PART II – Written Comments
Please answer following questions.

1. What did you particularly like about this experiment?

I really enjoyed making the little panelboard because I have never done anything like that before. That activity got me more interested in wiring things

2. What did you particularly dislike about this experiment?

The directions were kind of confusing at first but once they were explained, everything was clear.

3. Can you suggest anything to improve the experiment?

Just make the directions a little bit clearer.

4. What were the pros and cons for working your group?

There were none. I think that we both did an equal amount of work, except for the soldering because my partner didn't want to.

5. Other Comments?

I really enjoyed this program. I especially liked building the light tester. I have never had any interest in that type of thing, but after doing that activity, I would like to explore that field some more!

PART II – Written Comments
Please answer following questions.

1. What did you particularly like about this experiment?

I enjoyed making the panelboard and maki[illegible] it work because it was something I never rea[illegible] have done.

2. What did you particularly dislike about this experiment?

I didn't like this because I was kind of confu[illegible] at first, but once we started and every thing was explained better I understood it.

3. Can you suggest anything to improve the experiment?

Make the directions a little clear.

4. What were the pros and cons for working your group?

I don't really think that there were any. All the work was distributed equally (except for the ~~[illegible]~~ soldering).

5. Other Comments?

It was fun! i really enjoyed this experim[illegible] I learned alot about panelboards and how they can be confusing.

PART II – Written Comments
Please answer following questions.

1. What did you particularly like about this experiment?

2. What did you particularly dislike about this experiment?

3. Can you suggest anything to improve the experiment?

4. What were the pros and cons for working your group?

5. Other Comments?

PART II – Written Comments
Please answer following questions.

1. What did you particularly like about this experiment?
   I liked testing it when we were done and putting it together.

2. What did you particularly dislike about this experiment?
   nothing.

3. Can you suggest anything to improve the experiment?
   written directions as well as the diagram because the diagram alone was sort of confusing.

4. What were the pros and cons for working your group?
   pros- our group was small so we both got to participate,

   cons-

5. Other Comments?
   The experiment was fun to do. :)

End Question

What do you fell you leaned?

now to build an anemometer out of everyday objects

What, if any, question do you still have?

Why is it useful?

What did you like and dislike? What would you suggest for us to change or expand on?

I liked the clay.

There should be longer or different pins next time because we as, well as the other groups, had problems with it.

End Question

What do you fell you leaned?

What, if any, question do you still have?

What did you like and dislike? What would you suggest for us to change or expand on?

End Question

What do you feel you leaned?

How to measure wind.

What, if any, question do you still have?

Ø

What did you like and dislike? What would you suggest for us to change or expand on?

I liked everything. It was fine. maybe get something a little more stable than clay.

End Question

What do you fell you leaned?

how to count very fast &
measure wind

What, if any, question do you still have?

What did you like and dislike? What would you suggest for us to change or expand on?

There was nothing about this project that I didnt like. it was very fun and interesting

End Question

What do you fell you leaned?

I learned what an anemometer is, how it works, and how to build one. I learned how I would make rough calculations to figure out wind speed.

What, if any, question do you still have?

I don't have any questions

What did you like and dislike? What would you suggest for us to change or expand on?

I had fun building the anemometer and testing it. I would suggest that you should get a fan with more speeds so that more data could be taken. I also think that longer thumbtacks would be helpful in keeping the cardboard attached to the eraser. Other than that, It was very fun!!

End Question

What do you fell you leaned?

I have learned what an anemometer is and how it works.

What, if any, question do you still have?

I don't really have any questions.

What did you like and dislike? What would you suggest for us to change or expand on?

I didnot like the fact that our anemometer would not work on the high speed, but we figured everything out. I had fun building the anemometer, but I would suggest to get some longer (th) thumbtacks because our anemometer (~~keep~~) kept falling apart because the thumbtack(s) was not long enough

Pre workshop questions

1) What do you know about energy?

stuff

that there are different kinds like mechanical, potential, kinetic, solar, etc.

2) do you know what kinetic energy is?

energy of the motion of an object

3) Do you know what an anemometer does? (see picture if you are not sure what exactly an anemometer does.) measures speed of wind

4) Do you know wind how wind energy works? If so explain? If not please tell use any knowledge that you do have about wind energy.

wind can be used to turn devices to make electricity to power machines

Pre workshop questions

1) What do you know about energy?

2) do you know what kinetic energy is?

3) Do you know what an anemometer does? (see picture if you are not sure what exactly an anemometer does.)

4) Do you know wind how wind energy works? If so explain? If not please tell use any knowledge that you do have about wind energy.

Pre workshop questions

1) What do you know about energy?

It is used to power all kinds of things. Without it there would be no life.

2) do you know what kinetic energy is?

Not sure. Energy used in electricity?

3) Do you know what an anemometer does? (see picture if you are not sure what exactly an anemometer does.)

Measure wind speed.

4) Do you know wind how wind energy works? If so explain? If not please tell use any knowledge that you do have about wind energy.

Not really.

Pre workshop questions

1) What do you know about energy?

That you can never make or destroy it.

2) do you know what kinetic energy is?

yes

3) Do you know what an anemometer does? (see picture if you are not sure what exactly an anemometer does.)

no

4) Do you know wind how wind energy works? If so explain? If not please tell use any knowledge that you do have about wind energy. no

Pre workshop questions

1) What do you know about energy?

The ability of an object to do work

2) do you know what kinetic energy is?

The energy of an object that is in motion.

3) Do you know what an anemometer does? (see picture if you are not sure what exactly an anemometer does.)

No idea

4) Do you know wind how wind energy works? If so explain? If not please tell use any knowledge that you do have about wind energy.

I think that windmills can measure wind energy. That's about all I know.

Pre workshop questions

1) What do you know about energy?

The ability of an object to do work.

2) do you know what kinetic energy is?

The energy of an object due to its mass & motion

3) Do you know what an anemometer does? (see picture if you are not sure what exactly an anemometer does.)

I don't know.

4) Do you know wind how wind energy works? If so explain? If not please tell use any knowledge that you do have about wind energy.

All I know is that windmills use wind energy to work

Appendix E

Flier Advertising Workshop

Former Camp REACH Campers:

Want to explore some more areas of engineering? You're invited to a one-day workshop to explore the relationship between the environment, energy, and engineering. We'll be completing two projects, building an anemometer, which tests wind speed, and a radiometer, which senses various colors found in light. Aside from building and testing these devices, we'll be discussing how these things may be used in real world situations. Snacks will be served during a break halfway through the workshop.

Workshop details:
Date: ________________
From: ________________ until ________________
In ________________ at Worcester Polytechnic Institute.
Call ________________ for more details at ________________.

If you're interested in joining us, please RSVP by ________________, by completing the form below, or by calling ________________ at ________________.

If attending, please remember to have your parents fill out the parent permission slip and to bring it with you on the day of the workshop.

The workshop will cost ________________, which will be collected at the start of the workshop. Fill out the form below, or call the number above to attend the workshop.

Your Name: ________________________________

Your Home Phone #: ____________________________

Your Address: ______________________________

____

Your Email Address: ___________________________

Send this form to:

____

____

____

My child/ward, ________________________ **DOES** have my permission to participate in the workshop taking place on _________________ at WPI. The workshop testing will involve building and testing anemometers (test wind speed) and radiometers (senses colors within light).

I give my permission for photographs to be taken during the activities of the workshop testing. These photographs will remain the property of WPI and may be used in publications and marketing campaigns.

I authorize the workshop testing leaders to secure medical care at a local medical facility for my daughter while she attends the day's activities.

If someone needs to be reached **DURING THE HOURS OF THE WORKSHOP TESTING TODAY --** please call:

(Name): __________________________________ (Telephone): ____________________

____ Date: ____________
(Signature of parent or person having custody or control)

Appendix F

Correspondence With SWE Regarding Volunteers

---------- Forwarded message ----------
Date: Thu, 12 Apr 2001 08:04:47 -0400
From: WPI SWE <swe@WPI.EDU>
To: Jodi Anne Campo <jcamp16@WPI.EDU>
Subject: Re: Question

Jodi,
I checked with the other officers and its seems to us that we'd be able to help. We actually put on a Girl Scout day to help the girls get their engineering badges, so we can do this type of stuff. Just give us about a month or more notice to get volunteers please.

Thanks,
Jen :-)

----- Original Message -----
From: "Jodi Anne Campo" <jcamp16@WPI.EDU>
To: "Society of Women Engineers" <swe@WPI.EDU>
Sent: Tuesday, April 10, 2001 7:08 PM
Subject: Question

Dear SWE members,

My IQP group is creation a workshop for the camp REACH program help here at WPI. This program is a summer camp for 11 and 12 year old girls that are interested in science and engineering. It is a 2-week even that is held over the summer. The problem with this program is that there is very little follow up afterwards. The workshop that we are creating is intended for 13 and 14 year old girls. It is a one day event that would be held some time prior to there freshmen year in high school.

I am righting to inquire about possible volunteers for this event.
We do not need actual people we are just inquiring to see in SWE would perhaps in the future be interested in participating in this event.

Volunteering would involve help the girls out with there projects and perhaps one volunteer would run the events of the day workshop.

This information is needed for out report so if you could get back to me as soon as possible it would be greatly appreciated.

Thanks for your time and input
Jodi Campo

Appendix G

Updated Worksheets for Students and Workshop Instructor

Workshop introduction

During the next few hours you will be constructing and testing two very different devices. An anemometer, which is a wind speed indicator and a radiometer, which measures the amount of energy, reflected from the earth in certain portions of the electromagnetic spectrum.

How are these two devices related?

Both the radiometer and the anemometer can be viewed in respect to the environment, and categorized under the subject areas of earth science, and physics.

Where do these devices relate to the environment?

The radiometer is used in satellites to monitor the condition of the earth's surface over large areas in a short time period. Satellite images are used to determine changes in global vegetation patterns, monitor the health of agricultural crops, and measure the amount of evaporation from the earth's surface.

The anemometer is used in weather prediction and in calculating wind patterns. These devices help in making decisions on where to place wind turbines so that wind energy can be converted to electricity. Wind energy is efficient in creating electricity while being environmentally friendly.

Lets get started

First we will construct and test the anemometer then the radiometer. Remember have FUN!

Anemometer Workshop

Pre workshop questions

1) What do you know about energy?

2) Do you know any of the different forms of energy? If so, state any that you know and give a brief description.

3) Do you know what an anemometer is and what it does? If yes explain.

4) Do you know how wind energy works? If so explain? If not please tell us any knowledge that you do have about wind energy.

What exactly is energy?

Energy is defined by the amount of work a physical system is capable of performing. Energy can neither be created, consumed nor destroyed, but it can be converted to different forms of energy.

For example the kinetic energy of moving air molecules may be converted to rotational energy by the rotor of a wind turbine, which in turn may be converted to electrical energy by the wind turbine generator. During each conversion some part of the source energy is converted in to heat energy.

Some Definitions:
Kinetic energy – energy possessed by an object, resulting from the motion of that object.
Rotational energy – The work that a rotating body does.
Electrical energy – The ability of an electrical source to carry out useful work, this energy can be used to drive an electrical motor and carry out some mechanical work. The electrical energy is usually expressed in units of watt-hour
Heat energy – a form of energy that is transferred by a change in temperature

So what is the difference between energy and power?

To decipher the difference between energy and power we look to the units that each are measured in. Energy has the units of kilowatt hours (a *kilowatt is equal to 1000 watts*), where as power units are kilowatts. Knowing this we can conclude that power is the amount of energy transferred per unit of time. Power may be measured at any point in time whereas energy has to be measured during a period of time.

You might be familiar with the term "horsepower," which is used when referring to automobile engines. If we think about power and energy in terms of a car engine, **power** defines how much "muscle" a generator or motor has, whereas **energy** tells you how much "work" a generator or motor performs during a certain period of time.

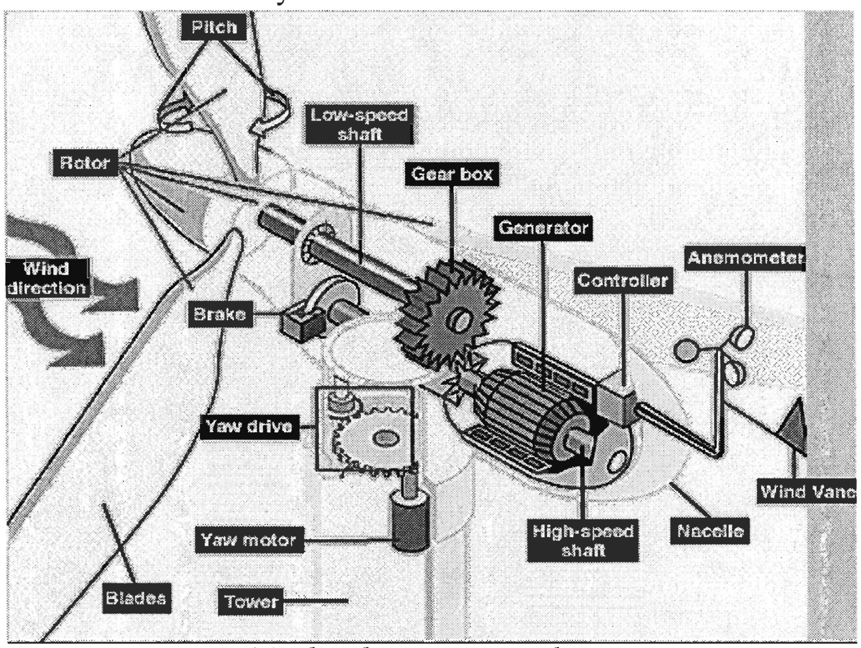
1kw (or 1000 watts) = 1.359 HP

Where does wind energy come from?

Ultimately it comes from the sun. The sun radiates 100,000,000,000,000-kilowatt hours of energy to the earth per hour. In other words, the earth receives 10 ^18th watts of power. About 1 to 2 percent of the energy coming from the sun is converted into wind energy.

How is wind energy converted in to electricity?

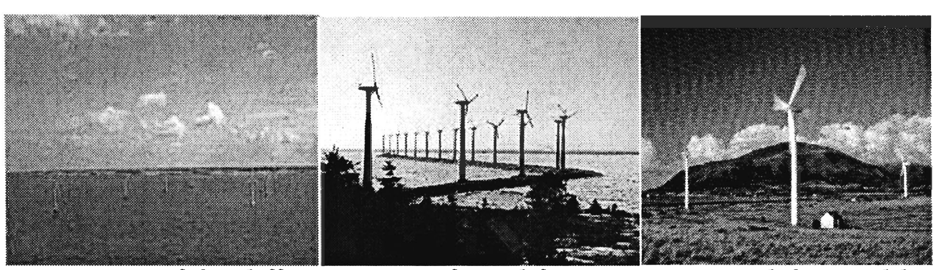
One of the devices used to convert wind energy to electricity is the wind turbine. The blades if the turbine spins with the wind, similar to a large toy pinwheel. The blades are attached to a hub that is mounted on a turning shaft. The shaft goes through a gear transmission box where the turning speed is increased. The transmission is attached to a high-speed shaft, which turns a generator that makes electricity. The diagram below may make these processes a bit clearer. But simply the tuning blade turns the inner workings of the generator and creates electricity.



Wind turbine inner workings

Winds must be at speeds about 12 or 14 miles per hour for the turbines to turn fast enough to generate electricity. A signal turbine will produce about 50 to 300 kilowatts of electricity. So at most, the electricity of one turbine can light 3,000 100watt light bulbs.

Turbines are grouped together in what are called wind "farms." These wind farms are located mostly in the three windiest areas of the state. The three wind farms in California make enough electricity to supply an entire city the size of San Francisco with power.

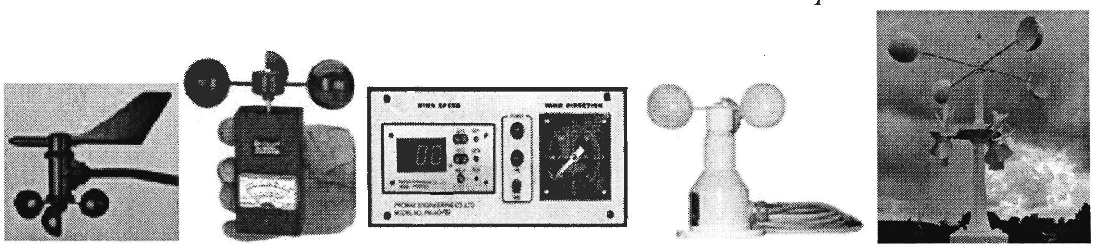


Above are some of the different types of wind farms seen around the world

What is an anemometer and how is it used?

An Anemometer is a weather instrument that measures the speed of wind. This instrument is useful because it rotates at the same speed as the wind and quite helpful in accurately determining wind speeds because it gives a direct measure of the speed of the wind.

There are many varieties of anemometers that have been developed since the fifteenth century. The one that we will be building is the rotational anemometer. It is a freely rotating device that has cups or vanes to capture the wind and rotate allowing it to rotate about a horizontal or vertical axis. *Below are some examples:*



An anemometer measures wind speed by counting the number of full rotations during a period of time. They are most useful in weather predictions and wind speed patterns.

<u>Making you anemometer</u>

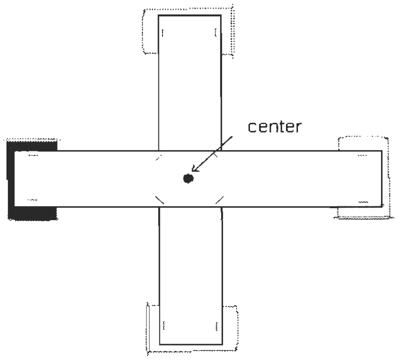
Materials

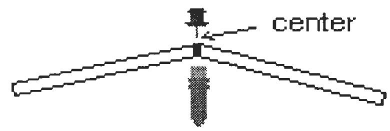
4 Paper cups
2 Evenly cut strips of cardboard
1 Long pin thumbtack
1 Pencil
Scissors
Stapler
Ruler
Firm Clay

Step one: Take the four cups in your anemometer building kit and cut the rolled edges off to make them lighter. The lightness ensures less resistance and higher accuracy. After all edges are cut take one cup and color the outside with a marker enough so that you can tell it apart from the other cups.

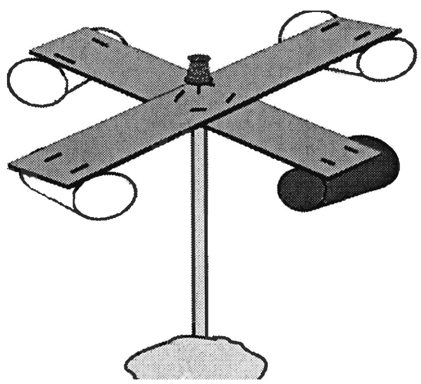
Step two: Cross the two cardboard strips so that they make a plus sign (+) and staple them together. With a ruler and pencil find the exact center of the crossed boards. (Must have the center or your anemometer will be off balance)

Step three: Staple the cups to the ends of the cardboard strips making sure they are all facing the same direction. Next take a pushpin and put it through the center that you previously found then attach the crossed cardboard and cups to the eraser of your pencil.





Step four: Use the clay as a base so that the device can stand on it's own, then test to see if the cardboard strips spin by blowing into the cups. (Loosen the push pin if no spinning occurs.)



Now we're ready to test it out!

Using the fan provided, place your anemometer in front of the fan. Turn the fan to the medium setting and count the number of times the colored cup comes around in 1 minute. (Use a stopwatch to keep track of time and make sure before starting the fan, the colored cup is directly in from of the person counting the rotations.) This measurement will give you the rotations per minute at that fan setting.

We know from using the pressure probe that the speed of the fan at medium setting is ---- miles per hour. Therefore:

_____ revolutions/minute = ------- miles/hour

Now turn the fan to its low setting and measure the number of revolutions per minute. Repeat this for the high fan setting as well
_____ revolutions/minute (low setting)
_____ revolutions/minute (high setting)

Now find the miles per hour speed using the ratio we found above.

Example:

$$\frac{\text{Know miles/hour}}{\text{Know rev/minute}} = \frac{\mathbf{X}}{\text{new rev/minute}}$$

Solve for **X**

Now we want to find the accuracy of our anemometer. To do this we will use the error equation to find **error**.

Error equation:

$$\frac{\text{Actual} - \text{Measured}}{\text{Actual}} = \text{error}$$

Knowing the %error and ratio of your anemometer you can calculate the speed of any wind with in a certain range of accuracy.

Approximate wind speed:

X ± **error** miles per hour

Now that we have all the variables needed we will take our anemometer out side and calculate the wind speed today.

Today's wind speed:

_____ revolutions/minute

So what did you calculate the wind speed to be outside today? Make sure to specify the error range of your measuring device.

What are some uses of wind energy?

Boats use wind energy to push them through the water by lifting a sail. Farmers have been using wind energy for many years to pump water from wells using windmills like the one pictured here. Wind is also used to turn large grinding stones to grind wheat or corn, just like a water wheel is turned by waterpower.

Aside from aiding humans in the things above wind energy is efficient in creating electricity. Wind energy is a free, renewable resource, so no matter how much is used today, there will still be the same supply in the future. Wind energy is also a source of clean, non-polluting, electricity. Unlike conventional power plants, wind plants emit no air pollutants. California's wind power plants make up for the emission of more than 2.5

billion pounds of carbon dioxide, and 15 million pounds of other pollutants that would have otherwise been produced.

End Question

What do you feel you learned?

What, if any, questions do you still have?

What did you like and dislike? What would you suggest for us to change or expand on?

Build a Simple Radiometer

Introduction

In order to collect important data about the earth NASA uses satellites equipped with highly sensitive instruments called **radiometers**. A radiometer measures the amounts of different types of light energy that are given off by the earth and its atmosphere. One way scientists and engineers can collect important data is by looking at what colors of light are present in a certain area. The color of light can tell them if plant life is healthy, how much water vapor is present in the air or even the temperature of the earth. By analyzing color information the computers in contact with these satellites can "see" what's going with our environment and help researchers collect important data.

Purpose

The objective of this experiment is to build your own simple radiometer that measures amounts of red and green light. The radiometer will be built using red and green LEDs (light emitting diodes) which will be used in reverse to create voltage rather than to create light. The voltage created by the LEDs will be measured using a volt meter to show how much red and green light is present at a test point.

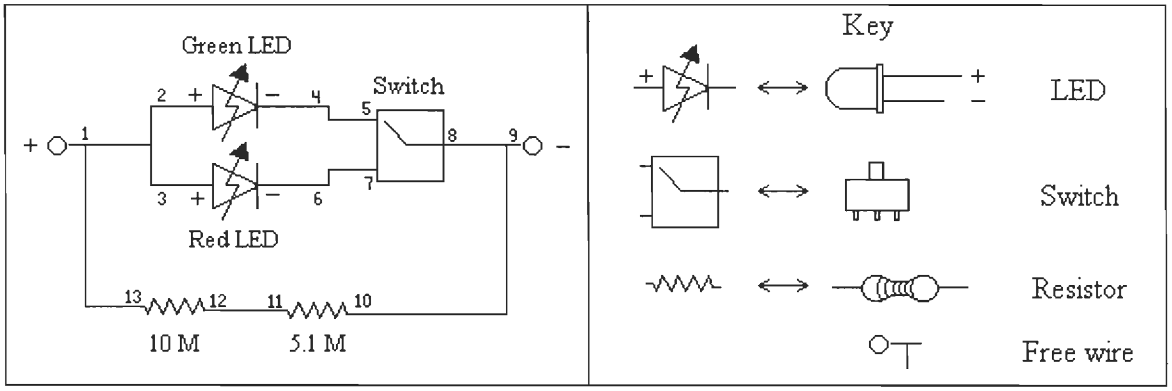
Procedure

First, identify that you have all the parts necessary to build your radiometer. You should have:

1 - prototyping board (fiberglass board with holes and copper pads on it)
5 - short pieces of connection wire (ask for more if you need them)
1 - red LED
1 - green LED
1 - two position, 3 contact switch
1 - small coil of solder
1 - 5.1 Mohm resistor (stripe pattern: gold, green, brown, green. Some also have a yellow stripe at the beginning)
1 - 10 Mohm resistor (stripe pattern: gold, blue, black, brown)

A circuit diagram of the radiometer is shown on the following page and should be useful in determining how to connect the components of your device:

Circuit Diagram



Place your components on your prototype board so that it will be easy to connect the appropriate pieces together with the connection wire. Therefore, components that are connected on the circuit diagram above should be close to each other on your board.

Component connections

Connect the following groups together as designated by number on the circuit diagram above.

1,2,3,13	(+ green LED lead, + red LED lead, + free wire, one end of 10 Mohm resistor)
4,5	(- green LED lead, one end tab of switch)
6,7	(- red LED lead, opposite end tab of switch)
8,9,10	(center tab of switch, - free wire, one end of 5.1 Mohm resistor)
11,12	(connect free ends of each resistor together)

Some things to remember:

The "free wires" shown in the circuit diagram are where readings will be taken by connecting them to a volt meter.

Place your components on the side of the prototype board that <u>does not</u> have the copper pads on it. Push them through the board so that the metal ends stick up through the copper pads on the board. This is important since you will be soldering the components from the back of the circuit.

If you place two components next to each other on the prototype board you do not need a wire between them. They can be connected with a neat blob of solder.

Some more things to remember:

The short lead wire on the LEDs is the negative side. It is important to connect your LEDs correctly or else you will get negative readings from your radiometer.

The switch must be connected so that the center terminal is connected to the resistors and the negative lead from an LED is connected to one of the outer terminals. It doesn't matter which LED goes on which outer terminal.

Be sure to show your circuit to one of the instructors before you begin to solder the components! Components are hard to remove once they have been soldered on!

After your radiometer circuit has been checked by an instructor you may begin to solder the components together at one of the soldering stations. If you need any help doing this please ask an instructor.

Once your radiometer is assembled...

Your radiometer is actually working already, but you can't see any results yet! The radiometer must be attached to the volt meter at your workstation so you can start measuring light. Instructions will be given on how to do this. The switch on your radiometer determines which color light you are measuring, red or green. The number you see on the volt meter is not any specific type of measurement, but you will be able to see the difference between how much red and green light exists at your test area.

A testing site will be available for you to see how your radiometer can be used to "look" at different kinds of land area so you can begin to understand how scientists and engineers use these instruments to look at the earth. At the testing area hold a terrain sample up to the lamp and place your radiometer on the other side. You should be able to distinguish the different colors of terrain by the numbers you see that indicate amounts of red and green light.

How it works

Ordinarily an LED works similarly to an ordinary light bulb. When a voltage is applied across the leads it creates light. Unlike a light bulb, however, an LED also works in reverse. Light gathered by the "bulb" is transformed into energy. This energy shows as a voltage between the leads. LED's also are also color specific meaning that certain types only produce or create voltage from certain colors of light. For example, the red LED in used in this workshop will only emit red light and will only create voltage relative to how much red light it receives. The more light is captured by the LED, the larger the voltage is across its leads. In this way measuring the voltage from an LED can tell us how much of a certain color light is present in an area.

Wrap-up

Today we learned about and constructed models of two devices used in environmental testing and observations. We learned principals of physics and earth science, along with to basic concepts of electrical engineering and electromagnets.

Using everyday objects we constructed an operational anemometer. With lab testing and the use of a pressure probe (pressure anemometer) we calculated the ratio and percent error for our device. These values showed the accuracy of our anemometer, and when it came time to test the wind speed of the day we were able to give a range in which we felt the wind blew today.

Through the testing of wind speed we discussed some of the things that an anemometer is used for, such at weather prediction and wind pattern analysis. We also learned that anemometers help in proper placement of wind farms that use the renewable wind energy to create environmentally safe electricity (i.e. no pollution is created).

We also explored aspects of electrical engineering, learning about LED's, resistors, switches, circuit diagrams, and soldering. We used these materials and techniques to assemble a LED Radiometer, a device that is able to detect different color light and different kinds of vegetation using principle of the electromagnetic spectrum. We learned LED's would create a voltage when exposed to different kinds of light. This voltage is compared to the values of the electromagnetic spectrum to determine the light being detected. Radiometers aid scientist and engineers in many ways; to review, global vegetation patterns, monitor the health of agricultural crops, and amount of evaporation from the earth's surface among many others.

Through the two projects we see that engineering holds a very important role in environmental issues. Without certain devices, the out knowledge of the environment and its issues would not be a great as they are today. Environmental engineers work to create devices and methods that will clean up pollution, better track weather, and find clean ways of producing energy, among many other things, making the world a safer and healthier place to live for years to come.

For the Instructor

Preparation

To start make sure all materials needed are present.

Anemometer materials

- Paper cups (need 4 for each group)
- Evenly cut strips of cardboard (need 2 for each group)
- Long pin thumbtack (one for each group)
- Pencil (one per group)
- Scissors (one per group would be helpful)
- Staplers (as many as possible, one per group would save time)
- Rulers (one per group would save time)
- Firm Clay (each group needs a wad)
- Fan (2 or more would make testing move faster)
- Pressure Probe (borrowed from the Mechanical Engineering department, contact Professor David J. Olinger <olinger@wpi.edu>)
- Clock or stopwatches
- Calculators

Pressure Probe Readings

This needs to be done prior the start of the workshop. Set up the probe and allow it to warm up for 10 to 15 minutes. Once warm set up the apparatus at the same distance from the fan that the anemometer will sit. (This range usually depends on the power of the fan… it's best to build a test anemometer to get the right length) take the reading from the probe and plug it in to the following equation.

$$V[mph] = 44.6\ (\quad h)$$

h is probe reading

Do this for all fan settings for every fan being used.

LED Radiometer materials (listed per group)

- 1 - prototyping board (fiberglass board with holes and copper pads on it)
- 5 - short pieces of connection wire (ask for more if you need them)
- 1 - red LED
- 1 - green LED
- 1 - two position, 3 contact switch
- 1 - small coil of solder
- 1 - 5.1 Mohm resistor (stripe pattern: gold, green, brown, green. Some also have a yellow stripe at the beginning)
- 1 - 10 Mohm resistor (stripe pattern: gold, blue, black, brown)

Pre-workshop Preparation

The material preparation that needs to be done is to split the dual prototyping boards into two pieces, precut wire pieces to about two inches long and measure out lengths of solder so that each group has a coil of about a foot long. It would be a very good idea to have an example circuit built and tested before the workshop date. Having an example circuit available for the girls to view helps them to build their own device correctly. Whether the circuit is built by the instructor, obtained from Professor Nicoletti (possibly left from this exploratory project) or outsourced to a willing electrical engineer, an example may prove to be a valuable resource. One advantage of personally building a circuit is that it will improve the instructor's comfort with soldering if he or she is inexperienced at it. At the very least, make sure at least one instructor is familiar with the operation of the circuit. Try out the example circuit with a volt meter and different sources of colored light (laser pointers work extremely well).

The test area should be set up beforehand and consists of a number of desk lamps, volt meters, different types of colored paper or polarizing filters, laser pointers or any other available colored light sources. The number of these test items should be determined by how many groups are estimated to be participating. At the very least, colored paper can be made by printing out fields of color on computer printer paper. One way to make this interesting is to draw simple terrain maps consisting of different areas of color that the girls can hold up to the desk lamps. The girls can "fly" their radiometers over the maps to simulate how a satellite might look at the earth.

<u>To start</u>

After all the girls have arrived, use the first 5 to 10 minutes for a short icebreaker. When you fell enough introductions have been done hand out the worksheets to the girls. There is an introduction page, discuss the contests of this page with the group so that they will get an idea of what they will be doing throughout the day.

Anemometer Lesson

Allow the group 2 to 3 minutes to answer the pre workshop questions for the anemometer project. Note that the workshop is broken up in a question answer format; this was intentional so that the material could be easily conveyed in a discussion. Start by asking the question seen in the section heading, allow a few seconds to think and see if any of the girls would like to share their knowledge. Discus any information not already brought up. Do this for all sections; be aware they do have all the information in front of them.

After all preliminary discussion is complete let the groups retrieve the materials needed. Inform them to use the steps given to them to build their anemometer. Walk around and answer any questions that arise. As the groups begin to finish construction, allow for testing to begin.

Note: Pressure Probe readings taken before will be needed during testing.

Revolutions per minute on a medium fan setting will be counted first. Pressure Probe readings for this setting should be given to the girls at this time. A ratio is calculated using these two values. Revolutions per minute on other settings are taken and predictions for fan speeds are made. After a groups' prediction calculations are complete, give them the remaining probe readings so that a percent error and be found.

Help any group that is having trouble with calculations.

If weather permits take the girls outside to test their anemometers. When they return inside discuss the last question of the handout; "What are some uses of wind energy?" Then have them answer the end questions; these will be discussed during the workshop warm-up.

Break

At this point in the workshop take a 5 to 10 minute snack break depending on how the girls are feeling.

Radiometer Lesson

Begin the lesson by asking the girls to read their handouts and get an idea about what this project involves. Explanation might be needed concerning the circuit diagram. Tell them that this type of diagram is an example of the way in which electrical engineers communicate the physical properties of a circuit. Inform them that they will be soldering the components to their prototype board and ensure them that this is not an overly difficult process.

Once they are comfortable to start assembling their circuit inform them that an instructor will verify their design before they begin the soldering process. Make sure that everything will be connected properly before the semi-permanent solder bond is applied.

In the trial workshop a technique that worked well was for the instructor to solder one component for each group while the group members looked on. This gave them a close-up example of proper soldering technique that most girls were able to pick up fairly quickly. Once a group is finished designing their circuit and it is verified for correctness, a quick soldering example should be given. Perform a single solder connection with the group watching so they can see that it is fairly easy. It is a good idea to walk around and check on the girls' progress so that any needed assistance can be given.

When a group has finished soldering their circuit together perform another quick inspection of the connections and then show them to the testing area. Depending on how many groups there are and how much time is left for the workshop you may be able to give each group a quick lesson on how the circuit reacts to different types of light.

To End

Make sure to discuss any of the end workshop questions. Once this is complete read through the content of the wrap-up pages, this is just a recap of all the things went over throughout the day. If any questions remain answer what you can.

Appendix H

Letter Sent to Campus Police

WPI
ECE Memorandum

To: John Hanlon, Campus Police

From: Denise Nicoletti, Electrical and Computer Engineering, nicolett@ece.wpi.edu, x5257

Re: Access to Atwater Kent

Date: March 21, 2001

I have three IQP students, Gillian Orlik, Jodi Campo, and Kevin Candiloro, who are working on a workshop for Camp REACH with me. We have reserved AK317 for March 25, 2001, from 12:00-4:00pm for am implementation of the workshop. This implementation will involve girls aged 12-15.

This letter is to notify your office and so that my students can be allowed to go into Atwater Kent that day, earlier than 12:00 in order to set up. Thank you very much.