Forming A Leadership Bridge Between High School And College: The Energy and STEM Leadership Program

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FORMING A LEADERSHIP BRIDGE BETWEEN HIGH SCHOOL AND COLLEGE: THE ENERGY and STEM LEADERSHIP PROGRAM

Abstract:

Engineering and Engineering Technology education is more important than it has ever been, as majority of the global challenges faced by humanity today ties to engineering and engineering technology majors. As the availability of the information and the wisdom of crowds increase, the need for preparing students to face challenges that are not only personal or local but also global increased tremendously. With the increased emphasis on engineering and engineering technology many higher education institutions developed STEM K12 programs, and organized outreach for middle and high school students. This trend also helped many high school students to complete college credits and gain college experience while they are still in high school. The most important component of these initiatives is no doubt closing the gap between high schools and higher education institutions, and making higher education institutions more approachable. This study will provide an overview of the proposed program that is currently being developed, and discuss components of the curriculum and laboratory development. It is important to note that this particular program is designed within the frame work of 7^{th}-12^{th} grade secondary science education in New York State.

Introduction:

High school students often have hesitations when it comes to decisions regarding college applications and major selection. These hesitations are usually tied to misconceptions such as college not being affordable[1] or the level of math and science skills needed to go to college. In today's competitive workforce and global economy the importance of college education is without a doubt known by many people. Especially the need for trained professionals in the fields of STEM (Science, Technology, Engineering, and Mathematics) increased within the last decade. Like many nations, United States of America is striving to create opportunities to increase the number of professionals in the fields of engineering and technology. [2] According to 2013 Spectrum Forecasters STEM Survey Report 76% of the survey takers stated that a career in STEM gives people opportunity to make a difference while only 22.2% thought that a career in STEM provides a job security. [3] In United States, the science and mathematics classes are fully integrated into the K-12 education, whereas engineering and technology "ET" is not yet a part of core STEM curricula.[4] In an effort to overcome students' hesitations regarding to college and affordability of the college, many high schools started to partner up with community colleges, colleges and universities. [5, 6] These partnerships can occur in many forms such as summer

outreach programs, day programs or students taking freshman level college courses while they are still in high school. These programs are designed to provide students introduction, encouragement, and excitement about college education and introduce them to different majors with many of the outreach programs focusing on STEM fields. As the demand for K-12 STEM outreach programs increased and success of outreach programs have been proved, the need to introduce STEM to students at a younger age became very important leading to the design and development of STEM modules for elementary school and middle school students. [7-9] While the majority of the K-12 STEM outreach programs focus on hands-on experiments and modules related to science and engineering, very few of them focus on the energy education, and its' relation to STEM. The concepts of science and engineering may not always be tangible, whereas when combined with energy-related topics, they provide a platform for students to integrate mathematics, science, engineering and energy concepts. [10, 11]

In addition science, technology and society are tightly interwoven, it is essential that the people be able to evaluate scientific evidence and make informed decisions. This is especially true for socio-scientific issues, such as energy consumption, where consumers' choices can collectively have a major impact both on themselves and their world. The importance of energy is also emphasized by the National Academy of Engineering (NAE) as a part of the 14 grand challenges for engineering in the 21st century. [12]

With the goal of providing 7th -12th grade students an outreach program that combines the concepts of STEM and Energy, a summer outreach program is currently being developed by the State University of New York, Farmingdale State College. The summer outreach program will focus on real-world challenges and energy issues and introduce different forms of energy generation through hands-on modules. Each module will focus on an energy component while emphasizing the use of engineering technology and science involved in energy generation, conversion and conservation. The outreach program's leadership component is embedded in a combination of activities such as: hands-on training, brainstorming sessions, world energy problem debate sessions and team presentation sessions.

Summer Program Description:

The STEM and Energy Leadership program is developed to be offered for the first time in the summer of 2014 at the State University of New York, Farmingdale State College. The summer program is a collaborative effort of faculty from Mechanical Engineering Technology, Electrical and Computer Engineering Technology and Architecture and Construction Management. A total of four faculty members are involved in the design, development and teaching of the STEM and Energy Leadership program. The summer program will be offered for two weeks during the second and third weeks of July 2014. An overview of the Energy and STEM Leadership program's tentative schedule is shown in Table 1 below.

Table 1: Energy and STEM Leadership Program Schedule

DATE	ACTIVITY
Monday – July 14, 2014	
Morning (9:00am-12:00pm)	Welcome Session – Overview of the Program
Afternoon (1:00pm-4:00pm)	Introduction to Energy & Engineering Technology - Ice Breaker Activity
Tuesday – July 15, 2014	
Morning (9:00am-12:00pm)	Wind Energy & Wind Turbine Project
Afternoon (1:00pm-4:00pm)	Wind Energy & Wind Turbine Project
Wednesday – July 16, 2014	
Morning (9:00am-12:00pm)	Energy Sustainability & Recyclability Module
Afternoon (1:00pm-4:00pm)	Energy Sustainability & Recyclability Module
Thursday – July 17, 2014	
Morning (9:00am-12:00pm)	Hydro Energy & Gear Pump Module
Afternoon (1:00pm-4:00pm)	Hydro Energy & Gear Pump Module
Friday – July 18, 2014	
Morning (9:00am-12:00pm)	Real World Energy Challenges Module
Afternoon (1:00pm-4:00pm)	Final Overview of Energy & Engineering Technology
Monday – July 21, 2014	
Morning (9:00am-12:00pm)	Welcome Session – Overview of the Program
Afternoon (1:00pm-4:00pm)	Introduction to Energy & Engineering Technology - Ice Breaker Activity
Tuesday – July 22, 2014	
Morning (9:00am-12:00pm)	Electrical Energy & Energy Generation Module
Afternoon (1:00pm-4:00pm)	Electrical Energy & Energy Generation Module
Wednesday – July 23, 2014	
Morning (9:00am-12:00pm)	Energy Efficiency Measurement with Robotics Module
Afternoon (1:00pm-4:00pm)	Energy Efficiency Measurement with Robotics Module
Thursday – July 24, 2014	
Morning (9:00am-12:00pm)	Solar Energy and Photovoltaic Cells
Afternoon (1:00pm-4:00pm)	Solar Energy and Photovoltaic Cells
Friday – July 25, 2014	
Morning (9:00am-12:00pm)	Real World Energy Challenges Module
Afternoon (1:00pm-4:00pm)	Final Overview of Energy & Engineering Technology

As shown in Table 1, the program meets 5 times a week, each week, during the weekdays, and each day faculty and students meet twice for 3 hour classes. By the end of the STEM and Energy Leadership program, students will complete a total of 60 hours of classes which will include theoretical and hands-on work as well as components of active learning. This program aims to increase students' familiarity with engineering, engineering majors, energy, challenges in the field of energy along with global challenges in sustainability, energy and engineering. Certain projects will require students to work in teams which will also give them the opportunity to work with other students towards a shared goal.

Summer Outreach Program Goals and Learning Outcomes:

For the 7th-12th grade summer outreach program, the overall program goal is to introduce students to the concepts of Energy and STEM through implementing hands-on modules. In order to be able to measure and understand if the program goal is achieved a pre-experience and a post-experience questionnaire will be provided to the participating students. The questionnaire aims to measure the students' understanding on a variety of concepts. The program concepts and goals can be summarized as:

- Students have an understanding of the concepts of energy and engineering
- Students have an understanding of the concepts of renewable and non-renewable energy
- Students have an understanding of the concept of energy generation and consumption
- Students have an understanding of the global energy challenges and the societal impact of these challenges
- Students have an understanding of the relationship between cost, availability, and maintainability
- Students have an understanding of the relationship between sustainability and energy efficient design
- Students gain decision-making and critical thinking skills

The pre and post experience questionnaires will be developed to measure students' understanding of these concepts. The evaluation of the results of the pre and post experience questionnaires will provide an understanding of the change in students' understanding of the concepts related to energy and STEM. When developing the pre and post experience questionnaires Pennsylvania State University Assessing Women and Men in Engineering (AWE) Program [15] Surveys will be used. "AWE program provides assessment tools for formal and informal educational outreach activities"[15]. Both the pre and post experience surveys will use a 5 point Likert scale to measure students' attitude towards Energy and Engineering technology prior to the summer program and at the end of the summer program. The assessment of these surveys will provide an in-depth analysis on how effective the program was in achieving its goals and objectives. A sample question from the pre and post experience surveys is presented below in Figure 1.

I know what renewable energy resources are, and I understand their role in the global energy challenge.

Strongly Disagree (0) Disagree (1) Neutral (2) Agree (3) Strongly Agree (4)

Figure 1: Sample Question from the Pre and Post Experience Questionnaire:

Overview of the Module Design and Development:

For the STEM and Energy Leadership summer program, a number of modules are developed by the faculty. Figure 2 provides an overview of the module design and development process.

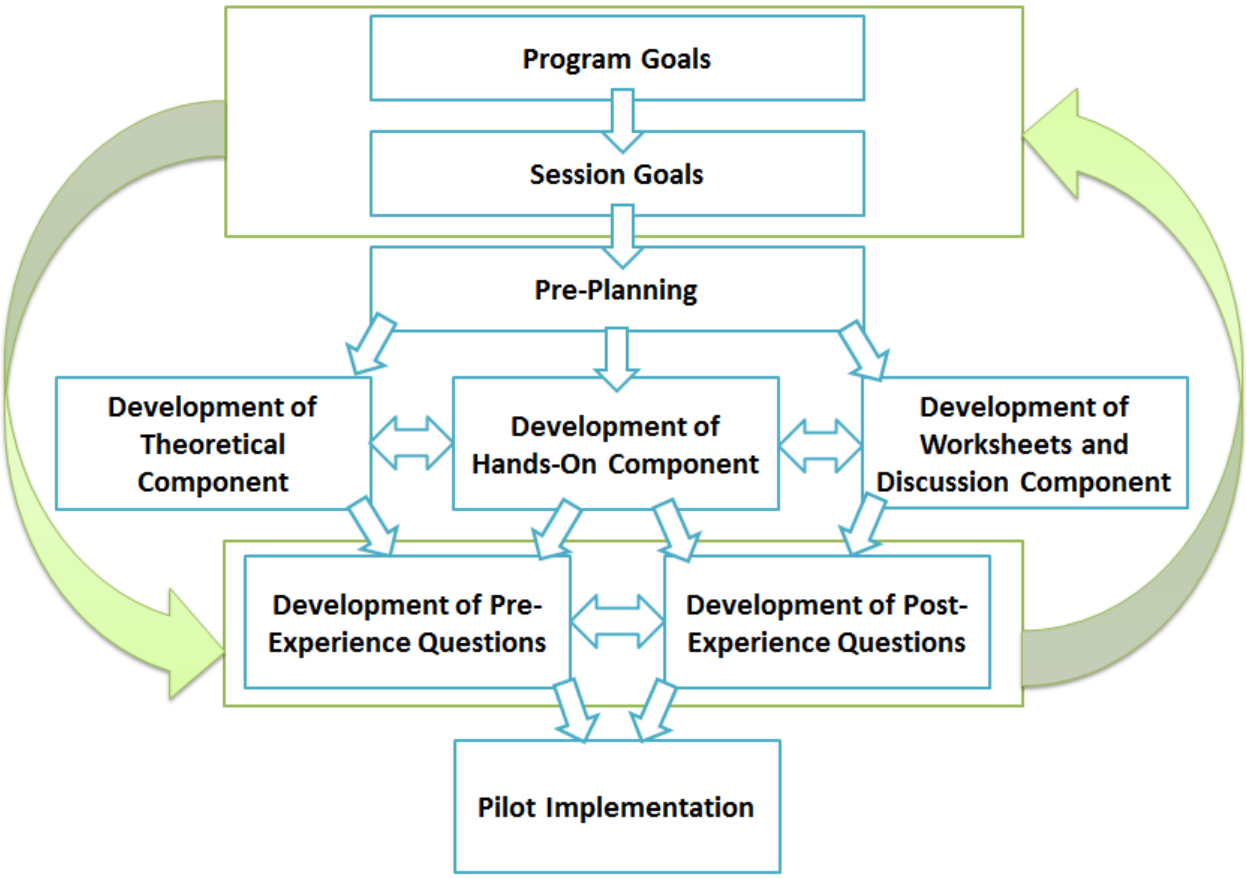

Figure 2: Overview of the Module Design and Development Process

Each module is designed so that individually they meet the program and the session goals through their theoretical, hands-on and discussion components. Each module also consists of pre-experience and post-experience questionnaires to measure students' knowledge and attitude to the subject matter prior to the module and after the module. The pre and post experiment questionnaires will help the faculty with the short term and long term goals. For the short term goals, it helps faculty to gain understanding to the students' current point of view and helps them as they convey their modules and classes. In the long term, faculty can benefit from the pre and post questionnaires results to further improve their modules and develop additional modules if needed. Even though each module is designed individually, the way the STEM and Engineering Leadership program is set so that all the modules complement one another through the concepts of energy, sustainability, engineering, science and technology. Figure 3 provides an overview of areas that the modules are created for, and how each module connects to the rest of the modules while highlighting the concepts of energy, engineering, sustainability, science and technology.

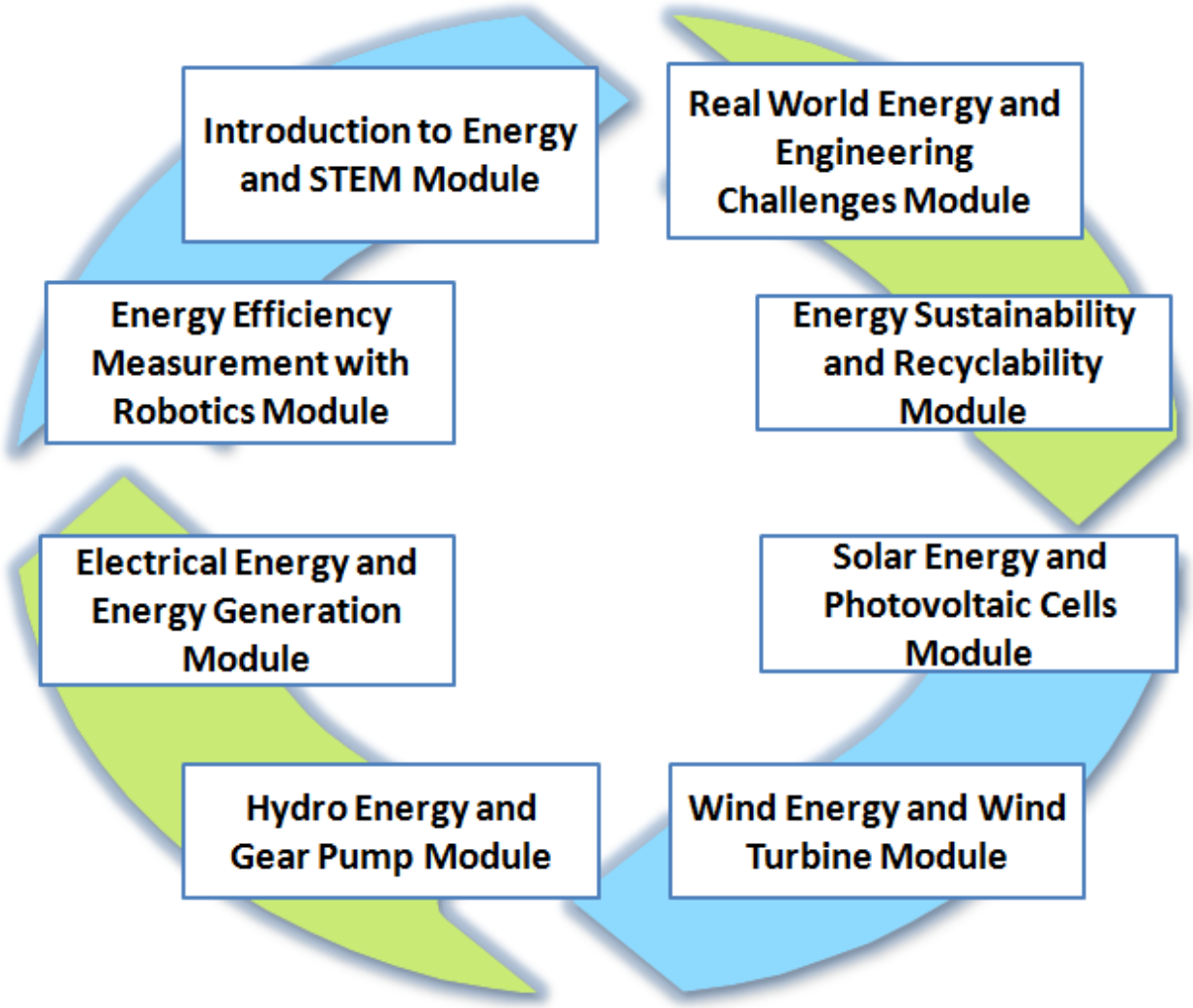

Figure 3: Overview of the Modules and Their Relation to the Program

Introduction to Energy and STEM Module: This module will be offered in the first day of the outreach summer program, and will provide students an overview of the summer program along with the in-depth review of the concepts of Energy, Engineering Technology, and their relation to one another. It will cover the type of projects and modules students will be completing through the 2-week summer program. This module will be supported by real-world examples, discussion questions and will be concluded with an ice-breaker project for students to complete in teams.[16]

Real World Energy and Engineering Challenges Module: This module will also be offered in the first day of the summer outreach program, and will give students the reasoning and understanding of why energy is important and how engineering and engineering technology work closely with energy fields when solving problems. This module will be supported by examples of current problems and challenges and will give opportunity for students to discuss

and propose solutions. This module aims to introduce students to the concepts of energy and engineering while improving their critical thinking skills.[16]

Energy Sustainability and Recyclability Module: In this module students will be introduced to the concepts of sustainability, and what it means to design and develop sustainable energy applications. Importance of sustainability will be highlighted with a hands-on recycling project that focuses on separating recycled plastic pellets. This hands-on module will teach students the effective ways to conserve energy while highlighting the importance of saving energy through the concepts of recycling. This module will also include a brainstorming session on sustainability, carbon foot print, energy conservation and engineering design.[16]

Solar Energy and Photovoltaic Cells Module: The Solar Energy Module will focus on solar as a source of renewable energy, and will encourage students to discuss the benefits, and the challenges of using solar energy. The module will be supported with hands-on experiments, where students will work in teams to set-up photovoltaic cells to generate electricity. In addition to the hands-on experiment, students will also be introduced to the Farmingdale State College's Solar Carport [13] where they will visit the Carport on the parking lot and will also be able to see the live data [14] for energy generation throughout the day.[16]

Wind Energy and Wind Turbine Module: Wind Energy and Wind Turbine Module will focus on wind as a source of renewable energy and will encourage students to discuss the benefits and the challenges related to using wind energy. Students will be introduced to the wind turbines, how wind turbines work, how to select the location of a wind turbine as well as how to decide the blade angels, how to decide the blade length on a wind turbine. Students will be using a hands-on experiment to set-up and test their wind turbines, and collect data to see their energy generation. Farmingdale State College has a small scale wind farm that can produce 7.2 kW of wind energy which feed the generated energy back to the campus grid [13]. Students will visit these wind turbines upon completion of their hands-on module.[16]

Hydro Energy and Gear Pump Module: Hydro Energy and Gear Pump Module will focus on hydro power as a source of renewable energy, and will provide students real-life examples regarding the watermills, textile mills, and how energy is collected using hydro power. Students will complete a hands-on gear pump example to learn about the energy conversion from mechanical to fluid power, and also to see how components are designed and developed in mechanical systems to form products that work on the principal of conversion of energy.[16]

Electrical Energy and Energy Generation Module: Electrical Energy and Energy Generation Module will focus on the concepts of electrical energy, how it is transformed and how the circuitry is connected on a board. Students will gain hands-on experience by completing the analog board module where they will learn how to connect electrical switches and wiring. They will gain experience with measuring certain electrical quantities such as voltage, current and resistance. They will understand how these quantities relate to power and energy calculations.

And they will also learn the concepts of electrical energy generation, conversion and consumption.[16]

Energy Efficiency Measurement with Robotics Module: Energy Efficiency Measurement with Robotics module will provide students an overview of history of robotics, how robots work and their applications in the field of energy. As a part of their hands-on example students will learn how to program a robot to move through the Energy Smart House to collect temperature samples from different rooms to understand the heat distribution throughout the rooms and will provide solutions on how to heat and cool the house more energy efficiently using the collected data.[16]

Conclusions and Future Work:

The goal of the proposed project is to demonstrate the feasibility of integrating engineering concepts in 7-12 grades science education. This workshop is focused on renewable energy technologies, addressing socio-technological issues of the current world. Students will learn about global impact of energy issues. The solutions to some of these issues will be demonstrated through implementation of hands-on projects. An expected outcome is the definition of a generalized framework that can be extended to integrate engineering in 7-12 science education as well as teach other socio-scientific topics.

The expected outcomes for the summer outreach program have two components: an expected outcome for the participating students, and an expected outcome for the program. The expected outcome for the students is for them to gain basic knowledge on energy and STEM as they understand the real-world challenges and the societal impact of energy related problems. This outcome will be measured in-class (qualitatively) and with the implementation of the pre and post experience questionnaires (quantitatively). The in-class measurement will be based on faculties' observation of the discussions and debates, whereas the pre and post experience surveys will provide quantitative results. The second component of the expected outcome – the program outcome – will be based on faculties' feedback on each module and will include the suggestions and proposals to change and improve the modules for the following summer program.

It is also expected to run into challenges when implementing a summer outreach program. Although the modules are designed to be exciting, encouraging and improving students' critical thinking skills, it is expected that faculty will tailor the modules to fit the needs of the students the best.

For the long term goals and future work of the program, it is expected to continue to hold the summer outreach program for every summer following this initial implementation. Additional modules will be developed. Also it is expected to offer more than one session per summer depending on the increase in the enrollment for the summer programs.

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