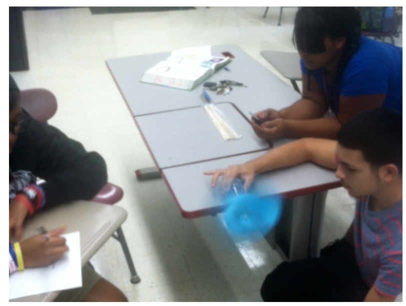
Energy For Education

Bringing reliable energy where its needed most: Schools.

Moijue Kaikai
Mechanical and Industrial Engineering Department
University of Massachusetts at Amherst
Amherst, MA
mkaikai@umass.edu

Dr. Erin D. Baker
Associate Professor, Director, Wind Energy IGERT
University of Massachusetts at Amherst
Amherst, MA
edbaker@ecs.umass.edu

Model Wind Turbine



Students Testing their Wind Turbines

***Abstract*-Many issues surround the global energy crisis, including climate change and peak oil. One crucial issue that is often overlooked is awareness about energy issues and the sustainable and renewable technologies being implemented and researched to solve them. Spreading awareness among youth is a way to engage the next generation in such topics, build their interest solving energy issues, and spread awareness across their own communities.**

Keywords—renewable; sustainable; curriculum; education; energy; awareness; lesson plans; wind

I. INTRODUCTION

Energy for Education is an initiative set forth by the student run non-profit organization World Energy Project. The goal is to educate grade school students on energy issues -- globally and within their own communities – and on sustainable practices used to resolve them. In order to achieve this, we have developed a curriculum composed of a series of lesson plans in the classroom. This curriculum was developed in the summer of 2013 by undergraduate Moijue Kaikai under the supervision of Dr. Erin Baker in the University of Massachusetts of Amherst Research Experience for Undergraduates (REU) Program. In the same summer, the curriculum was implemented in UMass Amherst's college-prep Upward Bound Summer Program, which hosted inner-city students from the High School of Commerce in Springfield, Massachusetts.

Not only does the curriculum build on students' global awareness, but it also serves to generate students' interest in attending college and studying within the STEM fields, and to improve the skill sets needed to pursue any major in college.

More specifically, the objectives of the curriculum are to improve communication through writing, discussions, and oral presentations; and to improve student skills in critical thinking and problem solving, especially engineering problem solving, and sharpen student skills in math and science. The various lessons plans are framed around a hands-on wind turbine project to achieve these objectives.

II. BACKROUND RESEARCH

Prior to developing any lesson plan, research was conducted on topics, including: Energy in Springfield, Currirculum Implementation, Mentoring Students of Color, and STEM Education.

A. Energy in Springfield

Knowing that this curriculum would be first implemented with students from Springfield, we researched how energy was generated in that area and if there were any recent renewable technology projects occurring in the city. We found that electric generation during peak periods came primarily from the West Springfield Generating Station, which is a peaking facility. Both units 1 and 2 are two natural gas and oil-fired combustion turbine generators, which can generate 48 MW each. They serve as the site's primary functioning units and operate when called upon to supply the grid with needed power [1]. Another relevant organization is Stop Toxic

Incineration in Springfield, a grassroots organization dedicated to stopping a proposed biomass incinerator in Springfield. This group, along with many other protesters, prevented the development of the Russell Biomass LLC $165 million, 50 megawatt biomass plant in Russell, of Eastern Springfield. 26 groups, societies, and councils joined together to oppose the biomass center [2]. It was concluded that lack of awareness and public acceptance were the reasons for the termination of this project. The plant did have environmental impacts but proved to emit less carbon dioxide than current generating plants. The state Department of Environmental Protection even approved an air permit for the Springfield project, saying it met all regulatory and environmental standards [3].

B. *Curriculum Implementation/Project Based Learning*

Team based projects and overall curriculum will have to draw on students' critical thinking abilities to be effective. Another important aspect is assessment, so the instructor can understand where the overall class environment is with their understanding and interest within the subject, thus allowing for changes based on that assessment where necessary. Goals of Action Research- participatory action research through means of community reflective and progressive problem solving- include the improvement of practice through continual learning and progressive problem solving, a deep understanding of practice and the development of a well specified theory of action, and an improvement in the community in which your practice is embedded through participatory research. A key question when designing research in an educational context is, If a teacher sets up community circle time to listen to students describe their learning experiences in the classroom, in what ways, if any, will the information about their learning processes help the teacher redesign the way he or she teaches [4]?

C. *Mentoring Students of Color*

There is evidence that certain classroom environments, as well as educational system barriers critically affect urban students' learning ability. On the other hand, personal connections help them develop a deeper self-awareness and understanding of the potential they possess. Smaller classrooms make such personal connections more feasible. A study examined teacher-student interactions and relationship quality among poor, urban, African-American children expressing differential school satisfaction. The results of this study suggested that the social context of the classroom influences students' appraisals of school as a likeable and satisfying environment. Successful schooling for at-risk students may also involve altering the classroom or learning environment rather than attempting to alter the student [5].

D. *STEM Education*

Articles discuss STEM (science, technology, engineering, and math) classroom practice and how engineering should be taught as a more practical and inter-disciplinary practice rather than simply as math and science textbook questions. Other factors including school type and grade levels, school resources as well as teaching practices should be investigated for empirical purposes. Therefore, researchers should design multiple studies in different school settings such as public versus private, primary school versus secondary school, and rural school versus urban school. These types of studies may help scholars to understand how school context could affect teacher classroom practice even if they have similar teaching styles [6]. This curriculum was implemented in a public, urban school setting.

III. The Curriculum

The Energy for Education Curriculum is composed of six main parts. When implemented in the Upward Bound science class the curriculum took about two weeks (nine days, one hour each day) to complete.

A. *Math/Physics Basics*

The first of the six parts was a form of assessment we called the Math/Physics Lesson Plan. The objective was to improve the students' skills in areas of math and problem solving that they will need for the upcoming wind project and in most math/physics related courses. This was achieved through example problems involving unit conversions, order of operations, and multiple step problem solving. When implemented with the nine Upward Bound students, they had great familiarity with these areas in their past physics course. We got through the seven example problems within the first day, with only a few students needing some reminders. The amount of time needed for this lesson would depend on the current skills of the students. One using this curriculum should plan for more assessment time in case some students do not understand the material.

B. *Global Awarnesss*

The next section of the curriculum was geared to making the students aware of global energy issues; including global warming, peak oil, and conflicts over oil. We used two documentary clips for this. The first film, Crude Impact, did not really engage the students Most of the students were falling asleep or just did not retain most of the information watching it. For the second documentary, An Inconvenient Truth, we prepared 40 study guide questions. The students took the assignment home after watching the 90 minute clip, and had until the end of the week to complete. Now that the students had to stay attentive to complete the guide they saw interest in the issues presented in the film. It caused for great discussion in the classroom when the assignment was due that Friday. This part of the curriculum took 2 class periods, 1 for each movie and 1 for a discussion.

C. *Renewable Energy Technology*

The remainder of the first week (Wednesday to Friday) was committed to the third part of the curriculum, Introduction to Renewable Energy Technologies. We developed PowerPoint slides to display the five renewable energy resources (sun, wind, biomass, geothermal, and hydroelectric) and the technologies and processes in which they produce electricity. This area required a cycle of assessment and development of new methods. The method that was most effective was a drawing of a simple web diagram with the five renewable

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sources starting on one side of the blackboard, electricity ending on the other. As a class, we then filled in the lines in between to describe the processes in which electricity energy is generated. As art of this, we concentrated on the fact that energy is never created nor destroyed, but transferred. That is, they were introduced to the first law of thermodynamics. For example, for a wind turbine, kinetic energy from the wind is captured by the turbines rotor blades, which turn that kinetic energy into mechanical energy. That mechanical energy then spins the shaft, which then drives the generator and produces electrical energy. This process could be compared to other forms of renewable energy as it is compared to geothermal energy in figure 1.

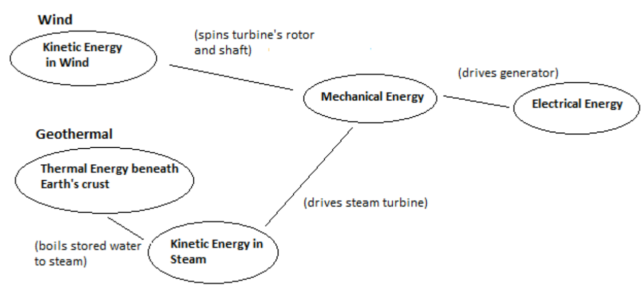

Figure 1: Wind and Geothermal Energy Generation web diagram

Once they understood how one process worked they could apply them to real world scenarios; for example solar has the most potential of all the renewable because of the abundance of sunlight and low cost of constructing, operating, and maintaining a solar panel as compared to an entire plant or turbine. Biomass and solar processes were explained on Wednesday, geothermal and hydroelectric on Thursday, and then we finished up explaining wind power on Friday.

D. Wind Project

After the first week of assessment, videos, and classroom lectures, and discussions, the students were prepared to take on the second half of the curriculum: the wind project. The fourth portion of the curriculum allowed the students to construct a rotor nacelle assembly (wind turbine without the tower). The parts were easy to come by consisting of a pencil for the shaft, a water bottle for the nacelle that holds everything together, and stiff cardstock paper cut into a pinwheel to act as the rotor blades. The kids attached metal washer weights to a string, which was then attached to the shaft. They had a fan blow on the blades and calculated the mechanical energy (work) and power their turbines produced. With three groups of three students, they were each constrained to the same blade design, number of washers, and length of string for the first test run. After a 15 minute introduction to the project and the associated equations, the three groups quickly made their turbines, tested, and calculated a power value within the hour.

E. Turbine Optimization

The fifth portion of the curriculum was for experimentation. Without much supervision, the teams had to work together to change features of their turbine to gain a higher power value after testing. The groups got really creative. They changed their blade designs to capture more wind, some changed the number of washers and length of the string carrying them, and some used additional washers and cardstock paper to stabilize the shaft and lessen friction. On this Tuesday the hour ran out but they took the projects back to the dorms and tested that night and each came in with high power values the next day.

F. Presentation

The final portion of this curriculum was the presentation. Each group had ten minutes maximum to present what they had learned within the curriculum. The groups were to act as if they were wind companies wanting to sell their product to potential investors. They were to assume that their investors did not have much knowledge on global warming or sustainable technology, so they would have to also pitch how urgent the issue is while convincing the audience why they should choose their turbines over the competitions'. This portion was the most rushed because they were due to present the next day. Their posters would have been better and their presentations would have lasted longer have they had more time to prepare and practice. They presented their results to wind research faculty and graduate students. Their ability to answer questions posed by the visitors was evidence the comprehension in the material they learned over the two weeks.

IV. Future Use

After the successful implementation of this project, the Diversity Programs Office of the College of Engineering adapted the wind turbine project for 300 female students, teachers, and guidance counselors from various local high schools in Western Massachusetts for this year's UMass Amherst annual Women in Engineering and Computing Career Day Conference. The lesson plan currently holds as a learning module for the outreach leaders of DPO, where other engineering students use parts of the curriculum when they visit other schools and afterschool programs or vise-versa. The next upcoming project is to work with the Cape Verde Student Alliance (CVSA) to translate the lesson plans to Portuguese-Creole in efforts to implement the curriculum in at Olavo Moniz, a secondary school in Sal Cape Verde, by summer's end.

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