BIOENERGY and BIOPRODUCTS EDUCATION PROGRAMS

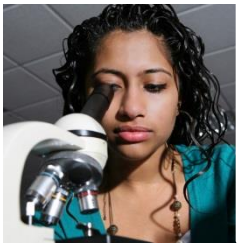
POSTER ABSTRACTS

NATIONAL STEM TEACHERS WORKSHOP

Bioenergy and Bioproducts Education 2015





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Teacher Impact Poster Session
2015 BBEP National Conference, Horseheads NY
Wednesday, July 29th, 2015

BBEP PARTNER SITES

Increasing the Yield of Sweet Potato plants (*Ipomoea batatas*) in Shorter Crop Duration for use as a Potential Source of Bioproducts and Biofuel

Teacher Name Marlon Francis
School Trinity High School, Louisville, KY
Essential Elements Biomass, Biofuel

Sweet potato (Ipomoea batatas) is a perennial, starchy, root tuber that exist in several hundred varieties, skin and flesh colors. It is widely distributed across many geographical locations around the globe, but production is mainly in tropical and sub-tropical regions. It is cultivated in a wide range agro-ecological zones and farming systems from subsistence to commercial production and is a staple crop for many people and livestock. The high number of plant varieties provide a genetic basis for a wide range of uses and great potential as a biofuel and a source of bioproducts for diabetes.

Sweet potato prefers warm, summer-like temperatures ranging from 21 to 28°C for fleshy root development and >25°C for top growth, making crop production best suited to the 4-5 summer months of the year. There is significant yield variation between geographic locations and growing conditions. For example, in the Caribbean, with has summer-like weather, all year- long the yields of the crop are low, ranging between 8000-20,000lbs. /Acre (Titus, Lawrence, Adams, Iton, Pilgrim & Robin, 2010).

Considering that the problem of generally low, inconsistent crop yields may be partly influenced by several physiological factors, the proposed solution is to increase yields by growing the crop under modified greenhouse conditions. Plants are provided optimum growing temperatures, carbon dioxide (CO_2) enriched-air, together with photoperiod adjustments to initiate tuberization. At crop maturation, DNA fingerprinting will be done to identify plant varieties with the highest biomass. These plants will be selected for further investigation of bioproducts and biofuel production.

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Growing Biofuels: Germination!

Teacher Name	Kimberly LaCelle
School	Wheatland-Chili Central School District, Scottsville, NY
BBEP Site	Boyce Thompson Institute
Essential Elements	Biomass, Biofuel

One major feedstock candidate for biofuels is the native perennial grass switchgrass (Panicum virgatum). This plant is advantageous because it can grow in marginal soils without fertilizer or water inputs and is not invasive. Higher germination rates reduce the amount of seed needed to grow a certain amount of biomass. Less seed means a lower cost to grow the plant and thus, a lower overall production cost of the biofuel.

We looked at the germination rates of switchgrass varieties that were being evaluated as possible biofuel feedstock. Students chose three varieties of switchgrass seeds to test germination rates. Between 10 and 20 seeds were placed on water saturated blotter paper inside a 100 X 15 mm Petri dish. The Petri dishes were placed inside plastic sealed transparent germination containers and kept at room temperature (23-25 °C) for 2-3 weeks. Students calculated % germination . Our results showed that the switchgrass variety Dacotah had the highest germination rate (66%) and Sunburst exhibited the lowest rate (11%).

Students learned what research development of a biofuel would include. In observing variation between individual results and total class results, students learned why repeating an experiment is important in research. Other factors were discussed such as time requirements, good observations, graphing to make a visual representation of our data, variables that might affect our experiment, and sources of error. Future studies could include establishing a stand of the different varieties and measuring the amount of biomass produced, or measuring glucose production across varieties.

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Radical Radishes – Improving Urban Soil

Teacher Name	Dr. Peter Mecca
School	George Mason High School, Falls Church, VA
BBEP Site	Pennsylvania State University
Essential Elements	Biomass, Sustainability

Students from George Mason and George Marshall High Schools (VA) designed an investigation to rehabilitate urban soils on their schools' campuses using Daikon radishes. Daikon radishes have been used as a "bio-tiller" for years to break up soil compaction in farm fields. Using a sod cutter, grass layers were removed and the exposed soil was amended with compost and tilled. A square-foot cardboard template served as a planting guide while students placed a total of 8 Daikon radish seeds per square-foot area within each of the plots. Part of one of the plots did not receive radish seeds.

Infiltration rates were obtained for all the plots. Results for grassy area, for control plots (had compost but not radish seeds), and for plots that had both compost and radish seeds, had infiltration rates of 5.08 cm/h, 22.7 cm/h, and 27.2 cm/h, respectively. The Daikon radish has a long taproot that can drill through compacted soil layers, absorb nitrogen and other nutrients, increase infiltration, and reduce runoff. If successful, bio-tilling using Daikon radishes could become a practice throughout the Chesapeake Bay Watershed to improve both soil and water quality.

How Will Your Garden Grow? Investigating Biofuel Feedstocks Growth in the Greenhouse and in Saline Conditions

Teacher Name Samantha Neubert
School Appoquinimink High School, Middletown, DE
BBEP Site Delaware State University
Essential Elements Biomass, Biofuel, Sustainability, Systems Thinking

During my AP Environmental Science class, students designed an investigation around biofuel feedstocks from the seeds provided from the BEEP Workshop. Students chose and researched about a particular seed, and planted the seeds based on their requirements for growth. Plants were grown inside – either in the greenhouse or the classroom. Students observed germination; replanted seeds, watered and fertilized as needed. Plant growth was monitored from September through May. The final product was a research paper outlining the introduction and design of their "garden", consideration for future design of the garden, and review of published articles from current biofuel feedstock research. A possible extension for next year would be to observe drought conditions.

In a second investigation, students monitored the impact of a salt on their feedstock seeds. They observed how different levels of salt would impact seed germination and growth. Students used serial dilutions to determine the level of salt in the water. Essential questions during this investigation included: Would a certain type of seed be better to grow in a more saline environment than another? Could we use this feedstock in fields that have been diminished due to the change in the salinity of the soil? Unfortunately, the results of this experiment were inconclusive.

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Bioenergy from Vegetable Oil

Teacher Name	Sara Chen
School	South River High School, Edgewater, MD
BBEP Site	University of Maryland Eastern Shore
Essential Elements	Biofuel, Systems Thinking

The BBEP workshop I attended at University of Maryland Eastern Shore (UMES) in 2014 positively impacted my students' learning about the topic of bioenergy as a better "material" for energy production. In class, the students looked at alternative *renewable* fuel sources rather than nonrenewable sources such as fossil fuel and used BITES (Buildings Industry Transportation & Electricity Scenarios) to examine the energy sources surrounding the gasoline shortage of the 1970's and to understand the importance of (developing and commercializing) alternative sustainable fuel source(s).

By participating in the BBEP workshop, I was able to confidently lead my students through the transesterification process as they made an alternative fuel, bio-diesel using vegetable oil, for use in the operation of a diesel engine. In the presence of a strong base, the triglycerides, a major component of the vegetable oil, reacted with methanol to form fatty acid methanol esters or biodiesel fuel. Further, the students recognized that glycerin, the by-product from the process can be converted to soap - a useful consumer product. During the 2014-2015 school year, the students utilized used vegetable oil to make a sustainable bio-base fuel. To minimize waste, they took the glycerin by-product from the washed bio-diesel and converted to a soap which was used in the classroom. Next year, I expect the students to test their bio-diesel as well.

Teaching and Learning Ecology Using a Classroom Algal Photobioreactor

Teacher Name Karen Horikawa
School Wilmington Friends School, Wilmington, DE
BBEP Site Boyce Thompson Institute, University of Delaware
Essential Elements Biofuel

The algal photobioreactor laboratory (APBL) is a project-based activity designed to increase awareness of sustainable biofuel production systems through traditional ecology lessons. APBL was introduced in an eighth grade biology class at a Quaker independent school in Wilmington, Delaware. This investigation increased the students' interest in ecology and sustainable systems thinking as well as provided hands-on learning opportunities relative to core concepts in environmental science. Students increased their facility with the scientific method by engineering solutions to real-world challenges via hypothesis testing, experimental design, data analysis/modeling, and exploring the downstream implications of their work. The learning experiences offered in the APBL (scientific discovery, ecological stewardship, sustainability) aligned with the school's core beliefs of environmental conservation and stewardship.

Students grew the alga *Chlorella prototheco*ides in photobioreactors using protocols shared by the Boyce Thompson Institute's Curriculum Development Projects in Plant Biology Program. Using nutrient-light combinations, groups designed model ecosystems to predict and support optimum algal growth. Cell concentration was measured using a spectrophotometer. Students presented their findings through charts, graphs, and photos and shared insights on the carbon footprint of biofuels and requirements for growth. Students also discerned how biofuels could play an important role in mitigating global environmental and energy challenges, and their role in shaping and preserving the natural world.

Biomass to Biofuel: Using an Advanced Placement (AP) Environment Science Lab to Enrich non-AP High School Students' Understanding of Bioenergy and Sustainability

Teacher Name Brianna M. Miller
School Middletown Area High School, Middletown, PA
BBEP Site PACE/Dutchess County Cornell Cooperative Extension
Essential Elements Biofuel, Biomass, Sustainability

For the 2014-2015 school year, the Middletown Area High School (MAHS) initiated a schedule change and designated a mid-day time slot for the instruction of new course content deemed "enrichment." The initiative was designed to promote cross-curricular collaboration between teachers and to *enrich* students' interests in areas of study not encompassed within our course offerings. Twenty teacher pairs collaborated in the design and implementation of 20 new enrichment courses. My colleague and I created an enrichment course entitled *Biofuels* and 18 students of all abilities, grades 9-12 enrolled. The course centered on the completion of an Advanced Placement (AP) Environmental Science Lab from Carolina Biological, *Biomass to Biofuel: Grasses for Ethanol Production*, as distributed during the Bioenergy and Bioproducts Education Program (BBEP) Workshop hosted at Cornell Cooperative Extension Dutchess County.

During 10-one hour *Biofuels* enrichment classes, students were guided through the background knowledge and completion of this AP-level lab investigation, enhancing their knowledge of bioenergy within the larger societal context. The AP-level lab included cross-curricular connections through inclusion of mathematical analysis. The *Biofuels* enrichment course offered a unique experience to the students enrolled because none of them have the opportunity to take AP Environmental Science as a regular course- we simply do not offer it at our high school. Additionally, many of the students enrolled in *Biofuels*, will graduate high school without exposure to any AP-level courses. Through *Biofuels*, those students will now graduate with at least 10 hours of AP-level content; and, in an area of emerging importance-bioenergy.

Growing Algae in a Community College Biology Course: Inquiry Into The Algae-to-Biodiesel Pipeline

Teacher Name Dr. Pushpa Ramakrishna
School Chandler-Gilbert Community College, Chandler, AZ
BBEP Site Boyce Thompson Institute
Essential Elements Biofuel, Biomass

Fast-growing algae fix the greenhouse gas carbon dioxide via photosynthesis and absorb environmental contaminants while accumulating on average 20-35% of their dry-weight in neutral lipids (1). These lipid molecules can be harvested and reacted with simple alcohols to produce biodiesel. While algae are a potential source of liquid transportation fuel, there remain many challenges that scientists presently are attempting to overcome including optimizing culture conditions for algal growth (2).

Honors biology students at Chandler Gilbert Community College in Chandler, AZ, were assigned the scenario of being scientific advisors to a biofuel startup company and asked to determine the optimal conditions for growing the alga, *Chlorella protothecoides*. Each student group, acting as independent biofuel companies, created a testable hypothesis and designed experiments to examine algal growth in mini-photobioreactors across different culture media. Photoperiod, light intensity, and ambient temperature across media combinations were identical and a media minus treatment (water) was utilized as a negative control. The students collected algal growth data at various intervals throughout the duration of their experiments using hemocytometers (cell/mL) and spectrophotometers (optical density at 550 nm). Cell concentration in culture media was analyzed and according to these results, students prepared a recommendations for optimal algal growth for the company and "informed stakeholders". Students conceived innovative ideas for future experiments including determining whether light color influences algal growth. For future semesters, students will be provided with resources to study additional variables and the opportunity to participate in a civic engagement module on energy policy, thereby providing an interdisciplinary focus.

References: (1) Kirrolia et al. Renew. Sust. Energ. Rev. 20: 642-656, 2013. (2) Pragya et al. Renew. Sust. Energ. Rev. 24:159-171, 2013.

Could Photosynthesis Be the Key to Solving Today's Energy Needs?

Teacher Name Gary Silverman
School RJK Middle School, Monticello, NY
BBEP Site Boyce Thompson Institute
Essential Elements Biofuel

Students investigated a number of hypotheses to determine variables that would result in maximal algal growth. Some of the variables tested were acidity, alkalinity, exposure to light, available organic matter (Urea and fish fertilizer) and salinity. Students began by reading about an algae-powered building and asked to contemplate the idea that the lipid content in algae could be converted to usable fuel. They developed hypotheses by choosing an independent variable that could be measured and maintained accurately. Students were divided into groups and peer reviewed the hypotheses, selecting the hypothesis that was deemed most promising. Each group constructed 4 photobioreactors: a control group and three variations of their independent variable. Each reactor had 1mL of a colony of *Chlorella sp*. added and a cell count was taken to determine the baseline population. Reactors were monitored for 10 days using a color chart of varying gradations of green to indicate relative algae concentration. After 10 days, cell counts were performed on each reactor to determine cell concentration.

Initial testing indicated that *Chorella sp.* multiply most quickly in neutral to slightly alkaline pH with maximal light exposure and a specific gravity of 1.02. Increased organic content yielded rapid initial growth of algae, but those colonies diminished in concentration toward the end of the ten-day trial.
Through this experience, students engaged in true STEM learning and incorporated skills in microscopy, monitoring a controlled experiment, and calculating specific gravity and cell concentration. Numerous observation skills were utilized with significant attention paid to measurement accuracy. Additionally, students considered the importance of alternative energy sources and how bioenergy may reduce reliance on fossil fuels.

Don't be Afraid to Take the Journey(s) with Your Students: Project Based Learning Activities that Enrich Your Curriculum

Teacher Name Paul Heasley
School State College Area High School, State College, PA
BBEP Site Pennsylvania State University
Essential Elements Bioproducts, Systems Thinking, Sustainability

Bioenergy and biomass energy activities have provided my Agricultural Science students and program educational journeys that built more opportunities and partnerships for enriched curriculum. Challenge yourself and let project-based learning lead your journey with students.

Curricular activities were developed via a STEM framework to process biodiesel from our school district's used French fry oil and utilizing it as a supplemental district fuel source. An outgrowth of this project was a student-led research project that enriched deer feed using the biodiesel by-product. Feed energy was increased to improve body maintenance, antler growth and hair quality in male deer. These projects opened many avenues and opportunities for student to research and present their activities and data to groups at local, state and national venues.

After the BBEP workshop, students sought additional investigations in biomass energy experiences. We planted biomass feedstock in our greenhouse and planted a biomass garden. Our program received funds to purchase a biomass hammer mill, pelleter as well as a cardboard/paper re-purposing device. Students successfully grew, harvested and processed perennial grasses into biomass fuel pellets. One of our project's goals was to recycle the high school's paper and cardboard into biomass fuel pellets. An accidental outcome experience for students was producing and marketing "No Weeds Plants Mats" that reduce weed growth and conserve soil mositure around garden plants. This project recycled 600 pounds of cardboard and sold over $1,200.00 of this product. It also earned students a "Pennsylvania Waste Watchers" Award from the Professional Recyclers of Pennsylvania.

Glycerin Feed Trials with Whitetail Deer: Palatability, Antler Development, & Haircoat Quality

Teacher Name Paul Heasley
School State College Area High School, State College, PA
BBEP Site Pennsylvania State University
Essential Elements Bioproducts, Systems Thinking, Sustainability

An outgrowth project of our biodiesel production project was to seek uses for the crude glycerin (10% of production) that was being generated as a waste product. At first, we distilled the glycerin and made scented soaps for sale at our school store. Students researched additional uses of glycerin as an enhanced energy feed source for whitetail deer. Since deer needed higher energy levels for breeding season and body maintenance during the winter months, students thought this was a viable option. Glycerin energy values were similar to corn and it was much like molasses in a ruminant ration. We had our glycerin analyzed to find feed component information as well as tested for feed safety, especially for residual methanol levels.
A pilot study was undertaken to determine the acceptance and palatability for deer using whitetail does at the Whitetail Research Facility at The Pennsylvania State University.

After positive results, we set up an experimental protocol to test glycerin's feed attributes for body maintenance, hair coat quality and antler development in whitetail bucks. Yearling bucks were photographed, weighed, and their antlers were scored. This data was used to place them in two feed groups. The control group was fed their typical diet and our study group was fed the same diet enhanced with glycerin for 12 months. Students again gathered weights, scored antlers and compared hair coat appearance. The experimental group had: lower feed intake over the trial; did improve hair coat quality; and showed a slight increase in antler growth but not significant enough to warrant further study.

North Elba Digester Project: A Regional Food Waste Recycling Program From Case Study to Community Action

Teacher Name Tammy Morgan
School Lake Placid High School, Lake Placid, NY
BBEP Site PACE/Dutchess County Cornell Cooperative Extension
Essential Elements Bioproducts, Systems Thinking

Food wastes are the single most abundant type of wastes going to landfills today. This project diverts municipal food wastes from landfills decreasing costs and creates bioproducts from wastes. As a result of the case study developed source separated food wastes from the North Elba region, located in Northern NY, will be collected and recycled in an anaerobic digester.

Using systems thinking AP Environmental Science Students helped develop the sustainable organic waste management program for their community and continue to learn about biomass production, development and logistics by growing an energy garden. The resulting case study describing the economic impact of converting biomass wastes to renewable biogas was used to obtain a $1.06 million Regional Economic Development Award. Using these funds our region will soon be home to an anaerobic digester that will completely recycle food and organic wastes from institutions and businesses in our region.

Biology and life science classes learn about environment, policy and economics by developing educational materials to encourage organic recycling in the community. By participating in a pilot organics recycling program this year, students throughout the district model sustainable waste management practices. The case study approach to learning is engaging students and connecting youth to their communities.

Using Bio-Products as an Avenue to Introduce Urban Students to Agricultural Based Industries

Teacher Name Rachel Sanders
School Global STEM Impact Academy, Springfield, OH
BBEP Site Ohio Biological Innovation Center
Essential Elements Bioproducts

In 2011, I was selected by OBIC (Ohio Biological Innovation Center) to participate in the Northeast Bioenergy and Bioproduct (NBB) Master Teacher Training. This experience enriched my personal knowledge base and provided me with a network of agricultural/industrial professionals to interact with as colleagues. This exposure opened my eyes to the vast number of ag-bioscience career opportunities and was able to share these careers as possibilities for my students. I became inspired to use bioproducts as a way to introduce my urban students to new opportunities in agriculture, bioscience, technology, and engineering.

In 2012 and 2013, my biotech students created a group called Cats for Cubs where they took the BBEP lab activities and created outreach activities for our local elementary students. They used the decreasing polar bear population to tie in the need for more environmentally-friendly products for consumers. They taught these activities at 5 elementary schools in the Springfield City School district, reaching approximately 400 5th -6th graders. In 2014, with the help of my female students, we turned bioproduct activities into "Women in STEM" nights. My female students worked with 100 local middle school females, their parents and teachers on how to read Standard Laboratory Operating Procedures (SLOPs) and use science equipment to make bio-based beauty products, such as soy-based chapstick and soymilk soaps. The unit was titled "Soy Beautiful". Next year, we will be in a brand new facility and hope to create bioenergy garden test plots and host our local elementary students in our new labs to continue the outreach work with bioproducts and bioenergy.

BBEP Significant Improves Program Quality, Retention, and Re-Enrollment for Long Running Urban STEM Enrichment Program

Teacher Name Rodney Dotson
School Center for Quality in Urban Education, Inc. New York, NY
BBEP Site PACE
Essential Elements Systems Thinking, Sustainability

Eleven teachers affiliated with Center for Quality in Urban Education's (CQUE) program, Institute for High Performance Learning (HPL) attended the Cornell University's Bioproducts and Bioproducts Education Program (BBEP). A review of 11 years of data revealed that HPL participant and program success factors improved significantly after BBEP training, and peaked drastically once all staff were trained through BBEP. HPL is STEM career education and pipeline program designed to enhance STEM teacher effectiveness and to raise interest among urban youth for pursuing careers in the so-called STEM professions. The HPL program targets academically under-performing schools with high enrollments in federal free-lunch programs. HPL exposures participants to an advanced scientific curriculum, data-driven STEM inquiry, and technical communications skills.

BBEP improved the HPL program through 1.) Increased knowledge and professionalization, 2.) Improved teamwork, and 3.) Stronger curriculum, and 4.) Improved logistics. After BBEP, the HPL curriculum now also includes modules for Food Product Development; Organic Soil Amendments, and Sustainable Agriculture by Design. The most important impact of the BBEP training was an increase in program quality and 100% student retention – both for middle and high school cohorts, with n=14. HPL's 11-year retention statistics serving 90 students rose from 82% to 84%. In 2014, for 11 of 14 participants completing a third-party administered survey, 100% of students indicated their willingness to re-enroll. Benefits gained from participation in BBEP training and curriculum projects would have addressed some of the earlier curricular and implementation shortcomings and challenges within the HPL program.

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Sustainability: A Launchpad for Next Generation Science Instruction

Teacher Name Andrea Harpen
School Blanchester High School, Blanchester, OH
BBEP Site Ohio Biological Innovation Center

Essential Elements Systems Thinking, Sustainability

Participation in the Biofuels and Bioproducts Educational Program (BBEP) provided the tools in the classroom that enable instruction to serve as a model for the implementation of the National Research Council's Framework for K-12 Science Education, the Next Generation Science Standards. As a result of this program, a new cross-curricular approach to teaching science, incorporating real world challenges into core instruction is implemented that is highly motivational, individualized, connects students to the world around them and provides them with the fundamental core knowledge students need. Through the use of the tools gained from BBEP in terms of lesson plans, materials and connections made with industry and academia, instruction is connected to topics in sustainability and big ideas of my discipline, chemistry. These big ideas give students a vision of the world and a launch pad for research.

As a result of this program, student research topics in sustainability at Blanchester High School increased from 0% to about 30% starting from year one and continuing to this date; student research awards in sustainability for Science Fair and Believe in Ohio occurred every year; with awards totally over $30,000. New relationships were forged with industry resulting in over $30,000 support for field trips and teacher professional development and interest in STEM careers greatly increased. Additionally, working with the head of Chemistry at Southern State Community College in Hilsboro, these ideas will be shared with teachers in the Southern Ohio Appalachian belt through the College Credit-Plus Chemistry Program and through partnership with the Ohio Soybean Council and their educational site, GrowNextGen.org. On a national level, these ideas will be shared at the ChemEd 2015 Conference in July.

Sowing the Seeds of Sustainability

Teacher Name Kelly Mackey
School Islip High School, Islip, NY
BBEP Site Boyce Thompson Institute
Essential Elements Systems Thinking, Sustainability, Biomass

The Bioenergy and Bioproducts Education Program has been instrumental in teaching overarching concepts in Environmental Science. Through an extensive six month long experiment in the viability of using Switchgrass as a lignocellulosic feedstock for ethanol production; A.P. Environmental Science students gained understanding of concepts related to energy use, alternative fuels, problems associated with petroleum use and today's agricultural practices, and the integration of multiple disciplines in global problem solving. Three different varieties of switchgrass were examined for their ability to germinate under ever increasing saline gradients. Then each variety was cultivated for six months in our greenhouse.

After the A.P. exam, students then analyzed each variety for the crude mass above ground, percent biomass composition, root depth and mass, carbon sequestered by the root system, and glucose yielded per gram. For the 2014-2015 academic year, the candidates were Kanlow, Cave-In-Rock, and Alfalfa. While Alfalfa appeared to be the run-away winner after germination and overall growth were determined; Kanlow's high percentage of biomass and glucose/gram yield made it the clear choice as a feedstock. Cave-In-Rock seemed to be the best candidate for carbon sequestration and topsoil replenishment. Finally, each group was allotted an amount of ethanol corresponding to the glucose their plants would have produced, and ethanol powered boat races capped off the project.

BBEP: Providing Teachers and Students the Opportunity to Succeed in STEM

Teacher Name Morina Ricablanca
School East Hoke Middle School, Raeford, NC
BBEP Site PACE/Dutchess County Cornell Cooperative Extension
Essential Elements Systems Thinking, Sustainability

This presentation shows how attending the BBEP impacts exceptional children (EC) by providing access to STEM-related projects, improving their academic performance and award-winning participation in the school's science fair. I had 12 students with exceptional needs in my caseload for the school year 2014-2015. Part of the science curriculum in our school is the Science Projects, where students were encouraged to do scientific research projects in the following categories: Technology and Engineering, Physics, Chemistry, Environmental Science, Biology A (Animal Science, Medicine and Health Science and Microbiology) and Biology B (Behavioral and Social Science, Biochemistry, Cellular & Molecular Biology and Plant Science).

Working with students with exceptional needs, I became their research adviser and mentor. Five of these students won the school's Science Fair, four competed in the regional division and one went to the state competition. With their participation in the science fair competition, the students' academic performance and attitude towards learning changed dramatically. The BBEP workbook and kit served as a valuable resource for students conducting their research and experiments. I was able to share the things that I learned from the workshop to my students, which led my students to want to succeed.

Two students conducted their research on Bioenergy and Bioproducts. These are the titles of their topics: Homemade Anaerobic Digester using kitchen waste to generate biogas and Grass for Ethanol: How do temperature and pH affect the amount of glucose in a Timothy Hay. Two students focused on sustainability and one student did her research on the environment.

Repurposing of Organic Waste in an Urban Setting Business Proposals

Teacher Name Katie Rouse
School Muchin College Prep, Chicago, IL
BBEP Site PACE/Dutchess County Cornell Cooperative Extension
Essential Elements Systems Thinking, Biomass, Biofuel, Sustainability

Inspired by a presentation at last year's BBEP conference on Lake Placid's BioBelly Project, I asked my students to investigate sustainable methods for waste management. My students were first introduced to the staggering amount of waste generated/person in the City of Chicago. During the this unit they learned that over half of our waste generated is organic and that the organic waste could be put to use outside of being placed in a traditional landfill.

Students were required to research alternative uses for organic waste and repurposing of landfill areas. Students researched three different energy conversion of options, including anaerobic digesters, landfill gas capping systems, and bioreactor landfills. Students then created a business proposal, identified a location for their business and presented their proposals to the class.

During this project, students were first and foremost amazed at the level of waste generated and they were able to see that there are alternatives to current waste management practices. Making the real-world connection, students learned that there can be lucrative business opportunities in waste management, gained experience planning and organizing their ideas, and learned how to defend those ideas to justify their views. Students were creative in their business designs with some researching other waste management companies to partner with in regards to collection of waste, while their business focused solely on the processing and conversion of the waste collected.

Houston, We Have a Problem…Teaching Fossil Fuel Alternatives to Students in the Oil and Gas Capital

Teacher Name Elizabeth Spike
School St. John's School, Houston, TX
BBEP Site PACE/Dutchess County Cornell Cooperative Extension
Essential Elements Systems Thinking, Sustainability, Biofuel

Humanity can limit global temperature rise to two degrees Celsius, but how? Understanding externalities such as decreases in water resources, crop loss, ocean pH, biodiversity, and increases in pest and disease distribution, drought, storm surge, caused by burning fossil fuels is prerequisite for slowing the rise in global temperature. Environmental and social costs are the motivations to develop large-scale, sustainable markets for less intense carbon fuel alternatives. Bioenergy and Bioproduct Education Program (BBEP) investigations enabled students to envision practical, real-world solutions to the market failures that encourage burning fossil fuels. BBEP investigations introduced these alternatives and let students explore how they worked in the laboratory.

BBEP activities supported curricular goals in AP Environmental Science: 1) compare and contrast biofuels, 2) describe how biofuels achieve sustainable systems, and 3) explain the costs and benefits, trade-offs, and impacts. I used guided inquiry methods to teach bioenergy garden, biodiesel, and grasses to sugars labs. I posed engaging questions to pique student curiosity, trigger student reflection on the meaning of energy and biofuels, and provided materials with a simple lab protocol for students to follow. Subsequently, students extended these labs, by designing their own protocols to answer the original questions. These experiences allowed me to plan ahead for more elaborate investigations, such as assigning students to propose a plan for the production and distribution of biofuels into the Houston market. I will share my methods, student learning outcomes, discussion, suggestions for improvement, remaining questions, as well as future directions to take.

The New York State Master Teacher Program

Dominick Fantacone, Chief Campus Coordinator for the NYS Master Teacher Program, SUNY Cortland, Cortland, NY

Responding to the call to strengthen our nation's K-12 STEM education, Governor Andrew M. Cuomo launched the New York State Master Teacher Program (NYSMTP) in partnership with The State University of New York and Math for America. The program creates a state-wide network of the highest-performing STEM teachers dedicated to sharing their expertise with peers and attracting high school graduates to careers in STEM. Participating teachers receive $15,000 stipends annually over four years. In the coming year, Master Teachers from across NYS will get the opportunity to utilize materials from BBEP in their professional development. They will be encouraged to and supported in implementing lessons and activities on Bioenergy and Bioproducts in their classrooms.

Bioenergy and Bioproducts Education Program (BBEP) Promotes Multidisciplinary Content in STEM Education

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During the one-week summer institute on Bioenergy and Bioproducts, held at the University of Maryland Eastern Shore (UMES), educators across STEM (Science, Technology, Engineering, and Mathematics) participated. The objectives of the institute were: 1) to provide a systems-perspective in renewable energy with a particular focus on bioenergy and bioproducts to STEM educators; and 2) to develop and provide curricular materials and a set of teaching tools for educators for enhancing multidisciplinary instruction in the areas of sustainable bioenergy and bioproducts. The institute focused on lessons and engaging activities pertaining to sustainability, systems thinking, bioenergy, bioproducts, bioheat, biopower, and environment and policies related to energy issues. The participants got the opportunity to acquire concrete experiences involving teamwork, time management, and project execution skills; and reflected on their learning experiences through presentations. A total of forty-one educators have been trained through this program over a period of four years. The evaluation surveys (content and perceptions) reveal that educators gained substantial knowledge in the areas of bioenergy and bioproducts, and felt comfortable in implementing the content in their curricula. Various STEM courses have been impacted positively through the infusion of components in sustainability and renewable energy offered by the program.

OBIC, BBEP, and the "Biobased Promise"

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OBIC Bioproducts Innovation Center at The Ohio State University is a champion of biobased materials as a resource for improved sustainability. OBIC's mission is to expedite bioproduct commercialization through cluster development and stewardship. To date, OBIC has assisted clients with over $100 million in supplemental funding and a current estimated value of nearly $500 million. In November of 2012, OBIC launched a Bioproduct Network as a vehicle for multi-organizational collaboration. Over 60 organizations have taken advantage of this networking tool to date. The goal of OBIC's Educational programming is to provide a means to bring bioproducts into classrooms, providing a vehicle for educators to meet rigorous academic content standards, address STEM (Science, Technology, Engineering and Mathematics) goals, develop workforce skills and inspire future innovators to develop sustainable solutions to global problems through hands-on, experiential learning.

Over the course of the BBEP program, OBIC hosted 4 one-week and 4 one-day BBEP teacher workshops reaching a total of 72 teachers. In 2014, OBIC expanded its reach beyond Ohio by hosting a tri-state, one week workshop with collaboration from Purdue University and Michigan State University. The workshop attracted 20 participants from the states of Ohio, Indiana, Michigan, Kentucky, and California. The number of students reached through these teachers is estimated at more than 2,000. In addition, OBIC provided in-service training to ag science teachers twice during this time period reaching 120 teachers. OBIC also engaged consultants to refine the OBIC and BBEP lessons to target middle school students.

In October 2014, OBIC hosted the Inaugural Bioproducts World 2014, an international conference to showcase biobased products and foster growth of the industry. This event attracted 250 attendees, 41 exhibitors, as well as a visit by USDA Secretary Vilsack. OBIC along with support from the Ohio Soybean Council hosted 50 students and their teachers at the conference on October 7, 2014. The students were from Blanchester High School and Global STEM Academy. The students had the opportunity to walk the tradeshow floor and engage with exhibitors. The visit was well received by industry exhibitors. Andrea Harpen, master teacher trainer and facilitator at the 2014 Tri-State Workshop was in attendance with her students from Blanchester High School.

Finally, OBIC launched the Sustainable World Tour (SWT) in May 2014 to promote the Biobased Promise. The tour is a first-of-its-kind public awareness campaign to optimize marketplace engagement and promote biobased alternatives. It includes interactive exhibits transported by a biobased-branded vehicle to encourage consumers to purchase biobased alternatives and excite young people about future careers in sustainability. The OBIC SWT has attended 43 events including 4-H camp, Bioenergy & Bioproducts Education Program Workshop, Biofuel plants, Biobased product retailer events, Cincinnati Zoo, Classrooms/schools, Dayton Dragons Baseball Game, Farm Science Review, Ohio FFA Convention, and the Ohio State Fair. BBEP lessons are presented during SWT events.

Bioenergy and Biofuels: Past, Present, and Future

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The energy stored in annually produced biomass by terrestrial plants is 3–4 times greater than the current global energy demand. Civil utilization of bioenergy in different forms of biofuels has been practiced since the dawn of humans. Solid biofuels include firewood, wood chips, wood pellets, and wood charcoal. Liquid biofuels cover bioethanol, biodiesel, pyrolysis bio-oil, and drop-in transportation fuels. Gaseous biofuels extend to biogas and syngas. Currently 40% of the world population relies on solid biofuels for energy. The annual bioethanol production predominantly from food crops reaches 22 billion gallons and biodiesel production from oil seeds reaches 5,670 million gallons. Production of bioethanol from lignocellulosic materials, however, has commercially started. Production of biogas from organic wastes by anaerobic digestion has been rapidly increasing in Europe and China, with the potential to displace 25% of the current natural gas consumption. Overall, the global development and utilization of bioenergy and biofuels will continue to increase, particularly in the biopower, lignocellulosic bioethanol, and biogas sectors. It is expected that by 2050 bioenergy will provide 30% of the world's demanded energy.

Bioenergy and Bioproducts Education in Delaware

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Bioenergy and bioproducts education in Delaware was largely initiated and significantly promoted by the USDA-funded project "Northeast bioenergy and bioproducts education program: Providing faculty (grades 8 - 16) with training, tools, and in-classroom support." With financial support from the project, essential teaching materials and toolkits and interactive learning modules were developed. Intensive training workshops were conducted to prepare in-service and pre-service teachers with the concepts and science of bioenergy and bioproducts. Through efforts of the trained and certified master teachers, bioenergy and bioproducts education has been integrated into the existing K8-16 curriculum, demonstration projects, and student supervision of schools across the State of Delaware. The terms and phrases such as sustainability, energy efficiency, bioproduct, biofuel, bioenergy, bioethanol, biodiesel, composting, anaerobic digestion, and biochar have been popular in the student community and the general public.