Addressing one of the Engineering Challenges in Pre-College Programs: Modernizing the Electric Grid

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Adam Stevens is currently a PhD student in the College of Electrical and Computer Engineering and North Carolina State. Adam received his Bachelor's Degree in Electrical Engineering from UNC Charlotte in 2007 and his Master's from North Carolina State in 2015. His research interests are in electric machines and drives as well as self-driving vehicles. He is particularly interested in vehicle localization using sparse distance measurements obtained from LIDAR measurement units. He is currently serving as the Education Officer for the Student Leadership Council of the FREEDM Systems Center at North Carolina State.

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Electric power and electronic equipment have been my passion as long as I can remember. One of my favorite photographs of myself as a child is of me building my first transistor radio as a young boy. The circuits and power electronics that I now use are far more sophisticated than a transistor radio, and my passion for the field has grown with that sophistication.

At a young age I found myself drawn to the armed services and with stunning evaluations on the Armed Services Vocational Aptitude Battery (ASVAB), I received multiple distinguished offers and found my calling in the United States Naval Nuclear Propulsion Program, where I served as a Nuclear Submarine Electrician for six years.

I expanded my expertise through qualifying all senior watches as an electrician, and continuing to qualify both reactor operations and mechanical watch stations. I assisted the ship through an extensive overhaul period in which I coordinated activities and testing with shipyard entities. Following military service, I continued to hone my skills as an electrician and mechanic, while directly interfacing with customers as an overhead crane technician for KoneCranes. Working in hazardous environments such as chemical plants, steel mills, and mines cultivated a passion for excellence in occupational safety.

I completed my Masters of Science at North Carolina State University in December 2016 and am pursuing a Doctorate in Philosophy in Electrical Engineering. My internships at Ford Motor Company in Detroit, Michigan, USA and ABB Corporate Research Center in Dätwill, Aargau, Switzerland provided me with hands on testing and design experience in power electronics. I reciprocated my value to the projects through improving testing procedures, redesigning main testing facilities, and improving the schedule outlook of the projects.

Throughout my graduate studies I have worked with undergraduate engineering and business students, high school students, high school teachers, community college students and many more to aid in development of a well-rounded professionals. Mentorship is an integral part of the engineer I want to be, through giving back to my peers and fostering a community where we encourage each other to reach their full potential, I know that I am positively impacting my community.

Catherine M. McEntee, North Carolina State University

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Introduction and Overview

The Future Renewable Electric Energy Delivery and Management's (FREEDM) System Center, an engineering research center, precollege program at North Carolina State University was revised for the summer of 2016. The modification was to not only teach about renewable energy technologies and the importance of science, technology, engineering, and mathematics (STEM), but also educate precollege students about the electric grid and how FREEDM is addressing challenges of modernizing the grid through research and technologies. High school students apply to the Young Scholars (YS) program and are selected to participate in the four-week summer program at the Center. The program includes engineering educators and electrical engineering graduate students providing content and hands-on activities. Additionally, industry tours provide students the opportunity to learn more about different workforce environments that are involved in the electric grid, renewable energy technologies and engineering preparation and careers. Finally, weekly webinars, social activities to promote collaboration and inclusion in addition to interaction with both undergraduate and graduate students at the Center provide a balanced summer educational experience. The goal of the program is to promote higher level thinking skills, problem solving, and innovation and learning the engineering design process. Subject matter experts present on topics such as microgrids, solar farms, electric vehicles, battery storage, and careers. Students work with Arduinos and 1/10 scale model electric vehicles to design a solar charging station to charge the vehicle enforcing knowledge of battery technologies. Students also work with wind turbines to calculate energy consumption, and learn introductory coding and programming. During the program, students select a research project, which they work on developing a demonstration project. In addition to the project, students learn how to create a research poster and deliver a "Perfect Pitch" about their research. Upon conclusion of the program, students participate in a symposium event demonstrating their research projects to faculty, administrators, students, staff, parents and teachers. Students worked on projects that included smart use of smart meters, autonomous problem solving and adaptability to quickly and efficiently maintain power distribution, and batteries researching the future-wet versus dry batteries. A comparison of pre and post program survey results for the pre college program indicated that students had a better understanding of engineering and energy related topics. The goals of the newly revised program included:

1. Establish curriculum that is aligned with the program's goals and vision
2. Create a team with relevant content knowledge within and outside the Center interested in the program
3. Purchase equipment and supplies for activities that are engaging and can be replicated in schools
4. Stimulate the interest of the YS through exposure to engineering tools and technologies
5. Foster collaboration with other centers, institutes and industry on and around campus
6. Provide YS with a greater understanding of the social relevance of engineering
7. Provide Young Scholars with an understanding of engineering careers and the necessary courses and pathways

Education Programs Structure

We all depend on an array of electronic devices such as smartphones, smart appliances, computers and even electric cars, however the U.S. electric grid that powers those devices, has hardly changed for decades. The electric grid still operates largely on sources that harm the environment and compromise national security. The outdated infrastructure exposes consumers in the U.S. to outages anywhere at anytime and still has little capacity for integrating renewable energy sources. The FREEDM Center is constructing the Internet of energy. This Internet of energy is a network of distributed energy resources that intelligently manages power using secure communications and advanced power electronics. The center's research priorities include power electronics packaging, controls theory, solid state transformers, fault isolation devices and power systems simulation and demonstration.

This paper targets the center's Young Scholars' program at FREEDM at North Carolina State University and the newly revised program in the summer of 2016. The precollege program expanded its outreach to local schools in 2016 to further impact teachers, students, schools and communities with its outreach and summer programs. Applications to the program are solicited in the fall and early spring and three high school students are accepted into the four-week program each year. Young Scholars are typically 9th, 10th and 11th grade students participating the program. The foundation of the program is teaching the engineering design process and enforcing it throughout the summer.

"The design process, the engineering approach to identifying and solving problems, is (1) highly iterative, (2) open-ended, in that a problem may have many possible solutions, (3) a meaningful context for learning scientific, mathematical, and technological concepts, and (4) a stimulus to systems thinking, modeling, and analysis. In all of these ways, engineering design is a potentially useful pedagogical strategy" (Katehi, Pearson & Feder, 2009). Factual and conceptual knowledge is an understanding of systems, subsystems and components of the technology being examined. Questions posed included: what is the basic design, how does it work, and what are the expected outcomes. This building of knowledge is gained through lectures, readings and the exploration of how research develops the basic understanding necessary prior to working with the design and problem solving process (Lumsdaine, Shelnutt & Lumsdaine, 1999). Procedural knowledge is an understanding of the engineering design and/or problem solving processes that lead to innovative outcomes and solutions. First, the approach to processes and strategies used to solve problems and make informed decisions must be understood (Schweiger, 2003; Woods, 2000). These processes include equations used to calculate system performance, examine and analyze data, make predictions, and problem-solving processes such as troubleshooting and project management that help assist in reaching solutions.

Electric power, which we observe when turning on the light switch, is not magic. Rather is it comprised of fundamental science and engineering that are part of the equation along with societal impacts, security, reliability, resiliency, economics, policy, finance and other components. Renewable energy is appealing, and rightfully so since it is a form of clean energy that is safe for the environment and planet, however harnessing and storing this energy is a challenge. The center is addressing two of the grand challenges in engineering; reducing the cost of solar and storage and cybersecurity. "Overcoming the barriers to wide-spread solar power generation will require engineering innovations in several arenas — for capturing the sun's energy, converting it to useful forms, and storing it for use when the sun itself is obscured." (Grand Challenges of Engineering, p. 7).

The majority of teachers and students in K-12 are not exposed to content about the electric grid, its fundamental elements, its impact, and its relevance to their daily lives. It is a luxury that we take for granted while other parts of the world live in energy poverty with little or no access to electricity. The FREEDM Center's education programs are designed to educate and prepare the next generation of engineers and scientists about the electric grid and modernization of the grid. The center aims to use the classroom as a means to inspire the next generation of scientists and engineers and create a technologically literate society. According to "Technically Speaking", "our economy is increasingly being driven by technological innovation and because an increasing percentage of jobs require technological skills, a rise in technological literacy would have economic impacts" (National Academy of Engineering National Research Council, 2002).

There are multiple explanations why the career pathways may be lacking in K-12 STEM education in the United States and contributing to a shortage of workforce in STEM. The first is that students without a solid background in science and mathematics are not prepared to train for and enter STEM fields. Another reason is that science and technology offerings in K-12 are not prevalent and therefore students may not have an opportunity to participate in courses that would provide a strong background in STEM. (U.S. Congress Joint Economic Committee, 2012). It is critical to provide high school students and the K-12 community of teachers and students with multiple opportunities in STEM to learn about content, relevant courses and skills and careers. Additionally, technological literacy "is the ability to use, manage, assess, and understand technology" (Standards for Technological Literacy, p. 9) and further states that a technologically literate person can understand a specific technology, its creation and evolution and the impact on society along with being capable of making an informed decision about the technology. While not all students will pursue STEM fields, it is significant that students as future citizens understand engineering design and technologies because these products will affect all areas of their lives from personal to perhaps pursuing other careers. As shown in Figure 1, there are multiple pathways for lifelong learning.

Figure 1 - Promoting lifelong learning

Pre College Programs

The FREEDM Center's precollege program was revised in 2016 to reflect the vision and mission of the Center via modernizing the electric grid and to engage participants in engineering education-problem solving, engineering design process, and creating products. After a summer program in 2015, graduate students joined with area teachers and the education staff frequently to discuss approaches to better align the summer precollege program with the Center's mission and revamp the program to engage students in more relevant curriculum and activities. The program through past years had been effective, but the team aimed to develop a program that was cutting edge which could inform and excite students about STEM careers, electric grid, modernization of the grid, energy, hybrid and electric vehicles along with developing their soft skills. Curriculum was obtained through multiple sources and past projects and lessons learned to develop a solid program. Equipment was purchased to align with the projects related to engineering education. Candidates were selected from approximately 28 applicants based on interests, GPA, geographic location and letters of recommendation.

Objectives:

1. Define, formulate, and solve problems related to power and energy systems
2. Design a power energy system or some of its components
3. Demonstrate an understanding of professional and ethical responsibility
4. Strengthen understanding of innovation and creativity
5. Develop the needed knowledge, skills and experiences in the areas of renewable energy, energy storage, and power semiconductors
6. Expose students to innovation/creativity
7. Problem solving skills
8. Communication skills
9. Design skills
10. Modeling skills
11. Standards for Technological Literacy: Standards 3, 4, 5, 11 and 16 (ITEEA, 2007)

Curriculum:

The team identified the ideal curriculum that had been developed and requested permission to use the resources and utilized curriculum that had been developed through the center's program. The curriculum included smart grid, electric grid, renewables, and electric vehicles.

Project Topics:

Project topics were suggested however students were encouraged to explore resources through online searches and talk to the center's students to determine the project that would be their research project for the summer. Several of the projects are listed below:

- Design and Simulation of Off-Grid Residential PV Systems
- Making a Micro-Grid Circuit
- Design and Simulation Home Energy Management Scenarios (HEMS) and Assisting in Graphical Interface Design for HEMS
- Introduction to Analog-to-Digital Converters
- Evaluating Performance and Economics of Wind Farm Siting
- Hybrid and Electric vehicles and the charging infrastructure

Program Schedule

The Young Scholars are engaged in activities throughout the day that include lectures, research at the library and online resources, projects, industry tours, collaboration with faculty, staff and students. Additionally, YS are coached later in the program on learning how to deliver a *Perfect Pitch* (90 seconds explaining the problem being addressed, how the problem is being addressed, and impacts), and how to write and present a research poster at a symposium. These aspects of the YS program are illustrated in Figure 2.

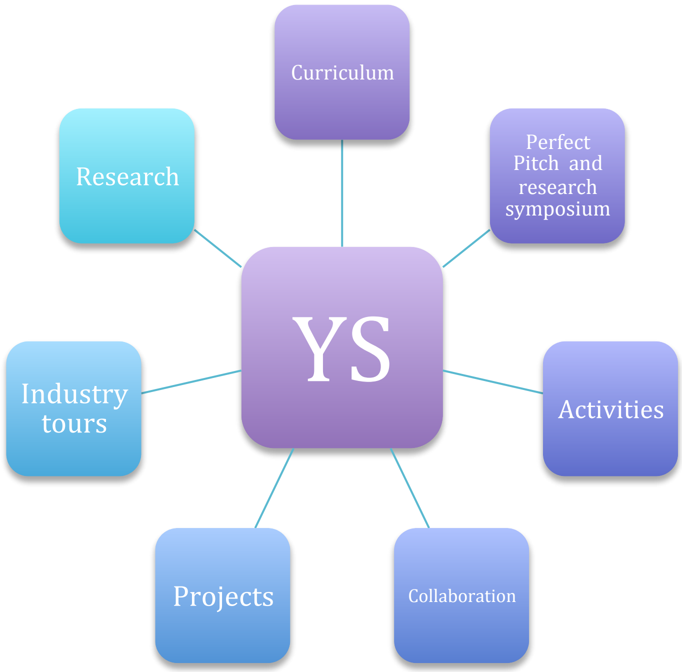

Figure 2 - Young Scholars Program

2016 Young Scholars' Programs Schedule

Table 1

Time/Day	Monday –	Tuesday –	Wednesday –	Thursday –
9-11:00	**Program overview, schedule, introductions, safety training, , (Center)**	Introduction to Electricity and circuit development – Using Arduino UNO (SIK) complete Intro to circuits and projects 1 – Your first circuit: Blinking an LED, 2- Potentiometer, and 3 – RGB LED.	GridModernization Renewables Lecture and Discussion	Engineering Research Presentations
11:00- 12	**Introduction to engineering (EBII Lab) – Students will complete an activity on the Engineering Design Process**	Introduction to Electric Grid Energy Efficiency Energy Consumption Students will calculate energy consumption	Engineering activity Arduino UNO (SIK) – complete projects 6 – photo resistor and 7 – Temperature Sensor	Engineering Projects
12-1P	Lunch (Pam arrange for lunch)	Lunch	Lunch	Lunch
1:00-3:30	Pre Survey All Campus Cards(Michelle) Campus tour on Main	**Field Trip-Utility Energy Control Center (1-3P)**	Modeling and Simulation – Students will learn about Sketchup and Solidworks then they will create a 3D rendering of an object.	Engineering Activity: Arduino UNO (SIK) – complete projects 4 – Multiple LEDs, 5 – Push Buttons, 8 – A Single Servo, and 9 – Flex Sensor

Week 2

Time/Day	Monday–	Tuesday–	Wednesday–	Thursday–
9:00- 11:00	Introduction to engineering software	Research Project and collaboration	EV car building, designing and testing	Research
11:00- 12N	Engineering activity – Arduino UNO (SIK) – Project 12 – Spinning a Motor. Possibly incorporate Matlab. Students will look into the circuitry and programming of an electric motor.	Skills and career paths	Engineering activity – Test RC Cars and Solar Charging Station	Update on research (problem identified and concept map of project)
12N-1P	Lunch			
1:00-3:30	Research Skills and concept	Introduce	Field Trip	Wind turbines

	mapping Brainstorm research ideas	Hybrid and Electric vehicles Smart Grid integration Begin assembling RC Cars		

Time/Day	Monday	Tuesday	Wednesday	Thursday
9-11A	National Advanced Manufacturing Institute	Battery Storage and PowerAmerica	Research	Research Updates
11-12N	Cybersecurity	Cybersecurity	Microgrids	Program Collaboration
12-1P	Lunch	Lunch	Lunch with center's students and seminar speaker (12N-1P)	Lunch
1:00-3:30	**Engineering Activity**	Field Trip	PV Design project	Engineering Activity **Funduino -** Students will take a tutorial from their SIKs and create a functioning models of how their chosen tutorial is applied in the real-world

Time/Day	Monday	Tuesday	Wednesday	Thursday	Friday
9-11:00	Research	Perfect Pitch	Prepare Posters	Post Surveys	Poster Presentations
11-12N		Practice	Practice Perfect Pitch	Wrap up	
12-1P	Lunch	Lunch	Lunch with center's students Seminar speaker (12-1P)	Lunch	11A-1P Social Barbeque RET, MS, YS, REU
1:00-3:30	Electric Vehicle competition	Field Trip	Mock Presentations	Field Trip	Poster Presentations

Teaching, Mentors and Collaboration

A teacher from the Technology, Engineering, and Design local high school led the precollege program. The teacher is prepared with curriculum and activities that give students the awareness, knowledge, and skills in engineering education as it relates to modernization of the electric grid and hybrid and electric vehicles. Four graduate students at the FREEDM Center assisted with the program and two interns from the Technology, Engineering, and Design program in the College of Education at North Carolina State University volunteered their time during the program. Additionally, the program was supported by a Kenan Institute of Engineering, Math, and Science teacher. Finally, students, staff, and faculty interacted with the Young Scholars as shown in Figure 3 below.

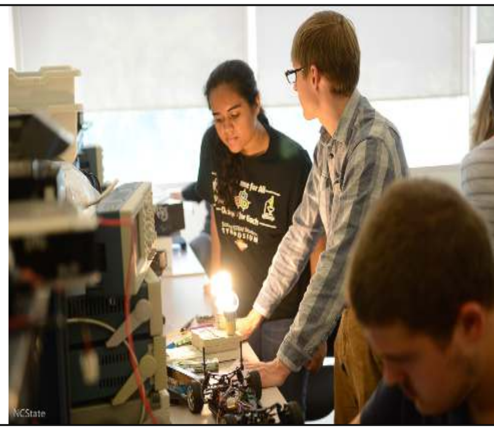

Figure 3 - Project based learning with Young Scholars working in the Laboratory

The FREEDM Center has delivered a Research Experience for Undergraduate (REU) program since 2008 for 10-weeks in the summer and approximately 12-15 participate in the program each year. Students are paired with a faculty member based on project rankings, student's background, academic level and experience. The REUs are also paired with a graduate mentor to guide and mentor them throughout the summer. REUs participated in weekly seminars on topics related to industry, entrepreneurship, graduate school, research ethics, policy and other topics. The REUs, Young Scholars, Research Experience for Teachers (middle and high school teachers), and others met weekly for the seminar series, and also engaged in other opportunities for collaboration.

The REUs met with Young Scholars for lunch and to share their own experiences in their education, projects, and what sparked their interest in engineering. A community was created through experiences like this one example, but also through the efforts with graduate and undergraduate students, the precollege staff, and others working together on select projects, field trips, tours, social events, and other activities. While the research experience is important to the Young Scholar, it is also critical to create an inclusive, supportive and caring community around this environment to have a positive impact on high school students.

The goal is to develop an increased interest, awareness, knowledge and hone skills in engineering, but specifically in the electric power and energy industries. The center accomplishes this by creating a career pathway to engage students in learning the skills, research, and projects along with developing skills in presentation, research posters, and perfect pitches.

Activities

Electric Circuits – Ph.D. Student at the Engineering Research Center

A lecture giving an overview of electric circuits was presented to the summer program students. Due to the limited time, it was determined that the most important component to convey to the students was the free resources available to them, not only to learn the theory behind the operation of electric circuits, but also the tools available that would enable them to design their own circuits that could be manufactured. Two free available courses were presented on circuits and electronics including one through Coursera, and the other through EdX (Georgia Tech and MIT, 2017). These courses would normally take approximately fifteen weeks working between six to ten hours per week for the student to achieve a level of proficiency comparable with a student who has completed the undergraduate circuits curriculum in electrical engineering. The purpose of presenting these resources was twofold; one, to let the students know that a high-level knowledge of electric circuits is possible to obtain within a reasonable amount of time, and two, to open the door to the high quality educational resources available through sites like Coursera and EdX in many fields inside and outside of engineering.

The second part of the lecture presented a freely available professional grade circuit simulation tool called LTspice (Sparkfun, 2008) with a brief overview of how datasheet and schematics are used in circuit design. Finally, a resource was given which the students could use to design their own boards and have them manufactured for $66 (Advanced Circuits and Light in the Box). While it would require much more time to acquire the skills using all these tools, this presentation was meant to demystify the field of electronics and frame it such that the students could see the thought process from beginning to end. Students who have attended an undergraduate curriculum in electrical engineering should be exposed to lectures like this early on to help in connecting the theory to practice and show the knowledge required to make working devices. These skills will aid students graduating with STEM degrees when entering the workforce.

The main recommendation for this lecture would be to make this part of the course to teach the basics required to design a simple printed circuit board (PCB) and then to have the students use the freely available software to design the board and have it manufactured. The boards are returned within two weeks and the students can solder the components on the board and power it up. This opportunity leaves a lasting impression on the students and provides them some very valuable hands on experience.

Figure 4 - University Students working with Young Scholars in the Laboratory

Robot Build and Programming – Ph.D. student in Electrical and Computer Engineering and Research Assistant at the center

This section involved putting together a robot called a "Smart Turtle" that uses an Arduino as the control center of the vehicle (Light in the Box). A manual was written based on what was provided by the Smart Turtle product manual itself, but with more pictures and clearer instructions on putting the robot together. In the process of building the robot, the students learned about ultrasonic sensors, infrared sensors (IR), IR transceivers and remotes, motor drivers, servomotors, and lithium ion batteries. During the building of the robots, all of the students were fully engaged and only one robot was damaged in the process.

The next section the students explored code written for the Arduino that they read in the sensor information and controlled the robot doing a variety of functions as shown in Figure 6. The activities included:

1. Testing the forward and reverse directions of the motors
2. Testing the IR sensors for remote control
3. Following a path made from a black piece of tape
4. Testing the ultrasonic sensor and using it to navigate an environment without hitting any obstacles. Other projects that could be added in the future could include that the robots follow each other on the black tape and maintain a set distance between each robot (known as platooning) as well as controlling the robot through Bluetooth.

While this part of the course was fun for the students, the concern was that they did not take the time necessary to understand the programming code in enough detail.

The lesson learned from this experience is to leave key sections of the code blank, requiring the students to fill in the missing code based on similar code already in the program. This would ensure that the students at least read the code in detail before implementing it on the robot. The students were fully engaged in both the building of the robot and running the programming exercises. Difficulties in the code could easily be explained through context and clues without giving information away to the students as shown in Figure 5 below.

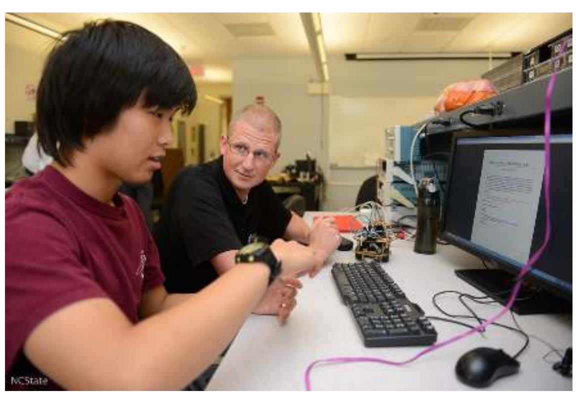

Figure 5 - Graduate Mentor working with Young Scholar

Ph.D. Student's Reflection

This was a rewarding experience for me in many ways. It was great to feel my knowledge of engineering could have an immediate impact on the students' lives and potentially their future *decisions regarding science related and engineering fields. Also, seeing the quality and passion of the teachers participating was inspiring and it gave me a great deal of hope in the public education system. I generally got the sense that the time was well spent for everyone involved including myself. As a person who is considering going into education it was a good experience to see how the other teachers interacted with the students and the passion they shared for learning as well as teaching. It was a unique experience to see teachers and students learning the same topic together and I felt this was beneficial to the students as well as the teachers. The students because they could see what a person with more knowledge still struggled with and for the teacher to see firsthand what was stimulating for the student and what also was difficult for them. I am proud to have been a part of the program and feel it will positively impact the futures of all who were involved.*

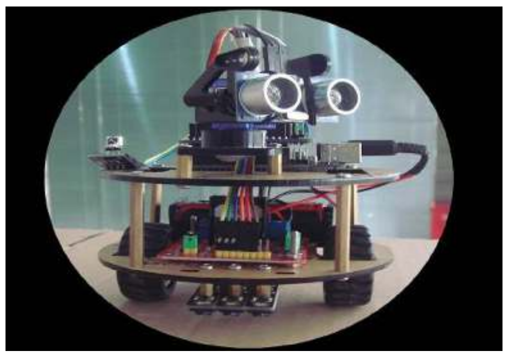

Figure 6 - Arduino "Smart Turtle" using ultrasonic sensor and light sensor to avoid obstacles

Micro Grid and Smart Grid Lessons – Ph.D. Students

The lessons discussed here are “Micro-Grid” and “Smart Grid.” These lessons were designed as a continuation and advancement from the Grid Modernization and Renewables presentation given earlier during the summer program. Grid modernization discussed how the Electric Grid Currently worked and the tennis ball activity was designed to emphasize the complications of multi-directional power flow caused by renewable energy integration and the need for Grid Modernization. The Micro-Grid and Smart Grid lessons explained two approaches that can be used independently or in collaboration with one another to deal with the challenges of Renewable Integration.

Micro-Grid Lesson

This lesson was presented as a means to define smaller systems that are analogous to a micro-grid such as Electric Vehicles, islanded communities with single interconnects, etc. The primary mechanism to explain the correlation was that of an electric vehicle.

- When the vehicle is charging, the micro-grid is operating in grid-connected mode
- When the vehicle is operating under its own power, it is in islanded mode
- When the vehicle is using regenerative breaking going down a hill, it is self- charging its storage such as a neighborhood solar array powering the neighborhood and charging a battery.
- The management system in the vehicle tracks battery capacity and informs the operator when supplemental energy is needed

- On-board storage allows the option to operate autonomously, auxiliaries can be controlled to allocate energy where / when needed.
- High power demand (driving fast or running the heat) will require grid connection sooner
- Low power demand (driving conservatively and keeping auxiliaries off) will prolong battery life

These concepts were used to show that a single point of connection to the grid, I.E. the charging Port of the electric vehicle, defines a Micro-Grid. However, within that micro-grid there is storage, multiple ways to conserve and use energy, management, that equate directly to a larger scale micro-grid such as a neighborhood or a town.

Smart Grid Lesson

The Smart-Grid lesson emphasized the importance of communications and automation within the power grid. The foundation of the lesson began with a storm outage, recovery, and a discussion of lights flickering being far less disruptive than the power going out for prolonged periods of time. This was expanded to the discussion that through communications embedded within the power system, a branch could determine precisely where a fault has occurred, and re-route power to all areas not directly affected by the fault, such as a damaged piece of equipment or fallen tree.

This conversation was expanded to the grid modernization and renewables topic showing that if there are multiple energy sources along a feeder, such as a solar farm, hydro-plant, or wind farm then these separate systems could each power their unaffected portion of the smart-grid in the event of a failure at one points, additionally these resources could *share* the energy demand burden as they are available through more defined communications, rather than have to operate at pre-determined values.

The complexity of these levels was meant to match the expertise of the high school students attending the lessons. Smart Grid and Micro-Grid were both highly collaborative lessons with interaction amongst all parties to promote self-discovery of the system in discussion.

Assessment

The Young Scholar's group knowledge and experience gains were observed in several areas including science self-efficacy, science understanding, sense of inclusion, and energy beliefs, knowledge, and behavior. (Assessing Women and Men in Engineering (AWE). (n.d.),DeWaters, J. Quaqish, B.,Graham, M., & Powers, S. (2013). Riggs, I.M.& Enochs, L.G. (1990)).

Comments included: *I always knew I wanted to an engineer, but I never really knew what electrical engineers did. The camp experience really helped me understand the basics of what electrical engineering is, and how it's a great industry field. Also considering the engineering field is lacking girls it would be a great opportunity to encourage them to see that engineering isn't just for guys and anyone can do it if they're passionate about it.*

Students indicated that they would prefer more coding opportunities versus having the coding already prepared, as it would allow the students to perform different functions. All participants indicated that they would like more building and creating opportunities. Another part of the program is that Young Scholars were able to explore multiple topics, they had flexibility to learn and explore about topics that they were interested in and weren't "just told what to do" as one participant reported. The majority reported that they learned what engineers do and specifically what electrical engineers do, that engineers have an influence on making a difference in the world, and other positive impacts about engineers and engineering careers.

Conclusion

This was the first year of the revised program and while feedback both verbally and through the pre and post surveys was positive, the program will be revised to reflect the feedback and recommendations from the Young Scholar, Technology, Engineering, and Design education teacher, graduate students, and Education Director. The program will include more time for exploring different topics and working on projects, literature review, and providing resources such as journals. The collaborative environment and flexibility of the program will continue to be an integral part of the program as all participants indicated this was important in their learning experience.

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