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Bridging Academia and Industry Through Project-Based Learning: Insights from a High School Renewable Energy Engineering Summer Camp

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Abstract

The 2024 Exploring Renewable Energy Engineering Summer Camp at George Mason University offered high school students an immersive introduction to renewable energy engineering. This innovative program utilized project-based learning, featuring interactive labs, group projects, and virtual reality (VR) sessions to tackle real-world challenges. Central to the camp was its strong academia-industry collaboration, highlighted by an industry panel with representatives from AES Corporation, Amazon Web Services (AWS), Dominion Energy, Hispanic in Energy (HIE), MPR Associates, Northern Virginia Electric Cooperative (NOVEC), and Solar Hands-on Instructional Network of Excellence (SHINE). These interactions provided students with valuable insights into career pathways in the energy sector. By combining hands-on projects, collaborative problem-solving, and direct engagement with industry leaders, the camp equipped students with technical skills and professional awareness, preparing them to address future challenges in sustainable energy. This paper outlines the program's framework, implementation, and outcomes, illustrating the integration of industry expertise in an academic setting to inspire the next generation of engineers.

Keywords

Renewable Energy Education, Integrative and Inclusive Approach, High School Summer Camp, University-industry Collaborations (UIC), Community Outreach, Project-based Learning, Sustainable Connected Communities

Introduction

University-industry collaborations (UICs) play a crucial role in shaping engineering education by integrating academic knowledge with real-world industry practices. These collaborations play a vital role of aligning curriculum with evolving technological demands, thus ensuring that students are better prepared for professional challenges upon graduation. UIC models include guest lectures, field visits, internships, and industry-sponsored capstone projects, and research sponsorships [1]. These partnerships are mutually beneficial, providing students with real-world applications of theoretical concepts and helping industries recruit and retain skilled engineers in fields such as power and renewable energy.

This paper builds on this premise by showcasing a successful example of UIC-driven experiential learning. At the heart of the 2024 Exploring Renewable Energy Engineering Summer Camp held at George Mason University was a dynamic partnership between academia and leading energy companies. Through hands-on, project-based learning modules and direct interaction with professionals in the energy sector, the camp provided high school students with a unique opportunity to explore career pathways in renewable energy while developing foundational engineering skills.

Summer Camp Overview

The summer camp was designed to provide a comprehensive, integrated educational experience, bridging academic concepts with practical applications in renewable energy engineering. By leveraging state-of-the-art facilities and project-based approaches, the camp ensured students gained both theoretical knowledge and hands-on skills necessary for future success in the power and energy sector.

The camp was designed with the following objectives:

- Develop Technical Skills: Provide students with hands-on experience in renewable energy engineering concepts, including energy generation, storage, and distribution.
- Enhance Problem-Solving and Teamwork Skills: Engage students in a collaborative project of building sustainable connected communities simulating real-world challenges.
- Foster Industry Connections: Introduce students to career pathways and opportunities through direct interactions with industry professionals and leaderships.
- Promote Renewable Energy Education among Underrepresented Minority (URM) groups: The camp hosted a diverse group of high school students from six school districts in the Greater Washington region.

Program Structure

The camp structure revolved around engaging and interactive activities tailored to immerse students in renewable energy technologies. From exploring the fundamentals of energy generation to participating in interactive hands-on labs and the group project, the summer camp offered a comprehensive learning experience. Daily activities integrated a balance of hands-on labs, interactive industry-based presentations and activities and group project work. The camp's daily schedule is illustrated in Table 1 below:

Table 1 Daily Camp Schedule

Time	**Activity**
09:45	Morning Welcome and Briefing
10:00	Lecture on Renewable Energy Topics
11:25	Hands-on Labs or Activities
12:40	Lunch Break
13:10	Guest Lectures or On-site Demonstrations
14:35	Team Project Work
15:50	End of Day Wrap-Up

Renewable Energy Lectures

Interactive lectures provided students with an overview of power systems, renewable energy technology and applications, smart grid advancement with an emphasis on sustainability and incorporation of hands-on learning instruction in the areas of solar and wind energy. Energy

fundamentals were presented detailing the modernization of our nation's power grids as we shift from one-way power flow to two-way smart grids with the ability to integrate distributed energy resources (DERs). State-of-the-art lab resources, including the Smart Grid and Renewable Energy Lab were introduced, demonstrating diverse research opportunities in power and energy analytics.

Solar and wind energy presentations provided students with understanding of renewable energy generation through both theoretical instruction and hands-on activities. Fundamentals of solar panel lectures provided details on sunlight conversion into electricity and the factors affecting efficiency with opportunities to experiment with lighting conditions, angle and such as angle, lighting conditions, and material composition. Wind energy instruction covered wind turbine design and optimization, introducing key concepts like blade pitch, material selection, airfoil design, and turbine efficiency.

Integrative Hands-on Labs

Students engaged in active learning and design thinking through interactive labs requiring real-world problem-solving skills [2]. Topics such as smart grids, solar energy, wind turbines as well as basic electrical engineering principles were explored.

Interactive lab simulation experiments on industry-grade training equipment brought students closer to the smart grid, covering transmission line concepts demonstrating varying load conditions, transmission efficiency and fault conditions.

Hands-on solar energy activates allowed students to investigate solar panels ultimately integrating them into a model tiny house. The solar panels were assessed under varying lighting conditions and angle relative to the light source. After investigating the available output voltage using a handheld multimeter, the panels were installed on the roof of the house with the ability to power a small fan inside. This process demonstrated real-world energy applications and sustainable home design.

Wind energy exploration focused on wind turbine design and optimization. In a hands-on wind turbine challenge, students built and tested unique student-generated turbine blade assemblies. A lab testing rig and handheld multimeters were used to evaluate the performance of the blade assembly under different wind conditions. This hands-on analysis provided valuable insights, allowing for design feedback and optimization to enhance efficiency. Ultimately, a combination of these student-designed and built turbine assemblies was incorporated into the sustainable connected community wind farm as a part of the off-shore wind demonstration.

These interactive activities help students apply iterative engineering design thinking principles [2], analyze real-world renewable energy challenges, and develop innovative solutions for sustainable power generation.

During student presentations one student indicated they learned everything they knew about electricity during the week. Without physics, they didn't know the difference between volts and

watts before they began. They remarked how fun it was to learn about energy and renewable energy. As one student noted, “the future’s really bright”.

Industry-Based Experiences

Students engaged with industry experts to develop domain knowledge in renewable power generation, transmission and distribution. Industry experts guided students through substation exploration making use of a scale-model and structural representations. Students interacted with full-sized solar panels, exploring their construction and taking real-time voltage measurements.

There were discussions regarding large-scale solar and wind energy development projects, including their growth and future in the U.S., specifically covering an offshore wind project underway in the Atlantic coastal region of Virginia. A VR session enriched the experience, allowing students to explore the windfarm in a simulated environment. Additional topics included the role of solar power in space.

Direct interaction with industry experts improves program relevance and enhances student engagement [1]. The camp-facilitated activities served to bridge the gap between education and practical real-world applications offering students valuable contextual insights related to renewable energy.

During the final presentation, students expressed it was not only the content they learned, but also the opportunity to speak to industry professionals they were thankful for, demonstrating the value of this interaction.

Group Project

A highlight of the program was the group project, where students worked in teams to design and build sustainable connected communities. The project encouraged creativity, critical thinking, and teamwork, culminating in final presentations showcasing their innovative design and solutions to an audience of peers, faculty, family, friends, and industry professionals.

Industry Panel

The program’s centerpiece was the industry panel, featuring representatives from AES Corporation, AWS, Dominion Energy, NOVEC, Hispanics in Energy, MPR Associates, and SHINE. Moderated by the leaderships of Dominion Energy and AWS, the panel provided valuable insights into the energy sector’s trends, challenges, and career opportunities. Students engaged in a Q&A session, deepening their understanding of the field and building professional connections.

Developing Sustainable Connected Communities

The group project was the "Sustainable Connected Communities" initiative. Students were tasked with designing a model community incorporating renewable energy sources such as solar panels and wind turbines, alongside energy-efficient buildings, green spaces, and sustainable

transportation systems. As shown in Figure 1, the sustainable connected communities include a residential community, an institutional community, a commercial community and an industrial community.

Figure 1. A framework of the connected communities

Students were presented with a scenario: a fictional town in southern Virginia aiming to secure a fictional $10 million grant to become a renewable energy demonstration town. They assumed roles such as engineers, environmentalists, town officials, and financial analysts, tasked with collaborating to develop a comprehensive proposal. Community demographics such as population, population density, household size and average energy consumption played a role in the decision-making process defining the sustainable connected communities. Key deliverables included energy-efficient housing designs, renewable energy policies, and necessary plans for integrating community resources required to achieve sustainability goals.

The project emphasized practical application. During discussions, students considered key community stakeholder perspectives in their proposal, researching potential real-life ramifications of their decisions. Students hypothesized realistic project implementation., designing energy-efficient homes using passive solar principles, and exploring strategies for reducing energy consumption. Final presentations showcased creative and data-driven approaches, with students defending their plans to a panel acting as the grant sponsors. Figure 2 is the photo of the sustainable connected communities built by the students.

Beyond the physical outcome, development of the sustainable connected community fostered creativity and imaginative thinking in the group, giving students the ability to express their ideas from multiple perspectives while iterating on solutions to hands-on technical problems in renewable energy [2].

One example of this iterative design process emerged when the group recognized that the planned data center would generate significant heat. Instead of viewing this as a challenge, they explored how to repurpose the excess energy, ultimately deciding to incorporate silicon and steel production facilities. This creative integration not only enhanced energy efficiency but also reinforced the interconnectedness of the community's infrastructure.

Figure 2. The sustainable connected communities designed and built by the students.

Camp Logistics

Camper Demographics and Recruitment

The camp hosted 14 rising 10th graders from diverse backgrounds, including underrepresented minority groups. There were five and nine female and male students, respectively. Recruitment efforts targeted six school districts, leveraging partnerships with local high schools and community organizations.

Leadership and Staff

The camp was led by a faculty member and supported by 24 industry professionals, two volunteers, two staff members, and three graduate students who served as instructors.

Student Feedback

A post-camp survey was conducted after the camp concluded. The survey included the following questions:

1) What are your top three favorite activities during the camp? You can choose among the main project and the following activities or presentations:
    a. Substation puzzle and drone inspection
    b. SHINE on-site demo (solar panel installation)
    c. Floating wind turbine project
    d. Overview of solar power by Dominion Energy
    e. Dominion offshore wind project
    f. Solar in space I
    g. Solar in space II
    h. Virtual reality—offshore wind and solar projects
    i. Sustainable Connected Community project
2) What aspect of the camp did you enjoy the most?
    a. Interactive sessions
    b. Presentations

c. Hands-on labs
d. Group projects
e. Panel discussions
f. Onsite demonstrations
g. Networking opportunities
h. Other (Please specify)

3) What suggestions do you have for improving future camps?

Although only two students submitted responses, the feedback was overwhelmingly positive. They highlighted the hands-on labs, industry panels, and the Sustainable Connected Community project as the most impactful activities. One key lesson learned was the importance of administering the survey before students left the camp. This adjustment will help ensure higher response rates and more comprehensive feedback in future camps.

Impact and Outcomes

Development of the sustainable connected community fostered creativity and imaginative thinking with students given the ability to express their ideas from multiple perspectives and iterate on solutions to hands-on technical problems in renewable energy. Through the project-based learning methodology coupled with university and industry interaction and support, students enhanced technical skills, teamwork, problem-solving abilities and ultimately industry readiness. Students engaged in learning as individuals, as a group of peers and with the renewable engineering community as a whole [3].

- Technical and Professional Skill Development
  The hands-on activities and industry interactions equipped students with both technical skills and professional awareness emphasizing critical thinking. Students demonstrated increased proficiency in renewable energy concepts, as evidenced by their group project outcomes and feedback from industry mentors.
- Networking Opportunities
  The inclusion of a high-profile industry panel and networking sessions created opportunities for students to connect with industry leaders. These interactions inspired students and provided a clearer vision of potential career paths in renewable energy engineering.
- Student Feedback and Recruitment
  Post-camp surveys [1] revealed overwhelmingly positive feedback. Students highlighted the engaging nature of the activities, the value of industry insights, and the opportunity to work collaboratively on a meaningful group project. Twelve of 14 students expressed newfound interest in pursuing careers in renewable energy engineering demonstrating the impact of the program.
- Academia-Industry Collaboration
  The camp exemplified the benefits of academia-industry partnerships [1]. Industry involvement not only enriched the educational content but also demonstrated the practical applications of engineering concepts, making the learning experience more relevant and impactful.

- Follow-Up Opportunities and Scholarships
  Two students demonstrated exceptional interest in renewable energy engineering and have since joined the faculty's research group to pursue further studies and research in the field pointing to success from two-way teaching [1] . Their participation underscores the camp's impact on fostering academic and professional growth [4].

  Additionally, the authors' institution received funding from an industry participant to support student scholarships at the next summer camp. These scholarships will help ensure broader access and inclusivity for future students, especially those from underrepresented backgrounds.

Conclusion

The 2024 Exploring Renewable Energy Engineering Summer Camp successfully demonstrated a model for integrating academic learning with industry expertise to prepare students for future challenges in sustainable energy. By combining interactive labs, project-based learning, and direct industry engagement, the camp created a dynamic environment, inspiring and empowering students. The holistic approach not only strengthened their technical competencies but also broadened their understanding of real-world energy challenges and career pathways.

This experience highlights, the potential of similar initiatives to cultivate technical skills, professional awareness, and a passion for renewable energy in the next generation of engineers. Such programs are essential for building a talented workforce capable of driving innovation and sustainability in the evolving power and renewable energy landscape. The energy and highlight of the camp are captured in a video [5] and a news article [6]. These resources showcase student projects, industry panel insights, and reflections from participants, providing a comprehensive look at how academia and industry can work together to inspire the next generation of engineers.

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