

AEESP Foundation Grant

Final Report

**Preparing our future scientists and engineers to advance
Sustainability at the Food-Energy-Water nexus**

The SAFE-Water Project

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1. Overview

The goals of the SAFE-Water Project were to **1)** introduce sciences, technologies and applications at the nexus of food, energy and water to K-12 students (ages from 11 to 16 years old) and teachers, especially women and underrepresented minorities, with the intention of heightening students' interest in pursuing higher education in Science, Technology, Engineering and Mathematics (STEM); **2)** provide the FAMU-FSU College of Engineering undergraduate students opportunities to develop their communication and leadership skills; **3)** create a platform for K-12 students/teachers and undergraduate students to receive education/career advice and support from experts in local universities, government agencies and industry. To achieve these goals, three workshops covering the topics of bioelectrochemical systems, groundwater remediation, water resources, and soil nutrient management were carried out between March and June 2019. During each of these workshops, our undergraduate engineering students (who received prior training from Dr. Simeng Li) served as tutors and mentors for our younger students. We have built up an advisory team of professors, scientists and engineers willing to share their expertise with all the students and teachers. We have also created a project website (<https://simengineering.wixsite.com/aeesp-safewater>), where all the contacts and updates are accessible to the public. According to our exit survey results, the SAFE-Water Project successfully motivated our participating students to consider becoming environmental engineers and scientists in the future.

2. Accomplished Tasks

2.1. Training undergraduate students

From January to February 2019, three Environmental/Civil Engineering undergraduate students (Lindsey Furrow, Pranav Muthuraman Geetha and Kyle Long) were trained by Dr. Simeng Li on a weekly basis to become familiar with the topics of bioelectrochemical systems, groundwater remediation, water resources, and soil nutrient management. With the funds from the AEESP Foundation Grant, the undergraduate team worked together and managed to **1)** build a microbial fuel cell reactor using everyday materials (e.g., soda bottles, cotton rope, aluminum wire mesh, etc.); **2)** construct a groundwater flow demonstration model; **3)** grow different plants (e.g., lima beans, radish and wheatgrass) in silica sand with/without the addition of biochar. Through the different workshops, the three undergraduate students were well trained in technical communication and public speaking to a wide variety of audiences. In spite of the completion of the SAFE-Water project, our undergraduate students will continue being the mentors and role models for our youth participants. They will also receive academic and professional advice and support from our advisory team of professors, scientists and engineers (please see Section 2.2).

2.2. Building up the advisory committee

An advisory committee consisting of local professors, scientists and engineers was formed for this project in January 2019. Members of this committee include Dr. Gang Chen from the Florida State University, Dr. Johnny Grace from the Florida Agricultural & Mechanical University, Dr. Liang Li from the Florida Department of Environmental Protection, and Mr. Cale Madden from Mott McDonald. Our committee members agree to share their contacts with all the participating students in this project and constantly provide advice and support for students' career development.

In order to facilitate the communications between participating students, teachers and our advisory committee, as well as to make this project visible and accessible to any interested public, a project website (<https://simengineering.wixsite.com/aeesp-safewater>) was built up in February 2019 and updated regularly thereafter.

2.3. The 1st Workshop

The first workshop was held on the FAMU-FSU College of Engineering campus and welcomed 34 students of 11 or 12 years old from the Richardson Sixth Grade Academy (RSGA) of Lake City, FL. The RSGA serves a diverse and underprivileged student population (approximately 40% African American and 9% Hispanic), with nearly 70% from low-income families.

Led by our undergraduate volunteers, the visiting students were divided into small groups to explore our Water Treatment Laboratory for undergraduate teaching. The children learned how groundwater contamination could happen because of leaky landfills and chemical spills, with the demonstrations using a groundwater flow model (Figure 1). They also learned from our undergraduate students the differences between in-situ and ex-situ remediation of the contaminated water. In small groups assisted by our undergraduate students, the children performed jar testing (consisting of the processes of coagulation, flocculation and sedimentation) to determine the optimal coagulant (alum) dosage for water treatment. After learning the brief mechanisms of sand filters, the groups of children used different materials such as wood chips, pebbles, gravels, sand, cotton balls and cotton balls to construct their own filters to purify the sedimented water samples. They discovered how they arranged the different filter layers could have significant influences on the performance of their filters. The children were surprised by how these simple physical and chemical processes could make hazy water look cleaner and cleaner. The children also learned different parameters (e.g., turbidity, pH, hardness, and color) for the evaluation of water quality, as well as the various devices for water quality analyses. When they used turbidimeters to analyze their samples of treated water, they were impressed at how the turbidity was lowered from several hundreds NTU to less

than five NTU. During their two-hour visit, all the children were highly engaged and asked many great questions about the real-world applications and emerging technologies for water and wastewater treatment.



Figure 1. Undergraduate student Pranav Muthuraman Geetha was explaining groundwater contamination and answering questions from RSGA students

2.4. The 2nd Workshop

For the second workshop, we invited a group of 28 female students (ages 12 to 14) from the Florida A&M University Developmental Research School (FAMU-DRS) and Florida State University Schools (FSUS) to visit our Hydraulics Laboratory for undergraduate teaching on the campus of the FAMU-FSU College of Engineering. In FAMU-DRS, 95% of the students are African American and 3% are Hispanic. While in FSUS, the total minority enrollment is more than 51%. Among the twenty-eight girls from FAMU-DRS and FSUS, twenty-one are African Americans.

The workshop began with the presentation by Dr. Simeng Li on the energies of flowing water in pressurized pipes. The students learned the different energy forms as well as the possible causes of energy losses in water supply systems (e.g., municipal mains). The students were then encouraged to discuss how the energy losses could be minimized to reduce energy consumptions for water supplies. All the students expressed high levels of engagement during the discussion. Some students were inspired by the topic of water-energy

nexus and proposed many creative ideas such as taking advantage of excess water pressure for energy recovery. After the discussion, the students gathered around the hydraulic flume and observed the phenomenon of hydraulic jump over weirs of different shapes (Figure 2). The students also learned how we can change the characteristics of the upstream flow by adjusting the tailgate at the end of the flume. The students were motivated to related these observations with real-world applications such as dams. Another discussion was initiated as to how a reservoir can be created with the operations of a dam for flood control, irrigation, municipal water supply, and other human activities. The workshop ended with an interactive game, in which the students made paper boats and let their boats sail in the flume as we changed the tailgate depths to create different flow conditions.



Figure 2. Students were observing hydraulic jumps in an open-channel flume

2.5. The 3rd Workshop

We incorporated four one-hour presentations introducing the sustainability at the food-energy-water nexus in the Advanced Placement (AP) Environmental Science classes for freshmen high school students (ages 14 to 16) at Leon High School (Tallahassee, FL). For each session, there were at least 20 students, making the number of our attendees nearly 100 in total. In Leon High School, 44% of the students are

underrepresented minorities (34% African American, 8% Hispanic and 2% Asian) and 26% are from economically disadvantaged families.

The presentation, given by Dr. Simeng Li and two undergraduate students from the FAMU-FSU College of Engineering, covered a series sustainability-related technologies including green energy/resource recovery using bioelectrochemical systems, groundwater remediation, water treatment, and soil amendment with biochar. We brought a microbial fuel cell reactor built with everyday materials, a groundwater flow model, and different plants grown in silica sand with/without biochar to the AP classroom to engage our young audiences (Figure 3). We introduced the concept of system thinking for solving the food-energy-water nexus issues, which was new to these budding engineers and was in alignment with the high school curriculum. As our collaborator AP teacher Ms. Colleen Graham wrote in our follow-up survey, “This ties to a lot of things we are talking about in class, including wastewater and sustainability. Our students learned a new way to think about things and the need for research and funding for environmental engineering.” For each session, we spared at least 15 minutes to answer questions from the students. The students were particularly interested in the applications of biochar and bioelectrochemical systems, and they kept raising their hands up to ask questions. To our surprise, 15 minutes was clearly not enough for us to answer all the awesome questions from these curious students. We encouraged all the students to visit our project website for more information and contact us whenever they need our help. According to Ms. Graham, hosting this presentation was a great dovetail and may also inspire her students to pursue a career in this field.



Figure 3. Dr. Simeng Li was giving a welcome remarks to the students at Leon High School

This event at Leon High School was reported by the FAMU-FSU College of Engineering. The story can be found on the College's website (<https://www.eng.famu.fsu.edu/news/simeng-li-AEESP>) as well as its Instagram page ([famufsucoeng](#)).

3. Conclusions and Future Prospects

The SAFE-Water Project was successfully completed. We organized three workshops entailing a variety of topics related to the sustainability at the food-energy-water nexus. We engaged diverse interactive activities involving nearly 150 students of different age, gender and ethnic groups. We also formed an advisory committee to continue advising and supporting all the participants (both students and teachers) in the future. A project website is accessible to the general public, which may further broaden the impacts of this project. According to our exit survey for our middle school and high school students, 96.4% of the students found this project very interesting and they had a great learning experience to know more about environmental engineering and science. In addition, 76.2% of the surveyed students indicated that this project motivated them to consider STEM majors in colleges because they are very interested in solving sustainability issues in the future. All the teachers collaborated with us spoke highly of this project and expressed that they would be absolutely interested in similar projects on a regular basis. The undergraduate students in this project also had the opportunity to learn new concepts and develop their communication and leadership skills. "The SAFE-Water project was fulfilling in a number of ways. It opened my eyes to a worldwide issue that is taking effect, furthered my public speaking skills (one of my weaker skills), and educated me on the other parts of the project covered by my teammates. Overall it was an enriching experience and I hope I am lucky enough to get involved with more projects like this in the future." said Pranav Muthuraman Geetha, one of the undergraduate leaders in the SAFE-Water project.

In the future, in addition to hosting workshops targeting K-12 students, it is equally important to tighten the connections with K-12 schools and train their teachers so that they can independently provide these activities and curricula in their classrooms.

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