Final project report titled, "Healthy Sustainable Buildings

Name of organization: Department of Civil and Environmental Engineering, University of South Carolina

Organization's address: 300 Main street, Columbia, SC 29208

Email for organization's contact: hoques@cec.sc.edu

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Report:

The project objective was to introduce K 12 students, to the concept of healthy sustainable buildings. It was designed based on the Next Generation Science Standards (NGSS) guidelines which state that the framework for three-dimensional learning should be such that science would be learned, not just as concepts and facts, but rather through the integration of disciplinary core ideas, science and engineering practices and crosscutting concepts. This project applied that principle to educate future generations about indoor environments, building design through considering sustainability, energy efficiency and health of occupants. The module had three components, 1) Field sampling, 2) Building Construction and 3) All about Universities. The first two components focused on students discovering the hidden world of microbes that live with us in our building spaces and understanding that engineering goes beyond physical safety. The third component introduced participating students to the University campus and the cutting-edge research Civil and Environmental Engineers do through visiting the College of Engineering at University of South Carolina. The funds from the AEESP Foundation grant were used for purchase of materials and supplies.

The outcomes of the project are 1) Students learn about the methods of collecting samples from air and for surfaces for bacteria and fungi, 2) Students learn about design and construction based on a given set of parameters and required performance metrics, 3) Students learn to take results from small scale tests and apply the knowledge in a larger scale, 4) Students learn about an array of instruments for measuring indoor environmental parameters such as temperature, humidity, flow rates and particle concentration and 5) Students learn to incorporate health parameters when designing and constructing buildings balancing sustainability and energy efficiency.

Field sampling: The project was executed in two high schools, 24 students participated in this portion, of which 70 to 75% were from minority and underrepresented groups. The PI kicked it off through a presentation and demonstration about indoor environments, ventilation systems, aerosols and included sampling protocol for collecting microbial samples and recording indoor air quality data.

Building Construction: This portion of the project was executed as a week-long summer camp, the GEAR UP (Gaining Early Awareness and Readiness for Undergraduate Programs) in collaboration with the International Baccalaureate (IB) Program at Richland Northeast High school in Columbia, SC. The camp was a summer bridge program designed to familiarize the students with certain expectations of the IB Science courses, in which they would be enrolled for the 2019-2020 school year There were 23 participants, of which 61% were female, 44% African American and 13% identified as Hispanic or Latino.

The camp was designed around constructing single room houses and testing the performance of built designs under two simulated weather conditions – hot/dry and cold/humid. It was executed in two steps. In the first step two undergraduate civil and environmental engineering students who received McNair Junior Fellowships from University of South Carolina (given to students who show potential in research and plans to pursue graduate school) planned the camp with instructions and guidance from teachers at the high school

and the PI. They designed the weather tents, tested material performance under different conditions, determined best range of measurements for students to both execute on time and obtain data for assessing performance as well as testing criteria. A range of materials and construction approaches were chosen from least to most sustainable (based on cost, manufacturing carbon footprint, recyclable or not) and least to most energy efficient (based on temperature maintenance indoors).

Once the camp was planned, on the first day, each group was given one weather condition to design for – and the criteria to adhere to, which were: 1) ensure indoor temperature and humidity are maintained and 2) ensure 'particle' number in the room did not increase or spread when outdoor and indoor particle sources are introduced. They were also provided with a range of building materials such as cardboard, Styrofoam, newspaper, old clothes, plastic wrap, aluminum foil, sealants, tape, hot glue etc. for construction and insultation. Each group was equipped with a humidifier, heat lamp, and a fan for simulating different weather conditions. Talcum powder outside the houses represented dust simulating outdoor source and fluorescent particles sprayed indoors simulated and indoor source such as a sneeze. During the design and construction phase students were asked to think what steps could be taken so that it would be energy efficient' i.e. locate the window at a height such that it receives maximum/minimum sunlight or choose a wall material that does not lose heat. For ensuring healthy indoors, students ascertained how their design fared in terms of keeping outdoor particle sources outside and control the dispersion of indoor sources. Over the next four days, students designed, constructed, tested, and assessed the performance of the 'house' for their given weather conditions as well as the alternative weather conditions for a range of parameters – outside wind speed (altered by blowing fans), outside temperature (number of lamps), and humidity (using humidifiers. Makeshift air conditioners were built from Styrofoam boxes and connected to the HVAC system incorporated inside each building using pool noodles.

[FIGURE- At the PI, Shamia Hoque's laboratory, planning phase]

[FIGURE – A constructed house prototype with makeshift air conditioning unit]

[FIGURE – PI, Shamia Hoque, students and the weather tent]

All about universities: One day of the week-long camp, was scheduled for a visit to the University of South Carolina campus by the participating students and teachers. It involved among other things, activities at the PI's lab. One activity involved identifying different microbes grown on plates created from samples collected from known locations. Students were asked to guess what those locations could be and what the species are based on a database of pictures and corresponding species as well as other pertinent characteristics, color, shape, size. The students enjoyed guessing locations! The other activity was to see the laser setup in operation in the PI's lab for capturing air and particle movement as a function of varying indoor environmental conditions. Besides visiting the PI's lab, students had the opportunity of touring the facilities at College of Engineering. The day culminated with a visit at the research symposium being held that day at the university. Their work was showcased through posters presented by the undergraduate students, McNair fellows at the symposium.

[FIGURE – PI, Shamia Hoque and the high school students during lab activity]

[FIGURE – At College of Engineering and Computing, University of South Carolina]

Impact

The projects were executed with a diverse group of students with majority of the students coming from under-represented and minority populations. Students expressed great enthusiasm and was very engaged for both portions of the project. It was evident also by parents' testimonies such as' "My son was not sure about engineering, but this project has definitely lit a fire for him". The GEAR UP camp also attracted higher proportion of female students. The PI plans to make this camp a yearly event expanding to other high schools and redesigning for middle school.

Contribution to the AEESP Foundation mission

AEESP Foundation states that their mission, "is to improve the state of knowledge in environmental engineering and science through support and encourage of excellent education, outreach and scientific research". The project fulfilled this mission and exposed 'budding' engineers to the 'humane' and 'social' aspect of engineering and was successful in generating intense enthusiasm among students as it showed how engineers can shape the future from a very personal viewpoint: the spaces we live in, our homes The numbers based on pre and post assessment surveys showed better perception about the role of environmental engineering in designing and constructing buildings and the importance of health as well as physical safety and sustainability.