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International Research Experience for Native American Students in IoT-Enabled Environmental Monitoring Technologies

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Abstract

Native American students were recruited from five Tribal Colleges in North Dakota to participate in a 5-week, National Science Foundation-funded summer research experience in Beijing, China. Goals of the broader, three-year program are to provide 12 students with the opportunity to obtain tailored knowledge, skills, and mentoring needed to understand, create, and apply Internet of Things (IoT)-enabled technology for environmental monitoring systems and obtain exposure to different sociocultural experiences. In the first year of the program, students participated in one week of preparation at North Dakota State University and four weeks of training at the Beijing University of Technology. Surveys and interviews conducted among the first-year cohort offers evidence that this international research experience provides students with unique, personal- and professional-growth opportunities. Participant responses specifically highlighted increases in globally-engaged perspectives, deepened comprehension of engineering techniques, and the enhanced peer-support skills. Experiencing, and successfully adapting to, the unique behaviors and traditions of an unfamiliar cultures builds social capital and confidence in individuals. Obtaining the ability to experience unfamiliar cultures, by eliminating physical, financial, and conventional barriers, helps seed ideas and insights on how these obstacles can be overcome in the future. In time, collective knowledge obtained from these learning experiences will provide new wisdom in the lives of the Native American student participants, their family and peers, and future students. Similar to all cycles in life: Providing opportunity seeds hope; hope nurtures motivation, and; motivation blooms change.

1. Activities

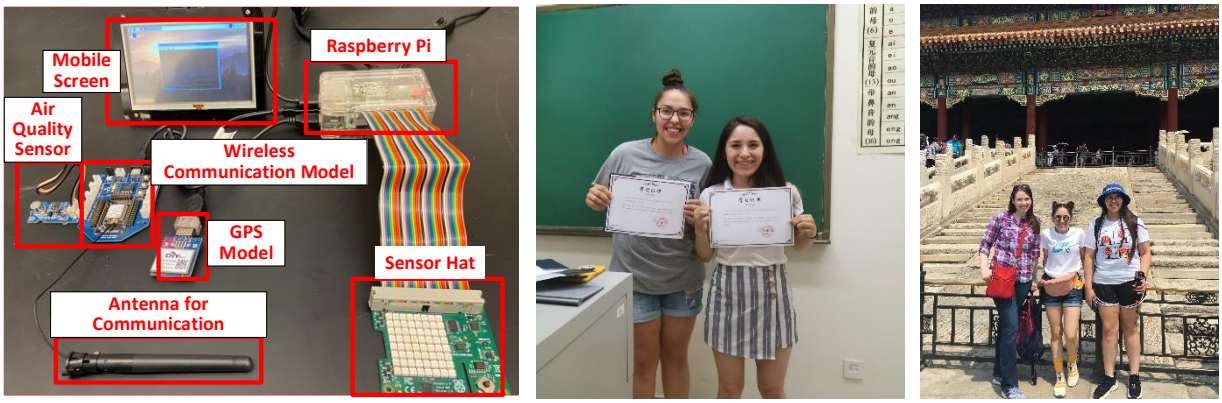
We completed the first year of the project. Two Native American students from Nueta Hidatsa Sahnish College (NHSC) joined the 5-week program. The students had preparatory training at North Dakota State University (NDSU), which focused on the basic knowledge about the program schedule, international travel information and precautions, IoT technology, and Chinese customs. When the students arrived at the Beijing University of Technology (BJUT), they studied how to develop IoT-enabled environmental monitoring systems.

At BJUT, the participating students received training in the eight specific topics of IoT technology [1-2]:

Training 1: Introduction to Embedded Systems.
Training 2: Introduction to Sensors for environmental monitoring system.
Training 3: Python Language and variable in Python.
Training 4: Data Collection using Sensors for an environmental monitoring system.
Training 5: Introducing and operating lists in Python.
Training 6: If statements and dictionaries in Python.

Training 7: User input and while loops in Python.
Training 8: Functions and classes in Python.

Student participants directly worked on sensor selections, sensor driver design, and interface circuits design. In environmental monitoring systems, the sensors are extremely important for directly collecting data and delivering the data to loggers or stations. In diverse environments and long-term monitoring applications, the performance, power consumption, size, cost, and reliability of sensors are the primary concerns. The students used the embedded system development board to try different sensors, discover how to drive sensors, and how to collect data from sensors. The sensors used included air quality sensors, pressure sensors, temperature sensors, and humidity sensors, in addition to a gyroscope, accelerometer, and magnetometer. As shown in Figure 1 (a), the system used Raspberry Pi as microcontroller and processor, and GPS and wireless communication models are added for position information and building network for data transmission [3-6].



(a) (b) (c)

Figure 1. (a) A developed IoT system, including microcontrollers, processors, sensors, screen, and wireless communication system; (b) Student participants being awarded a Certificate of Completion for BJUT Mandarin Chinese language study; and (c) Students participants during a culture tour of the Forbidden City in Beijing, China.

In addition to engineering applications, the students also studied the Mandarin Chinese language at BJUT. Every week, students had five days of Mandarin Chinese language classes. The Chinese language sessions helped the students better communicate with the Chinese mentors and students during the program, which effectively improved their designs and even gave them the capability for independent study in reading technical materials in Chinese. Studying of the Chinese language also opened the conversation to learn about the associated fields of Chinese politics, economy, history or archaeology. As a part of these critical conversations, the students were exposed to the Chinese culture and people. At the heart of the Chinese civilization is its rich heritage of novels, short stories, poetry, drama, and, more recently, film. The artistic pieces reflect the values, the struggles, the sensibility, the joys, and the sorrows of Chinese people, which often offers insights into even the most intimate feelings of people. These works help participating students understand what was behind the language, what makes the culture powerful, and how groups of people

actually function in Chinese society. To be at ease and effective in a Chinese environment learning the language is half the battle, but knowing about the culture behind the language completes the cultural puzzle. As shown in Figure 1 (b), two participating students were awarded the certificate for the Mandarin Chinese language study.

To provide tangible experiences for the students, several cultural activities and tours were organized. These cultural activities included visiting and touring the Forbidden City (Figure 1(c)), Great Wall of China, National Museum of China, Shijiatutong Museum, Temple of Confucius and Guozijian Museum, and China Red Sandalwood Museum. The students also participated in class to learn Chinese paper cutting. These experiences provided student participants with unique opportunities to learn a culture completely different than they had ever been exposed to before in the U.S., which enabled them to have gain a broader understanding of the world. Developing this broader understanding will aid in developing the student participants as individuals, as a group, within their communities, within society, and as globally-engaged citizens.

2. Educational Development in Engineering

Student participants gained new knowledge and engineering-based skills in 11 learning areas. Proficiency in the 11 learning areas were assessed formatively throughout the program by assembling and practicing on the metering device. A summative evaluation was also conducted by ensuring the students were able to use and explain device operation.

1) Understanding the control for air pressure sensor, temperature sensor, humidity sensor, gyroscope, accelerometer, and magnetometer.
2) Understanding the communication between Raspberry Pi and the Sense HAT using Python.
3) Being able to access the outputs of the Sense HAT.
4) Learning to program the inputs of the Sense HAT.
5) Using the Sense HAT library to display messages and images.
6) Using variables to store sensor data.
7) Using loops to repeat behaviors.
8) Using a computer or microcontroller to design and write programs, in addition to processing data from external sources, and controlling output devices that react to or alter their environment.
9) Combining and processing data from multiple sources to build a real-time system.
10) Using, and extrapolate values from, input data to make predictions about a system.
11) Using output devices to react to live data.

3. Survey and Interview Results

After students came back from China, they completed a survey and individual interviews. An example of five key survey questions and a summary of the answers provided are listed below:

1) ***Does this IRES program benefit your current study and future career? If yes, could you give some details and comments?***

Students expressed that IRES program gave them excellent experience to use computers and sensors to collect environmental data. There was also a mention that this IRES program helped them pursue their Environmental Science degrees.

2) ***Does this IRES program provide a unique globally-engaged chance for you to study abroad? If yes, what is most benefit from it?***

Students expressed that the most benefit from this IRES program is the opportunity to study abroad about something regarding the career path and study a new language and culture.

3) ***If you have participated other international program, what is difference between it and this IRES program?***

One student replied that this program is unique, because other study abroad program she had before was just for travel, but this IRES program included technology part. Also, this program granted a certificate for the work she accomplished at the Beijing University of Technology (BJUT).

4) ***Besides academic study, do you have culture study in this IRES program? Does such culture study benefit your life and future career?***

Both students were introduced to the Mandarin language and were able to form a better understanding of the Chinese culture. It will benefit their life by teaching them the ways of life of a different country, as well as help them to communicate well with others in different country.

5) ***Do you share this international study experience provided by this IRES program to other students? If yes, are they interested in this program? If not, do you plan to do that?***

Both students replied that they have shared this program with other students and recommended this program to their classmates to study abroad during the summer in Beijing.

4. Conclusion

This is an international learning experience that aims at being the key highlight of the academic careers of the Native American student participants, and possibility, the experience that will help shape their future professional lives. This opportunity is especially important for Native American students, as they have less opportunities for studying abroad. In the broader picture, the involvement in the program provides the participating students with unique cultural and educational opportunities and chances to build their international scientific networks. The recruitment of IRES from the five North Dakota Tribal Colleges ensures a diverse student group to receive international mentoring and research-based education.

In many big cities of U.S., there are environmental problems similar to Beijing, so the monitoring technology learned by participating students brings valuable reference and an essential technology reserve. Many Native American Reservations are in very rural locations; learning to use this technology is an asset especially to Environmental Science students who wish to do research on their homelands. This IoT gives them a tool that they can use to answer research questions pertaining to their tribal lands, which is essential in their participation in scientific research. These students also learn the value of cultural exchange and how that applies to networking, which is a critical communication skill for any scientist. In time, collective knowledge obtained from these learning experiences will provide new wisdom in the lives of the Native American student participants, their family and peers, and future students.

Acknowledgement

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Reference

[1] R. Ge, Z. Lin, N. Gong, and J. Wang, "Design and Performance Analysis of Energy Harvesting Sensor Networks with Supercapacitor," *IEEE 60th International Midwest Symposium on Circuits and Systems (MWSCAS'17)*, 2017, Boston, MA, USA, pp. 64-67.

[2] H. Pan, R. Ge, J. Wang, N. Gong, and Z. Lin, "Integrated Wireless Sensor Networks with UAS for Damage Detection and Monitoring of Bridges and Other Large-Scale Critical Civil Infrastructures," *NDE/NDT for Highways & Bridges: Structural Materials Technology 2016*, Portland, OR, USA.

[3] R. Ge, H. Pan, Z. Lin, N. Gong, and J. Wang, "RF-Powered Battery-less Wireless Sensor Network in Structure Monitoring," *IEEE 2016 International Electro-Information Technology Conference (EIT'16)*, 2016, Grand Forks, ND, USA, pp. 547-552.

[4] D. Chen, J. Edstrom, X. Chen, W. Jin, J. Wang, and N. Gong, "Data-Driven Low-Cost On-Chip Memory with Adaptive Power-Quality Trade-off for Mobile Video Streaming," *IEEE/ACM International Symposium on Low Power Electronics and Design (ISLPED'16)*, 2016, San Francisco, CA, USA.

[5] Y. He, S. Geng, X. Peng, L. Hou, X. Gao, and J. Wang, "Design of Outdoor Air Quality Monitoring System Based on ZigBee Wireless Sensor Network," *IEEE 13th International Conference on Solid -State and Integrated Circuit Technology (ICSICT'16)*, 2016, Hangzhou, China.

[6] J. Edstrom, D. Chen, J. Wang, M. McCourt, and N. Gong, "Luminance Adaptive Smart Video Storage System," *IEEE International Symposium on Circuits and Systems (ISCAS'16)*, 2016, Montreal, Canada, pp. 734-737.