An Outreach Program for Introducing Nuclear Power through Training STEM Educators

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Abstract

This paper describes development and implementation of a collaborative outreach effort that involved a nuclear-themed workshop for STEM educators and subsequent outreach activities at regional schools in North Texas. The goal of the workshop was to introduce nuclear power, emphasize related energy conversion process, and familiarize the participants on the instrumentation and control aspects that have broad applications including nuclear. The workshop featured carefully developed lectures, as well as lab/in-class demonstrations and a hands-on project involving parts integration, coding, and testing. Thus, besides disseminating the fundamental knowledge on nuclear power, the workshop had appealing and meaningful elements that educators can use to encourage students towards STEM field in general. Following the workshop, educators implemented the modular lessons into their curriculum, and reached out a diverse student population in North Texas at high, middle, and elementary school grades at their institutions.

Introduction

As reported in the widely cited, comprehensive National Academies study[1], the number of U.S. engineering students pursuing STEM careers has been declining, and therefore causing a shortage of new talent and threatening future U.S. prosperity. Similarly, the nuclear field has challenges in terms of attracting and developing talent, and particularly, nuclear power industry faces difficulties for maintaining a positive outlook in the public's eye and replacing the current aging workforce, despite its unique advantages and strategic importance in the nation's energy mix.

The University of North Texas (UNT) aspires to serve the greater North Texas and the nation by continuing to train a qualified workforce for the STEM fields including nuclear industry. Over the years, UNT has collaborated with the Nuclear Power Institute, a statewide partnership led by the Texas A&M Engineering Experiment Station and headquartered at the Texas A&M University, on several programs to offer Nuclear Power Technology certificates through online courses, provide Systems Engineering Initiative with industry-inspired nuclear-themed engineering projects for undergraduate researchers, and conduct online summer STEM camps.

Most recently, in summer 2022, the authors developed and implemented a collaborative outreach program for introducing nuclear power. The outreach program had two phases, including (1) a nuclear-themed workshop for STEM educators and (2) subsequent outreach activities at high, middle, and elementary schools in the region. Therefore, this outreach effort applied the train-the-

trainer approach, which can be defined as a framework that aims to educate selected participants on a subject matter to enable them to teach other members of their organization, and has been utilized effectively in many settings.[2-5]

This paper describes the overall outreach program and related activities, and outlines its impact on students.

Development and Implementation of the Outreach Program

Nuclear-Themed Workshop for STEM Educators

A one-day workshop was developed with a theme "Introduction to Nuclear Power: Energy Conversion, Instrumentation, and Control" for 15 educators from the high, middle, and elementary schools in the region. The goal of the workshop was to introduce nuclear power, emphasize related energy conversion process, and familiarize the participants on the instrumentation and control aspects that have broad applications including nuclear. The workshop featured carefully developed lectures, as well as lab/in-class demonstrations and a hands-on project involving parts integration, coding, and testing. Thus, besides disseminating the fundamental knowledge on nuclear power, the workshop had appealing and meaningful elements that educators can use to encourage grade school students towards STEM field in general.

Specifically, the workshop covered the following topics:

- Nuclear Energy, Fission, Chain Reaction, Nuclear Fuel
- Nuclear Reactor, Nuclear Power Plant Systems, Waste from Nuclear Power Plants
- Thermal-hydraulics Measurements and Instrumentation for Temperature, Pressure, and Flow
- Hands-on Lab Demonstration with Power Cycle Application: The Rankine Cycle Operation
- Introduction to Microcontrollers, Arduino Boards
- Introduction to Programming using Arduino Language
- Hands-on Project with Microcontroller Application: Nuclear Power Plant Monitoring

The workshop incorporated lectures emphasizing practical and relatable examples, in-class discussions, and use of associated hardware and software.

The workshop started with reviewing energy sources and U.S. energy facts, and gradually introduced basics of nuclear energy, fission, chain reaction, and nuclear fuel. Then, nuclear power aspects were covered by explaining common nuclear reactors (pressurized water reactor (PWR)), nuclear power plant systems enabling conversion of energy from nuclear to thermal to electrical, and discussing waste from nuclear power plants. The lectures leveraged DOE's relevant educational resources[6] and integrated active discussions on the current nuclear issues. The workshop allowed educators to review common thermal-hydraulics measurements for temperature, pressure, and flow, and experience use of the relevant instrumentation. The workshop involved a hands-on lab demonstration with the Rankine cycle unit resembling a typical thermodynamic vapor power cycle used in nuclear power plants. During the lab session, participants had a chance to operate the system and test various operating parameters.

The workshop's second half focused on control aspects and started with discussing microcontrollers and their broad applications, and introduced Arduino boards. Then, the workshop included a lecture on coding with Arduino by using simple examples such as turning an LED on and off, so educators got familiar with the program language and the use of its integrated library. During the hands-on project session, each participant was provided a hardware kit (Arduino UNO and several sensors modules). They worked on integrating parts, creating codes for Arduino microcontroller, and running their systems using sample coding. After being exposed to hardware and software, they used a system featuring a 3D printed model of a nuclear power plant with an electric/battery powered heater, temperature and pressure sensors, and LED lights changing intensity based on temperature levels, where they can automate the system and shut down the plant to avoid issues.

Educators in the region (approximately within 90 miles radius of Denton, TX) were contacted early in summer for proper planning, and points of contacts included school principals or science teachers UNT recently collaborated with during previous UNT summer camps. They were provided with a flyer describing the workshop, agenda, and requirements. After the participating educators were identified, contracts were prepared and executed with each educator per the sponsor guidelines. The workshop took place on July 21, 2022 at the UNT Department of Mechanical Engineering located in the Discovery Park Campus, utilizing a classroom equipped with computers and the Thermal-Fluid Sciences Lab. Educators attended four sessions led by the authors in the morning and afternoon, including lectures as well as lab/in-class demonstrations and a hands-on project. Finally, the workshop had group brainstorming sessions on development of curricular modules and strategies for practical implementation.

Outreach Activities at Regional Schools

After the workshop, the participated educators planned and delivered lectures to students and fellow educators in their schools at the beginning of the semester in August based on the knowledge they gained from the workshop. They also utilized the provided lecture notes, hardware kits and codes, and implemented the discussed strategies. Educators then prepared a brief report outlining the demographics of the attendees in their lectures, shared their observations, and submitted the report to the program organizers.

Based on the collected data, STEM educators participated in the workshop eventually reached out to 780 students at their institutions ranging from 3rd grade to 12th grade levels, as shown in Figure 1. Majority of those students (74.9%) were in high school, while 7.9% and 17.2% were in middle and elementary schools, respectively.

Reports also provided insights on student demographics in terms of gender and ethnicity distribution, as shown in Figure 2. Data indicated the following distribution (a) by gender: Female 354 (45.4%), Male 426 (54.6%), and (b) by ethnicity: White 360 (46.2%), Hispanic/Latino 278 (35.6%), Asian 68 (8.7%), Black 58 (7.4%), and Other 16 (2.1%).

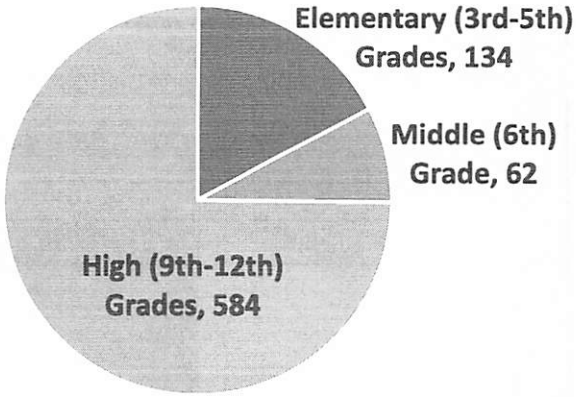

Figure 1. Student distribution per grade level reached out by the STEM educators.

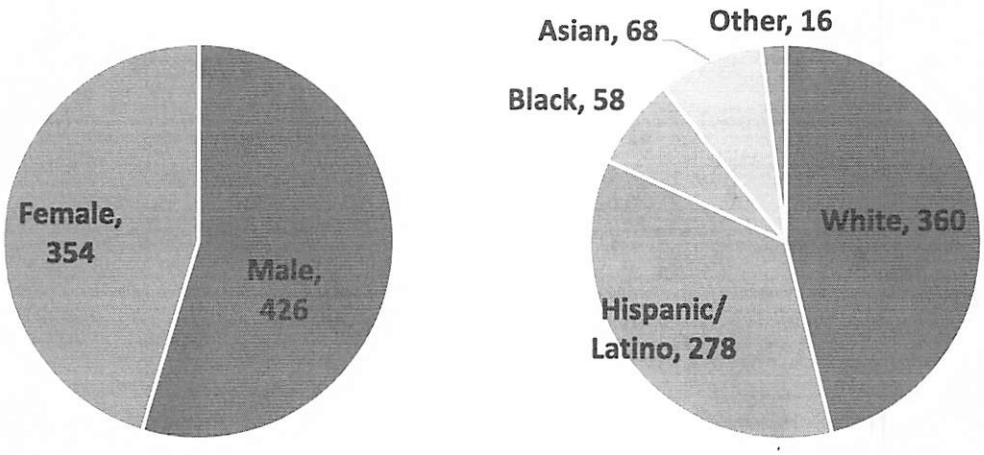

Figure 2. Student demographics by gender and ethnicity reached out by the STEM educators.

Overall, participants stated they enjoyed the workshop and provided positive and encouraging comments. An online survey was also conducted after the workshop to better understand its impact and collect additional feedbacks. As part of the survey, teachers were asked to provide their level of familiarity (a) with the nuclear power and thermal-hydraulics instrumentation, and (b) with microcontrollers, Arduino, and programming. The participants of the survey (10 teachers) were all in agreement (very familiar/familiar) about gaining knowledge about the workshop material.

Summary and Conclusions

An outreach program was developed and implemented through UNT's continued partnership with the Nuclear Power Institute to offer a nuclear-themed workshop designed for educators to eventually facilitate training of students in North Texas and introduce them basics of nuclear power, associated energy conversion process, instrumentation, and control aspects. The program reached out to a diverse group of 780 students ranging from 3rd grade to 12th grade and was impactful in raising awareness and interest in STEM field.

Acknowledgement

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