Online Nuclear Power Summer Institute and Day of Science: A two-pronged approach to increasing girls and under-represented minorities towards STEM careers

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Online Nuclear Power Summer Institute and Day of Science: A two-pronged approach to increasing girls and under-represented minorities towards STEM careers

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Abstract

In July 2020, during the height of the COVID-19 pandemic, a team of interdisciplinary faculty from chemical engineering, electrical engineering, physics, NASA, and a local community organizer conducted a highly successful Nuclear Power Summer Institute [NPSI] online "virtual summer camp" for five days. Participants included 37 high school students and four teachers from schools within approximately 50 miles of Prairie View A&M University [PVAMU]. Approximately 90% of the students were underrepresented minorities in STEM. The participants learned about the nuclear industry, careers, myths, radiation, nuclear physics and chemistry, and a mathematics refresher, among other topics.

A key element for the virtual camp was that students were sent a kit of carefully selected educational tools to participate in various hands-on activities at their homes. The students kept daily journal
entries of their camp experience and participated in a group competition to capture the elements of what they had learned during the camp in a video. The video competition was judged by a group of elementary and middle school girl students that participated in a parallel Day of Science on the last day of the institute. The young girls were members of a local non-profit organization called "A Message of Love" [AMOL]. This organization's mission is to invest in the whole girls: spiritual, social, emotional, physical, and intellectual. The targeted focus of AMOL's partnership with PVAMU was the intellectual element to expose more minority girls to STEM. Guest speakers included Dr. Roy Elmore, a deputy division leader with the US Department of Defense; Dr. Craig Marianno, assistant professor in nuclear engineering and Deputy Director Center for Nuclear Security Science and Policy Initiative (NSSPI) at Texas A&M University; and special guest NASA Astronaut Captain Stephen Bowen who served on a US Navy nuclear submarine - the first submarine officer selected for the astronaut program with three missions to the ISS. The post-camp NPSI survey results from the high school students indicated a 95% increase in understanding of nuclear science. In July 2021, the Nuclear Science Summer Institute was shortened to two days online and the Day of Science was held separately face to face.

Our paper describes the methods used to transform what was initially planned as a face-to-face summer camp on the PVAMU campus to an effective virtual format in response to the pandemic. We describe the elements of the kit sent to students and how these were used to engage and teach STEM concepts in general and nuclear science and engineering concepts in particular to high school students. We also present the advantages, disadvantages, and data related to the success of the virtual camp.

**Introduction**

Under-represented minorities have grown in population to make up to 30% of our demographics yet are not proportionally matched in higher education. It is critical to our country's economic success to ensure the participation of women and under-represented minorities at graduate schools and entrance into the job market with technical skills\(^1\). Research has shown that participation in a STEM-based summer program increases the admission of students into STEM-based careers\(^2\). High school students with hands-on experiences with a STEM-focused summer experience had a 61% of graduating college with a STEM career \(^3\). There were several other virtual camps concentrating on nuclear power and related science and technology during 2020\(^4-7\).

However, to the best of our knowledge, these camps did not have a specific focus on under-represented minority students, did not have the interactions between high school students and younger students, did not have the participation of a local community organization, and/or did not recruit regionally like our camp. In addition, the other institutions supported by the Texas NPI held virtual STEM camps in summer 2020, but did not focus on specific nuclear related topics.

The goals of the NPSI were to increase the high school student's knowledge of the nuclear industry and increase their interest in STEM. The highlights of the NPSI/Day of Science event included the high school students reporting that they had a significant increase in their knowledge of nuclear science and their interest in physics. The Day of Science also had feedback that 76% of the
participants had increased their liking of science, and 95% would like to come back to another Day of Science event.

**Two-Pronged approach: Day of Science and NPSI**

Introducing science concepts to young girls and involving them in hands-on activities increase their interest in STEM. The Day of Science is one prong towards increasing women and underrepresented minorities in STEM careers. It is accomplished by sharing the joys of science with hands-on activities with young elementary and middle school girls from the local community surrounding Prairie View A&M University. For the past three years, young girls have been involved in the Day of Science, and their feedback was positive and encouraging to continue.

The second prong is the high school students NPSI online initiative that involves multiple teaching methods, including lectures, hands-on activities, guest speakers, homework, and interactive question and answers. The NPSI is aimed at under-represented minorities boys and girls from local high schools around PVAMU. Increasing women and under-represented minorities are to be achieved by having the young and older students in a pipeline of participating in yearly scientific activities with follow-up feedback for program improvement.

![Figure 1. Day of Science and NPSI to feed into a pipeline to increase the number of women and underrepresented minorities in STEM careers.](image)

**Mentors**

The interdisciplinary team of mentors had included:

- Tierasha Adair, Founder, A Message of Love (AMOL) Inc., community liaison with local schools [PVAMU Alumni]
- Brad Gersey, Ph.D., Research Scientist Leader, NASA PVAMU CRESSE

*Proceedings of the 2022 ASEE Gulf-Southwest Annual Conference*

*Prairie View A&M University, Prairie View, TX*

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NPSI/Day of Science 2020

NPSI
The NPSI in 2020 was an online five-day summer learning experience. To attract high school students to NPSI, our strategy involved marketing, recruiting, and ensuring we had involvement from parents for legal matters such as the students' indemnification forms and photo releases. Marketing had included developing a webpage [http://www.geocities.ws/npsi/index.html], a Qualtrics survey to collect the submitted data, a flyer and recruitment letter, as well as a social media blast. Recruiting had involved identifying high schools in the area and email blasts to students and parents. The schools that participated in the program are shown in Figure 2 below.

![Figure 2. Distribution of high schools that had students participate in NPSI.](image-url)

The flyer was sent to high schools and social media, shown below in Figure 3. It stated the program description, goals, expectations, and the mentors. There was also a website for students to apply to the program.
Figure 3. The flyer was used for recruiting, involving who we were and our goals for NPSI.

Our high school students had a gender distribution of 31% male to 69% female. Of the 37 students, 62% were Black, 27% were Hispanic, 5% were White, and 6% were Asian American and Other. The ethnic distribution is shown in Figure 4 below,

Figure 4. Ethnic distribution for high school participants
For the hands-on activities, we had given the students a string backpack with various items:

- poster of the periodic table
- poster of the EM spectrum
- notebook/pen
- balloons
- UV beads
- Irradiated salts
- Electromagnetic meter (EMF) meter to measure non-ionizing radiation
- UV pen to help demonstrate energy levels through fluorescence
- Globe stress ball to discuss nuclear-capable countries and location of fusion projects

A few of the items listed here are shown in Figure 5 below.

![Figure 5. Items sent to students for hands-on activities.](image)

The NPSI curriculum included the following topics: nuclear physics, radiation, mathematics review, nuclear chemistry, myths about the nuclear industry, and careers in the nuclear industry. The methods utilized in teaching these topics included: Lectures, Hands-on activities, Competitive team project videos, Videos, Homework, and Daily journaling.

As the online topics were taught, various pictures of the students engaging with the mentors were taken, it was interesting to note how curious the students were, and the nature of their questions and comments were quite inquisitive. Pictures of students engaging with their mentors during these zoom lectures are shown in Figures 6 and 7 below.
Hands-on activities engaged the students with the topics that were being discussed. The hands-on activities used the EM meter with various household appliances, such as the laptop, microwave, washing machines, both on and off and at distances to see how far the EM field the appliance was emitting. An example of this is shown in Figure 8 below.

Another hands-on activity was the UV beads that had changed color when taken outside. This activity had generated much excitement among the students, as they could see in their hands the power of UV light. This demonstration is captured in Figure 9 below.
Figure 9. Shining a UV penlight on the white UV beads activated the UV-sensitive polymer to change color.

Guest speakers

In addition to the interdisciplinary mentors, NPSI also had guest speakers from the nuclear industry and NASA to add to their learning experiences.

• Academia: Craig Marianno, Assistant Professor, Deputy Director Center for Nuclear Security Science and Policy Initiative (NSSPI), Texas A&M University
  o Research interests include: Nuclear Counter-Terrorism, Nuclear Instrumentation Development, Exercise Development, Radiological Consequence Management, Environmental Health Physics
• Defense sector: Roy Elmore, Deputy Division Leader, Department of Defense
  o Research interests include: Nuclear Nonproliferation, International Safeguards, Nuclear Forensics, Technology, and Policy Integration
• NASA: Astronaut Stephen G. Bowen,
  o First nuclear submarine officer to be selected as an astronaut, veteran of STS-126,132,133, and logged more than 40 days in seven spacewalks

The students were engaged with our guest speakers and were asking many questions. A screenshot of the students listening to Astronaut Bowen is shown in Figure 10 below.
Figure 10. NASA Astronaut Bowen discussed his path to space from childhood with ardent listeners; both students and mentors were engaged. Astronaut Bowen is pictured in a yellow frame above.

**Group video competition**
The high school students were split into five groups and were asked to produce a video explaining a topic from their week of learning about the nuclear industry on the fifth day of their five-day online experience. These group videos were a competition, and the judges were the young girls from the Day of Science.

**Day of Science**
They had also participated in various hands-on experiences and had joined the older students to watch the videos on the fifth day and decide which video they liked the best. It was impressive to see the creativity and knowledge of our high school students after just four days of participating in NPSI. The videos created by the students can be seen at this link: [https://www.youtube.com/playlist?list=PLDICXVPAgfGfFtubnCsMTvZU-fbMMpCvO](https://www.youtube.com/playlist?list=PLDICXVPAgfGfFtubnCsMTvZU-fbMMpCvO).

A screenshot of the younger participants from the concurrent Day of Science is shown in Figure 11 below.

Figure 11. Screenshot of the younger girls of the Day of Science judging the videos from the older high school students of NPSI. The founder of AMOL is highlighted in the yellow frame above.
Student Feedback

To understand the effectiveness of our online institute, we had given students a brief survey asking them to rate their knowledge and likelihood of specific preferences pre and post the five-day summer institute. The data is shown in Table 1 below.

<table>
<thead>
<tr>
<th>On a scale of 0-10 [0 is low, 10 is high], how do you feel about:</th>
<th>↑% Diff</th>
</tr>
</thead>
<tbody>
<tr>
<td>How interested are you in STEM?</td>
<td>13%</td>
</tr>
<tr>
<td>How much do you know about nuclear science?</td>
<td>95%</td>
</tr>
<tr>
<td>How interested are you in attending college after graduating high school?</td>
<td>12%</td>
</tr>
<tr>
<td>How interested are you in physics?</td>
<td>17%</td>
</tr>
<tr>
<td>How interested are you in attending PVAMU for college?</td>
<td>17%</td>
</tr>
</tbody>
</table>

The students had a 95% increase in their self-assessment of their knowledge gained after five days of NPSI. This increase was especially encouraging to the team of mentors. The students also increased 17% in their interest in physics and attending PVAMU. The goals were to increase students' knowledge of the nuclear industry and increase their interest in STEM. These survey results indicate that the goals were met.

Discussion

According to the students' responses in both groups, this initiative increased their interest in science. Significantly in physics, for the NPSI high school students and the young girls in the Day of Science group. It is interesting to note that some students wished for longer days for the NPSI event in 2021. It was five days long in 2020's NPSI virtual event.

The mentoring team knew each other for over 20 years, and had worked so well with each other the trust between the mentors contributed to the success of the program, with each of the mentors contributing to the success of each other. This extraordinary collaboration was conducive to the remarkable results of this program.

Summary and Conclusion

The feedback from the students was encouraging as it gave us evidence that this event with lectures and hands-on activities made a positive impact on both age groups of students. Future goals include organizing three Days of Science events in one year and a week-long summer NPSI event. We will be tracking the feedback data of these students as they progress in high school/college. Our long-term goals are to increase the number of women and under-represented minorities into STEM careers and pursue those STEM careers at PVAMU. These goals result in women and underrepresented minorities contributing their technical skills to our future challenges.
References


MERLYN X. PULIKKATHARA, assistant professor in physics. Her research involves nanomaterials for aerospace, environmental and biomedical applications.

TIERASHA ADAIR, the founder of A Message of Love, is an author of children's books and leads a ministry.

RICHARD T. WILKINS, Professor in Electrical and Computer Engineering, Director of NASA Center for Applied Radiation Research and CREESE.

IRVIN OSBORNE-LEE, Professor in Chemical Engineering, involved in funding efforts towards increasing under-represented minorities in STEM, including the Louis Stokes STEM Pathways & Research Alliance (TAMUS LSAMP-RA), Nuclear Power Institute (NPI), Nuclear Forensics at Minority Serving Institutions (NFMSI),

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