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Harper Academy All Stars: a summer program aimed at improving diversity, innovation, and interest in the nuclear engineering technologies

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Introduction

Nuclear energy systems development has gained new momentum in recent years as the need to decarbonize our energy systems increases, advances in reactor design quicken, and large-scale implementation of fusion energy systems becomes more plausible [1]. While the nuclear industry has long sought to increase its workforce, the United States' recent commitment to triple its nuclear capacity by 2050 has intensified this need [2]. National Labs and the private sector alike seek employees with nuclear and nuclear-related expertise, even as student and public interest remains somewhat lower than other engineering disciplines and careers [2]. At the same time, the nuclear community continues to seek a diverse workforce, knowing that diversity improves work quality and innovation across project teams and organizations. Nuclear engineering as a discipline has also committed to, in recent years, rectifying injustices of the past, where minoritized communities were taken advantage of or harmed by way of nuclear research and development [3]. All of these forces combine to shape an engaging but challenging space for workforce development. This paper provides an overview of a pilot project aimed at attracting a diverse group of young people to the nuclear sector through the development of a nuclear-focused summer academy for high school students.

The Harper Summer Academy is a 4-week summer program for rising high school juniors located at a large research university in the Midwest. Summer 2024 marked the inaugural year of the residential program, during which a group of eight students (four male and four female) learned about nuclear engineering and radiological sciences from faculty and other experts in the field. By all accounts, the program was a success, and plans to double enrollment for summer 2025 are in progress (applications increased fourfold for summer 2025). The sections below provide additional background information about the program, an overview of curriculum development, and a discussion of initial outcomes (including student perspectives), conclusions, and plans for future work.

Background

This summer academy was many years in the making, originating as the dream of Jeff Harper, an executive from X-energy engineering firm and a veteran in the field. As an underrepresented minority, Dr. Harper is keenly interested in making nuclear engineering more inviting and engaging to a wide range of workers. Notably, most students in the United States tend to learn about nuclear energy by way of disasters like Chernobyl or acts of war like the bombs dropped on Hiroshima and Nagasaki, Japan, during World War II. Indeed, public sentiment on nuclear power is evolving, but many people are still fearful of nuclear energy or generally confused about how the technology works [4]. Public engagement plans and K-12 initiatives have been launched or are under development to address these concerns [5]. But much work remains. Thus, working with university faculty members, a small-scale plan to increase interest in nuclear energy among high school students began to emerge several years ago. With funding from the university and external sources, the summer academy became a viable option, and planning began in earnest approximately six months prior to the program's mid-July 2024 start. While the summer academy was affiliated with the university's nuclear engineering department, the plan was for the university's Office for Culture, Community, and Equity (OCCE) to administer the program. Each summer, this office hosts a series of camps and academies for middle and high school students across various STEM disciplines, making it a logical fit to collaborate on the academy framework and design. At four weeks in length, the Harper Academy is the longest OCCE offers, and it features a somewhat smaller cohort of students than other summer programs. A team of ten faculty and staff members from the university, primarily from the nuclear engineering program, was recruited to develop the curriculum. Notably, accepted students were not required to pay to participate in the academy. Instead, each student was offered a stipend for their participation and program completion.

Curriculum

The summer academy featured a mix of daily college-like courses, lab visits, enrichment activities, and project-based work. The content was designed to fit into a series of modules, with coursework and learning activities running from 8:00 a.m. to 3:00 p.m., Monday through Friday. Classroom topics included nuclear energy basics (both fission and fusion), radiation detection, math, physics, technical writing, and community-engaged design. Instructors were encouraged to develop engaged or immersive learning activities rather than relying on lecture-based lesson plans.

Importantly, teaching high school students presents a somewhat different set of challenges and opportunities compared to teaching college students. Therefore, advisors from OCCE collaborated with the academy instructors to develop lesson plans that better aligned with high school students' frameworks of knowledge and attention. Leading up to the academy, students were also asked to complete a short survey to gauge their experience with math and physics topics so instructors had a clear starting point for their lessons. Complex subjects, such as physics and math, were scheduled during morning sessions when students' attention was at its strongest. Afternoon learning modules focused on communication, design, community engagement, or similar topics that tend to be more active. As reflected in one program participant's experience: "I particularly enjoyed having a graduate student as our instructor for the math section of the curriculum. Despite teaching Calculus, a topic we had no familiarity with, his instruction was fast-paced, but digestible, and tailored to high school students' learning style. The physics and math was challenging, but became more approachable due to the smaller cohort size, allowing for lessons to be more individualized, ensuring that each student grasped topics to the best of their ability. The thoughtfully structured schedule helped to reinforce information, with the interactive activities, such as lab tours, reflecting what we learned in class. "

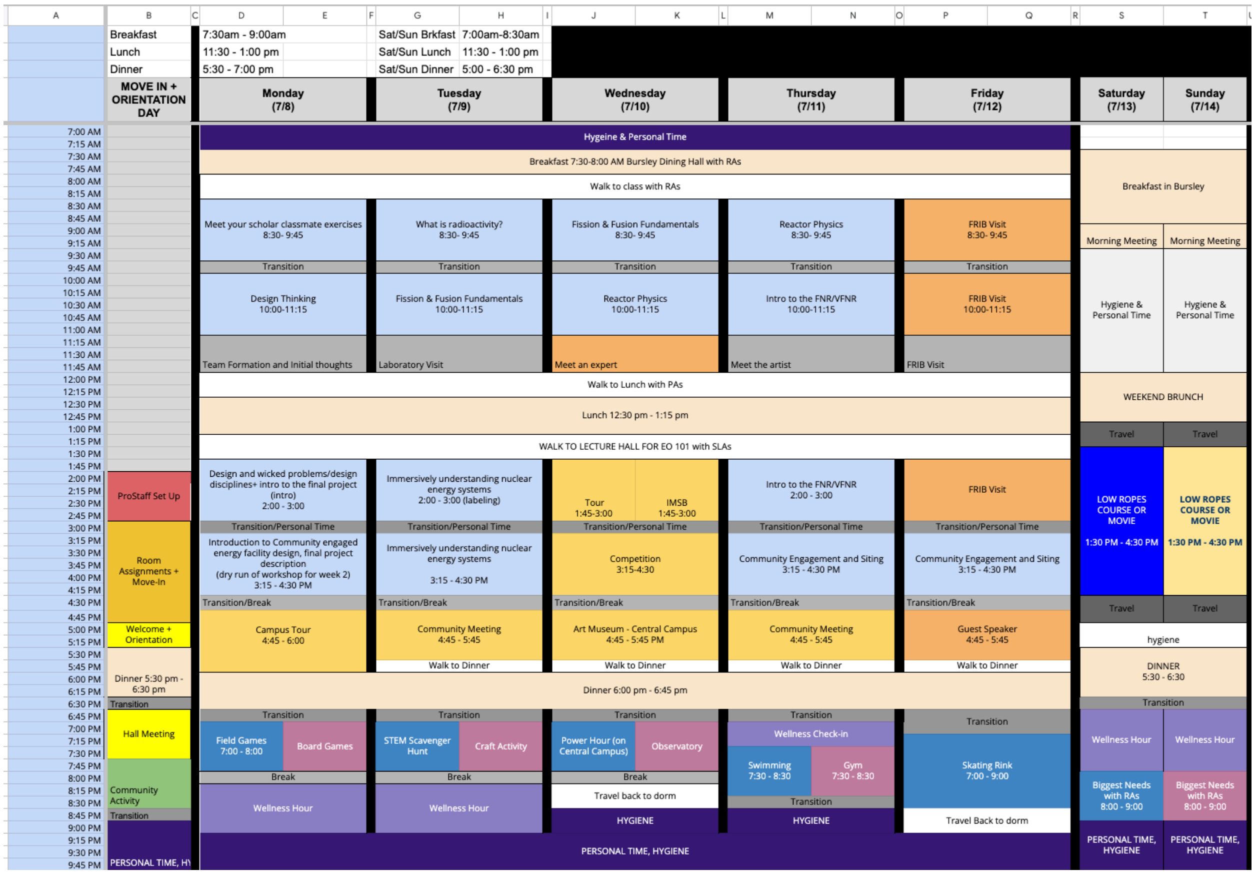

Fig 1. Sample schedule. This snapshot displays the curriculum and activities scheduled for the first week of the summer academy. Subsequent weeks included lessons on math, physics, and technical communication.

Virtual reality tools were also used on several occasions to provide students with an immersive experience in nuclear reactor and energy system design. Working in the university's VR lab, students were able to tour and engage with models of several virtual nuclear reactors, including both fission and fusion, as well as visit two nuclear energy facilities. Students were also asked to create futuristic objects inspired by nuclear technology using scrap materials from a local reuse shop. As a field trip, students visited the shop to select materials for their designs. Then, working in pairs, they developed nuclear or nuclear-related objects that might appear 100 years in the future. Students then had to create a story or a narrative about their objects and share those with the group. This project was framed according to speculative design theory, a strategy for creatively imagining and then designing for the future.

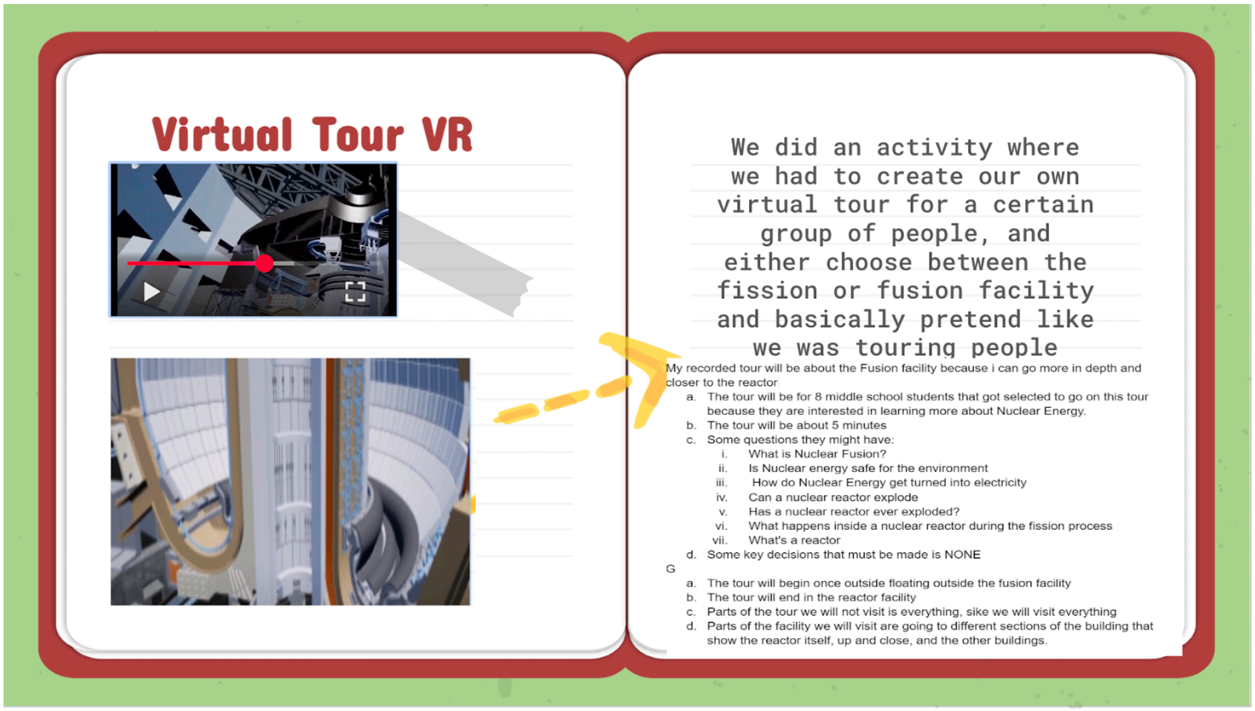

Figure 2. During the final presentation, a student discussed their VR model work, including a guided tour and related screenshots. Students were asked to choose a specific audience for their guided tour and then decide what to highlight based on their selected audience's background and perceived interest.

Curriculum development for this program was challenging, primarily because four weeks is a very short amount of time to introduce students to an entire field of study. Nuclear engineering has, as noted above, a complex history, and introducing students to the field while acknowledging the risks, complications, and very real damage it has wrought is an important aspect to get right. One way that instructors aimed to set the desired tone was by using speculative design strategies noted above. Another approach was to introduce participatory, community-engaged design as a central tenet of nuclear energy systems design. Several of the instructors had experience with these design strategies and introduced students to relevant methods and models. Students were able to participate in both an online and an in-person workshop with local community members. As a group, they were tasked with collaboratively siting and designing the exterior of an imagined nuclear energy facility near the university. Project teams discussed the values and beliefs that would inform their design decisions, mapped out their ideas, and utilized AI image generators to develop prototypes of their designs. Each team presented its ideas to the group at the end of the five-hour workshop. One student commented, “The professors thoroughly introduced us to an all-encompassing perspective of Nuclear Engineering, from the technical side, to ethics and history. A myriad of diverse insights from guest speakers, instructors, industry officials, and graduate students allowed for us to understand the field holistically, discussing criticisms as well as advancements. Personally, one of the most captivating topics covered was nuclear policy, a highly debated subject I hadn’t considered before. The inclusion of contemporary technology, like VR and AI image generation, along with the creative process gave me an helpful idea of how vast the scope of modern engineers can be, and the potential opportunities today.”

Figure 3. Also, during final presentations, another student described their in-person workshop experience, including an outline of the assigned task, a cover slide for their presentation (their energy system was called the “chicken coop”), and an image of their design (including an egg-shaped building and an on-site chicken wing restaurant).

Outside of coursework, the students visited a variety of research labs, toured a working nuclear energy facility, and participated in various on-campus activities, including swimming, ice skating, attending a local art fair, and sampling nearby restaurants. Importantly, students’ independence was gradually increased as they proceeded through the program. Initially, students were chaperoned from one learning session to the next by an OCCE student advisor. As they became more familiar with the campus, they were able to move about independently, with specific guidelines and mechanisms in place for regular check-ins with OCCE staff. “After the second week, once we got more adjusted to our schedule and the campus, having the freedom to move around on our own was a really cool experience. I think this program was the closest I could get to a real college experience as a high school student. It felt great being trusted to manage our daily responsibilities, and I think we all built a strong relationship of trust with the program coordinators because of that,” a student from the academy adds. This approach differed somewhat from other summer programs, which offered less freedom to their students (because they were younger or had spent less time getting to know the campus and building trust with OCCE staff).

In sum, academy development was a wide-ranging and multifaceted project that was made successful by bringing in experienced instructors and staff committed to working with young students. Fortunately, the project produced very promising results, the preliminary details of which are provided in the sections below.

Initial Outcomes

Initial project outcomes are outlined below, including additional student perspectives and key takeaways.

Benefits

The benefits of this program are numerous, with more emerging as time passes. We can say, quantitatively, that seven of our eight summer academy students have expressed interest in studying nuclear engineering in college. Notably, none of the students had this intention when they enrolled in the program. In fact, several were enrolled in an arts-focused high school and had no prior interest in nuclear engineering. One student shared, “When I started the program, I had a totally different idea of what I wanted my future to look like. I was thinking about going to college for psychology, but I wasn’t really sure if that was the right path for me. After learning so much about the nuclear industry and all the different career options it offers, I feel like I’ve finally found something that fits my interests and gives me a lot of versatility in my future career. I’m really thankful for the program—not just for teaching me about the technology, but for showing me how many opportunities there are in the field, even beyond engineering. It opened my eyes to a whole new world I didn’t even know existed, and that’s been really exciting.”

Another student commented, “Before enrolling at the Harper Academy, I had no clue the direction I wanted to take my professional career, and the thought of anything STEM related was daunting and intimidating, but during the program, the accessibility of information and resources presented to me the many outlets I could pursue in the Nuclear world. Each hand I shook, conversation I had, and all the advice I received allowed me the confidence to pursue Mechanical Engineering in college, with the intention of including an aspect of Nuclear Energy in the future. Outside of my academic outlook, the friendships and mentors I acquired in my four weeks will hopefully last a lifetime. I am prideful to call myself one of eight students in the inaugural cohort of this innovative learning experience."

Notably, until arriving at the summer academy, students generally had a negative impression of nuclear energy and shared that people in their communities mostly opposed it. At the end of the program, however, as they presented their final work and experiences, each student clearly articulated the risks and benefits of nuclear energy technologies, with a strong emphasis on the importance of advancing nuclear research and development. At the closing ceremony, one of the students' parents in attendance even commented on how much the student's presentations had shifted her perspective on nuclear engineering, such that she was now very interested in supporting the development of nuclear energy and felt it was much safer than she had initially understood. In terms of building interest and improving sentiment among the general public, the program was a success.

Another benefit was that several research opportunities opened up at the university, and four of the high school students were invited to join faculty researchers on projects of interest as they entered their senior year of high school. Three of these students are working on community-engaged design projects related to nuclear energy systems and are currently planning to host a workshop about nuclear energy in their hometowns. A student researcher stated, "Community-engaged design was a topic that I increasingly became passionate about during the experience. Conducting research on the topic is an exciting opportunity to engage my community and educate others on a newfound enthusiasm I have. It's been interesting to challenge myself academically outside of coursework in a textbook, but rather in a more creative, thought-provoking way, while relating to the Nuclear sector."

Another student shared, "Being able to do research in nuclear science has been such a rewarding experience in so many ways," a student shares. "I've had the chance to get a head start on something I wanted to pursue in college and beyond, all while still in high school. It's given me a real sense of security and confidence. When I first applied to the Harper Academy, I wasn't even sure if I was the right fit for an engineering program at a top university. Now, every opportunity I pursue in the STEM field, I do so knowing I have two solid experiences to draw from — and that I truly have a place in this field."

With some additional work, these students hope to present that research at upcoming conferences, leaving them well-prepared to begin their college careers as active researchers and scholars.

Challenges

That said, the program is not without its challenges. As instructors begin to plan for the summer ahead, feedback and observations have informed important changes in programming. For example, students often struggled to pay attention during 90-minute learning modules. Even in the morning, when they were well-rested, at least one student fell asleep regularly in class. Others found themselves distracted and ready to move on. Instructors have developed new content, and some learning modules have been shortened to enhance engagement. A student added,"During my first week of the academy, I definitely struggled to be an active participant in some of the classes. I was also taking online college courses at the time, so when I got back to my dorm around ten o'clock at night, I often had to stay up late to finish my coursework — which really threw off my sleep schedule. That lack of rest definitely affected my performance early on. But by the second week, once I figured out how to manage my time better and found pockets throughout the day to get my homework done, I started to feel much more balanced and engaged in the program."

Several students also noted that they had to wake up too early, and the program ran longer than expected. Others were clearly homesick as we entered the fourth week. These complaints were fairly minor, however, when considered in the context of the overwhelmingly positive feedback that students and parents alike provided during the final presentations and closing ceremonies.

Another challenge is the amount of time needed to recruit students, find funders, develop curriculum, organize guest speakers, and arrange lab visits. The program is not an easy lift. That said, as it becomes well-established, the workload decreases dramatically. Over time, the hope is that this type of program will be implemented at universities nationwide to further increase access across a range of demographics.

Conclusions & Future Work

While the summer academy can be a labor-intensive approach to building interest, capacity, and diversity in nuclear engineering, the ripple effects of such programs may be quite significant. Providing high school students with an immersive, cutting-edge learning experience guided by experts in the field creates the opportunity to build a strong counter-narrative (and myth-busting narrative) against the anti-nuclear sentiment that remains prevalent in the United States and other nations. Indeed, we cannot expect nuclear energy to solve the impending energy crisis on its own, but excluding nuclear energy from our plans for a carbon-neutral energy future would be a serious misstep. The path to decarbonization will include a variety of energy feedstocks and systems, likely tailored to local geographies, cultures, and resources. Bringing more people into the conversation, particularly young people considering their future careers, is a vital task that requires more effective models like the summer academy described above.

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