Experiential Learning in Nuclear Engineering Through a Reactor Sharing Program

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Introduction

As of 2026, only 24 universities in the United States have an operational research reactor, limiting opportunities for many students to gain direct experience with nuclear systems. At the same time, the U.S. nuclear industry faces growing workforce demands driven by license extensions of the existing power reactor fleet and the anticipated deployment of advanced reactor technologies. Expanding access to nuclear engineering education, particularly for students at institutions without reactor infrastructure, is therefore increasingly important for long-term workforce development.

In response, the U.S. Department of Energy (DOE) supports reactor sharing programs that enable universities with research reactors to provide broader access to their facilities. The program at the University of Florida has three primary thrust areas: (1) higher education institutions, (2) K–12 teacher workshops and tours, and (3) public engagement through youth organizations such as Scouting America and Girl Scouts. This paper focuses on the higher education component, which brings students and faculty from institutions without nuclear engineering programs into an operating reactor environment for structured multiday learning experiences. We describe the program design, implementation, and assessment outcomes, with particular attention to how experiential learning influences conceptual understanding and interest in the nuclear field.

Background

Workforce Demand and Infrastructure Constraints

More than 90% of the U.S. commercial nuclear fleet is pursuing license extensions to 80 years, and advanced reactor technologies are progressing toward demonstration and deployment [1]. DOE analyses estimate that advanced reactor manufacturing, construction, and operation alone could require approximately 236,000 workers by 2035, increasing to roughly 376,000 by 2050 [2]. Meeting these workforce needs will require expanding access to nuclear education for students enrolled in STEM programs at institutions that do not offer nuclear engineering degrees or operate research reactors.

Experiential access to nuclear systems, however, remains limited. Without reactor facilities, students typically encounter nuclear topics through simulations, textbook problems, or secondary datasets. While valuable, these approaches cannot fully replicate the operational complexity, instrumentation, and real-time decision-making associated with an operating reactor environment.

Experiential Learning in Nuclear Engineering

Engineering education research shows that experiential learning approaches, particularly those that place students in authentic engineering environments, improve student engagement and support the development of practical technical skills [3]. Additionally, studies of public attitudes toward nuclear energy indicate that increased knowledge and familiarity with nuclear concepts are associated with more informed perspectives of nuclear technology [4, 5].

Reactor sharing programs provide broader access to experiential learning activities at universities with research reactors. Supported activities often include laboratory experiments, reactor tours, short courses, and teacher workshops serving K–12 schools, community colleges, and other institutions without reactors. By extending access to operating reactors and related laboratory infrastructure, these programs connect classroom learning with real-world nuclear systems while also supporting broader workforce development efforts.

Program Overview

The higher education component of the Reactor Sharing Program at the University of Florida was developed to expand access to hands-on nuclear engineering experiences for students at institutions without research reactors, while fostering sustained academic and research collaboration across the region. Broad program goals include increasing nuclear literacy, strengthening interdisciplinary connections between nuclear engineering and other STEM fields, supporting workforce development, and creating pathways into graduate education and nuclear-related careers.

The primary learning objectives are for participants to (1) understand foundational concepts in reactor physics and radiation detection, (2) describe the capabilities and operational characteristics of a nuclear research reactor, (3) connect nuclear engineering principles to their primary discipline, and (4) identify academic and professional pathways within the nuclear field.

Partner institutions were selected based on prior collaborations, interest in nuclear-related research or coursework, and geographic considerations. The final partners were the University of Central Florida, Florida International University, and the University of Puerto Rico-Mayagüez, all federally designated Minority-Serving Institutions and Hispanic-Serving Institutions (HSIs). None of the partner institutions maintain nuclear engineering programs, though some offer introductory nuclear-related courses.

The program consists of multiday workshops at the University of Florida centered on activities at the University of Florida Training Reactor (UFTR). The instructional model is intentionally layered with the following categories of activities:

1. Classroom-based foundational instruction
2. Interactive conceptual learning activities
3. Reactor-based instructional laboratories
4. Partner-institution-led research campaigns

This structure was designed to establish a shared knowledge base, reinforce concepts through direct measurements, and extend learning into applied, open-ended contexts.

Instructional Design and Implementation

Foundational Instruction

Because participants represented mechanical engineering, electrical engineering, chemistry, physics, and related disciplines, initial sessions established a shared conceptual baseline. Core sessions included nuclear physics and nuclear reactor operations. Supplemental sessions supported specific experiments, such as approach to criticality, power calculations, and neutron radiography. The objective was not to summarize a semester-long course on any of these topics, but to provide sufficient foundation to enable meaningful engagement with reactor operations and experimental data.

Interactive Conceptual Activity: Chart of Nuclides

To strengthen conceptual understanding of nuclear stability, the program incorporated the Isotope Discovery Kit (IDK) developed by Wabbersen [6]. Participants constructed isotope stacks and reorganized them into a chart of the nuclides, making the line of stability visually apparent. This activity helped participants take prior knowledge from chemistry and use it for a nuclear application.

Reactor-Based Instructional Laboratories

All participants engaged in reactor-based laboratories aligned with their disciplinary interests. Activities included measurements of reactivity, control blade worth, neutron activation analysis, power calibration, temperature coefficients of reactivity, and neutron radiography.

These laboratories placed participants inside a licensed operating facility, requiring adherence to safety protocols, operational procedures, and instrumentation practices. Participants collected data, interpreted measurements, and observed how theoretical concepts translate into system behavior.

Partner-Institution-Led Research Campaigns

Partner institutions were invited to propose research activities that could leverage the reactor and its associated resources. The goal was to extend the program beyond traditional laboratory exercises and aligned closely with partner institutions' research interests.

One campaign focused on robotic facility characterization using LiDAR and radiation sensors deployed inside the reactor bay. Students operated a Boston Robotics Spot to collect spatial and radiological data during reactor operations, which were subsequently processed into three-dimensional radiation-mapped models of the facility. This activity strengthened connections between sensing technologies, data analysis, and the operational considerations associated with working in a reactor.

Another campaign supported validation of a prototype bubble neutron detector using a calibrated Cf-252 source. Because the partner institution did not have access to a suitable neutron source, the reactor sharing visit enabled controlled testing and calibration of the device. During this process, students evaluated detector response and sensitivity while gaining hands-on experience with radiation measurements, source handling, and safety procedures.

Results and Discussion

Participant Characteristics

The program has included four faculty members and 31 students. Prior to the program, participants reported their familiarity with nuclear science and engineering topics. Responses indicated that most entered with either basic (52%) or intermediate (40%) knowledge, with a few participants reporting advanced (8%) knowledge.

As shown in Figure 1, participants represented a range of STEM majors, including mechanical engineering, chemistry, electrical and computer engineering, and physics, along with smaller numbers from chemical, civil, and materials engineering.

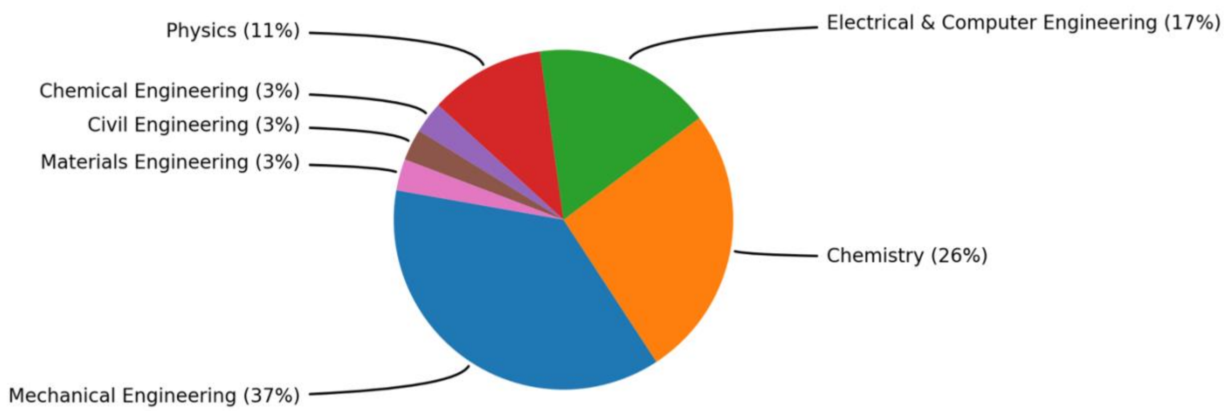

Figure 1. Disciplinary distribution of participants.

Figure 2 shows participant demographics by gender and race/ethnicity. The high proportion of Hispanic/Latino participants reflects the designation of all partner institutions as federally designated Hispanic-Serving Institutions (HSIs) and indicates strong engagement from populations historically underrepresented in engineering.

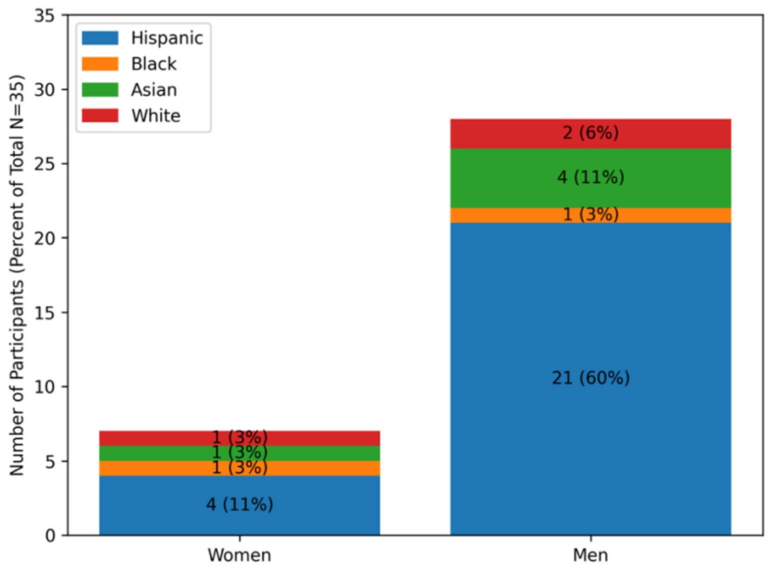

Figure 2. Distribution of participants by self-identified gender and racial/ethnic identification.

Assessment Approach

Educational impact was examined using pre- and post-program surveys supplemented by written reflections. Because the workshop was designed as a short-term enrichment experience rather than a credit-bearing course, formal direct assessments (e.g., quizzes or exams aligned to learning objectives) were not used.

The pre-program survey was intended to characterize participants' academic preparation, including prior coursework and general familiarity with nuclear science and engineering concepts. The post-program survey included a single Likert-scale item asking participants to rate whether the program increased their knowledge of nuclear science and engineering overall, along with items addressing workshop organization and instructional quality. Written reflections provided additional qualitative insight into the learning experience and were analyzed using a simplified thematic analysis approach consistent with Braun and Clarke, emphasizing iterative coding and recurring themes [7].

Educational Impact

Although individual learning outcomes were not directly assessed, responses to the post-program survey indicate strong perceived educational impact. When asked whether the program increased their knowledge of nuclear science and engineering, 94% of participants selected *Strongly Agree* and 6% selected *Somewhat Agree*.

Three primary themes emerged from the written reflections:

- Strong perceived value of hands-on reactor activities
- Effectiveness of interactive conceptual exercises
- Variation in desired technical depth

Reactor-based activities were consistently identified as the most valuable component of the program. Participants emphasized that direct interaction with the reactor and associated instrumentation strengthened their understanding of nuclear concepts and increased their interest in the field, while interactive exercises such as the chart of the nuclides activity helped connect prior coursework in physics, chemistry, and engineering to nuclear applications. Participants also noted that the combination of lectures, reactor experiments, and applied research activities helped them move from “learning the theory” to applying it.

Preferences regarding technical depth varied. For participants new to nuclear engineering, the introductory foundation was essential. Those with stronger technical backgrounds expressed interest in additional advanced or discipline-specific content, suggesting opportunities for future differentiation.

The program may also influence educational pathways. During the visit, participants attended a panel featuring Hispanic/Latino graduate students who discussed their research experiences and graduate school trajectories. Prior research indicates that graduate aspirations among Hispanic engineering students at HSIs are shaped by access to networks and relatable role models [8]. Several participants have since applied or expressed interest in graduate study at the University of Florida suggesting that the program may have contributed to making advanced study appear more accessible.

Sustainability

Long-term sustainability will require funding beyond the initial DOE award period. Potential pathways include developing joint research proposals with partner institutions and exploring industry partnerships aligned with workforce development. These options represent possible ways to transition the program from a grant-supported initiative to a sustained regional collaboration.

The reactor sharing model makes efficient use of existing infrastructure: a single operating reactor can serve numerous institutions across a region. While the current program has partnered with three institutions, many additional institutions in the region represent potential collaborators. Shared infrastructure models such as this provide a practical method for expanding experiential nuclear education without requiring the construction of new facilities.

Future Programs

Future iterations of the program will incorporate more direct measures of learning outcomes. A brief concept-based quiz administered at the conclusion of the workshop and aligned with the stated objectives would provide quantitative evidence of participant understanding. In addition, performance-based tasks embedded within reactor activities could offer further insight into applied reasoning and technical comprehension. Together, these additions would extend the assessment approach beyond self-reported perception while maintaining the enrichment-focused structure of the program.

Variation in participants' prior preparation also suggests opportunities for program refinement. While establishing a common foundation in nuclear concepts is important, future offerings could include optional advanced sessions or parallel activities to better challenge participants with stronger technical backgrounds, while keeping the core program accessible to those who are new to nuclear engineering.

Conclusions

This reactor sharing program demonstrates how university research reactors can function as shared educational infrastructure for institutions without nuclear facilities. By integrating foundational instruction, immersive laboratory experiences, and applied research activities, the program enables participants from a range of STEM disciplines the opportunity to engage directly a nuclear research reactor.

Preliminary outcomes suggest improved conceptual understanding, increased awareness of career pathways, and stronger interdisciplinary connections. Although longitudinal assessment is still needed to evaluate long-term impacts, the model provides a practical framework for expanding experiential nuclear engineering education. In the context of growing workforce demands, reactor sharing programs represent an effective strategy for broadening access to nuclear education, strengthening regional partnerships, and supporting development of the future nuclear workforce.

Acknowledgements

We express our gratitude to the Department of Energy for funding DE-NE0009531.

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