

Materials Research Experiences for Community College Students at Purdue University

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In the United States, more than 575,000 students are enrolled in engineering, engineering technology, computer science, mathematics, or natural science degree programs at public two-year colleges [1]. Upon matriculation, nearly 80% express an intention of transferring to a four-year institution, but ultimately, only 30% make the transfer [1]. Potential explanations for this gulf in transfer persistence are not well understood. However, two-year college or community college students have long been overlooked and underserved in discussions around STEM research and engagement. As an initial step toward encouraging transfer persistence, Purdue University has stood up a summer research experience for community college students.

The concept of this research experience was motivated by the well-documented success of hands-on learning experiences and laboratories in enhancing community college student engagement [2–7]. This concept also extends the success of undergraduate level research experiences to the community college level, as a means to encourage students to pursue post-baccalaureate studies in STEM fields [8–14].

The community college research experience pilot program was established in 2017 through the Network for Computational Nanotechnology (NCN) – a National Science Foundation (NSF) funded multi-institutional center led by Purdue University, focused on developing modeling and simulation tools to predict multiscale behaviors of nanosystems. The pilot program integrated two-year college students in the existing formalized NCN Undergraduate Research Experience (URE), which had previously been open only to students from four-year colleges and universities.

The NCN URE is a paid summer research program focusing on applying computational simulations and developing computational tools for physical processes, systems, and devices. The most unique and defining feature of the NCN URE program is that the student-developed computational tools

are published on nanoHUB.org, a cloud-based resource for interactive simulation tools that enable research and teaching across nanotechnology. The URE participants receive training on Jupyter Notebooks and Python, providing them with the necessary skills to build a nanoHUB tool. All URE students are paired with a faculty advisor and a graduate student mentor who define their research projects and provide day-to-day guidance. Students also participate in professional development workshops, attend research seminars, and engage in networking and social activities. At the conclusion of the program, students deliver poster presentations at the NCN URE research symposium.

Through the pilot program, five students from Pasadena City College (PCC) spent eight weeks conducting guided research at Purdue. During the pilot program, the PCC students explored scientific problems spanning a broad range of materials science topics. For example, one student developed the ‘DualfoilUQ’ nanoHUB tool to improve uncertainty quantification for battery electrode material performance. Two students validated the mechanical properties of powder compacts for the ‘Powder Compaction’ nanoHUB tool. Another student optimized plasma treatment process parameters on liquid crystal fiber wetting.

Esteban Bautista, a first-generation college graduate, participated in the pilot program. During his NCN URE, Esteban investigated the long-term thermal aging of Inconel 625 and 690, comparing the performance of alloys fabricated by conventional forging to those fabricated by powder metallurgy with hot isostatic pressing (PM-HIP). By coupling his own experiments with data gathered from the archival literature, Esteban built a data-science tool on nanoHUB to predict the mechanical degradation of these alloys in nuclear power plant environments. Esteban’s NCN URE research contributed to two peer-reviewed publications [15,16]. Following his research experience at Purdue, Esteban transferred to California State University – Northridge, where he has recently graduated with a degree in Biochemistry. He will pursue his Ph.D. in Chemistry at the University of California – Irvine beginning fall 2020.

Following on the success of the pilot program, research opportunities for two-year and community college students were formally integrated into the NCN URE program. Students were primarily recruited from Ivy Tech, the public community college within the State of Indiana. Of the Ivy

Tech students who transfer to four-year institutions, nearly 15% matriculate to Purdue, making the NCN URE partnership between Purdue and Ivy Tech a natural fit. Between three and five community college students participate in NCN URE each year. To date, more than 12 students from two-year institutions have participated in the program.

Timothy Pownell is one such student who participated in NCN URE at Purdue in 2018, while he was enrolled at Ivy Tech. Timothy is a first-generation college student. His NCN URE project focused on the phenomenon of radiation-induced grain boundary segregation (RIS) in FeCrAl alloys, which are candidate alloys for accident-tolerant nuclear fuel claddings. Timothy analyzed composition maps previously acquired by transmission electron microscopy (TEM) with energy dispersive x-ray spectroscopy (EDX). Timothy built a nanoHUB tool that predicts RIS behavior from key parameters he identified, including grain size, irradiated microstructure, and irradiation conditions. This tool lays the foundation for a future machine learning program to predict RIS in Fe-Cr alloys. Timothy returned to Purdue in 2019 for summer research, and continues materials science research today. He has since transferred to Purdue, where he is pursuing a degree in Mechanical Engineering, and was selected for a summer internship at a brass foundry.

Lessons Learned

The program is formally evaluated using the Undergraduate Research Student Self-Assessment (URSSA), administered anonymously through the Student Assessment of their Learning Gains (SALG) web site. Video interviews have also been conducted with pilot program participants approximately six months following the conclusion of their NCN URE.

Evaluations indicate that the NCN URE has enhanced self-efficacy in all participating two-year college students. This is evidenced by a strengthened determination to attain higher education, an enhanced desire to transfer to a large research university, and an interest in continued pursuit of research. Students participating in video interviews also consistently discuss a heightened confidence in their

capabilities overall, their ability to be successful in unfamiliar or new situations, and their ability to achieve goals previously thought unattainable.

A challenge the community college students often cited, however, was difficulty in reconciling the scale of research conducted at a research intensive institution. Prior to NCN URE, the students' exposure to research at the two-year college level involved seeing the scientific method through, from hypothesis to conclusion. But when they participated in NCN URE, their project was a small task within a larger research scope. This led to "cog in the wheel" feelings and some lack of ownership over their work. However, discussions with their faculty and graduate student mentors about the context of their NCN URE projects helped students understand the scale of federally-funded research, and improve their sense of accomplishment.

With proper research mentorship and project design, the Purdue NCN URE program enables community college students to improve their self-efficacy and gain research experience that influences their educational and career paths.

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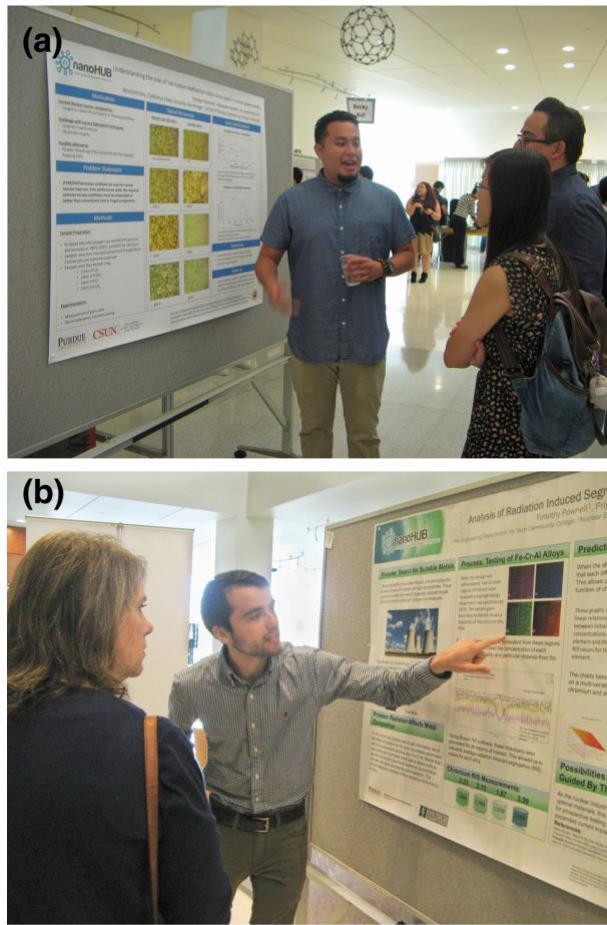


Figure 1. (a) Esteban Bautista and (b) Timothy Pownell present their research posters at the NCN URE symposium.

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