MNT-CURN and START: Successful Nationwide Programs for Connecting Community College and Technical Education Students to Research Opportunities

Sophia Isabela Salter, Micro Nano Technology Education Center

Sophia Salter graduated with a BS in Neurobiology from UC San Diego in June 2023. She has been a mentor within the Micro Nano Technology Education Center for the past four years and will be starting medical school at the University of Chicago in August 2025.

Dr. Jared Ashcroft, Pasadena City College

Jared Ashcroft graduated with a BS in Chemistry from Long Beach State in California and subsequently attended Rice University, where he worked for Dr. Lon J. Wilson, developing carbon based nano-bio immunoconjugates for use in medical applications. After

Dr. Tanya Faltens, Purdue University at West Lafayette (PPI)

Tanya Faltens is the Assistant Director of Education and Community Partnerships for the Network for Computational Nanotechnology (NCN) at Purdue University.

Dr. Kendrick Davis, University of Southern California

Kendrick B. Davis, Ph.D. is an Associate Professor and Chief Research Officer at the USC Race & Equity Center at the University of Southern California. A mechanical engineer and roboticist by training, his research interrogates the intersections of education, science, and policy and has been funded by the National Science Foundation (NSF), the US Department of Defense (Army Educational Outreach Program), Walmart, and the Bill and Melinda Gates Foundation. Prior to USC, Dr. Davis was an American Association for the Advancement of Science (AAAS) Congressional Fellow in the United State Senate. He has been an education and science policy advisor locally, nationally, and internationally.

Dr. Peter D Kazarinoff, Portland Community College

Peter D. Kazarinoff is a full-time faculty member in Engineering at Portland Community College in Portland, OR. He is the Editor-in-Chief of the Journal of Advanced Technological Education (J ATE). J ATE is the peer-reviewed journal focused on technician education at community colleges. Peter is a co-PI of MNT-EC, the National NSF ATE Center for Micro and Nano Technology. Peter is passionate about helping community college faculty and staff publish their work in peer-reviewed journals like J ATE. In addition to his work on J ATE, Peter is also the voice of the Talking Technicians Podcast, a podcast about working technicians.

Justice Robinson, Micro Nano Technology Education Center

Justice Robinson is a graduate of the University of North Carolina at Chapel Hill (Neuroscience) and a mentor for Micro Nano Technology Education Center.

Paula Kirya, Micro Nano Technology Education Center

Paula Kirya is a graduate student at UC San Diego studying Mechanical Engineering. She graduated from UCSD with a degree in Bioengineering in June 2023.

Antar A. Tichavakunda

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Abstract

To prepare a diverse group of community college students to apply for and succeed in hands-on research experiences in high-tech STEM fields, the Micro Nano Technology Education Center (MNT-EC) founded the Collaborative Undergraduate Research Network (MNT-CURN), an academic-year online program for community college students from across the country followed by optional in-person or online summer research experiences at research universities. MNT-CURN used the Zoom online meeting platform to reach diverse students attending community colleges across the country and prepare them to participate in summer research opportunities. These opportunities were provided by a set of MNT-CURN university partners who developed in-person and remote summer research experiences for the students that ranged from one to ten weeks in duration. A few partners also provided remote academic year computational research projects. The following year, MNT-EC founded the Skills Training in Advanced Research and Technology (START) program to provide community college students with a more intensive year-long, in-person research opportunity at a nearby research university. Students who participated in MNT-CURN were invited to apply to the START program the following year. Program evaluation results show that the programs were successful in reaching a diverse group of community college students and that participation in the programs increased students' belief that they could be successful in a STEM field, conduct research, and analyze scientific data. Both stipends and research experiences were rated as important aspects of the program. The MNT-CURN to START model demonstrates how a longitudinal approach to undergraduate research prepares students for research projects of increasing complexity and leads to more impactful outcomes for the students and success in retaining community college students in STEM. In this paper, we report on practices employed in the MNT-CURN and START programs as well as their effects on student recruiting, retention, satisfaction and participation in research.

Introduction

In the United States, science, technology, engineering, and mathematics (STEM) fields continue to have a low representation of Black, Hispanic, Native American, women, and those who qualify as low-income or first-generation college students [1], [2]. Community colleges are often instrumental in providing these students with pathways into STEM careers through opportunities for collaborative learning and by building early momentum in STEM education [3], [4]. Community colleges are well-poised to reach students from underrepresented groups: they serve 40 percent of all Black undergraduates, 51 percent of all Hispanic undergraduates, and 38 percent of Native American undergraduates [5], [6]. Additionally, within the community college population, 58 percent are women and approximately 30 percent would qualify as first

generation college or low income students [2], [7] . Overall, 41 percent of all undergraduates attend community college [5].

First generation students make up almost one-third of all undergraduates and are more likely to attend community college [8], [9]. Additionally, first generation students with low-income backgrounds and an underrepresented racial identity often have less personal experience in academic planning and are aware of fewer academic and career opportunities. These factors contribute to the struggle many face with completing STEM degree programs. Supporting STEM development and retention at the community college level is thus an important equity practice to reach diverse students who are statistically disadvantaged in STEM fields [10].

One vital mission of The Micro Nano Technology Education Center (MNT-EC) [11] is the advancement of STEM education by enhancing community college students' skillsets, providing outreach and retention to underrepresented students, and promoting student success with research opportunities and technical training. To prepare a diverse group of community college students to apply for and succeed in hands-on research experiences in high-tech STEM fields, the Micro Nano Technology Education Center (MNT-EC) founded the Collaborative Undergraduate Research Network (MNT-CURN) and the Skills Training in Advanced Research and Technology (START) programs, which are described in the next section.

Program Descriptions

The Collaborative Undergraduate Research Network (MNT-CURN) was an academic-year online program for community college students from across the country that ran for three years, from October 2021- May 2024. The online academic year portion of the program used the Zoom online meeting platform to reach diverse students attending community colleges across the country and prepared students to participate in summer research opportunities. These opportunities were provided by a set of MNT-CURN university partners who developed in-person and remote summer research experiences for the students that ranged from one to ten weeks in duration. A few partners also provided academic year remote computational research projects. Students received support in preparing for and applying to these "internal" as well as "external" research opportunities (those not affiliated with MNT-CURN) from a team of near-peer mentors who had themselves started research in community college.

Each cohort met online weekly with center staff to hear speakers from universities, projects, and national labs talk about current research and opportunities for summer research related to micro and nano technologies or participate in workshops on technical and professional development skills. Workshop topics included Python and MATLAB coding, writing a resume, establishing a LinkedIn presence, requesting a letter of recommendation, communicating scientifically, and writing to publish their research in a peer-reviewed journal. Recordings of these presentations

and workshops were shared with students who could not attend meetings live, and published on the open-access nanoHUB platform where they are available to the public at no cost; they can be freely used to prepare students in other programs for research opportunities [12]. Students also created e-portfolios consisting of responses to challenges related to the weekly meetings.

To promote equity among the students, who had a wide range of financial backgrounds, students were awarded stipends of $3,000 for full participation in the Fall and Spring semesters, as well as generous funding for travel to in-person undergraduate summer research opportunities. Students also had options to partake in one-on-one near peer mentorship, resume and CV workshops, scientific writing groups, and peer-reviewed article authorship. The conclusion of this NSF-funded program saw many underrepresented, first generation, and low-income students obtain hands-on STEM opportunities with university partner labs that lead to a greater confidence in their ability to continue in a STEM-related field.

After the first year, MNT-EC founded the Skills Training in Advanced Research and Technology (START) program, which provided community college students with a more intensive year-long, in-person research opportunity at a nearby four-year research university. Students who had participated in the MNT-CURN program and completed a summer internship could apply for the more intensive START program, which included office hours and weekly meetings, in addition to a year-long research internship and weekly one-on-one in-person mentoring from a graduate student at their research site. Table 1 presents the MNT-CURN and START logic model to describe the similarities and differences between the programs.

Table 1: MNT-CURN (2021-2023) and START (2022-2023) Logic Models

| | Planned Work | | Intended Results | | |
	Resources/Inputs	Activities	Outputs/Results	Short-Term Outcomes	Long-Term Outcomes
MNT-CURN	University Partnerships	Online presentations from internship representatives	Student publications and Poster presentations	Participation in a year-long or summer internship	Pursuit of a career or career-growth in MNT fields
	Peer and Faculty Mentorship	Professional development workshops, scientific writing workshops, dedicated office hours	Students awarded the Barry Goldwater Scholarship	Increased interest in the MNT fields	Career preparedness and increased self-sufficacy
	Student stipends ($3,000)	Weekly virtual meetings	Evaluation Report	Participation for full duration of program	Commitment to science and technology focused careers
	On-line resources: MNT-folio, nanoHUB, remote research	MNT-folio assignments	E-Portfolio	Documentation of practical experience gained during program	Students hired for science and technology positions
START	University Partnerships	Participate in interdisciplinary research with a team of researchers	Student publications and Poster presentations	Participate in interdisciplinary research with a team of researchers	Increased student desire to pursue degrees in STEM
	One-on-one Mentoring with Graduate Student	Hands-on training and development of analytical skills within mentor's field	Students awarded the Barry Goldwater Scholarship, Additional internships at 4-year universities	Increased interest in STEM fields	Preparedness to work independently in analytically demanding projects
	Student stipends ($10,000)	Year-long internship with Caltech or USC	Evaluation Report	Participation for full duration of program	Commitment to science and technology focused careers

START built upon the foundation of MNT-CURN by applying the weekly meeting model with the addition of hands-on academic year research through partnerships with nearby four-year universities. Students were paired with their own graduate student mentor and participated in year-long micro or nanotechnology research projects being conducted within their labs. The START cohorts were comprised primarily of former MNT-CURN students who had developed the foundational skills and self-confidence needed to succeed in a year-long internship at the university level.

The MNT-CURN and START programs served as collaborative learning opportunities that provided community college students with an entry into STEM research and technological training. These programs used practices in the weekly meetings that promoted active engagement, including peer-mentorship, and the high-impact practice of involving students in undergraduate research led by subject matter experts. The MNT-CURN to START model demonstrates how a longitudinal approach to undergraduate research prepares students for research projects of increasing complexity and leads to more impactful outcomes for the students and success in retaining community college students in STEM.

Literature shows that conducting undergraduate research aids in decreasing academic outcome gaps between underrepresented or first generation students and their peers [13]. The opportunities granted by MNT-CURN and START thus directly contribute to creating lasting impacts for community college STEM majors. At the core of these programs lies the goal of recruiting and retaining underrepresented community college students in STEM programs by using high impact practices to enhance their comfort and confidence in a space often considered out of their reach. This was achieved by the selection of diverse faculty and staff, establishing partnerships with four-year universities, and providing competitive student stipends. The program benefitted by ongoing external program evaluation that provided both formative and summative feedback.

Program Evaluation

Program evaluation was covered by the Center's blanket IRB and provided by MNT-EC's external evaluators, who attended the online meetings and provided process and outcome evaluation based on an adaptation of the Context-Input-Process-Product (CIPP) evaluation model developed by the Evaluation Center at Western Michigan University. Project data-gathering activities and subsequent data analysis were guided by standards developed by the Joint Committee on Educational Standards and Evaluation. Data collection instruments included pre- and post- surveys, as well as a series of student focus-group interviews that focused on diversity, equity, and inclusion (DEI) issues related to this program. Analysis of student and program outcomes, in concert with formative feedback provided by the evaluators, led to modifications in the program structure and implementation from cohort to cohort. Significantly, while the first

two MNT-CURN cohorts were open to any community college student, cohort three was restricted to community college students who were enrolled in technical education courses and programs.

Results

Table 2 provides overall demographic data for the three MNT-CURN cohorts (2021-2023) and two START cohorts (2022-2023) implemented by MNT-EC. This data was used to evaluate equity and inclusion within the MNT-CURN and START programs, specifically regarding historically underrepresented groups. Additionally, the students included 44% first generation students to attend college, 11% growing up in a rural area, 10% having a disability, and 45% coming from a low-income background.

Table 2: Overall Student Demographics

Race/Ethnicity	% of Students	Gender	% of Students
Black	16.1%	Male	50.3%
American Indian or Alaska Native	0.6%	Female	41.1%
Asian	24.8%	Non-binary	4.4%
White (non-Hispanic/ Latine)	21.1%	Prefer not to say	3.7%
Hispanic / Latine	20.5%		
Native Hawaiian or other Pacific Islander	0.6%		
More than one race	10.6%		
Prefer not to say	5.6%		

To evaluate the importance of stipends and summer research opportunities in MNT-CURN recruitment, students were asked to rank their perceived importance of these program factors from "Not Important" to "Very Important." Among MNT-CURN respondents, 75% selected "Very Important" or "Important" concerning the importance of the stipend on the pre-survey, increasing slightly to 79% on the post-survey (**Figure 1**). When asked about their perceived importance of a summer research opportunity at a university, 93% of students selected "Very Important" or "Important" on the pre-survey, decreasing slightly to 89% on the post-survey (**Figure 1**). In both cases, however, students still overwhelmingly believed stipends and summer research opportunities were either "Very Important" or "Important."
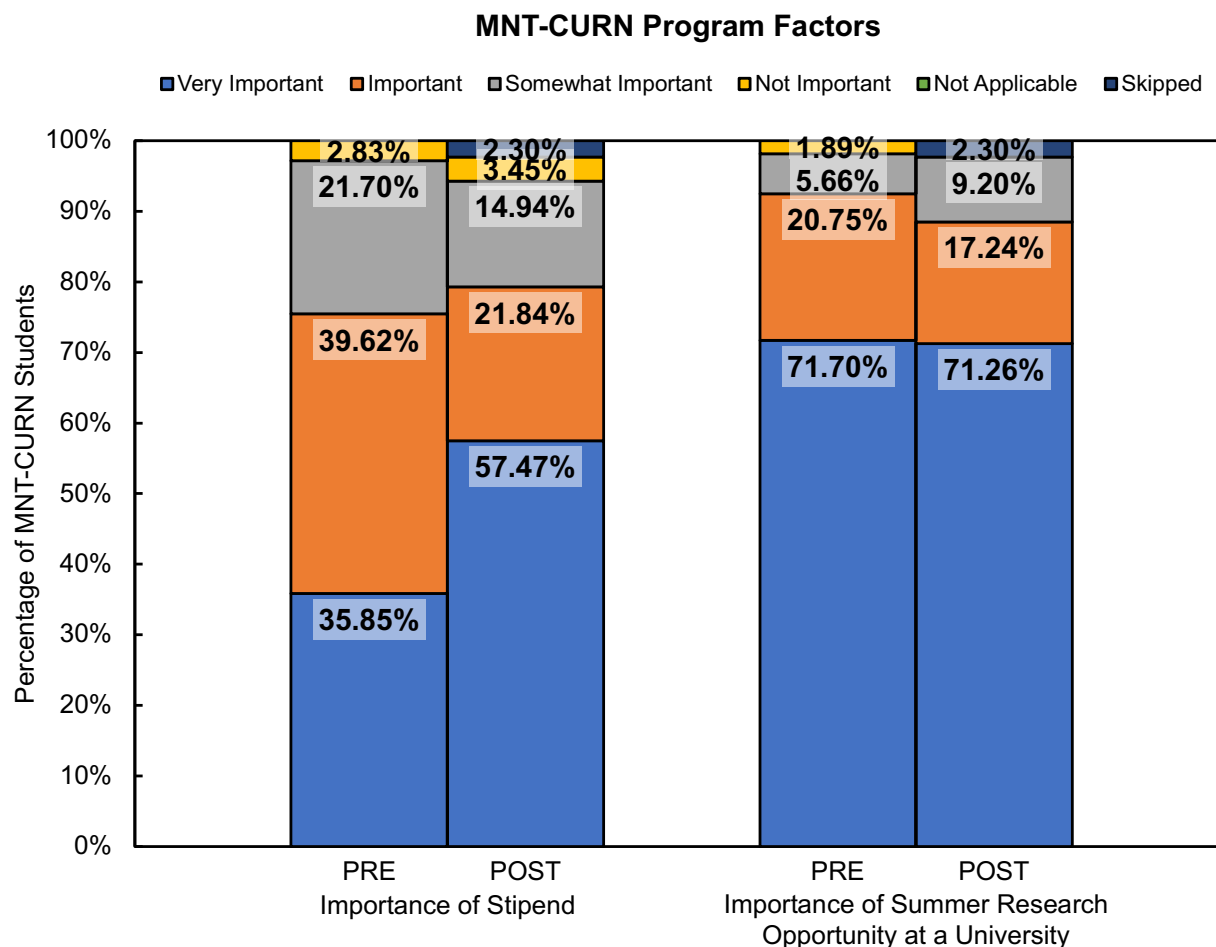
MNT-CURN Program Factors

Fig. 1. Importance of various aspects of the MNT-CURN program, as declared by student participants. Data displayed as pre-survey and post-survey results for all 3 years of the MNT-CURN program. Pre N=106; Post N=87.

To evaluate MNT-CURN's effectiveness in increasing student confidence, MNT-CURN participants were asked for their level of agreement with the statements "I know how to advocate for myself and my career development" and "I can succeed in a STEM research curriculum" before and after participating in the MNT-CURN program (**Figure 2**).

In response to the prompt "I know how to advocate for myself and my career development.", we observed an increase in confidence from the pre-survey to the post-survey responses, with 78% of the respondents selecting "Agree" or "Strongly Agree" for the pre-survey, compared to 84% for the post-survey. When asked about their agreement with the statement "I can succeed in a STEM research curriculum.", we also observed an increase in confidence from the pre-survey to the post-survey responses, with 89% of pre-survey respondents selecting "Agree" or "Strongly Agree" and 93% post-survey respondents selecting "Agree" or "Strongly Agree".
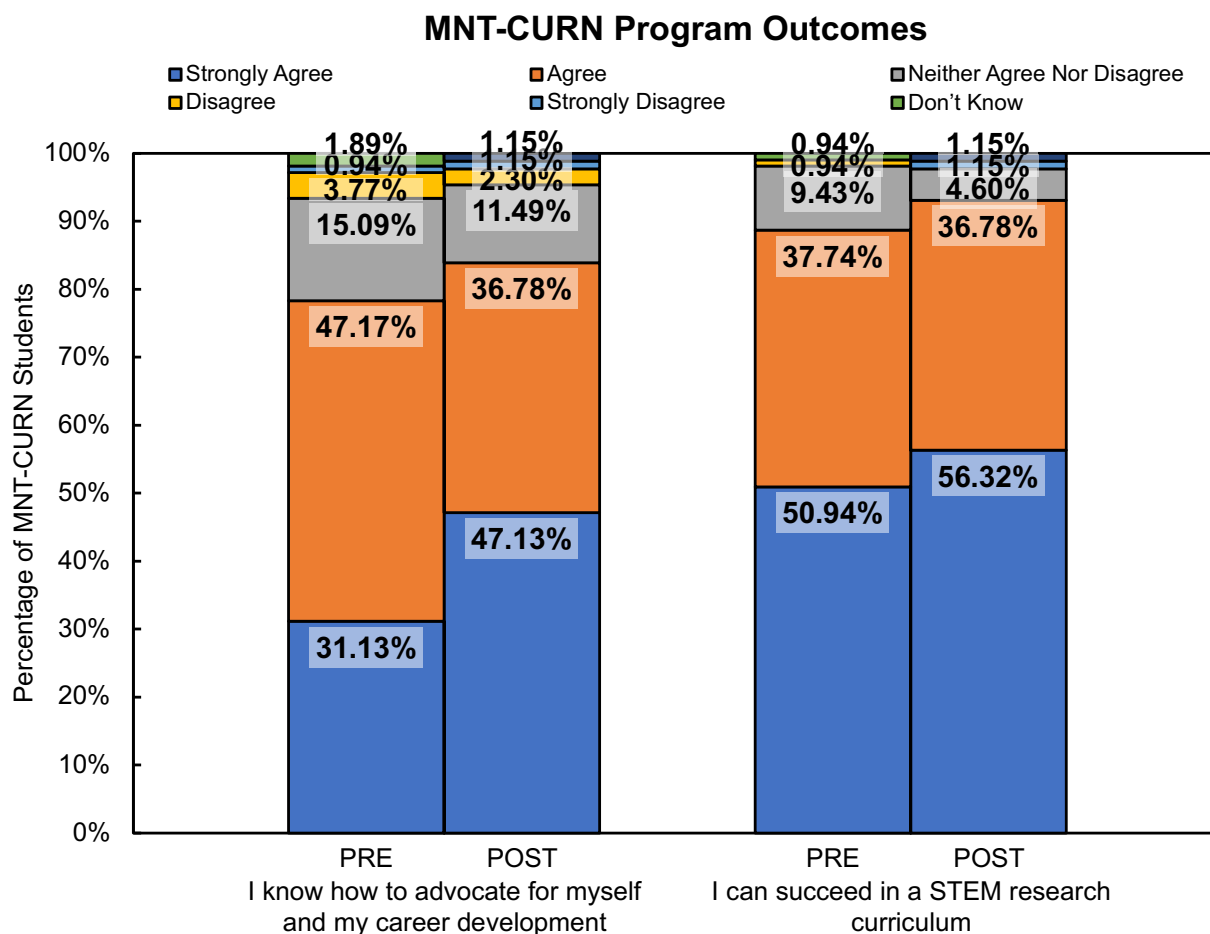
Fig. 2. Student self-confidence before and after participating in the MNT-CURN program. Data displayed as pre-survey and post-survey results from MNT-CURN students from all 3 years. Pre N=106; Post N=87.

Data collected for the START program primarily focused on the long-term impacts of this extended research experience on community college students. **Figure 3** provides data on START students' self-declared confidence within a STEM research environment. We observed a significant increase in student confidence in both their ability to "Conduct research supervised by a research mentor" and "Analyze Scientific Data". In response to their confidence conducting research supervised by a research mentor, we saw a substantial increase in confidence from pre- to post-survey, with 78% of students selecting "Prepared" or "Very Prepared" on the pre-survey, compared to 94% on the post-survey. When asked to rate their confidence in analyzing scientific results, 69% of students selected "Prepared" or "Very Prepared" on the pre-survey, compared to 94% on the post-survey.
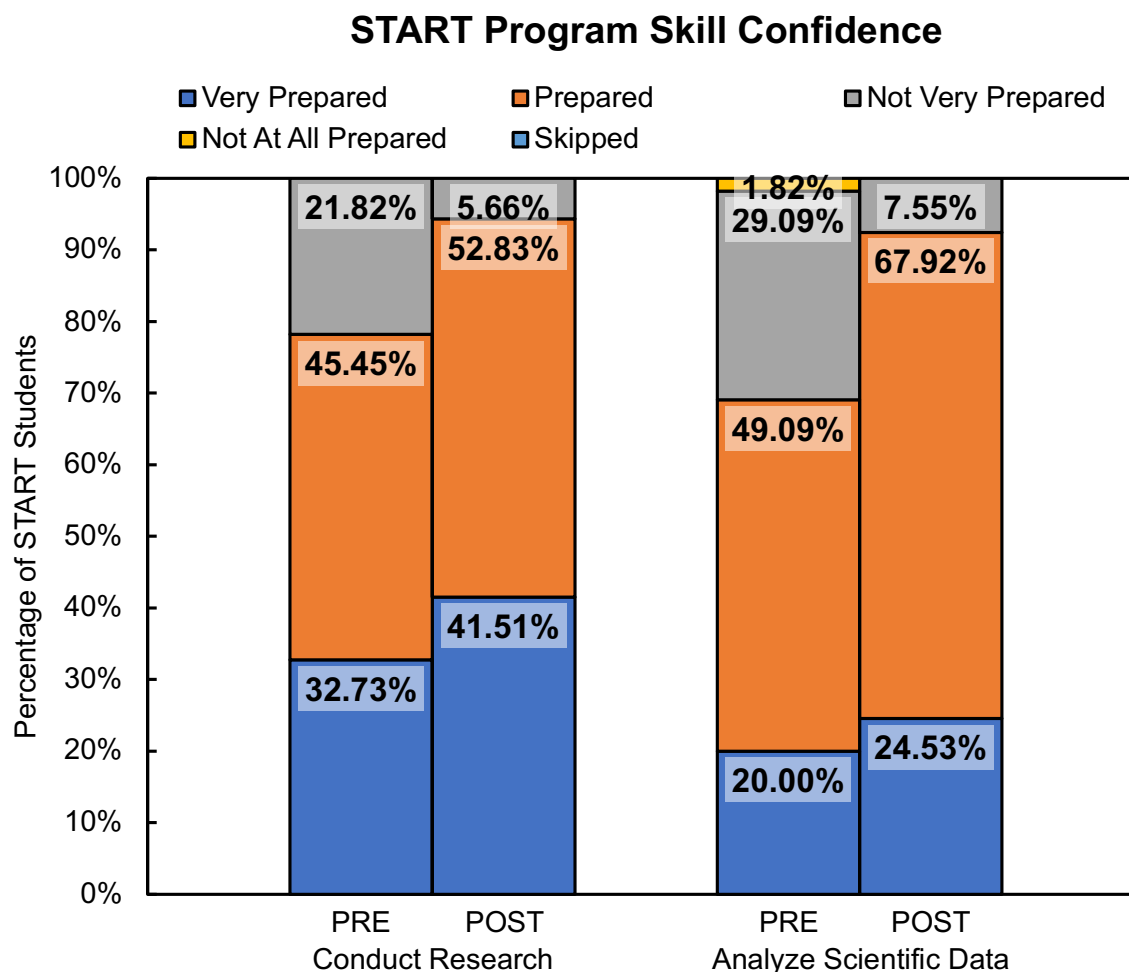
START Program Skill Confidence

Fig. 3. Confidence in a STEM research environment, as declared by student participants. Data displayed as pre-survey and post-survey results for START students from both cohorts. Pre N=55; Post N=53.

Student Testimonials

This evaluation included focus-group interviews and open-ended survey questions to gather student perspectives on the MNT-CURN and START programs. Below are student testimonials on the topics of diversity, inclusion, accessibility, and motivation to pursue a career in STEM.

Diversity:
"I think MNT-CURN also does bring a lot of people that have very unique experiences from around the country. It also does feel like it is an accepting environment for a diverse group"

"I feel that MNT-CURN does value [diversity] [...] It's like no matter who you are or where you come from you can get these opportunities...as someone who comes from a background of

poverty, it's difficult to pursue a stem major, especially for having my parents not really go to college so seeing these opportunities brought to everyone, idk, it hits a soft spot."

"You see diversity in the surveys. It's brought up a lot from the speakers. It's kind of everywhere in reference to the program. It's well established."

Inclusion:
"They are inclusive to all races, genders, ethnicities, field of STEM, etc. And I feel like I fit into the group."

"There is no implicit bias and I can tell MNT-CURN believes everyone and anyone can succeed in STEM."

"I am relatively new to research and academics in general and MNT-CURN has helped me feel less intimidated. Like I'm not scared of the idea of getting involved."

Accessibility:
"I just have a busy schedule with school and work. It gets difficult to manage sometimes. MNT-CURN does a great job of helping me with being involved even when I'm not able to make the meetings."

"MNT-CURN promotes academic diversity by providing research opportunities for college students that would not be as accessible elsewhere, especially for community college student participants."

Motivation to pursue a career in STEM:
"The START program definitely made me more academically driven and a hunger for more research internships like this one. I hope that once I transfer to a college, I can get the chance to do more opportunities like this."

"As a community college student, undergraduate research is not something as easily available as it may be at a 4-year university. The START Program allows students that normally may not have this opportunity to participate and learn, and at Caltech nonetheless."

"Working on a longer-term research project during the school year was a terrific experience. I was able to take more time and go into more depth with my research project than if I'd only had a summer to work on it. I also got to see what it's really like to do research as a graduate student, which confirmed for me that I want to go to graduate school."

Discussion

According to the American Association of Community Colleges (AACC) data on students enrolled for academic credit, the average demographic makeup of students attending community colleges nationally is 28% Hispanic, 12% Black, 43% White, 6% Asian/Pacific Islander, 1% Native American, and 4% 2 or more races [7]. As was shown in Table 2, nearly half of students in the MNT-CURN and START programs belonged to historically underrepresented groups, reflecting MNT-EC's commitment to creating a diverse and accessible program aimed at increasing opportunities for a broader student population.

In addition to increasing racial equity in STEM, MNT-EC has made an active effort to increase opportunities for students who are the first in their family to attend college and who come from low-income backgrounds. Both first generation students and students from low-income backgrounds face reduced graduation rates and are likely to work throughout college [8], [9], [14], [15]. By providing a stipend, MNT-EC hopes to provide the financial support needed for first generation and low-income students to pursue career-building programs like MNT-CURN and START, thus increasing the percentage of low-income and first-generation students in the STEM workforce.

According to the AACC, 32% of students attending community college are the first generation in their family to pursue a college education [7]. 40% of students in MNT-CURN and 51% of students in START are the first generation in their family to pursue a college education, exceeding the national average and demonstrating the success of the MNT-CURN and START programs in serving first-generation college students.

Furthermore, 59% of students came from childhood household incomes of less than $55,000, with 45% under $35,000. While the definition of low-income households can vary depending on the size of the household, these figures highlight the significant role of MNT-CURN in providing educational opportunities to students from economically disadvantaged backgrounds. Unfortunately, comparable data on childhood household income was not collected for the START program.

Figure 1 displays student perceptions of the importance of a stipend before and after participating in MNT-CURN. Each year, the majority of students stated that receiving a stipend was a major factor in their decision to participate in an undergraduate research experience, demonstrating the critical role of financial support in attracting and retaining low-income and first-generation students in STEM programs like MNT-CURN and START. This trend remained consistent when students were asked for their perceptions of the importance of acquiring a summer research opportunity at a university.

Finally, the student's testimonials demonstrate MNT-EC's success in fostering diversity, inclusion, and accessibility in the MNT-CURN program. Students overwhelmingly shared feelings of belonging, appreciation for the diverse environment MNT-EC fosters, and gratitude regarding the accessibility of the program. This provides a strong indication that MNT-EC effectively creates an inclusive and welcoming environment for all students, regardless of their background.

A core goal in the MNT-CURN program was to increase student confidence and preparedness to the point that they no longer felt any imposter syndrome when applying and participating in programs like START. To determine MNT-CURN's effectiveness in this goal, participants in the MNT-CURN program were asked to rank their confidence levels in advocating for themselves and their career development and in their belief that they can succeed in a STEM research curriculum (**Figure 2**). The increase shown in both advocating for oneself and in career development demonstrates that the MNT-CURN model is effective as a recruitment, retention, and progression step on the STEM academic and career pathway journey. This indicates that, similar to the confidence increase seen in students' perceived ability to succeed in a STEM research curriculum, participation in the MNT-CURN program effectively increased students' confidence in their ability to succeed in STEM environments.

Many students from the MNT-CURN program applied to and were accepted into the START program. Given the year-long research experience START students engage in, a core goal of the START program was to continue to increase students' confidence, with an emphasis on preparedness while working in STEM research settings. To evaluate this, students in the START program were asked to rank their confidence levels regarding various aspects of work in a STEM research environment. These questions included writing up scientific results and conducting research supervised by a research mentor. The dramatic increase in each of these research skills indicates that participation in the START program strongly improved students' confidence in scientific analysis and had a positive impact on continuing the students STEM academic goals. Looking at these results together, participation in the START program significantly improved students' feelings of confidence in STEM spaces and research environments.

Lastly, students in the MNT-CURN and START programs stated that participating in MNT-CURN and START made them feel "less intimidated," made them "hunger for more research internships" and "confirmed for [them] that [they] want to go to graduate school." These testimonials demonstrate MNT-EC's success in building students' confidence in STEM environments and students' motivation to pursue a career in STEM.

The goal of the MNT-EC Center is to develop a roadmap for community college students to have access to year-long undergraduate research programs that continually build upon one another. The focus of the MNT-CURN program is easy access to university and national lab STEM

leaders and researchers with a focus on making students aware of opportunities and helping students to apply for entry-level research experiences. Once they complete the MNT-CURN experience they will be more prepared and confident when applying for more advanced research experiences. The expectation is that MNT-CURN students will then apply to programs, such as START, that involve working in a university lab for nine hours a week during the academic terms. Without preparation, expecting a community college student to be successful in direct placement into a program like START oftentimes leads to frustration and students feeling a sense of imposter syndrome. Thus, this strategic multi-year plan for students to complete MNT-CURN activities and then continue into the START program provided a progression where students could continue their involvement in STEM research and benefit from the increased impact of this longer experience.

Next Steps: Current MNT-EC Endeavors

After the conclusion of the MNT-CURN and START programs, MNT-EC founded the Advanced Technology Technician Training (AT3) program [16], which focuses on technician workforce development and assistance with applications for industry internships. Expanding its reach, the AT3 program serves 400 students nationwide, a significant increase over the MNT-CURN and START cohorts of under 50 each. Building upon the framework of the MNT-CURN and START programs, the first round of the AT3 program provides an eight-month online academic year experience featuring weekly meetings, industry-focused presentations, dedicated mentorship by a larger team of mentors led by the MNT-CURN near-peer mentors, and access to virtual reality learning modules and headsets. The center is also working with industry partners to secure summer internship experiences. Furthermore, the AT3 program incorporates enhanced communication and collaboration among participants through a dedicated Discord server to share program updates, internship opportunities, and foster a strong student community.

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