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Mentored Undergraduate Research at Community Colleges

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Abstract

This study investigates the impact of community college students' participation in mentored undergraduate research, with an emphasis on STEM transfer students. The STEM Academic Research and Training (START) program at Wake Technical Community College was designed and implemented by community college faculty and staff and was evaluated in a randomized control trial. Early evidence showed statistically significant positive effects on students' attitudes toward STEM.

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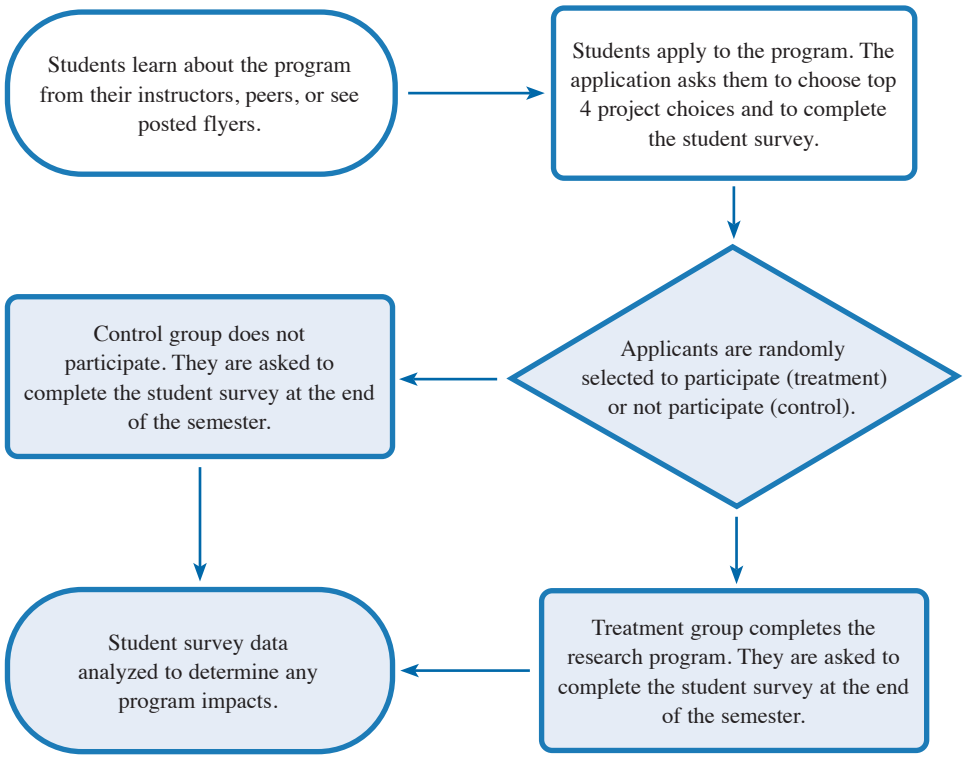
Numerous studies (Hernandez et al. 2018) have shown the impacts of undergraduate research experiences at four-year institutions, particularly as they relate to academic achievement and retention. The latest research is focusing on the effect of undergraduate research experiences at community colleges (Allison et al. 2022; Bhattacharyya and Chan 2021; Haeger et al. 2020; Nerio et al. 2019). By examining STEM Academic Research and Training (START), a mentored research program at Wake Technical Community College (Wake Tech), this study seeks to contribute to understanding the effects of these experiences on community college students' transfer to four-year institutions and persistence in STEM. The study employed a randomized controlled trial to compare outcomes for students randomly selected to participate with those randomly selected not to participate. This rigorous study provides stronger evidence for decisions concerning investment in student research in the two-year community college context.

START was designed to engage first- and second-year community college students in STEM research to improve their success in transferring to bachelor's degree programs and to encourage long-term persistence in STEM education and careers. START has 18 to 20 mentors, with each person mentoring from one to five students. Students are recruited by posted fliers and communication with their instructors and peers. Program eligibility includes enrollment in a credit course and being at least 18 years old. There are no GPA or program of study requirements. Of the students that apply, 55 students are randomly selected to participate in the program and compensated $1000 each semester, for up to four semesters. During the application process students select four of the twenty project choices and are matched to a project. The number of applicants varies, but averages 150 applicants each semester. In the last two years, START has offered 160 experiences, serving 102 unique students. The faculty-mentored research within the program includes biology, chemistry, engineering, geology, math, physics, and science communication.

START currently operates at three of Wake Tech's six campuses, with locations determined by the mentors' locations. Mentors are recruited by email communications from START leadership and are incentivized to participate by monetary compensation. The research consists of two primary types of projects: Wake Tech faculty-driven and partnership-driven, with projects usually equally split between the two types. The level of involvement from the partners varies from low involvement to highly involved.

FIGURE 1. Overview of Recruitment and Selection of Participants



In the lower-involved partner projects, the partner provides a project idea but has little involvement with the student, whereas in highly involved partner projects the student conducts research in the partner's laboratory, and the partner actively engages with the student. There are seven different university and community partners, including three highly involved partners. Evaluation is ongoing to elucidate program outcome differences based upon project location and partner involvement.

To help students develop skills and knowledge related to the STEM profession and research, several Principles of Research Training (PRT) modules were developed. These online modules are based upon Entering Research curriculum (Balster 2010) and differ based on a student's length in the program. First-semester students participate in online, asynchronous modules that explore responsible conduct of research, data analysis, communication of findings, and diversity, equity, and inclusion topics. The second semester PRT consists of three online modules that encompass more career-readiness tasks such as writing a resume, participating in mock interviews, and developing an elevator pitch. Students in their third or fourth semesters have virtual, synchronous "lab-style" meetings in which they give brief project updates and discuss primary literature. START leadership has also developed online training modules for mentors, based upon the Entering Research curriculum (Balster 2010), which covers ethical mentoring, research integrity, conflicts of interest, and data management.

More students apply than the program can accommodate, allowing the evaluation team to randomly select students for program participation; this type of design is frequently used to assess the impact of educational programs in which students elect to participate based on interest (Edmunds et al. 2020; Tuttle, Gleason, and Clark 2012). The study compared outcomes for students who applied and were randomly accepted to the program (the treatment group) with students who applied and were randomly not accepted (the control group; see Figure 1).

Because of this approach, the effects of the program can be determined without bias or other confounding factors, lending support to differences in impact being due to the program and not to the characteristics of students in the program. The lottery-based experimental design is a significant strength of this research project, because only one other study of undergraduate research has used a similar experimental design (Nagda et al. 1998). However, that study was in a university setting and not a community college setting like this one. A recent review of the research called for more causal impact studies, especially those that can meet What Works Clearinghouse standards without reservations (Haeger et al. 2020).

TABLE 1. Impact on Students' Attitudes and Skills

	Treatment (N=82)		Control (N=85)				
Scale	Adjusted mean	Standard deviation	Mean	Standard deviation	Impact estimate	Effect size	*p* value
STEM Self-Efficacy	4.41	0.64	4.23	0.78	0.18	0.25	0.0618
STEM Career Awareness	4.43	0.63	4.15	0.85	0.29	0.38	0.0093
Comfort with STEM Research	4.19	0.57	3.87	0.82	0.32	0.44	0.0011
Scientific Literacy	4.21	0.72	3.95	0.87	0.26	0.32	0.0182
Diversity and Inclusion in STEM	4.24	0.66	3.96	0.83	0.28	0.37	0.0136
Grit and Perseverance	4.34	0.77	4.16	0.89	0.18	0.21	0.1137
Transfer Confidence	4.39	0.63	4.16	0.88	0.23	0.29	0.0532

Note: The impact of the research program was assessed in a randomized control trial. The treatment group were students who applied to the program and were randomly selected to participate. The control group were students who applied to the program but were randomly selected not to participate. Treatment students in the academic year 2022–2023 reported statistically significantly higher levels than students in the control group on almost all measures, with the greatest impact on comfort with STEM research.

A student survey was employed to measure short-term outcomes, including self-assessed STEM skills and attitudes toward STEM education and careers. The survey was developed by an external evaluation team in collaboration with START leadership. It included items adapted from the validated Entering Research Learning Assessment (Butz and Branchaw 2020), as well as original items that reflected the goals and context of START. The scales on the student survey were:

- STEM Self-Efficacy. Ten questions about whether students could see themselves working in a STEM field, were confident they could do well in STEM, and believed they could transfer to a four-year institution STEM program.
- STEM Career Awareness. Three items to assess students' awareness of different STEM careers, their plan for a STEM career, and their confidence in having a STEM career.
- Comfort with STEM Research. Fourteen questions focusing on students' skills with STEM research activities, such as collecting and analyzing data and designing studies.
- Science Literacy. Seven questions examining students' self-reported skills in areas such as identifying reliable sources of information and interpreting presentations of scientific results.
- Diversity and Inclusion in STEM. Six questions examining to what extent students are aware of their own and others' biases in STEM fields and the extent to which they see themselves represented in STEM fields.
- Grit and Perseverance. Six questions focusing on students' reported ability to finish what they begin and work independently.
- Transfer Confidence. Five questions focusing on students' perceptions of their knowledge and skills relative to transferring to a four-year institution.

The student survey was administered online twice to each cohort, capturing changes in students' attitudes during the treatment semester. Reliability was good, ranging 0.81 for the STEM Career Awareness scale to 0.95 for the Comfort with STEM Research scale. The survey was administered at the time of students' application to the program and at the end of each semester. A total of 167 students (43 percent) out of 386 responded to both surveys. The evaluation team determined that the treatment and control students were equivalent on baseline measures of the survey scales. The survey analysis showed that treatment students reported statistically significantly higher levels than students in the control group on almost all measures (see Table 1).

As shown in Table 1, participants reported higher comfort with STEM research, higher awareness of STEM careers, higher understanding of issues related to diversity and inclusion in STEM, higher scientific literacy, and higher confidence in their ability to transfer successfully. Although students also reported descriptively higher rates of grit and perseverance, those differences were not statistically significant. The survey was supplemented by interviews conducted by the evaluation team, with two focus groups of students conducted during two sets of different semesters, consisting of five students each time for a total of ten students, as well as 12 interviews with a total of ten

mentors over the course of a year. These interviews, which were recorded, transcribed, and analyzed, focused on understanding students' and mentors' experiences and the perceived benefits of the program. In the interviews, many of the students and mentors remarked on students' growth in areas related to the outcomes listed in Table 1. Common themes were students' increased content knowledge and skills, increased confidence in their ability to be successful in STEM, and increased confidence in their scientific research skills. Furthermore, they were now more likely to see themselves as scientists. One student said,

> I feel like this is the first time ever where I actually felt like I could actually be a scientist and do research, because doing it in class is not anywhere close to what we did for this [program].

Future analyses will examine the impact of the program on students' persistence in undergraduate education and their completion of STEM-related courses, using administrative data from Wake Tech and the National Student Clearinghouse. These preliminary results are promising and indicate that there is a role for mentored undergraduate research in community colleges.

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Data Availability Statement

The data, critical questions used in scripts, and instruments underlying this study are available in the text.

Institutional Review Board Statement

Approval was not required as the research did not involve human or animal subjects or samples.

COI Statement

The authors have no conflict of interest to declare.

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Sarah Horstman is START coordinator and associate professor of mathematics at Wake Technical Community College. As coordinator, she is responsible for day-to-day operations, including pairing students and mentors, data collection, and all administrative paperwork. Horstman earned her MS in teaching and professional growth for K-12 teachers and community college faculty.

Carolyn Hoffman is an associate professor of mathematics and START ambassador director at Wake Technical Community College. With a background in engineering, she most enjoys teaching mathematics in context. Outside the classroom, Hoffman also seeks out student interactions and has enjoyed advising students on their engineering pathways, being a START undergraduate research mentor, and advising the engineering club.

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