Cohort Intervention Impacts on Undergraduate Science Students' Success

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Abstract

Step Up to Physical Science and Engineering at Randolph (SUPER) is a recruitment and retention program for natural science and mathematics majors at Randolph College, a small liberal arts college in central Virginia. Begun as a pilot program in 2010, and then funded by two National Science Foundation (NSF) Scholarships in Science, Technology, Engineering, and Mathematics (S-STEM) grants, the program has multiple cohort experiences throughout a student's four years of college. This paper analyzes the college-wide recruitment and retention impacts of the SUPER program by examining applicant interests and declared majors as well as college-wide retention. This paper also analyzes the recruitment and retention impacts of the associated scholarships and inclusion in the SUPER program by comparing scholarship vs. non-scholarship students, and students in the SUPER program vs. students not included in the SUPER program. We are interested in the recruitment and retention of all students in STEM and, because of long-standing patterns of exclusion, the impact on women, African American/Black, Hispanic/Latino(a), and Native American students. The program has led to an increase in students majoring in physical science from 6.2% of all declared majors at the college in 2012 to 14.2% of all declared majors in 2019, and improved retention to graduation in STEM (31% for students entering in 2013 to 40% for students entering 2015) while overall retention at the college declined. While the scholarships associated with the NSF grants were effective at increasing applications to the program, retention rates for scholarship students and non-scholarship students were not significantly different. Students within the SUPER program showed higher retention to graduation in STEM when compared to other STEM-interested students across all demographics (54% vs. 29%) and among female students (62% vs. 33%). Retention to graduation in STEM among students identifying in traditionally under-represented racial and ethnic groups is also higher for SUPER students than other STEM students (42% vs. 24%), though this difference was not statistically significant. This analysis demonstrates the effectiveness of the SUPER program in improving the recruitment and retention of STEM students at Randolph College and can provide a template for similar programs at other institutions.

Keywords: scholarships, recruitment, retention, inclusion

The economic competitiveness of the U.S. in the global market demands a highly qualified STEM (science, technology, engineering, and math) workforce (American Association of State Colleges and Universities, 2005; National Science Board, 2019). From 2009 to 2015, employment in STEM occupations grew at more than double the rate of employment in non-STEM occupations (Fayer et al., 2017), and faster growth for STEM employment vs non-STEM employment is expected to continue (Employment Projections, 2021). Unfortunately, inadequate K-12 science and math education, difficulties with retention in STEM disciplines at the university level, and the inability of students to cover the cost of education negatively impact the development of this STEM workforce (U.S Department of Education, 2016; Desilver, 2017; Sithole et al., 2017). For example, in 2017, almost half of all graduating high school seniors indicated an interest in STEM, but only 21% were academically prepared, with students who were low-income, first-generation, and/or from traditionally under-represented racial and ethnic groups less likely to demonstrate preparedness for college-level STEM courses (ACT, 2018). The challenges of retention and degree attainment in STEM are intensified for many students, including Black/African American, Latino/a, and Native American/Alaska Native students, because of a history of exclusionary practices in the field. While degree completion rates in STEM are low for all demographics, with only 40% of students who begin college interested in STEM graduating with a STEM degree in 6 years (PCAST, 2012), degree completion rates for Black/African American, Latino/a, and Native American/Alaska Native students are roughly half that of the national average (Hurtado et al., 2010).

To help students interested in STEM degrees persist and complete STEM degrees, we implemented various components of a program tied together in a cohort model. In 2010, Randolph College piloted a summer transition program, a two-week, intensive math and science course for entering first-year students. In 2013, with funding from the National Science Foundation (NSF) Scholarships in Science, Technology, Engineering, and Mathematics program (S-STEM), we were able to launch a four-year program with the programming components that, from experience, we believe all students could benefit from, including the summer transition program. The NSF funding also supported need-based merit scholarships for approximately half of the students in the program. We created this program by choosing those components that we have learned from experience help students succeed, but that students will often neglect without some incentive or guidance to complete. While the components were selected and designed based on educator experience, the individual elements (listed below) are well-supported in the STEM education research (e.g., Dagley et al, 2016; Tomasko et al, 2016; Sithole et al, 2017, D'Souza et al, 2018). These components were selected to provide financial and academic support while also building community among the students in this program. Research demonstrating the importance of science self-efficacy and STEM identity as mediating factors in the impact of science support services (e.g., Chemers et al 2011) and demonstrating the importance of belonging in college student retention (e.g., Walton and Cohen 2011) was just emerging when the program was developed. However, the underlying theme of this work, that the effectiveness of support services and interventions depends on how these actions impact a student's perception of themselves, is consistent with the experience-based decisions made in the development of the program. Here we discuss the efficacy of the program, called Step Up to Physical Science and Engineering at Randolph (SUPER).

This paper examines the effectiveness of this program in reaching its goals to recruit, retain and educate future scientists, particularly in fields outside the life sciences, by examining the impact of the program on the college as a whole and by comparing SUPER students to students at the college who are not in the SUPER program. While the overall goal is to increase the number of STEM students successfully graduating, success in the program's goal must include recruitment and retention of students who are traditionally underrepresented in these fields, so we also look at our success across the demographic characteristics of gender and race/ethnicity. This paper is not an analysis of the impact of individual programmatic elements of the SUPER program but is instead an examination of the effectiveness of a comprehensive cohort program and of the effectiveness of offering scholarships in that program. The results of the program can guide other schools in developing programs to improve the recruitment and retention of STEM students.

Researching the effectiveness of the SUPER program

Because of the size of Randolph College, we were particularly interested in the ability of a program like this to impact the whole college community. Because financial concerns are a primary factor in the decision of where to attend college, we are interested in the impact of scholarships connected to this particular program. And because a primary goal of the SUPER program is to produce future scientists, we need to assess whether SUPER is helping us to attract more STEM students, and whether students in the program are more likely to stay in a STEM field. Thus, this paper assesses the impact of the SUPER program relative to its goal of improving recruitment and retention by answering the following questions:

1) **College-wide impacts:** Has the SUPER program affected the recruitment and retention of STEM students at the college, regardless of inclusion in the SUPER program?
2) **Impact of the scholarships**: Do the SUPER scholarships affect the likelihood of a student enrolling and being retained in a STEM field at the college?
3) **Impact of inclusion in the SUPER program**: Does inclusion in the SUPER program affect the likelihood of a student enrolling and being retained in a STEM field at the college?

Due to historical and systemic roadblocks, improvements in recruitment and retention in STEM must include significant impacts on historically marginalized students, so if the SUPER program is effective, we both expect to see increases in recruitment and retention for all students and for sub-groups of students who are traditionally underrepresented in STEM. Here we focus on the cohorts entering the college 2013-2018 (limited to the 2013-2015 cohorts for retention to graduation), each cohort representing 22-27 incoming students.

Components of the SUPER program

The SUPER program includes a significant recruitment effort from program faculty, scholarships offered to prospective program participants with financial need, and six programmatic components throughout the participants' four years of college (Table 1).

Recruitment

Faculty involved in the SUPER program are actively involved in helping to recruit students to the college. Efforts include going to high school college and career fairs with college admissions counselors, having a SUPER information session at most on-campus recruiting events, and emailing many student prospects and all qualified STEM applicants to the college about the opportunity to apply to the program. Targeted recruitment of individual students begins in the fall of the student's senior year of high school.

Scholarships

All students in the SUPER program receive regular financial aid packages from the college based on need and merit. In addition, 81 out of 149 students who started in the cohorts studied received additional annual NSF S-STEM scholarships, with the scholarship offer made in the spring (February through June) before the student enrolled at the college. Students were awarded scholarships based on academic merit as shown through test scores and high school GPA, a brief application, and financial need. A minimum of 3.0 GPA and 500 math SAT were recommended for admission to the program, although we considered the complete transcript and application in a holistic way to determine acceptance and scholarships. The scholarships were only available to students intending to major in a physical science (as defined below) with unmet financial need and students were required to maintain a 3.0 GPA to retain their scholarships. If a student did not earn a 3.0 in either semester during an academic year, the student was placed on probation. If the student did not earn a 3.0 in either of the two following semesters while on probation, the student was suspended from the program, losing any associated scholarship. If the student earned a 3.0 in a semester while on suspension, the student earned back the scholarship for the following year. The number of scholarships available and the value of the scholarships varied (Table 2). There were typically two levels of annual scholarship, for example, $5000 and $7500 in 2017 and 2018, with the difference primarily based on merit (the higher scholarships were generally awarded to students above a GPA of 3.5 and math SAT of 600), but the scholarships went as low as $1500 if the student's unmet financial need was lower, as the total award package including federal aid and college merit scholarships cannot exceed the cost of attendance.

Programmatic Components

The six programmatic components include 1. sum-

Element of the SUPER program	Timing
Recruitment	Targeted recruitment to the SUPER program beginning during the student's senior year of high school
Scholarships	Scholarship offers are made in the spring before the student enrolls in the college; students can maintain their scholarships for four years
Summer transition program	Two weeks before the start of the first year of college
Living learning community	Begins during the summer transition program and continues through the first year of college
Resource and study groups	Begins during the summer transition program and continues through the first year of college
Mentoring	Begins during the summer transition program and continues through all four years of college
Annual seminars	During the first year of college only for the 2013-2016 cohorts, and one semeste each year for all four years of college for 2017-2018 cohorts.
Career development	Begins during the summer transition program and continues through all four years of college

Table 1. Identification of the key elements of the SUPER program and the timing of these elements.

Cohort	# of scholarships	Average annual scholarship
2013	12	$5,250
2014	14	$4,857
2015	7	$1,929
2016	13	$2,500*
2017	18	$5,694
2018	17	$5,588

Table 2 Summary of scholarships awarded to SUPER students. The 2013 and 2014 cohorts were supported by one NSF grant and the 2017 and 2018 cohorts were funded by a second NSF grant. Additional scholarships were awarded in subsequent years as a combination of NSF funds freed up by students who left the program and supplemental college funding. *The scholarships awarded to the 2016 cohort were only 2 years scholarships, while the scholarships in all other years were renewable for up to 4 years

mer transition program, 2. living-learning community, 3. resource and study groups, 4. annual seminars, 5. mentoring, and 6. career preparation. All SUPER students arrive two weeks early to begin the summer transition program and live together in the living-learning community. They also begin to participate in resource and study groups that continue throughout their first year. Each SUPER cohort has a class together in each of the four years they are at Randolph College. Mentoring begins when they arrive on campus and continues with both organized mentoring events and self-initiated mentoring connections. The career preparation component has the students make a connection with the Career Development Center each year, beginning with an introductory session during the summer transition program. These components are described further below.

1. Summer transition program

The SUPER summer transition program begins two weeks before the first-year class arrives on campus. The cost of tuition, room, and board for these two weeks is entirely covered by NSF funding or by the college for all students in the program. During the two-week program, students take physics, physics lab, and math for approximately 4.5 hours per day. When students are not in class, we take them on field trips to STEM facilities throughout the region, such as the Insurance Institute for Highway Safety's Vehicle Research Lab, Fleet Pharmaceuticals, and Framatome, a nuclear energy company. The students also meet with key offices and personnel on campus, such as the Career Development Center and the President of the College. A highlight of the program is a field trip to an amusement park for entertainment, bonding, and activities on the physics of roller coasters. Students in the summer transition program attend a resource and study session most nights staffed by one of the three faculty members in the program and peer tutors. The students also live together and have nightly social programming in the dorms with the resident assistant, who is an upper-class SUPER student. This program begins developing the cohort of SUPER students and helps bolster academic preparation.

2. Living-learning community

In addition to living together during the summer transition program, starting in 2014, all residential SUPER students lived together throughout their first year in a single hall of a dorm. Because of Randolph College's residential requirement that all students live on campus unless they are living with family within 50 miles, only eight out of 125 students participating during the years with a living-learning community did not live on campus. The students do not have any single class together, but all first-year SUPER students are together in one of two first-year seminar sections, and most students are taking introductory science or math courses together, most commonly introductory physics and calculus. The second cohort of SUPER students to live in a living-learning community created a petition at the end of their first year to be in the same dorm as the next cohort, and upper-class SUPER students have often lived near the first-year SUPER student hall since that time.

3. Resource and study group

First-year SUPER students continue the resource and study group established during the summer program during the fall and spring semesters. For all cohorts, in the fall semester, this resource and study group is held for one and a half hours on Sunday evenings and students are required to attend with a limited number of allowed absences. For the first four cohorts, we continued this Sunday evening resource and study group in the spring, but for the last two cohorts, we transitioned to a less formal Friday afternoon gathering. The transition to this modified resource and study group in the spring semester was inspired by student frustration with the traditional study hall model carrying over into the spring semester, when many students felt like they had already "figured out" college. Because these meetings serve as a chance to frequently check-in with all the first-year SUPER students, the modified resource and study group was developed rather than requiring only one semester of resource and study group. For all versions of the resource and study group, peer tutors were available for students and each week the faculty member in charge led a brief discussion or presentation on a topic of interest for first-year college students, such as time management or mental wellness, before students begin working on homework or other assignments.

4. Seminars

All Randolph College students are required to take a first-year seminar course. Initially, those seminars varied in topic, and the SUPER students were split into two groups, each with one faculty member and a specific topic. The two groups would switch faculty members and topics mid-semester. In 2018, the college initiated a common first-year seminar for all students in which faculty section leaders also serve as pre-major advisors. The SUPER students are still placed in two sections with faculty from the SUPER program, but they cover the same material and content as all first-year students and no longer switch content and instructors at midterm. In addition, SUPER students have always been assigned an academic advisor from faculty affiliated with the SUPER program until they declare their majors but are now advised solely by the two first-year seminar leaders until they declare their majors. Starting with the cohort that entered in 2017, we added one-credit sophomore, junior, and senior seminars that focus on research and career preparation.

5. Mentoring

The SUPER students are assigned either a peer mentor or an industry mentor at the start of their first year. For the 2013 and 2014 cohorts, all students were assigned industry mentors, from fields similar to that which the student intends to pursue. All students entering in 2015 and 2016 were assigned peer mentors (upper-class SUPER students) for the first two years and then industry mentors for the last two years of college. We made this shift in the mentoring program because many students needed more help adjusting to college in their first two years and were not prepared to work effectively with an industry mentor. Students entering the program since 2017 have been surveyed before arrival about their mentor type preference so that we can assign them the type of mentor they prefer. The intention is that initially half the students have a peer mentor, and half have an industry mentor, and this usually works out since many students do not have a preference. The mentoring program is supported by 3-4 mentor/mentee events during the academic year, such as a group lunch and professional networking events facilitated by the college's Career Development Center. The mentor/mentee pairs are expected to meet a minimum of two times per year on their own. The goal of the mentor program is to increase students' affiliation with their disciplines.

6. Career preparation

The SUPER program includes a requirement for research or internships and requires students to participate in a four-year career plan facilitated by the college's Career Development Center. We hold annual sessions stressing the importance of getting hands-on experience through research or internships, and we guide the students on how to find these experiences. Often, students will find an internship through their SUPER mentor. The SUPER students self-report participation in an internship or research experience, and 88% of them have reported completing at least one internship or research experience before graduation, with the other 12% unknown due to a lack of self-report. The career plan, which is a structured approach to career exploration and professional development, has tasks for the student each semester. This plan starts with resume development in the first year, includes exploration in Career Development Center events, such as mock interviews and internship exploration, and culminates in graduate school and job fairs in the final year.

Methods

Background

Randolph College is a small, nationally recognized, traditional liberal arts college in Virginia. Founded in 1891 as Randolph-Macon Woman's College, Randolph is known for its excellent academic program and diverse close-knit community. The college is known for being strong in the sciences – in part due to this program. The undergraduate population has ranged between 600-700 students during the years reported, and due to this size, each physical science major traditionally graduates fewer than 10 students each year.

College-wide impacts

To assess the impact of this program on the college as a whole, we looked at changes in the college since the establishment of the four-year SUPER program in 2013. We examined 1) changes in the stated interests of students enrolling in the college, 2) changes in the number of declared STEM majors, and 3) changes in retention to graduation for STEM and non-STEM students.

1) *Changes in the stated interests of students enrolling in the college*

Student interests at application to the college were categorized as PHYS (physical and mathematical science including chemistry, environmental science, mathematics, engineering, computer science, data science or physics), BIOL (biology), HEALTH (health professions including pre-vet, pre-nursing, pre-med, dental, and pharmacy) or OTH (other). Some students listed more than two interests, but only the first two were considered as primary interests. In addition, because the challenges for retention are often greatest in the physical and mathematical sciences, the classification of the students was done using a hierarchy of PHYS, BIOL, HEALTH, and then OTH, with a student classified based on an expression of interest in the highest category in this ranking. For example, a student who expressed interests in biology and chemistry was classified as a PHYS student. To account for changes in the college's enrollment, the percent of students interested in each field enrolling in the college was calculated for each year from 2011-2018. Inclusion of the classes entering in 2011 and 2012 provided a baseline level of interest in STEM at Randolph College before the SUPER program and affiliated scholarships were actively used in student recruitment.

2) *Changes in declared STEM majors*

Declared majors and majors at graduation were similarly classified into PHYS (chemistry, environmental science, mathematics, engineering physics, and physics), BIOL (biology) and OTH (other), using the same hierarchical approach. The HEALTH category is not included in declared majors because we do not have health science majors – those interests will generally declare a major in chemistry or biology. STEM interests may be PHYS, BIOL and HEALTH while STEM majors can only be declared in PHYS and BIOL. Similarly, while some students indicated an interest in computer science or data science at application, these majors were not available at Randolph College for the studied cohorts, so would likely have declared in PHYS (frequently mathematics or engineering physics). Multiple majors and interests, reflecting the breadth of the physical and mathematical sciences, are combined into the PHYS category, both to reflect the SUPER program's emphasis on physical and mathematical sciences and because the small numbers involved in this project do not allow further disaggregation. Students who double-major are counted twice since we are counting the number of declared majors at the college.

3) *Changes in retention to graduation for STEM and non-STEM students*

The percent of students retained to graduation overall, retained to graduation in STEM, and retained to graduation in PHYS was calculated for students entering the college from 2011-2015. Students who began with a STEM interest and graduated with a STEM major within 5 years were considered retained to graduation in STEM. Similarly, students who started with a PHYS interest and graduated with a PHYS major within 5 years were considered retained to graduation in PHYS (even if they changed majors within the PHYS category).

Impact of the scholarships

The NSF-funded SUPER scholarships are intended to be both a recruitment and retention tool. The impact of the scholarships on *recruitment* was examined by comparing the number of applicants to the SUPER program and to the college overall with the total monetary value of scholarships to be awarded that year, and by comparing the enrollment yield from students offered admission to the SUPER program with scholarships to those offered admission to the program without scholarships. The 2016 cohort is excluded from the analysis of the impacts of scholarships on recruitment because scholarships in 2016 were not awarded until after the students had committed to the program. The impact of the scholarships on retention was analyzed by comparing retention to the second year and to graduation (overall, in STEM and in PHYS) of the students in the program who received the NSF S-STEM scholarship to those in the program who did not. We also compared status in the program (if and how often students were placed on probation or suspended from the program) for scholarship and non-scholarship students.

Impact of inclusion in the SUPER program

The impact of inclusion in the SUPER program on student success was assessed by comparing students in the program with similar students at the college who were not in the SUPER program, including students who applied and were not accepted to the program, but who still came to the college. To assess the impact of inclusion in the SUPER program on recruitment, incoming applications – both to the college and to the SUPER program – and yield from the applications were compared. Because the SUPER program is for new college students and transfer students who planned to spend four years earning their undergraduate degree at Randolph, the SUPER students were compared to a) all first-time, first-year Randolph College applicants, b) all first-time, first-year Randolph College applicants with an interest in STEM, and c) applicants to the SUPER program who were not admitted to the program. We examined retention to the second year and retention to graduation (overall, in STEM, and in PHYS) and, when possible, examined retention for female students and students identifying in traditionally under-represented groups. We obtained a list of all applicants to the college for the years of interest which included demographics and academic interest. For demographic information, students were classified based on Randolph College's data for the Integrated Postsecondary Education Data System (IPEDS). Students who identified as American Indian or Alaska Native, Black or African American, Hispanic, and two or more races were classified as students identifying in traditionally under-represented groups.

Results

College-wide impacts

Since 2013, the beginning of the four-year SUPER program, the college has seen an increase in enrolling students interested in the physical sciences and an increase in declared physical science majors, but no change in these metrics for the life sciences. The percentage of enrolling students who expressed interest in studying life sciences (BIOL + HEALTH) has remained between 21-23% of all enrolled, while students interested in physical sciences increased from 17% before 2013 to 21-23% since then. Since spring 2013, the number of declared majors across the college has increased by 13% but the number of declared PHYS majors has increased by 84% (Fig 1).

Students traditionally do not declare their majors until their sophomore year, which indicates that students have passed a major attrition point from the first to second year. Interestingly, BIOL majors have not increased at the same

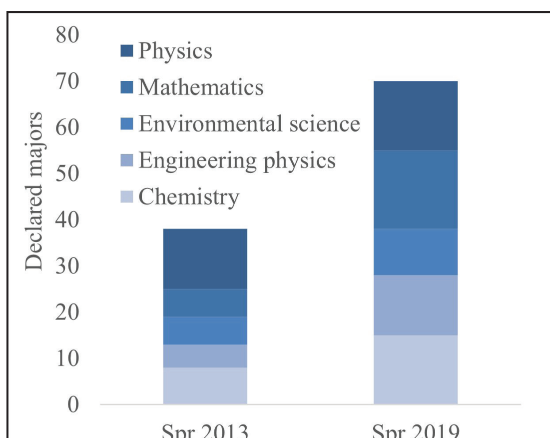

Figure 1. Number of declared majors in PHYS programs at Randolph College in Spring 2013 and Spring 2019. The majors emphasized in this program have seen much greater growth than other programs at the college.

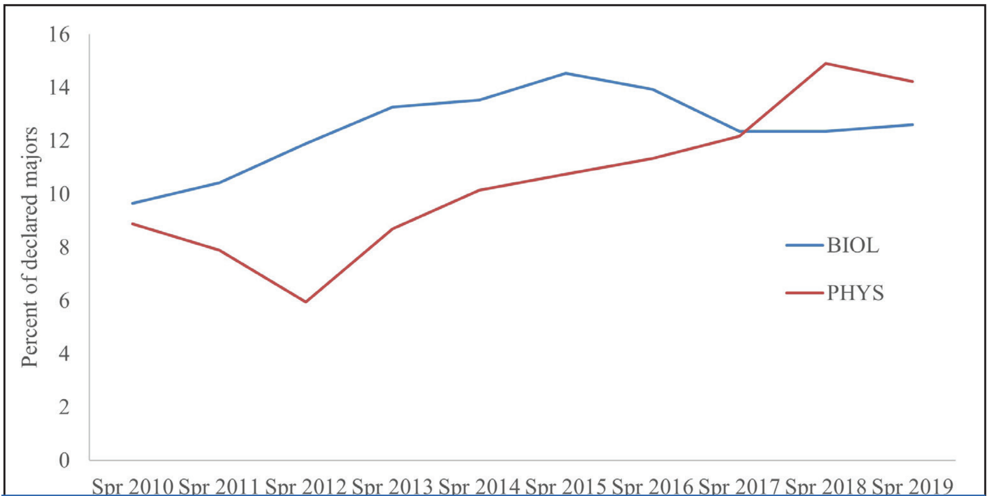

Figure 2. BIOL and PHYS majors as a percent of all declared majors. The percent of declared PHYS majors has increased since the start of the 4-year SUPER program while the percent of BIOL majors has remained static.

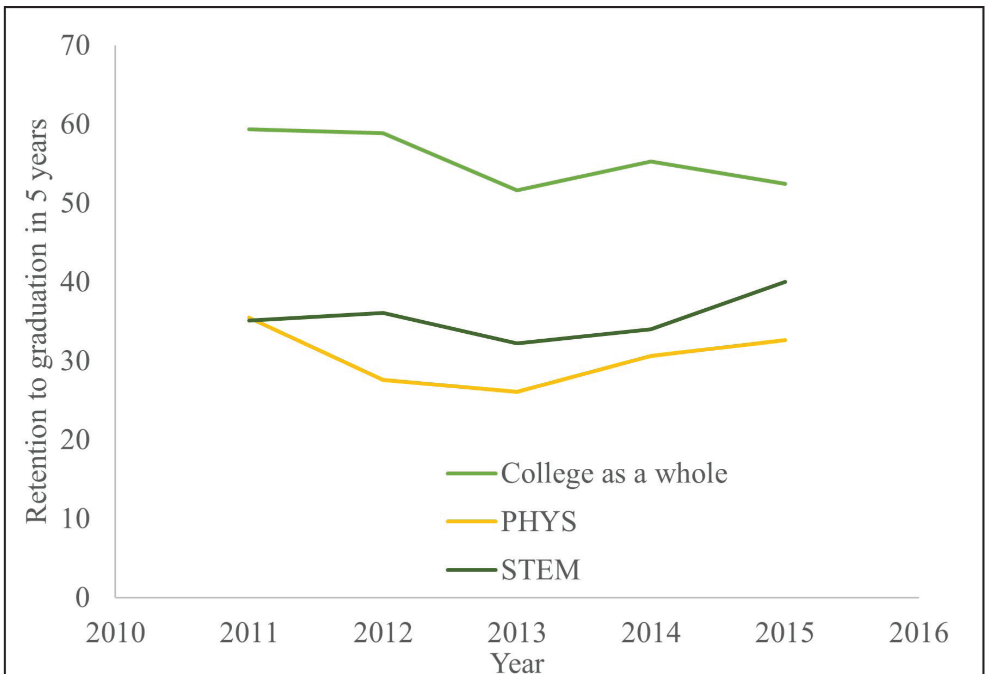

Figure 3: Percent of students entering in each cohort retained to graduation in 5 years. PHYS and STEM students retained are those who expressed an initial interest in the field and then graduated with a degree in the field. The college as a whole (which includes STEM graduates) has a decreasing trend in retention, while STEM graduates by themself have an increasing trend.

rate as PHYS majors. From spring 2013 – 2019, the percent of declared BIOL majors (as a percent of all declared majors at the school) did not show a significant trend (linear regression, p=0.14, df=6 Fig. 2), but the declared PHYS majors as a percent of all declared major increased by 0.8 per year (linear regression, p=0.001, R2=0.90, df= 6, Fig. 2).

The implementation of the SUPER program has also coincided with an increase in retention in STEM across the college. Overall, retention to graduation in five years at the college has been declining from 59% for students entering in 2011 to 52% for students entering in 2015, but this declining trend in retention was reversed for PHYS students and STEM students (BIOL+HEALTH+PHYS), with retention of students interested in PHYS increasing from 24% to 33% for the classes entering in 2013 to 2015 and retention of students interested in STEM (BIOL+HEALTH+PHYS) increasing from 31% to 40% over the same time period (Fig. 3). These numbers represent retention in STEM at Randolph College and underestimate overall retention in STEM (due to the fact that students who transfer out often still graduate in STEM fields), and underestimate retention of students to graduation (due to graduation in other fields).

Impact of scholarships

The availability of scholarships increased applications to the SUPER program but did not affect overall applications to the college, and earning a scholarship did not affect retention of SUPER students. The number of applications to the SUPER program increased with the total monetary value of scholarships available each year (linear regression, p =0.03, R^2 =0.75, df = 5), but the monetary value of the scholarships had no statistically significant impact on overall applications to the college (p = 0.08, R^2=0.58, df = 5), number of applications from students interested in STEM (p=0.09, R^2=0.55, df =5), or number of applications from students interested in PHYS (p=0.23, R^2=0.33, df = 5).

Scholarship offers increased enrollment yield and retention to second year, but not to graduation, though none of these differences are statistically significant (Table 3). This retention rate for SUPER was still higher than the general student population. Of the students with scholarships who left the program or left the program because they left the college, five out of 16 were suspended for low grades and one was on probation at the time they left the program. Of the 14 non-scholarship students who left the program, only one was on probation at the time they left. Throughout the years reported, 33 students with scholarships and 30 students without scholarships were placed on academic probation, and seven of the scholarship group and four of the non-scholarship group eventually returned to good academic standing.

Impact of inclusion in the SUPER program

Impact on recruitment

The changes at the college overall in terms of declared majors and retention in STEM are indicative of the impact of the SUPER program, but the impact of the SUPER program can also be assessed more directly by comparing students in the program to students at the college who are not in the program. Invitation to the SUPER program increased the likelihood of a student enrolling at the college compared to the general student population (Table 4). For all of the college's accepted students, those interested in STEM were equally as likely to enroll after acceptance as the overall student body, but students who applied to the SUPER program were approximately three times more likely to enroll in the college across all demographics, whether or not they were accepted into the SUPER program.

Impact on retention

We see in Tables 4 and 5 that retention to the second year and to graduation are always higher for SUPER students than the college population as a whole, though these differences are not always significant. Retention of the college population as a whole in STEM and PHYS was significantly lower than retention for SUPER. These tables compare SUPER students to the broad student body, not to students with similar academic credentials from high school. The potential impact of these differences is explored in the discussion.

The retention estimates in Tables 5 and 6 overestimate the loss of students from the STEM pipeline because

	Scholarship	No scholarship
Enrollment Yield	56% (69/123)	46% (53/114)
Retention to 2nd Year	88% (71/81)	82% (55/68)
Retention to Graduation	52% (17/33)	65% (26/40)

Table 3. Enrollment yield, retention to second year, and retention to graduation by scholarship status. The scholarships increased yield and retention to second year, and while scholarships did not increase retention to graduation, the SUPER students in general retain to graduation better than the overall college population. None of these results are significant (Pearson chi-squared).

	Students accepted to Randolph College		Students accepted into the SUPER program
	% enrolled	% interested in STEM enrolled	% enrolled
All	17 (1162/6787)	17 (538/3164)	50 (148/298)
Traditionally Under-represented	13 (364/2759)	13 (170/1333)	35 (31/88)
Female	16 (724/4451)	15 (313/2050)	51 (76/149)

Table 4. Enrollment yield of all applicants, applicants interested in STEM, and applicants to the SUPER program. Enrollment yield for SUPER students was different from enrollment yield for all applicants to the college and applicants interested in STEM at the p<0.0001 level (Pearson Chi-squared test).

	All	Female	UR
Non-SUPER students	69% (700/1019)***	70% (452/650) **	64% (210/329) **
Non-SUPER STEM students	70% (263/376)**	71% (161/228) **	66% (80/121) **
SUPER students	86% (125/145)	88% (66/75)	90% (35/39)

Table 5. Retention to the second year for students in the SUPER program and all students not in the SUPER program (2013-2018). The students in the SUPER program were compared to both the general student population not in the SUPER program and to only students who indicated an interest in STEM at the time of application to the college. This comparison was completed for all demographics of students and then repeated for female students and students who identify in traditionally underrepresented groups (UR) using a Pearson's chi-squared test. Significant differences between the SUPER students and the non-SUPER students are indicated by *** = p<0.0001, ** = p<0.01, *=p<0.05. This is independent of GPA, that comparison is done in Table 7.

students who transferred to another institution and graduated with a STEM degree are counted as unretained. To partially correct this overestimation, the analysis was repeated with all students who transferred from Randolph College removed from the calculation (Table 7). Table 7 shows that students in the SUPER program were retained to graduation in STEM and PHYS better than students not in the program across all analyzed demographics, though the differences for traditionally under-represented groups were not significant.

Comparison with students who applied but were not accepted to SUPER

Retention of students in the program can also be compared with the retention of students who applied to but were not accepted into the SUPER program. The latter group was retained at the college to their second year at a high rate (88%, 35/40) and retained to graduation at a high rate (70%, 19/27). However, retention to graduation in STEM (50%, 12/24) and in PHYS (45%, 5/11) was lower than for SUPER students, while still higher than for the college overall. The small sample size of students not accepted into the SUPER program precludes analysis of this data by demographic group or statistical analysis.

Discussion

The SUPER program has been effective at increasing the recruitment and retention of STEM students at Randolph College. Overall, SUPER students are retained in the sciences at a much greater rate than other STEM students at the college, and the college's physical science programs have seen increased enrollments since the development of the SUPER program. Both female students and students who identify in traditionally underrepresented groups (UR) were retained to graduation in the sciences at a higher rate if they were in the SUPER program than if they were not, though the difference in retention for UR was not statistically significant. This lack of significance was likely due to the small number of UR students enrolled in the SUPER program (12 out of 71 students in the 2013-2015 cohorts analyzed for retention to graduation in 5 years). When a larger data set (2013-2018 cohorts) was analyzed for retention to the second year, the SUPER program did significantly improve retention for students who identify in traditionally underrepresented groups.

One possible explanation for the higher retention of SUPER students is a stronger affinity for the college and a stronger affinity for STEM shown by SUPER applicants. To try to account for this difference, the SUPER students were also compared to students who applied to the SUPER program but were not accepted. These students enrolled at the college and were retained, both to the second year and to graduation in five years, at similar rates to the SUPER students, indicating a strong affinity for the college. However, these students showed lower retention in STEM and PHYS. Because of the small sample size, these trends were not analyzed statistically but do indicate that the components of the SUPER program improved STEM retention of the students in the SUPER program.

Another predictor for the higher retention of SUPER students is better academic preparation, but retention is still higher for SUPER students than students equally well prepared who are not in SUPER. High school GPA is a strong predictor of college success (Allensworth and Clark, 2020; Geiser and Santelices, 2007), which is what we have seen at Randolph College. Table 8 shows retention vs. GPA data from the fall of 2010 to the fall of 2020 where retention from the first to the second year incrementally increases from 53% for a GPA below 2.5 to 83% for a GPA above 4.0. In Table 9 we show the college's first to second year average retention rate as a function of GPA for those at the college who are not in the SUPER program vs. those who are in the SUPER program from the years 2013-2018. Note that the SUPER program has a minimum recommended high school GPA of 3.0, but during these years we accepted six students with GPA's just below 3.0 due to other, outstanding credentials. The SUPER program at Randolph College has a twofold effect on retention as it both attracts students with a higher GPA (average high

	Non-SUPER students			SUPER students		
	All	Female	UR	All	Female	UR
Retained to graduation	51% (265/517)	56% (194/346)	41% (56/136)	66% (47/71)	68% (28/41)	67% (8/12)
STEM interested students retained to graduation	53% (106/199)	57% (74/129)	45% (25/55)	66% (45/68)	69% (27/39)	67% (8/12)
STEM interested students retained to graduation in STEM	29% (57/199) ***	33% (42/129) **	24% (13/55)	54% (37/68)	62% (24/39)	42% (5/12)
PHYS interested students retained to graduation	53% (47/88)	60% (24/40)	44% (11/25)	68% (36/53)	73% (22/30)	70% (7/10)
PHYS interested students retained to graduation in PHYS	19% (17/88)***	17.5% (7/40) **	12% (3/25) *	47% (25/53)	50% (15/30)	50% (5/10)

Table 6. Retention to graduation in 5 years at Randolph College for students in the SUPER program and students not in the SUPER program (for classes starting in 2013-2015, graduating by 2020). The students in the SUPER program were compared to analogous groups of non-SUPER students grouped by demographics and student interest at the time of application. Significant differences between the SUPER students and the non-SUPER students are indicated by *** = p<0.0001, ** = p<0.01, and *=p<0.05.

	Non-SUPER students			SUPER students		
	All	Female	UR	All	Female	UR
Retained to graduation	68% (265/391)	75% (194/258)	60% (56/94)	76% (47/62)	80% (28/35)	80% (8/10)
STEM interested students retained to graduation	69% (106/153)	78% (74/95)	63% (25/40)	75% (45/60)	79% (27/34)	80% (8/10)
STEM interested students retained to graduation in STEM	37% (57/153) **	44% (42/95) **	33% (13/40)	62% (37/60)	71% (24/34)	50% (5/10)
PHYS interested students retained to graduation	67% (47/70)	77% (24/31)	58% (11/19)	78% (36/46)	88% (22/25)	78% (7/9)
PHYS interested students retained to graduation in PHYS	24% (17/70) **	23% (7/31) **	16% (3/19)	54% (25/46)	60% (15/25)	56% (5/9)

Table 7. Retention to graduation in 5 years at Randolph College for students in the SUPER program and students not in the SUPER program, with students who transferred to other colleges removed. The students in the SUPER program were compared to analogous groups of non-SUPER students grouped by demographics (females and students who identify in traditionally underrepresented groups - UR) and student interest at the time of application. Significant differences between the SUPER students and the non-SUPER students are indicated by *** = p<0.0001, ** = p<0.01, and *=p<0.05.

school GPA of 3.8), but it also has a significantly higher retention than is shown by GPA alone, due to additional positive factors related to the program. While retention is higher at all GPA levels, it is particularly interesting to note that the trend of higher GPA predicting higher retention is not seen for the SUPER students, which may indicate that the program is an excellent support mechanism particularly for the weakest students.

Given that the SUPER students outperform other students with similar incoming academic credentials, other aspects of the program must contribute to their improved retention. A sense of community and belonging has been shown to increase retention in STEM, particularly for students who identify in underrepresented groups. The summer transition program particularly gives the first-year SUPER students a chance to spend some time making campus their home before the campus fills with upperclass students, and the intensity of the summer transition program gives them a chance to bond with their small cohort. The living-learning community, study and resource groups, and academic oversight of the program help them to stay on academic track and not get lost. The mentoring, career plan, and research and internship programs give them something to look forward to, give them a sense of where they are going, and help them to set goals.

Scholarships were highly effective for recruitment. While SUPER students were in general retained at higher rates, scholarship students in SUPER were retained to graduation at lower rates than non-scholarship students. This does not mean that they are not positively impactful, just that many of the scholarship students chose to leave college while on academic probation or suspension, indicating that the loss or potential loss of scholarship funds may be what leads to attrition. The scholarship students were less successful in returning from academic probation and suspension, which could be because of a difference in majors (scholarship students are required to major in a physical science, while other students in the program can major in any science) or additional stresses on schol-

GPA	All students
under 2.50	53%
2.50-2.99	63%
3.00-3.49	66%
3.50-3.99	80%
4.00-up	83%

Table 8: classes starting 2010-2019 retention to second year

GPA	Students not in SUPER	SUPER
Under 3.50	61%	88%
3.50-3.99	77%	89%
4.00-up	78%	84%

Table 9: classes starting 2013-2018 retention to second year

arship students. Financial support has a strong impact on students embarking on STEM education, but limited impact on degree attainment (Castleman et al., 2018), demonstrating that additional support is needed to guide students to graduation. We do find that some level of scholarship dollars is essential for program success, in part due to getting the program noticed at the recruitment stage, and also in order to bring up the academic level of the students in the SUPER program. While the incoming classes at the college as a whole had an average GPA of just under 3.5 for the years reported, the SUPER students who were accepted without additional scholarships had an average GPA just over 3.7, and those with scholarships had an average GPA of over 3.9. Scholarship students continued to have greater GPAs than non-scholarship students after one year of college and at graduation (which increased to a GPA difference of 0.4 points). Interestingly, we do not see a significant difference between the years when scholarships were higher and the years when they were lower. Having a scholarship program helps to recruit stronger students.

Conclusion

A comprehensive support program such as the SUPER program developed at Randolph College can be used as an effective recruiting tool and support system for academic success. The added benefit of scholarships (which in this case have been funded by two NSF S-STEM grants) allows us to recruit academically stronger students, but the program will continue once the federal support runs out because we have shown that the academic support pieces are important to recruitment, retention, and academic success. While the stronger academic credentials of incoming SUPER students and the possibility of a higher affinity to STEM and to the college for students who apply to the SUPER program confound the analysis of the impact of the program, the higher retention of SUPER students compared to incoming non-SUPER students with similar academic credentials, and to students who applied to the SUPER program but were not accepted, support the claim that the programmatic components of the SUPER program are effective at improving retention of students in STEM. The overall, college-wide improvement in retention in STEM since the development of the SUPER program also indicates the efficacy of this program.

It is our hope that this program can serve as a model for others. The impact of individual components of the program is not discernible in this analysis but is a focus of future work in this project. We will use changes in the program over time to try to discern the impact of individual program components. In addition, we are continuing the program with additional supports for SUPER students: While the program components described here provide financial and academic support for students, we have realized a responsibility to support students' socio-emotional well-being, both by removing obstacles to their STEM education and helping students develop socio-emotional wellness. To this end, we have added a focus on inclusivity and socio-emotional programming, such as resilience training, to our newest version of the program. While others may wish only to implement certain parts of this program, we do see evidence that each piece may play a significant role by itself, with the most important underlying theme being that we make the students feel an important part of a group.

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