Improving Persistence of STEM Majors at a Liberal Arts College: Evaluation of the Scots Science Scholars Program

Angelia D. Gibson Maria Siopsis Karen Beale
Maryville College

Abstract

Consistent with national trends, only about ½ of students who intend to major in STEM disciplines at Maryville College (MC) complete bachelor's degrees in these fields. The Scots Science Scholars (S^3) program was funded through the National Science Foundation's STEM Talent Extension Program to increase the number of students graduating with STEM degrees from MC. The S^3 program enrolls college freshmen who have an interest in STEM majors and math ACT scores between 21 and 27, with emphasis on students from groups underrepresented in STEM and first-generation college students. The program consists of a summer bridge, a living-learning community, early engagement in STEM research, a seminar series that exposes students to STEM careers and research fields, academic support through a first-year seminar class, peer tutoring, and time-management counseling. The program has enrolled 6 cohorts of students (n = 97) since 2013, (54% female, 22% underrepresented minorities and 35% first-generation college students). From 2013-2017, S3 compared favorably to the general college population: 96% of all S^3 completed the first year of college, 69% declared STEM majors, and 85% returned to the college for a second year (compared to 71%, $p < 0.001$). Overall, S^3 students persist at the college longer than non-S^3 students ($P<0.01$). Compared to a matched control group, S^3 had significantly higher STEM major declaration rates (68% vs. 38%), higher rates of STEM retention through the junior year (41% vs. 20%), and improved overall college persistence ($P< 0.01$). Students report high levels of satisfaction with the summer program. At the end of the summer program, students report gains in skills and attitudes that are important for success in STEM. They also perform significantly better on math and chemistry assessments after completing the program. College-wide, the number of students enrolled in STEM majors at Maryville has increased by 52% since the inception of S^3, and STEM undergraduate research productivity has increased markedly. Our data suggest the S^3 program is an important component of institutional changes that are increasing the STEM population and building a robust and productive STEM culture at a liberal arts college.

Building Community	Enhancing Math Skills
• Mountain Challenge ropes course • Cohort housing in residence halls • Recreational trips to amusement park and baseball game	• Math workshops relating to lab and field experiences • Training with math software • Skill-specific math homework through Kahn Academy[12]
Improving Scientific Skills	**Exploring STEM Fields and Careers**
• Lab and field experiences in biology and chemistry • Training with chemistry and biology instrumentation • Participation in authentic research experiences	• Field trip to Oak Ridge National Laboratory • Field trip to Tennessee Valley Authority • Guest speakers from variety of STEM fields

Table 1. Summary of Strategies and Activities in S^3 Summer Experience

Introduction and Background

Maryville College (MC) is a private, liberal arts college that enrolls an average of 1100 students per year. Approximately 40% of entering freshman indicate an interest in a major in the natural or computer sciences, mathematics or engineering. Many students who enter MC come with poor preparation in math and science: the average math ACT score is 23, and the majority of STEM-interested students report participating in lab exercises less than 3 times per semester during high school. Moreover, approximately 42% of Maryville freshman are eligible for Pell grants and approximately 35% are first-generation college students. Like other colleges (Chen, National Center for Education Statistics, 2013; U.S. Department of Education 2013; President's Council on Science and Technology, 2012), Maryville sees considerable attrition among students pursuing STEM majors, especially after the first year of college. Overall, about 20% of degrees earned at MC are in STEM majors (excluding behavioral and social sciences).

The MC curriculum includes high impact practices and pedagogies that have been associated with student success and retention.(Tinto, 1990, 1999, 2017) All students take an orientation and first-year seminar course designed to build learning communities and relationships with faculty mentors, introduce students to their majors, and build academic and professional skills needed for success in college and career. Maryville has a strong academic support center that includes supplemental instruction and peer-led tutoring for all STEM gateway courses. The average class size at Maryville is 20 students, and many teachers employ active learning pedagogies. All students work with a faculty mentor on research in their field during their junior and senior years to fulfill the senior study graduation requirement.

Responding to the call to establish programs that would generate a larger and more diverse pool of STEM-educated students (Technology, 2012), we developed the Scots Science Scholars (S^3) program in 2013. Initially funded by the National Science Foundation, the program aims to increase the number of graduates in STEM majors, especially from traditionally underrepresented groups. We offer enrichment and support directly to select students at MC and indirectly through an outreach program that fosters knowledge and engagement in STEM fields. The core features of the program are grounded in literature that demonstrates bridge programs (Ashley, Cooper, Cala, & Brownell, 2017; Kathleen Stolle-McAllister, 2011; Tomasko, Ridgway, Waller, & Olesik, 2016), living-learning communities (Graham, Frederick, Byars-Winston, Hunter, & Handelsman, 2013), and early engagement in research (Lopatto, 2010; Nagda, Gregerman, Jonides, von Hippel, & Lerner, 1998) have positive impacts on college and STEM retention.

The program includes a 3-week summer "bridge" component that consists of experiences designed to build community, enhance math and science skills, and foster knowledge of and enthusiasm for STEM careers (Table 1). Beyond the 3-week summer experience, S^3 weaves into the MC curriculum through a STEM-focused section of first-year seminar and by integrating students into re-

search experiences as early as their freshman year. Additionally, S^3 hosts field trips and seminars that are open to all students at Maryville. Math and science learning outcomes, as well as STEM self-efficacy and attitudes about the program and STEM are measured to evaluate the efficacy of the summer program. Surveys, course evaluations, and focus groups aid in assessment of other programming components. Engagement in STEM is quantified by tracking of attendance at STEM events, surveys, and participation in STEM activities.

We report, here, the outcomes of these assessments, as well as overall and STEM-specific academic performance for the Scots Science Scholars. We contextualize these results by comparing to a matched cohort of STEM-interested students enrolled at Maryville during the same timeframe and discuss the impact of the program as an effector of STEM culture at Maryville.

Methods

The S^3 program was advertised to all students interested in MC by promotion on the college's website, recruiting booths at college fairs and MC recruiting events, and a social media presence (Facebook, Instagram and Twitter). Additionally, promotional letters and fliers were mailed to all STEM-interested students in the MC recruiting pool. All first-year students applying to Maryville College were eligible to apply to the S^3 program. Applicants were evaluated based on letters of recommendation, their responses to essay questions that gauge STEM interest, and their academic history (high-school GPA, high-school STEM activity, and Math ACT/SAT scores). Preference for selection was given to students in groups underrepresented in STEM (African-American, Hispanic, or Native American students; females interested in math and engineering; and first-generation college students) and to students with math ACT scores between 21 and 27. Four peer mentors were selected for each S^3 class from an applicant pool of rising sophomore, junior and senior STEM students; preference was given to S^3 alumni. Diversity and balance in gender, STEM interests and academic history were considered in selecting each cohort of S^3 participants and peer mentors.

At the start of the S^3 summer experience, a battery of assessments and surveys was administered to all participants including: the American Chemical Society (ACS) Toledo exam, which measures general math, general science and specific chemistry knowledge; a series of college-specific math placement tests, and the Classroom Undergraduate Research Experience (CURE) pre-course survey (Auchincloss et al., 2014; Lopatto, 2010). The same battery of assessments was completed at the end of the summer experience, along with surveys that measure satisfaction with the S^3 program, faculty, and peer mentors. Students were also polled before the summer experience, immediately after it and again at the end of their first year to measure STEM self-efficacy, feelings of inclusion, career success and math outcomes expectations using the longitudinal assessment of engineering self-efficacy (LAESE). The LAESE survey was originally designed to assess the self-efficacy of women studying engineering (Marra, Rodgers, Shen, & Bougue, 2009), but has been used and validated with other populations (Concannon & Barrow, 2012; Sankar & Raju, 2011). It includes items adapted from Blaisdell (2000) and Betz and Hackett (1981). (Betz & Hacket, 1981; Blaisdell, 2000; Lopatto, 2010)

College retention at MC, retention in STEM majors at MC, as well as grade point average (GPA) was tracked for S^3 participants. For comparison, a demographically matched control group was selected from a pool of first-year students who enrolled at MC between the years of 2013 and 2016, indicated an interest in STEM on college application materials, and took a STEM gateway class in their first year of college.

Maryville College majors that were considered STEM for the purpose of this analysis are: biochemistry, biology, biological sciences (veterinary track), biopharmaceutical sciences, chemistry, mathematics, statistics, computer science, business analytics, engineering, neuroscience (biochemistry track), and mathematics, chemistry or biology for secondary licensure.

Total	97
Sex	
Female (%)	52(53.6%)
Male (%)	45 (46.4%)
Ethnicity/Race	
African American (%)	14 (14.4%)
Asian (%)	3 (3.1%)
Hispanic (%)	7 (7.2%)
Native American (%)	1 (1%)
Two or More (%)	4 (4.1%)
White (%)	68 (70.1%)
Median Math ACT (IQR) (n = 88)	25.0 (22.2-26.0)
Median Math SAT (IQR) (n = 12)	560 (498-600)
Pell Eligible (%)	42 (42%)

Table 2. Baseline Demographics for all S^3 Participants. Interquartile Range (IQR)

Results

Enrollment and Demographics -Since 2013, there were 193 applicants to the program. The baseline demographics of the 97 who enrolled in the S^3 program are shown in Table 2. While the S^3 population had significantly higher scores on college entrance exams, (math and composite ACT or SAT) than the overall population of freshmen who entered Maryville at the same time (data not shown), the proportions of underrepresented minorities (URM), first-generation college students, students with high-financial need (estimated family contribution (EFC)< $15,000) were not significantly different. Academic performance data (overall GPA and retention) in this report has been analyzed for 81 S^3 students enrolled from 2013-2017.

	S^3	**Matched**
Total	66	253
Sex		
Female (%)	36(54.5%)	121 (47.8%)
Male (%)	30(45.5%)	131 (51.8%)
Ethnicity/Race		
African American (%)	11(16.7%)	26 (10.3%)
Asian (%)	3(4.5%)	2 (1.2%)
Hispanic (%)	3(4.5%)	3 (5.1%)
Native American (%)	0	0
Two or More (%)	2(3%)	12 (4.7%)
White (%)	46(69.7%)	195 (77.1%)
Total Underrepresented	14 (21.2%)	39 (15.4%)
Median Math ACT (IQR)	25.0 (23.0-26.0)	25.0 (22.0-27.0)
Median Math SAT (IQR)	540 (480-610)	550 (510-600)
Median Family Income (Range)	$6656 ($516 -17406)	$9766 ($1397-$28751)
High Need	45 (68.2%)	149 (59.1%)
No Parent with More than Associates Degree (%)*	28 (42.4%)	67 (26.5%)
High-School GPA (IQR)	3.7 (3.4-4.0)	3.8 (3.3-4.0)

Table 3. Summary Demographics For S^3 and Matched Cohort
Comparison of demographics of students who entered Maryville College between 2013 and 2016. * The proportion of first-generation college students was significantly higher in the S^3 group (Chi square P = 0.025).

Within that timeframe, there were programmatic, staffing and curricular changes in both of the divisions that offer STEM majors. In order to delineate specific effects of S^3 from these changes, we compared the academic performance of S^3 students with that of a group of STEM-interested students who enrolled at Maryville College during the same time period (Table 3). The groups were demographically matched, with the exception of the proportion of first-generation college students, which was significantly higher for S^3 students.

Academic Performance Outcomes-S^3 college retention rates compare favorably to both the general college population and the control group. S^3 students' first-year retention rate is significantly higher than the college population. Additionally, they persisted significantly longer in college and were less likely to withdraw overall (Figure 1). Although the rates of first-year completion and retention to second year did not differ significantly for S^3 and the control group, S^3 students were less likely to withdraw from the college at any point before graduation and had significantly longer overall college persistence (Log Rank, P 0.033, Figure 2). Scots Science Scholars were also more likely than students in the control group to declare STEM majors in spring of their first year and to persist as STEM majors at start of sophomore, junior and senior years (Figure 2). In fact, without controlling for confounding variables, S^3 students were more than twice as likely as the control group to be STEM majors at any retention point, indicating the program had a strong effect on students' likelihood to persist in STEM majors.

While there were no significant differences in cumulative GPA at any semester between the Scots Science Scholars and the matched cohort, the importance of GPA on retention for the two groups differed. In the control group, first- semester GPA and first-year GPA were both significantly lower for students who did not retain to second year, students who didn't declare STEM majors, students who didn't retain in STEM major at the start of year 2, and students who withdrew from the college at any point before graduation. For S^3, first-semester GPA was lower for students who didn't retain to sophomore year; otherwise there are no significant differences in GPA between those who retained (at the college or in STEM) and those who didn't at any time-point. This observation prompted us to examine what factors predicted college and STEM retention.

Predictors of Retention-We performed binary logistic regression analyses for the entire MC student population enrolled from 2013-2017, as well as S^3 and the matched cohort, to determine the important factors affecting college and STEM retention. In the general college population higher math ACT scores, high-school GPAs, and EFCs were significant predictors of both overall and STEM first-year retention (data not shown). In the control group, first-semester GPA and math ACT were predictors of STEM retention; however, for the S^3 students the only factor that correlated significantly with STEM retention was high-school GPA. In a model that controlled for all of these factors as well as financial need, students in S^3 were 3.7 times (95% CI: 1.9-7.3) more likely than those in the control group to retain in STEM at the start of their sophomore year ($p < 0.001$) (Table 4). Using the same model, at two years S^3 participants were 3.4 times (95% CI: 1.7-6.6) more likely than the control group to retain in STEM ($p = 0.001$). Overall, in these STEM-interested students, the best predictor of STEM retention was participation in the S^3 program.

Impact of S^3 on High Financial Need Students-Financial need was not a factor that we considered originally in designing the program. As the majority of incoming students at Maryville have high financial need (defined institutionally as EFC<$15000), we were interested in examining the impact of S^3 for high-need students. Within the general Maryville College population, students with high financial need had significantly lower rates of both overall and STEM retention (data not shown), compared to peers from wealthier families. In fact, even after controlling for other variables, high need was significantly correlated with both overall and STEM attrition in the general college population. In contrast, the effect of financial need was erased for the S^3 students. There were no significant differences in overall and STEM retention rates between high and low financial need students in either single variable or multivariate analysis. This observation prompted us to do a subgroup analysis of the impacts of S^3 in high and low need students with STEM interest. Indeed, STEM retention was significantly higher for S^3 than the control group in both low- and high- financial need subgroups. This result suggests that the enrichment and support provided by the program builds equity in students' ability to persist at college and in STEM.

Evaluation of the Program Components-We used surveys, focus groups, course evaluations, and general participation metrics to inform about efficacy and other impacts of program components. Due to the availability of multiple validated instruments, we were able to assess

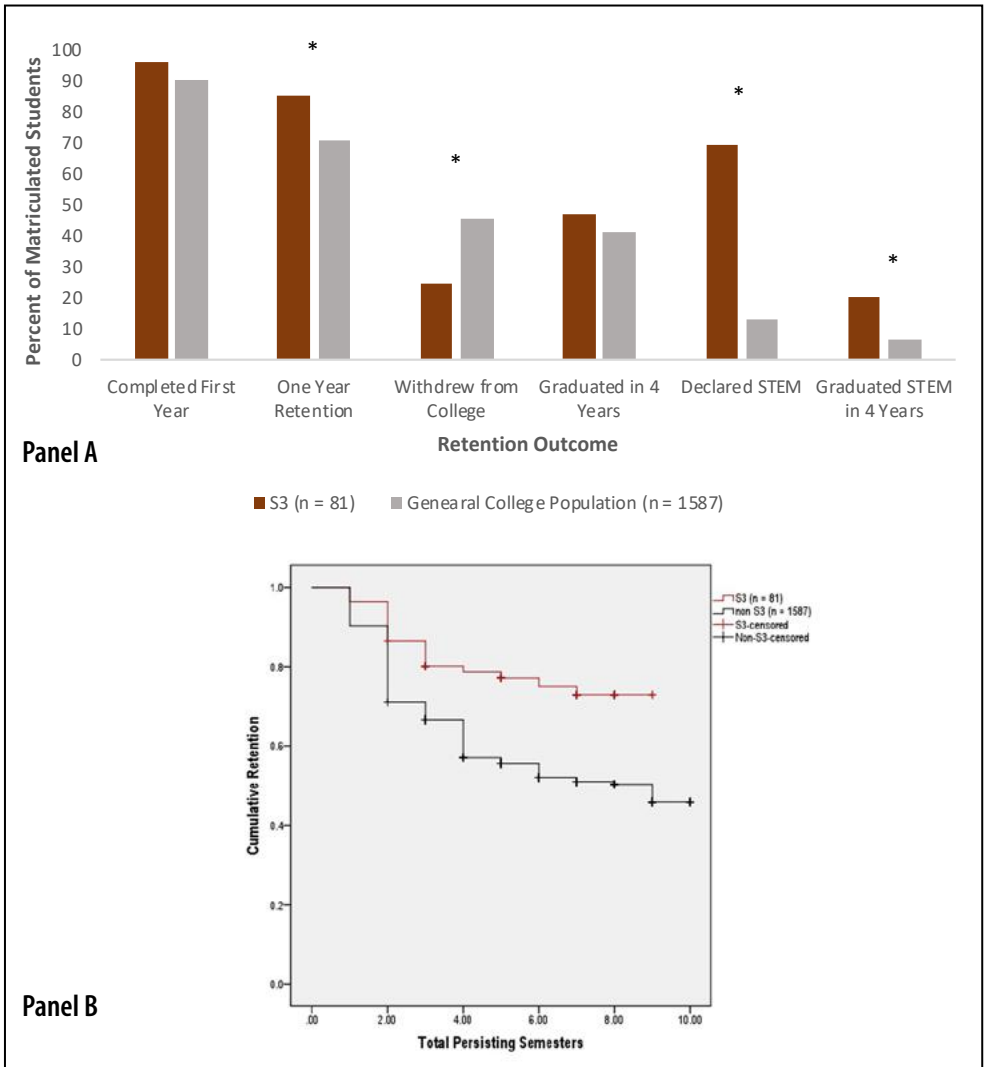
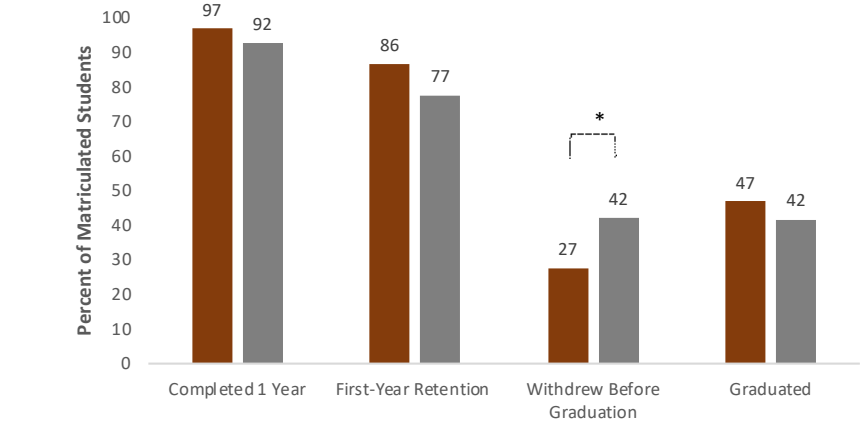
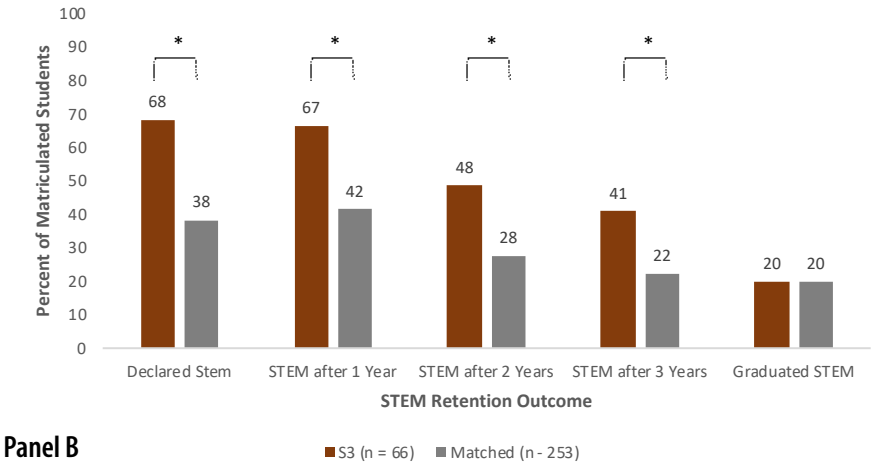


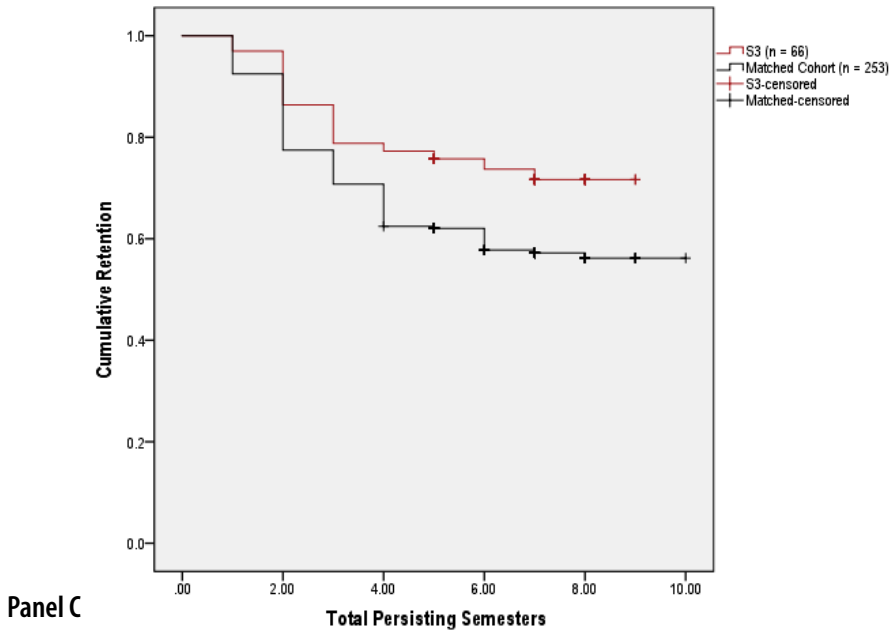
Figure 1. Panel A. Comparison of retention outcomes for S^3 students enrolled at Maryville College from 2013-2017 (red) and the non-S^3 general freshman population (grey). Outcomes with statistically significant difference in proportion (Chi Square, $P < 0.05$) are denoted with asterisk. Panel B. Kaplan-Meier retention analysis for S^3 (red) compared to non-S^3 general first-year population (black). Students were censored at highest matriculated semester. Log rank $P < 0.001$.



Panel A



Panel B



Panel C

Figure 2. Panels A and B Comparison of general and STEM-specific retention outcomes for S^3 students enrolled from 2013-2016 (red) and a matched cohort (grey). Outcomes with statistically significant difference in proportion (Chi Square, P < 0.05) are denoted with asterisk. Panel C. Kaplan-Meier retention analysis for S^3 (red) compared to matched cohort (black). Students were censored at highest matriculated semester. Log rank P = 0.033.

the impacts of the S^3 summer program on STEM attitudes and learning by using pre-program and post-program surveys and content tests.

Summer Experience-Satisfaction and Learning Gains -On multiple measures, it is clear that students were satisfied with their participation in the program and that they believe it influenced their choice to pursue a STEM major. When polled about their experience at the end of the summer program, more than 95% of the respondents (n = 58) reported that they were satisfied or very satisfied with the program, mentors, and instructors, with average satisfaction scores greater than 5 on a 6-point Likert scale for each prompt. No student reported dissatisfaction with the program. Additionally, S^3 Summer Experience participants' responses to the nationally validated CURE survey averaged higher than 4.5 on a 5-point Likert scale when rating efficacy of the course in helping them learn about the course subject and scientific research. Participants' average scores also exceeded 4.5 on a 5-point Likert scale when asked if the program had a positive effect on their interest in science. In a survey conducted in the fall of 2018, 26 current S^3 students answered general questions about the impact of various components of S^3. Eighteen of them (72%) responded that the S^3 Summer Experience was either very or extremely important for their decision to stay at Maryville College and 17 (68%) responded that it was either very or extremely important to their retention as a STEM major. Focus group responses also revealed enthusiasm for the program; every focus group participant said they would do the program again and that it positively impacted them.

Students also reported learning gains related to specific content areas that were of focus in the summer program and reported that the program was beneficial for developing research skills, giving them experience "doing science", and clarifying STEM career paths on both the national CURE survey and our program satisfaction survey. While a scientific qualitative analysis of open-ended survey responses and focus group responses is ongoing, we note that most responses to questions about specific benefits the program provides focus on math and science skills and exposure to /knowledge of STEM career options.

These self-reported academic gains were supported by results of math and chemistry placement tests administered before and after the program as well as quizzes on specific chemistry lab activities. Statistically significant gains were achieved on all metrics after completing specific lab exercises and the program overall (Table 5).

Summer Experience-Psychosocial Impacts-One of the strengths of the program appears to be cohort-building. Comments from a student satisfaction survey administered at the end of 2017 to all participants indicate the students felt they were part of a cohort. When asked "What did you enjoy/appreciate the most about your experience in S^3?", half of the comments included positive feedback about peer interactions and friendships. Focus

	Significance	Odds Ratio	95% Confidence Interval for Odds Ratio	
Matched Cohort			**Lower**	**Upper**
Cumulative GPA	0.002	1.984	1.287	3.049
ACT-M	0.007	1.144	1.037	1.263
HighNeed	0.709	0.888	0.476	1.656
HS GPA	0.636	1.205	0.557	2.604
S^3 Freshmen				
Cumulative GPA	0.889	3.067	1.125	0.412
ACT-M	0.653	0.942	0.723	1.225
HighNeed	0.826	1.161	0.305	4.425
HS GPA	0.027	8.264	1.279	52.632
All STEM Interested*				
Cumulative GPA	0.004	1.739	1.198	2.519
ACT-M	0.024	1.107	1.013	1.209
HighNeed	0.706	0.899	0.517	1.563
HS GPA	0.105	1.767	0.888	3.509
S^3	0.000	3.717	1.887	7.299

Table 4. Binary Logistic Regression for STEM retention for a Matched Cohort and S^3 students. Odds ratio represents odds of retaining in STEM at start of sophomore year. The model adjusted for first-semester GPA, math ACT sub-score (ACT-M) high-school GPA, and whether student had EFC< $15000 (high need). The final analysis also adjusted for whether student was part of S^3 program or not.

	Maximum Possible	Average Pre –Test Score	Standard Deviation of Pre-Test	Average Post – Test Score	Standard Deviation of Post-Test	P value
Pre-Algebra College Placement (n = 65)	30	22.7	4.2	23.5	5.4	0.038
Pre-Calculus College Placement (n = 65)	30	17.7	4.0	19.3	4.7	< 0.001
ACS Toledo Chemistry Placement Test (n = 83)	60	30.7	5.5	32.8	5.9	< 0.001
Antioxidants in Biology* (n = 18)	5	1.1	0.6	3.6	0.7	< 0.001
Measurements in Chemistry Lab (n =51)	10	3.6	0.8	4.3	0.9	< 0.001
Biochemistry Measurements* (n = 18)	10	5.6	2.6	6.8	1.5	0.028

Table 5. Average Scores on Learning Assessments Administered in the S^3 Summer Experience. Asterisks denote peer-led exercises that were part of original research projects. All others were global assessments administered at the beginning of and end of the program. P-values are for paired student t-test.

groups also highlighted the importance of the program for bonding with peers. In the Fall 2018 survey, 88% of respondents agreed with the statement "The summer program provided me with a peer group I identified with" either moderately (28%), very much (40%), or extremely (20%).

While students reported on both our program satisfaction survey and on the national CURE survey that the program was beneficial for improving their confidence and helping them become part of a learning community , average responses on STEM self-efficacy, math outcome, STEM career expectations and feelings of inclusion did not change significantly for S^3 participants after the summer experience. Average scores for S^3 participants (either before or after the summer Experience) did not differ significantly from those pre-college STEM self-efficacy metrics for students from the control group. We did note that after a full year of college, scores on all metrics declined significantly for both S^3 and the matched cohort (Figure 3).

STEM Success Center-Starting with the 2015 cohort, freshmen S^3 participants and any students on academic probation were required to attend structured tutoring in the STEM Success Center. The center operated with a manager and 18 tutors and served more than 50 students for a total of approximately 1000 hours. Attendance records reveal that some students continued attending the center even after having fulfilled requisite hours for their scholarship. On a recent survey, 48% of the 26 S^3 respondents reported that the center was important or very important for their retention at Maryville, and 52% reported it was important or very important in their decision to remain a STEM major. Students also responded overwhelmingly that the program was important for providing academic and personal support. Open-ended responses noted that the center provides a service that many students appreciate, and several believe is a key to their success.

S^3 Event Series- In total over 5 years, S^3 organized and hosted 37 different seminars from STEM professionals, STEM employers, and graduate school recruiters and peers. The program also highlighted STEM research or internship experiences by Maryville College students annually. All S^3 students attended these events in fulfillment of program requirements. In total 212 non-S^3 Maryville College students also attended these events. Altogether, each year approximately 10% of Maryville College students attended S^3-sponsored events between fall of 2013 and spring of 2017. On surveys, 84% of S^3 students agreed or strongly agreed that they learned about new opportunities and careers available to STEM professionals, 40% agree or strongly agree that the event series influenced academic or career goals, and 52% agree or strongly agreed that the series contributed to persistence in the STEM major.

Early Engagement in Academic STEM Research-While most students at Maryville College participate in research with faculty in fulfillment of the senior study graduation requirement, most students don't begin research until the spring of their junior year. Students in the S^3 program were engaged early in research, either by contributing to group data collection or analysis for ongoing STEM research projects or by collaborating with faculty members and other STEM students as part of ongoing research projects. Eighty-four of 97 S^3 students participated in original data collection and analysis as part of their summer program. Scots Science Scholars contributed to 9 STEM research projects that were presented at academic or scientific meetings and were presenters (in some cases, as early as their freshman year) of 20 conference talks and posters. Although they represent only about 20% of the STEM population at Maryville, Scots Science Scholars have been involved in more than 50% of student-generated research presentations from Maryville College. S^3 students received grants (as early as freshman year) from the Appalachian College Association to fund research projects. Two S^3 students participated in research that was published in Blood.(Morales-Ortiz et al., 2018) All of the students who participated in substantive authentic STEM research experiences have retained in STEM majors to their respective matriculation points.

Discussion

The program, very similar in design to the Meyerhoff program (Maton, Pollard, McDougall Weise, & Hrabowski, 2012; Kathleen Stolle-McAllister, 2011; Kathy Stolle-McAllister, Sto. Domingo, & Carrillo, 2011), and similar in structure to successful programs at other large universities (Wilson, Iyengar, Pang, Warner, & Luces, 2012; Yelamarthi & Mawasha, 2010), incorporates many high impact practices that focus on building community and STEM cultural capital, developing an awareness of STEM careers, and developing skills, attitudes, and practices needed for success in STEM gateway classes.

Attitudes towards participation in the summer program were overwhelmingly positive, and participants reported it was beneficial with regard to specific learning

goals and attitudes about STEM. Although students reported gains in confidence, clarity of career, and satisfaction with their STEM majors after the program, we did not find changes in measures of self-efficacy. Incoming students' average scores for self –efficacy were already very high: greater than 6.5 (on a 7-point scale), leaving little room for improvement. Additionally, most of our students are from Tennessee, where only 56% of graduating high school student are at or above basic levels in math and 17% are at or above proficient levels (US Department of Education, 2013), yet high-school GPA for our students was 3.7. These apparent paradoxes make us wonder if incoming self-efficacy may be inflated for this group, perhaps based on their relative superiority in the context of lower-performing schools. Other studies have noted that programming (or college) can be a calibrating experience (Schunk & Pajares, 2009; Wheeler & Wischusen, 2014), causing a similar decline in self-efficacy. A binary logistic regression showed that participating in S^3 was the best predictor of college and STEM retention, even overshadowing first-semester college GPA as a factor. Our analysis of GPA led to the realization that S^3 did not have improved academic performance as measured by overall GPA or STEM GPA compared to either the general population or matched cohort. This was surprising because nationally and college-wide, GPA and particularly performance in gateway courses are significant predictors of retention in STEM (Chen et al., 2013; Whalen & Shelley, 2010). While our study was not designed to delineate an explanation for this, we suggest two reasons that S^3 may have mitigated the impact of poor early performance on STEM retention. The threshold GPA for retaining the S^3 scholarship was lower than other state or competitive scholarships. This may have provided an important buffer against poor performance that allowed students to retain in college longer without losing scholarship. Second, the ongoing peer support, mentoring, and tutoring may have provided resources needed to persist, by fostering a growth mindset. Scots Science Scholars, regardless of their majors, report that the supports and enrichment provided through the program are important for college retention. As we go forward, we will continue to focus on improving academic skills.

Scots Science Scholars is an important component of a growing STEM culture at Maryville College, as assessed by increases in STEM engagement and participation in STEM programming, as well as a marked increase in number of students in STEM majors. There were 96 STEM majors at the inception of the S^3 program in 2013, and currently there are 146, a 50% increase in the number of STEM majors. While other curricular and programmatic changes may have contributed to the growth, the fact that S^3 participants retain longer in STEM compared to matched controls from similar high-risk background in the same educational context, confirms that Scots Science Scholars programming provides distinct benefits for participants and for the college. We are designing future studies to evaluate impacts of S^3 programming on the development of STEM identity and cultural capital, both on the student participants and within the broader population of STEM majors at our institution.

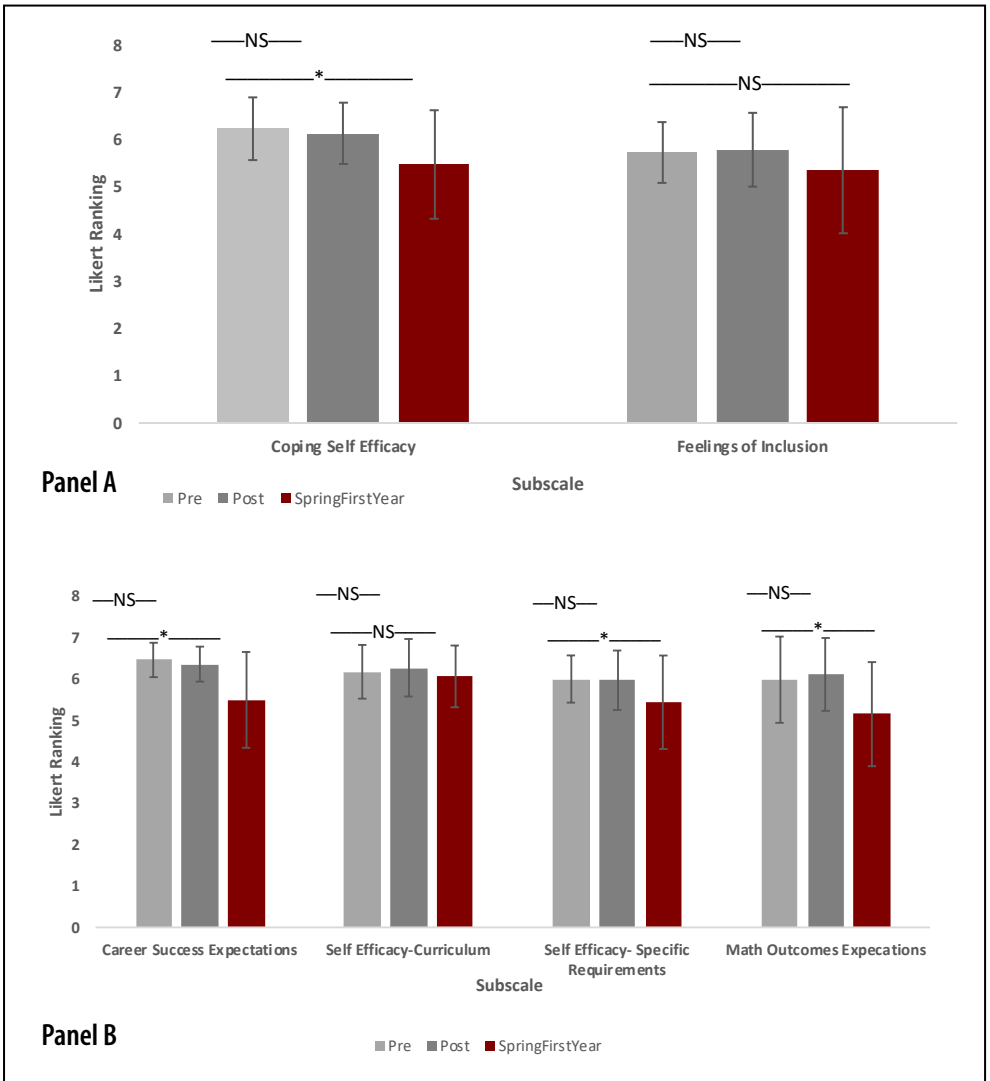


Figure 3. Self-efficacy and Feelings of Inclusion. S³students were surveyed about self-efficacy, feeling of inclusion and math outcome expectations before (light grey) and after the Summer Experience (dark grey) and at the end of their first- year. Students responded on a 7-point –likert scale.

Acknowledgements

This material is based on work supported by the National Science Foundation under grant number 1161297. The STEM Success Center was initially funded from a grant from the Arconic Foundation to Maryville College. We owe tremendous gratitude to faculty, staff, and student mentors who have served the program.

References

Ashley, M., Cooper, K. M., Cala, J. M., & Brownell, S. E. (2017). Building Better Bridges into STEM: A Synthesis of 25 Years of Literature on STEM Summer Bridge Programs. *CBE - Life Sciences Education, 16*(4).

Auchincloss, L. C., Laursen, S. L., Branchaw, J. L., Eagan, K., Graham, M., Hanauer, D. I., Dolan, E. L. (2014). Assessment of course-based undergraduate research experiences: a meeting report. *CBE Life Sci Educ, 13*(1), 29-40. doi:10.1187/cbe.14-01-0004

Betz, N., & Hacket, G. (1981). The relationship of career-related self-efficacy expectations to perceived career options in college women and men. *Journal of Counseling Psychology, 28*(5), 399-410.

Blaisdell, S. (2000). *Social cognitive theory predictors of entry into engineering majors for high school students.* Unpublished Dissertation. Arizona State University.

Chen, X., National Center for Education, Statistics, (2013). STEM Attrition: College Students' Paths into and out of STEM Fields. Statistical Analysis Report. NCES 2014-001.

Concannon, J., & Barrow, L. (2012). A Reanalysis of Engineering Majors' Self-Efficacy Beliefs. *Journal of Science Education & Technology, 21*(6), 742.

Graham, M. J., Frederick, J., Byars-Winston, A., Hunter, A. B., & Handelsman, J. (2013). Science education. Increasing persistence of college students in STEM. *Science, 341*(6153), 1455-1456. doi:10.1126/science.1240487

Lopatto, D. (2010). Undergraduate Research as a High-Impact Student Experience. *Peer Review, 12*(2), 27-30.

Marra, R., Schuurman, M., Moore, C., & Bogue, B. (2005, June 12-15). *Women engineering students' self-efficacy beliefs – The longitudinal picture.* Paper presented at the American Society for Engineering Education Annual Conference, Portland, OR.

Marra, R. M., Moore, C., Schuurman, M., & Bogue, B. (2004). *Assessing Women in Engineering (AWE): Assessment Women Engineering Students' Self-Efficacy Beliefs.* Paper presented at the Annual meeting of the Women Engineering Program Advocacy Network, Albuquerque, NM.

Marra, R. M., Rodgers, K., Shen, D., & Bougue, B. (2009). Women Engineering Students and Self-Efficacy: A Multi-Year, Multi-Institution Study of Women Engineeing Student Self Efficacy. *Journal of Engineering Education, 98*(1), 27-38.

Maton, K. I., Pollard, S. A., McDougall Weise, T. V., & Hrabowski, F. A. (2012). Meyerhoff Scholars Program: A Strengths-Based, Institution-Wide Approach to Increasing Diversity in Science, Technology, Engineering, and Mathematics. *Mount Sinai Journal of Medicine, 79*(5), 610-623. doi:10.1002/msj.21341

Morales-Ortiz, J., Deal, V., Reyes, F., Maldonado-Martinez, G., Ledesma, N., Staback, F., . . . Washington, A. V. (2018). Platelet-derived TLT-1 is a prognostic indicator in ALI/ARDS and prevents tissue damage in the lungs in a mouse model. *Blood, 132*(23), 2495-2505. doi:10.1182/blood-2018-03-841593

Nagda, B. A., Gregerman, S. R., Jonides, J., von Hippel, W., & Lerner, J. S. (1998). Undergraduate Student-Faculty Research Partnerships Affect Student Retention. *Review of Higher Education, 22*(1), 55-72.

President's Council of Advisors on Science and Technology. (2012). *Engage to Excel: Producing One Million Additional College Graduates with Degrees in Science Technology, Engineering and Math.* Washington, DC.

Sankar, C. S., & Raju, P. K. (2011). Use of Presage-Pedagogy-Process-Product Model to Assess the Effectiveness of Case Study Methodology in Achieving Learning Outcomes. *Journal of STEM Education: Innovations & Research, 12*(7), 45-56.

Schunk, D. H., & Pajares, F. (2009). *Self-efficacy theory*. New York: Routledge.

Stolle-McAllister, K. (2011). The Case for Summer Bridge: Building Social and Cultural Capital for Talented Black STEM Students. *Science Educator, 20*(2), 12-22.

Stolle-McAllister, K., Sto. Domingo, M., & Carrillo, A. (2011). The Meyerhoff Way: How the Meyerhoff Scholarship Program Helps Black Students Succeed in the Sciences. *Journal of Science Education & Technology, 20*(1), 5.

Tinto, V. (1990). The Principles of Effective Retention. Journal of the Freshman Year Exererience, 2, 35-48

Tinto, V. (1999). Taking Retention Seriously: Rethinking the First Year of College. *NACADA Journal, 19*(2), 5-9.

Tinto, V. (2017). Reflections on Student Persistence. *Student Success, 8*(2), 1.

Tomasko, D. L., Ridgway, J. S., Waller, R. J., & Olesik, S. V. (2016). Association of summer bridge program outcomes with STEM retention of targeted demographic groups, 90.

U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, National Assessment of Educational Progress (NAEP), 2013 Mathematics Assessment National Assessment of Educational Progress (NAEP). Nations Report CardRetrieved from https://www.nationsreportcard.gov/profiles/stateprofile?chort=3.

Whalen, D. F., & Shelley, M. C., II. (2010). Academic Success for STEM and Non-STEM Majors. *Journal of STEM Education: Innovations and Research, 11*(1), 45-60.

Wheeler, E. R., & Wischusen, S. M. (2014). Development self-regulation and self-efficacy: A cognitive mechanism for success of biology boot camps. *Electronic Journal of Science Education, 18*(1), 1-16.

Wilson, Z. S., Iyengar, S. S., Pang, S.-S., Warner, I. M., & Luces, C. A. (2012). Increasing Access for Economically Disadvantaged Students: The NSF/CSEM & S-STEM Programs at Louisiana State University. *Journal of Science Education and Technology, 21*(5), 581-587.

Yelamarthi, K., & Mawasha, P. R. (2010). A Scholarship Model for Student Recruitment and Retention in STEM Disciplines. *Journal of STEM Education: Innovations and Research, 11*(5), 64-71.

Dr. Angelia Gibson holds a PhD in Biochemistry and Cell and Molecular Biology from the University of Tennessee, Knoxville. After a post-doc at Howard Hughes Medical Institute, she worked as a medical writer before joining the faculty at Maryville College, where she is an Associate Professor and Chair of the Division of Natural Sciences at Maryville College. Dr. Gibson has been the co-PI for two NSF grants and one private foundation grant totaling $1.45 million and has supervised award-winning and grant-funded undergraduate research projects. Her research interests are in the quantification of macromolecular interactions and thermostability of plasma proteins.

Dr. Maria Siopsis is an Associate Professor in the Division of Math and Computer Science at Maryville College where she serves as co-director of the Scots Science Scholars program and the dual degree engineering program coordinator. She has served on the faculty for 19 years. Dr. Siopsis has been the PI or co-PI for two NSF grants and one private foundation grant totaling $1.45 million. Her research interests are in mathematical modeling and STEM education. She holds a PhD in Mathematics from the University of Tennessee, Knoxville.

Dr. Karen Beale is an Associate Professor of Psychology at Maryville College. She is a multi-award winning teacher and advisor, a certified sex-educator from the American Association of Sex Educators, Counselors, and Therapists, and co-director of the Appalachian College Association Teaching and Learning Summer Institute. She has held leadership positions in multiple teaching initiatives focused on engaged pedagogy for the diverse learner. Her passion for teaching is also evident in her grant-funded research lab; she regularly mentors undergraduate students who then present at regional, national, and international conferences.