Does Attending a Selective STEM High School Influence College Outcomes?

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The number of Science, Technology, Engineering, and Math (STEM) jobs has risen steadily over time and is expected to grow twice as much as non-STEM jobs over the next decade (U.S. Bureau of Labor Statistics, 2022). Rapid advancement in STEM presents a workforce challenge and an exciting opportunity for the field of education to prepare students to be capable scientists, innovators, and engaged citizens to solve the complex challenges facing society today and in the future. Although the number of students pursuing STEM degrees is increasing, substantial gaps remain in graduation rates and time to degree completion for underrepresented populations including Black, Pacific Islander, American Indian or Alaska Native, Hispanic, and female students (NCES, 2020; NSF, 2014). For example, Black students received 7.2% of STEM degrees in the United States in 2020 despite representing 13.6% of the population (NCES, 2020; U.S. Census Bureau, 2021). There are many historical and systemic factors behind these numbers which create barriers to participating in STEM. Some of these factors include inequitable learning opportunities (e.g., less access to quality education, advanced courses, and resources), lack of visible role models which may lead to feelings of isolation, and financial costs of higher education (Ramsay-Jordan, 2020; London et al., 2021; Lathifa, 2023).

Gender and racial disparities in STEM education have significant implications for social mobility and economic growth. The U.S. national average income for STEM careers is nearly double that of non-STEM careers (U.S. Bureau of Labor Statistics, 2015). Increasing STEM bachelor's degree attainment among historically underrepresented groups can be a catalyst for mitigating income inequality since entry into STEM jobs typically requires postsecondary education. Furthermore, advanced degrees in STEM fields can equip individuals with knowledge and skills to understand and tackle issues facing their communities and which impact daily life (e.g., environmental pollutants, personal health decisions, public safety).

Policy makers and researchers have identified a need for effective strategies that address inequities in STEM access and promote inclusion. Currently, the Biden-Harris administration has prioritized advancement in STEM education with their *Raise the Bar: STEM Excellence for All Students Initiative* which aims to improve access to and quality of STEM learning opportunities nationwide (U.S. Department of Education, 2022). This initiative funds and supports STEM programs including specialized STEM high schools. Compared to traditional high schools, STEM high schools typically provide students with more exposure to research, mentorship, STEM careers, and advanced STEM coursework (Subotnik et al., 2013). STEM high schools may be one approach to support interest in STEM learning and facilitate entry into the STEM pipeline.

The STEM pipeline metaphor is used to describe pathways students take from developing interest in STEM, participating in STEM programs, declaring a STEM major, earning a STEM degree, and pursuing a STEM career. When and how students decide to pursue STEM is complex and nonlinear (National Academies of Sciences, Engineering, and Medicine, 2016). Students often transfer schools, change academic interests, and exit or re-enter STEM pathways throughout their educational trajectory. Better understanding the role of specialized STEM high schools in cultivating students' persistence in STEM throughout higher education can inform how institutions sustain student engagement in the pipeline. Nearly half of the STEM high school graduates complete an undergraduate STEM degree in comparison to the national average of 22% (Almarode et al., 2014; Franco et al., 2012; National Science Board, 2012). However, another study finds no evidence that attending a high school with a STEM program influences STEM educational trajectories in college once self-selection into these types of schools is controlled for (Bottia et al., 2017).

Our study expands the body of literature on selective STEM high schools by examining long-term persistence in STEM from high school through college among students who attended a selective STEM high school. The sample in this study consists of attendees of a selective STEM high school in the Southeastern United States, who after graduating high school enrolled in one of the state's public universities for college. We follow students who participated in either the selective STEM high school's residential or online programs compared to state university (SU) system students who did not attend the selective STEM high school. An analysis of different types of STEM programs and their associated college outcomes (i.e., degree completion, time to degree completion, STEM degree completion, and time to STEM degree completion) provides new insights regarding the contributions of selective STEM high schools.

Previous studies highlight the need to account for students' interest in STEM when examining the effects of attending a STEM high school (Subotnik et al., 2013; Maltese & Tai, 2011). Interest influences one's desire to seek out opportunities to reengage in content such as a student choosing to take additional STEM courses in college (Hidi & Renninger, 2006). Since students in our sample self-selected to enroll in a selective STEM high school, thereby expressing interest in STEM, we identify a sub-group of students from within the comparison group, who have also expressed interest in STEM by declaring a STEM major at any point during their college careers.

We seek to better understand how a selective STEM high school influences students' continuation in the STEM pipeline as they move into post-secondary education and earn STEM degrees. Our study is guided by the following research question: What is the association between attending a selective STEM high school (i.e., online or residential programs) and college outcomes (i.e., degree completion, time to degree completion, STEM degree completion, and time to STEM degree completion)? We answer the questions comparing outcomes across race, gender, and interactions between race and gender to understand the impact of selective STEM high schools on promoting inclusivity in the STEM pipeline.

Literature Review

Current knowledge of the effect of attending a selective STEM high school on STEM degree attainment is inconclusive. Subotnik and colleagues (2013) report that graduates of selective STEM high schools are more likely to major in STEM than equally motivated and achieving students, 60% and 55.7% respectively, and this increase is greater if they participate in research in high school or have an internship or mentorship. However, when students' interest in STEM is included, there is no effect of attending a selective STEM high school. That is, students who attend a selective STEM school for reasons other than interest in STEM (e.g., rigorous curriculum) were not more likely than similar students who did not attend a selective STEM school to pursue a STEM degree. Similarly, Bottia et al. (2017) suggest that students' experiences prior to attending a selective STEM school are more important in determining long-term persistence in STEM than what occurs in school. For students from disadvantaged backgrounds, attending a selective STEM high school significantly improves SAT math scores by 3-5 percentile points and increases their enrollment in selective colleges (Shi, 2020). However, matching to more competitive colleges did not result in higher likelihoods of STEM degree attainment.

Longitudinal studies have demonstrated that students who take advanced academic courses in high school are more likely to obtain STEM degrees (Adelman, 2006; Trusty, 2002, Tyson, 2007). Providing exposure to STEM opportunities at an earlier age may be one explanation for how STEM high schools influence students' STEM trajectories. For example, students who attend STEM high schools compared to those who do not are more likely to have taken advanced STEM courses such as chemistry and pre-calculus (Means et al., 2017). This course-taking pattern can lead to increased involvement in STEM extracurricular activities which has been found to increase interest in science careers and aspirations to earn a graduate degree (Means et al., 2016).

However, rigorous coursework alone is not enough to increase STEM graduation rates; students' interest and identity may have more impactful effects on persistence (Anderson & Ward, 2014; Aschbacher, Li, & Roth, 2010; Maltese and Tai, 2011). Of students who earn a STEM degree, the majority make their decision to pursue STEM in high school and this decision is determined by their level of interest in STEM as opposed to advanced course-taking or achievement (Maltese & Tai, 2011). Students' science identity is shaped by their social interactions and experiences in everyday life and can influence sense of belongingness and ability to do well in science aspirations (Aschbacher, Li, & Roth, 2010). In a study of diverse, high achieving ninth graders, science identity was associated with STEM persistence (Anderson & Ward, 2014). Science identities can shift in different environments depending on students' perceptions of support and alignment with their cultural identities. Importantly, STEM high schools demonstrate positive impact on students' identity with science and mathematics and their interest in STEM careers (Means et al., 2021).

Types of STEM High Schools

Individual STEM high schools are often unique in their specialized courses and program offerings. As such, the experiences students receive at STEM high schools can vary widely across programs. Tofel-Grehl and Callahan (2014) identify four common characteristics across these specialized schools: a culture of intellectualism and inclusion, emphasis on research, prioritization of inquiry, and importance of personal responsibility and independent learning for students. While STEM high schools may have similar academic commitments, they can be classified into different categories based on their admissions processes (i.e., selective or inclusive) and program types (i.e., residential or online). There are also STEM career and technical education (CTE) schools and STEM programs embedded in otherwise traditional schools, but unlike STEM-focused schools, students determine if and how many STEM offerings in which they participate (National Research Council, 2011).

Selective vs. Inclusive

Selective STEM high schools, the focus of this study, serve highly motivated students with interest in STEM who are admitted based on their applications and prior academic histories; whereas inclusive STEM schools typically do not have an application process and often target underserved populations. A recent body of literature has focused on the effects of attending inclusive STEM high schools on broadening participation in STEM. Means and colleagues (2018) tracked students for two years and found that graduates of inclusive STEM high schools are three times more likely than comparison schools to be in a STEM bachelor's degree program at a four-year college and these odds are equally high for Hispanic, female, and economically disadvantaged students (Means et al. 2018). On the other hand, Eisenhart and colleagues (2015) found that inclusive STEM schools in two cities did not improve students' access to STEM opportunities and recommend that researchers pay special attention to school context. While inclusive STEM schools tend to serve more students from lower socioeconomic backgrounds, the racial and ethnic demographics of inclusive and selective STEM schools are similar (Erdogan & Stuessy, 2015; Rogers-Chapman, 2014). The learning environment at selective STEM schools may have affordances for fostering entry into the STEM pipeline since its student population consists of highly motivated students who typically enroll with prior interest in STEM.

Study Context

This study emerges from a partnership between a selective STEM high school in the Southeastern United States and a large public university within the same state. We designate this STEM high school as selective since its admissions process considers students' prior GPA and academic achievement as part of acceptance decisions. This selective STEM high school has both a residential program, where approximately 1,000 students live and learn on the school's campus during the academic year, and an online program, where approximately 450 students remain enrolled in their local high school and take advanced STEM courses online. For both programs, students enroll in the eleventh grade and participate for two years. Students who complete the residential program earn a high school degree from the selective STEM high school while students who complete the online program earn a certificate and have a transcript but receive a degree from their local high school. After graduating high school, many students attend public universities within the SU system.

Residential vs. Online Programs

This paper explores college outcomes associated with two types of programs at a selective STEM high school in the Southeastern United States: a residential program and an online program. Currently, there is no existing literature which examines different program types within STEM high schools. The distinction between residential and online programs is important. Firstly, the programs differ in the mode of delivery of instruction. Students enrolled in the residential program live and take courses at the STEM high school's campus, in comparison, students enrolled in the online program take advanced STEM coursework remotely and primarily asynchronously while remaining enrolled in their local high schools. From a sociocultural perspective, differences in learning contexts between residential and online programs may impact students' ability to interact with other students who may have similar academic interests or motivations, which in turn has implications for their learning and development (Vygotsky & Cole, 1978). There are some opportunities for students in the online program to interact with faculty and students in-person by visiting the campus for weekend experiences but these interactions do not occur on a daily basis as in the residential program. In general, high school students who take courses online are less likely to enroll in 4-year colleges than their in-person peers (Heinrich & Darling-Aduana, 2021). Secondly, the programs differ in the number of courses that students take as part of the curriculum. For the residential program, students are enrolled in five core courses during each semester. In contrast, students in the online program take one to two courses per semester in addition to courses provided by their local school. Taking a higher number of advanced courses is positively associated with STEM degree completion (Adelman, 2006; Trusty, 2002, Tyson, 2007). Thirdly, the programs differ in competitiveness of their admissions processes with the residential program being more highly sought and having a lower acceptance rate. Thus, the residential program may consist of higher performing students. Lastly, the programs vary in gender and racial demographics which are shown in Table 1. For example, the online program has a higher percentage of White students than the residential program, but they have similar percentages of URM students.

State University (SU) System

We track students from the selective STEM high school who attend one of fifteen public universities within the SU system. These universities are geographically distributed across the state and range in size including large schools with a student body greater than 36,000 and small schools with a study body of about 3,000.

Methodology

We used data from a selective STEM high school and SU system administrative records. The selective STEM high school data included students' demographic information and transfer credits. The SU system data included students' high school information, transfer credits, college course enrollment, credit accumulation, major declaration, and degree completion.

Analytic Sample

The analytic sample consisted of students who attended the selective STEM high school and then enrolled in a SU system university (N = 302) compared to SU system students (N = 94,170) who matriculated during the same period between 2015 and 2017. We made the assumption that students who chose to enroll in a selective STEM high school enter college with interest in STEM. This is a reasonable assumption given that 83% of students in the selective STEM high school sample declared a STEM major at some point in college. To account for this, we also conducted comparisons with a subset of the broader SU system sample: SU system students who declared a STEM major or enrolled in a STEM degree program at any point during their college careers. This allowed us to create a comparison group who indicated an interest in STEM (N = 32,190).

The demographic information of the STEM high school sample and comparison groups are presented in Table 1. For the racial subgroups, we focused on White, Asian, African American/Black, Native American/American Indian, and Hispanic/Latinx student populations, the largest subgroups. Due to small sample sizes and insufficient statistical power, we combined Black/African American, Hispanic/Latinx, and Native American/American Indian students into one group which we labeled as underrepresented minoritized (URM) students. We were unable to examine other racial and ethnic subgroups (e.g., Pacific Islander) since sample sizes were under ten students with some years having zero students of that demographic. The demographic makeup of the selective STEM high schools indicates that Asian students are proportionally over-represented and URM students under-represented relative to the SU system.

Table 1

Demographic Information of STEM High School Sample and Comparison Groups

	Attended Selective STEM High School		Comparison Groups	
	Residential	Online	SU System Full Sample	SU System Restricted Sample with STEM Interest
Female	0.44	0.46	0.57	0.47
White	0.44	0.63	0.58	0.58
Asian	0.29	0.14	0.05	0.08
URM	0.15	0.12	0.30	0.26
Total	205	97	94,170	32,190

Notes. Crosstabulation of analytic sample students who attended the STEM high school compared to UNC System students by race and gender. This table includes only students who matriculated in 2015, 2016, or 2017. 2015 is the first year of matriculation data for STEM High School students. The gender variable is based on IPEDS (2023) reporting, so students can be either female or male. Race/ethnicity categories will not sum to 100% because we exclude smaller race/ethnicity groups from sample. The restricted sample with STEM interest restricts the comparison group to UNC System students who ever declared a STEM major while in college.

Outcome Measures

We examined four college outcome measures for all subgroups: degree completion, time to degree completion, STEM degree completion, and time to STEM degree completion. For degree completion and STEM degree completion, we used binary outcomes. We measured degree completion based on whether an enrolled student ever earned a bachelor's degree. Then, we measured whether a degree completion was a STEM degree based on program CIP codes and the Department of Homeland Security (DHS) definition of STEM CIP codes. The DHS STEM list publishes a list of CIP code yearly that the federal government uses to define STEM and associated eligibility for grants and scholarships. We also used STEM degree completion as an indicator for persistence in the STEM pipeline. Next, we measured the amount of time in years that students took to earn their degrees. Time to degree completion was an important outcome measure for students who attended the STEM high school since they often completed many courses for college credit while in high school. Students who attended the STEM high school entered college with an average of 24 cumulative transfer credits from high school.

Empirical Approach

For each subgroup, we used the following regression model with interactions to estimate student outcomes:

$$Y_{ist} = \alpha + + \beta_1 STEM\ HS_i + \beta_2 Female_i + \beta_3 STEM\ HS_i * Female_i + X_{it} + \varphi_i + \phi_{st} + \upsilon_{ist} + \varepsilon_{ist}$$

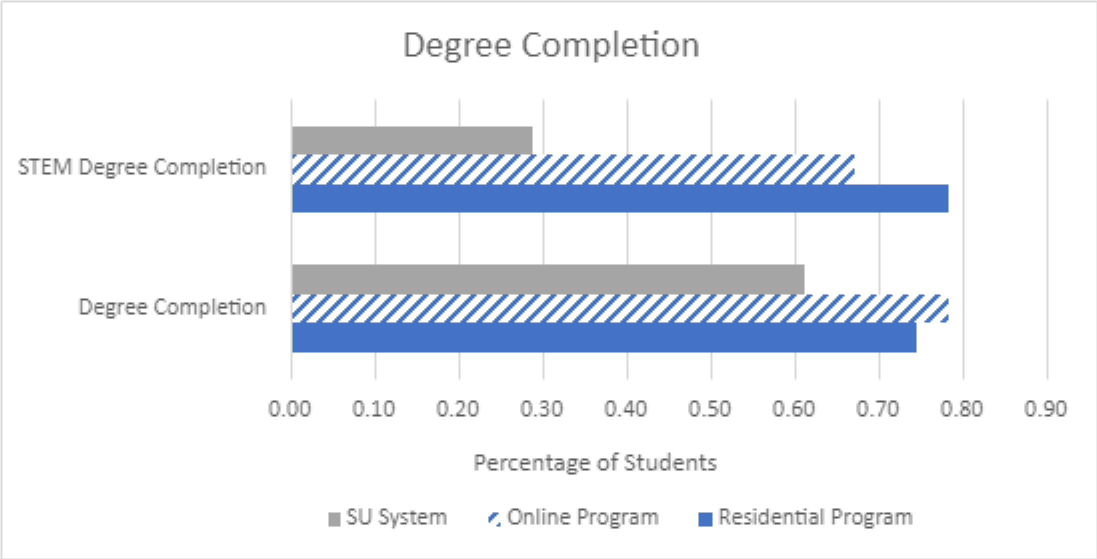
where outcome *Y* for student *i* at university *s* in year *t* predicted by a binary variable for attending the STEM high school or not (β_1). The outcomes were degree completion, time to completion, STEM degree completion, and time to STEM degree completion. β_2 was a binary indicator for student gender where 1 represented female and 0 represented male. β_3 represented the interaction between attending the STEM high school and gender. The combination of β_1, β_2, and β_3 estimated the association between attending the STEM high school, being female, and the outcome. In vector X_{it}, we controlled for race, attending another STEM high school within the same state, and cumulative transfer hours. We included fixed effects for the county each student was from (φ_i), the university they attended (ϕ_{st}), and their matriculation year into the SU system (υ_{ist}). We clustered the error term (ε_{ist}) at the student's county of residence level.

Results

We present the findings for each outcome measure, which are labeled as the section headers, by first describing overall trends for students who attended the selective STEM high school, in both residential and online programs, compared to SU system students who did not attend the selective STEM high school. Then, we present the associations between attending a selective STEM high school and college outcomes, using fixed effects regression models to determine whether the associations are statistically significant for gender and racial subgroups. The regression coefficients are displayed in Table 2-4. Table 2 shows college outcomes by gender, Table 3 shows college outcomes by race, and Table 4 shows college outcomes by gender and race. The column letters indicate the outcome measure, and the rows numbers indicate the STEM high school sample and comparison group, so we can reference the table cell (e.g., Table 2, A3) when discussing the findings. Each table is divided into two sections. The first section compares the STEM high school sample to the full SU system comparison group while the second section compares the STEM high school sample to the restricted SU system comparison group with STEM interest. It is important to note that *N* decreases for each successive outcome measure (columns A-D) in the tables because time to degree completion is conditional on degree completion which reduces the sample size. Similarly, STEM degree completion is conditional on degree completion, and time to STEM degree completion is conditional on degree completion and STEM degree completion.

Figure 1

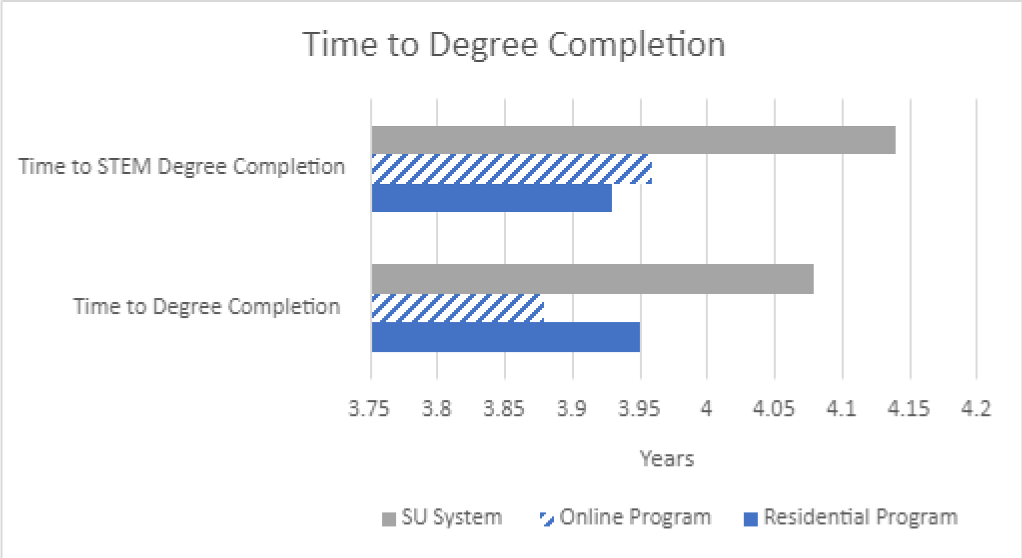
Percentage of Students Enrolled in SU system who Completed a Degree



Notes. Graph shows percentages of degree completion for full analytic sample of students who matriculate in fall 2015, 2016, or 2017. Degree completion is not limited to a time horizon. We look at completion by the time of last semester in our data: Spring 2021. STEM degree completion is the percentage of students who complete a STEM degree among all students who complete any degree. Since STEM degree completion is conditional on degree completion, the sample size is smaller which explains why the rate of STEM degree completion for the residential program is higher than degree completion.

Figure 2

Time to Degree Completion (years) for Students Enrolled in SU system who Completed a Degree



Notes. Graph displays time to degree completion and time to STEM degree completion in years from the first academic year of enrollment to the academic year of completion. Time to degree completion is limited to students who complete any degree. Time to STEM degree completion is limited to students who complete a STEM degree.

Table 2

Association between Attending a Selective STEM high school and College Outcomes by Program Type and Gender

Selective STEM High School Sample	Comparison Group	A. Degree Completion	B. Time to Degree Completion	C. STEM Degree Completion	D. Time to STEM Degree Completion
Full Sample for the Comparison Group					
1. Residential Females	SU system females	-0.020	0.110*	0.309***	0.050
2. Residential Males	SU system males	0.057*	-0.005	0.350***	-0.075
3. Online Females	SU system females	0.060	0.174*	0.323***	0.155*
4. Online Males	SU system males	0.072	0.009	0.157***	-0.005
N		94,472	57,926	57,926	16,840
Restricted Sample for Comparison Group with STEM Interest					
5. Residential Females	SU system females	0.002	0.073	-0.050	0.046
6. Residential Males	SU system males	0.064**	-0.082*	0.049	-0.077
7. Online Females	SU system females	0.089	0.091	-0.059	0.146*
8. Online Males	SU system males	0.078	-0.086	-0.164***	-0.006
N		32,492	21,346	21,346	16,124

Notes. Values represent the addition/subtraction of coefficients that represent the difference between the STEM high school students and the UNC System students. Significance for coefficients determined using an F test for whether the sum of coefficients is statistically equal to 0. Sample sizes refer to full sample size in regression. *p<0.05*, p<0.01**, p<0.001****

Table 3

Association between Attending a Selective STEM high school and College Outcomes by Program Type and Race

Selective STEM High School Sample	Comparison Group	A. Degree Completion	B. Time to Degree Completion	C. STEM Degree Completion	D. Time to STEM Degree Completion
Full Sample for the Comparison Group					
1. Residential White	SU system White	0.019	0.081*	0.297***	0.036
2. Residential Asian	SU system Asian	0.025	0.020	0.282***	-0.056
3. Residential URM	SU system URM	-0.022	0.024	0.426***	-0.025
4. Online White	SU system White	0.087	0.157*	0.221***	0.141*
5. Online Asian	SU system Asian	0.047***	0.039	0.371***	-0.039
6. Online URM	SU system URM	0.038	-0.160	0.175***	0.123*
N		87,566	53,970	53,970	15,446
Restricted Sample for the Comparison Group with STEM Interest					

7. Residential White	SU system White	0.032	0.027	-0.054	0.029
8. Residential Asian	SU system Asian	0.044*	-0.042	0.054	-0.062
9. Residential URM	SU system URM	0.011	0.009	0.090	-0.015
10. Online White	SU system White	0.115*	0.073	-0.148*	0.134*
11. Online Asian	SU system Asian	0.074***	-0.009	0.142***	-0.040
12. Online URM	SU system URM	0.037	-0.288	-0.262	0.099*
N		29,735	19,601	19,601	14,775

Notes. Values represent the addition/subtraction of coefficients that represent the difference between the STEM high school students and the UNC System students. Significance for coefficients determined using an F test for whether the sum of coefficients is statistically equal to 0. Sample sizes refer to full sample size in regression. *p<0.05*, p<0.01**, p<0.001****

Table 4. *Association between Attending a Selective STEM high school and College Outcomes (Programs Combined) and the Interaction of Gender and Race*

Selective STEM High School Sample	Comparison Group	A. Degree Completion	B. Time to Degree Completion	C. STEM Degree Completion	D. Time to STEM Degree Completion
Full Sample for the Comparison Group					
1. Female White	SU system Female White	0.056	0.142***	0.298***	0.134**
2. Female Asian	SU system Female Asian	-0.010	0.086	0.306***	0.001
3. Female URM	SU system Female URM	-0.075	0.056	0.246	0.050
N		87,566	53,970	53,970	15,446
Restricted Sample for the Comparison Group with Interest in STEM					
4. Female White	SU system Female White	0.079	0.111*	-0.088*	0.127**
5. Female Asian	SU system Female Asian	-0.002	0.030	0.039	-0.013
6. Female URM	SU system Female URM	-0.049	0.003	-0.127	0.054
N		29,780	19,637	19,637	14,778

Notes. Values represent the addition/subtraction of coefficients that represent the difference between the STEM high school students and the UNC System students. Significance for coefficients determined using an F test for whether the sum of coefficients is statistically equal to 0. Sample sizes refer to full sample size in regression. *p<0.05*, p<0.01**, p<0.001****

Degree Completion

In general, students who attended the selective STEM high school, either the residential or online program, had higher degree completion rates than SU system students. The overall completion rate for students who attended the selective STEM high school was 75% for the residential program and 78% for the online program, compared to 61% for the comparison group (Figure 1). However, we were unable to observe degree completion for students who dropout or transfer to another institution outside of SU system universities.

By Gender

There was no significant difference in the likelihood of degree completion for online or residential females compared to SU system females (See Table 2, A1 and A3). This finding remained consistent when we compared residential females to SU system females with interest in STEM (See Table 2, A5 and A7). In contrast, residential males were 5.66 percentage points more likely to graduate than SU system males (See Table 2, A2). When we limited the comparison group to male students with interest in STEM, residential males were 6.4 percentage points more likely to graduate than SU system males (See Table 2, A6). There was no significant difference in the likelihood of degree completion for online males compared to SU system males (See Table 2, A4), regardless of STEM interest (See Table 2, A8).

By Race

Across all three racial subgroups (i.e., White, Asian, URM), there were no significant differences in the likelihood of degree completion for students who attended the residential program compared to SU system students of the same race (See Table 3, A1-3). We also see no relationship when residential students were compared to SU system students with STEM interest (See Table 3, A7-9). For the online program, Asian students had a significantly higher likelihood of degree completion than SU system Asian students. They were 4.7 percentage points more likely to complete a degree than SU system Asian students (See Table 3, A5) and 7.4 percentage points more likely than SU system Asian students with STEM interest (See Table 3, A11). Residential Asian students also completed degrees at higher rates than UNC System Asian students with STEM interest (See Table 3, A8). For White students in comparison to SU system White students with STEM interest, the online program was associated with a higher likelihood of degree completion (See Table 3, A10).

By Gender and Race

There were no significant differences in the likelihood of degree completion for female White, female Asian, or female URM students compared to female SU system students of the same race (See Table 4, A1-3). These findings remained consistent after we restricted the comparison group to those with interest in STEM (See Table 4, A4-6).

Time to Degree Completion

On average, selective STEM high school students who attended the residential program took 3.95 years to complete a degree and those who attended the online program took 3.88 years to complete a degree (See Figure 2). In comparison, SU system students took on average 4.08 years to complete a degree.

By Gender

Residential and online females took 0.11 and 0.17 years (approximately 1-2 months) longer to complete a degree than SU system females (See Table 2, B1 and B3). However, this finding was no longer significant after limiting the comparison group to students with interest in STEM (See Table 2, B5 and B7). Compared to SU system male students with interest in STEM, residential males completed a degree 0.08 years (about 1 month) faster (See Table 2, B6). We did not observe a significant difference for male students who attended the online program compared to SU system males (See Table 2, B8).

By Race

White students who attended the residential or online program completed a degree 0.08-0.16 years (approximately 1-2 months) longer than SU system White students (See Table 3, B1 and B4). However, when the comparison group was restricted to students with STEM interest, there was no significant differences in time to degree completion for White students (See Table 3, B10). Similarly, Asian and URM students who attended the residential or online programs completed a degree in the same length of time compared to SU system students of their same race.

By Gender and Race

There were no significant differences in time to degree completion for female Asian or female URM students who attended the residential or online programs compared to SU system female Asian and female URM students. White females who attended either the residential or online program took approximately 0.1 more years (1 month) to complete a degree than SU system White females (See Table 4, B1 and B4).

STEM Degree Completion

For STEM degrees, the overall completion rate for students who attended the selective STEM high school was 78% for the residential program and 67% for the online program, compared to 29% for SU system students who did not attend.

By Gender

Residential females were 30 percentage points more likely and online females were 32 percentage points more likely to complete a STEM degree compared to all SU system females (See Table 2, C1 and C3). Similarly, residential males were 35 percentage points more likely and online males were 16 percentage points more likely to complete a STEM degree compared to all SU system males. When we restrict the comparison group to SU system students with STEM interest, residential and online females as well as residential males had similar outcomes for STEM degree completion in comparison to SU system females and males. However, online males were significantly less likely to earn a STEM degree than SU system males with STEM interest (See Table 2, C8).

By Race

Students across all racial subgroups who attended the online or residential program were significantly more likely to earn a STEM degree than SU system students of the same race (See Table 3, Column C1-6). When we compare STEM high school students to SU system students with STEM interest, only online Asian students were significantly more likely to complete a STEM degree (See Table 3, C11). URM students who attended the online or residential program were equally likely to complete a STEM degree than URM students in the SU system with STEM interest (See Table 3, C9 and 12). Residential White students were equally likely to earn a STEM degree as White SU system with STEM interest (See Table 3, C7), but online White students were significantly less likely (See Table 3, C10).

By Gender and Race

White females and Asian females who attended the selective STEM high school were 30 percentage points more likely to complete a STEM degree than their SU system comparison groups (See Table 4, C1 and C2). However, compared to the restricted sample with STEM interest, White females were 9 percentage points less likely to complete a STEM degree (See Table 4, C4). Asian females and URM females had similar likelihoods of STEM degree completion as SU system students of the same demographic with STEM interest (See Table 4, C5 and C6).

Time to STEM Degree Completion

STEM high school students took less time to complete a STEM degree than SU system students. On average, residential students took 3.9 years and online students took 3.93 years to complete a STEM degree while SU system students took 4.14 years to complete a STEM degree.

By Gender

Online females took 0.15 years (about 2 months) longer to complete a STEM degree than SU system females with and without STEM interest (See Table 2, D3 and D7) while residential females had similar time to STEM degree completion (See Table 2, D1 and D5). Online and residential males took the same length of time to graduate compared to SU system males.

By Race

Online White and online URM students took 0.1 years (1 month) longer to complete a STEM degree than White and URM students in the SU system with and without STEM interest (See Table 3, D4, D6, D10, D12). There was no significant difference for online Asian students (See Table 3, D5 and D11). Residential students in all racial subgroups took similar lengths of time to complete a STEM degree as their SU system counterparts.

By Gender and Race

White females who attended either the residential or online program took 0.13 years (about 1 month) longer to graduate with a STEM degree than SU system White females (See Table 4, D1 and D4). There were no significant differences in time to STEM degree completion for Asian females or URM females who attended the selective STEM high school compared to similar SU system students who did not attend.

Discussion

We examine college outcomes (i.e., degree completion, time to degree completion, STEM degree completion, and time to STEM degree completion) for students who attended a selective STEM high school and then enrolled in a SU system university in comparison to SU system students who did not attend the selective STEM high school and matriculated during the same time period from 2015 to 2017. Selective STEM high school students in our sample complete either a residential or online program, and we analyze outcomes for each program type by gender, race, and the interaction of gender and race. To account for students' self-selection to enroll in a high school with a STEM focus, we also make comparisons to a subset of SU system students who indicate similar interest in STEM by declaring a STEM major at any time during college. Although this method does not perfectly capture students' STEM interest, it serves as a proxy, allowing us to consider the role that STEM interest plays broadly in students' persistence in the STEM pipeline.

Overall trends from the descriptive statistics presented in Figures 1 and 2 indicate that students who attend a selective STEM high school have higher rates of degree completion and STEM degree completion as well as graduate in less time than students who do not attend in the SU system comparison group. While these findings are promising for the long-term benefits of STEM high schools on promoting the STEM pipeline, further regression analyses reveal that these trends are not significant for all student populations. It is important to acknowledge that the STEM high school sample (N = 302) is substantially smaller than the comparison group sample (N = 94,170). Therefore, even though the overall sample is large, the sample of students who attended the STEM school is modest, and numbers of STEM high school students in most specific demographic groups is small. For example, there are 31 students in the URM sample who attended the residential program in comparison to 28,251 URM students in the SU system sample. This may be one reason why we observe some positive associations, but the results are not always statistically significant. Furthermore, the regression analyses control for other variables such as cumulative transfer hours which the descriptive statistics do not account for. This is important since students who attend the STEM high school have on average 24 transfer credits, approximately one year of college, which is notably higher than most incoming students.

We also control for whether SU system students attended one of nineteen other STEM-focused high schools within the same state.

Analysis of the first outcome measure, degree completion, by gender shows that attending a selective STEM high school is significantly associated with a higher likelihood of degree completion for males in the residential program only (See Table 2, A6). Female students who attend a selective STEM high school have similar degree completion rates as SU system female students. Similarly, URM students including African American/Black, Hispanic/Latino, and Native American students perform the same as URM students in the comparison group for degree completion. We recognize that it is problematic to combine these racial and ethnic subgroups, which are very different, into one sample. However, due to small sample sizes under ten for these subgroups, we had to combine them to be able to make inferences about underrepresented student populations using statistical analyses. Our study does not provide evidence to support the notion that selective STEM high schools support undergraduate degree completion for underrepresented students including female and URM students any more so than traditional high schools. This is consistent with a previous study which finds that while disadvantaged students from selective STEM high schools are more likely to enroll in more selective colleges, they are equally likely to complete a degree as their peers (Shi, 2020). However, one limitation of our study is that we are unable to observe degree completion for students who attend public universities in a different state or private colleges. There may also be other benefits for female and URM students in terms of postsecondary outcomes (e.g., feelings of self-efficacy to do well in college or desires to attend graduate school) which we did not explore.

Regarding the second outcome measure, time to degree completion, attending a selective STEM high school reduces time to degree completion for males in the residential program by approximately one month. Female and URM students who attend the selective STEM high school graduate in the same length of time as female and URM students in the SU system. Similarly, another study finds no effect on time to degree completion for selective STEM high school students from underrepresented backgrounds (Shi, 2020). When looking at interactions of gender and race, we find that female White students who attend the STEM high school take approximately 1 month longer to complete their degrees than female White students in the comparison group.

There are positive associations between attending a selective STEM high school and STEM degree completion for both online and residential programs across all racial subgroups (See Table 3, C1-6). However, when we compare students who attended the STEM high school to SU system students who express interest in STEM by declaring a STEM major at any point during college, this finding only remains significant for Asian students in the online program (See Table 3, C11). In other words, students' interest in STEM may be a more important factor in their persistence to complete a STEM degree than whether they attended a STEM high school. Similarly, another study finds that once students' self-selection into a high school with a STEM focus is accounted for, there is no effect on STEM college outcomes (Bottia et al., 2017). One explanation for this is experiences outside of school such as STEM internships, research, mentorship, and informal learning opportunities may be more influential in cultivating desires to pursue STEM. Moreover, access to advanced STEM coursework does not necessarily result in stronger interest in STEM (Maltese & Tai, 2011; Subotnik et al., 2013). Other variables such as family and teacher reinforcement of STEM, students' perceptions of the value of STEM, role models, and alignment with their cultural identities also play an important role for female and

URM students (Espinosa, 2011; Herrmann et al., 2016; Aschbacher, Li, & Roth, 2010; Anderson & Ward, 2014).

An underlying assumption of our analysis is that selective STEM high school students have some level of interest in STEM when they enroll in college because they chose to attend a high school with a STEM focus. A disadvantage of our methodology is that it does not account for students who may have been interested in STEM in high school but decide not to pursue STEM in college. Previous research indicates that high school is a critical time in students' decisions to pursue STEM (Maltese & Tai, 2011; Bottia et al., 2015; Jiang et al., 2020). It is reasonable to assume that some students in our sample do not have interest in STEM or have varying degrees of STEM interest which we are unable to account for. However, this is small proportion of students in the sample since 83% of students who attended the selective STEM high school declared a STEM major at some point in college.

For the fourth outcome measure, time to STEM degree completion, we find that attending an online program at a STEM high school extends STEM degree completion time by approximately 1 month for female and URM students (See Table 2, D7 and Table 3, D12). Since the online program provides STEM instruction remotely and primarily asynchronously, it would be interesting for future research to investigate whether this affects students' confidence in their understandings of course materials, which may lead them to retake a STEM course in-person once in college. Among community college students, for instance, online course taking is associated with a higher likelihood of retaking the online class (Hart et al., 2018).

Implications

Based on the findings from this study, policies which aim to increase the number of URM and female students in STEM high schools may not be effective on their own to promote inclusion in the STEM pipeline. These student populations may need additional support once in a STEM high school. For example, previous research suggests that Black females in STEM can benefit from social support systems such as student groups that foster connections within STEM programs and counseling resources to mitigate feelings of isolation (Ireland et al., 2018). For Hispanic and Latino students, family and community support can be integral for academic success (Wagner, 2015). With regards to STEM curriculum, females are more likely to declare a STEM major if they take physics in high school and they are more motivated to do so if the curriculum feels personally meaningful (Bottia et al., 2015; Murphy & Whitelegg, 2006). One approach to boost underrepresented students' interest in STEM is to contextualize STEM content in socially relevant issues known as socioscientific issues (SSI). SSI-based learning is associated with building science interest and motivation among students by helping them relate their lived experiences to classroom learning (Sadler & Dawson, 2012). Recent research has shown how SSI approaches can align with Justice-Centered Science Pedagogy and help students to make personally meaningful connections with their science learning experiences (Lesnefsky et al. 2023). STEM high schools provide students with exceptional STEM opportunities such as advanced coursework, independent research, and mentorship which are unavailable to most students in traditional high schools. Above and beyond creating high quality STEM opportunities, strategies are needed to support students' personal connections between their STEM experiences in school and their own interests and degree aspirations after high school.

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