

# ***SPUTNIK, STEM, AND SUCCESS?\****

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Women and people of color (with the exception of Asian-Americans) were still found to be underrepresented in STEM disciplines in higher education. National data also revealed a lower persistence and graduation rates compared to their male and non-minority counterparts. This study utilized a multi-method approach. The quantitative aspect of the study investigated correlates of persistence and graduation using stepwise multiple regression. The phenomenological (qualitative) aspect consisted of focused interviews with STEM students, uncovering information about their personal and collegiate experiences and issues missed by the quantitative methodology. There were significant similarities and differences in the factors related to persistence and graduation by race and gender of STEM students.

## INTRODUCTION

Since *Sputnik*, the nation has clearly understood the roles that scientific knowledge and innovations play in the nation's scientific and economic well-being. In order to maintain its advantage in the scientific arena, there is a general expectation of a steady stream of competent college students being educated and trained in Science, Technology, Engineering, and Mathematics (STEM) disciplines in the nation's colleges and universities. Recognizing that this is a human resource matter, all Americans, regardless of their gender or race, should be represented in these disciplines. The concern has been about the differences in participation, persistence, and graduation rates by gender and race-ethnicity in STEM disciplines.

## BACKGROUND

There is evidence showing a persistent gap in STEM enrollments between the genders and race-ethnic status. By gender, Huang et al. (2000) reported a disparity between men and women of

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about 14%. Hayes (2002) reported that there is a 16% difference in men and women representing all first-time STEM freshmen. By race-ethnicity, Hayes (2002) reported that a great disparity—between 1 to 9% of all first-time STEM freshmen were people of color compared to 83% who were non-minorities. In addition, Hayes (2002) indicated that more women and people of color in STEM disciplines were enrolled in less selective institutions.

Pertaining to the persistence issue, Huang (2000) reported that a disparity between the race-ethnic groups. A greater number of students of color do not persist in their STEM disciplines compared to their non-minority counterparts. There were also more than twice as many students of color who switched to other non-STEM majors without finishing their STEM degrees than their non-minority counterparts. Hayes (2002) reported a similar pattern although the difference was not as pronounced. By gender, both Hayes (2002) and Huang (2002) were reporting only slight differences between the gender groups.

In terms of graduation, Hayes (2002) reported that a significant disparity between race-ethnic groups—41% of non-minorities graduated with their STEM majors in six years compared to 23% among underrepresented minorities. Huang (2000) reported that 46% of non-minority students and Asian-Americans graduated in their STEM disciplines in five years compared to 27% of underrepresented minority students. By gender, Huang (2000) reported that more women than men graduated in their STEM disciplines (49% compared to 40%). Hayes (2002), on the other hand, found the reverse—more men graduated with their STEM degrees than women (39% to 34.8%).

If there are differences in the persistence and graduation rates among the genders and racial-ethnic groups, what would help explain these differences?

Although the research and theories related to explanations of persistence and graduation among the general college population are comprehensive, there is relatively little known about persistence and graduation pertaining to STEM majors in specific. The few exceptions were studies conducted by Hill (1996), Huang (2000), and Sax (2001), but the knowledge base is far from complete. In order to gain some knowledge about the potential correlates of persistence and

graduation of STEM majors, the correlates of persistence and graduation related to the general college population could be identified and examined to see if they were also pertinent to STEM majors.

Among the variables identified as potential correlates of persistence and graduation of the general college population (and potentially of STEM majors) included institutional size, type (Carnegie classifications), or control (public-private) (Huang, 2001; Smith, 2001; US Congress, 1992); institutional selectivity (Smart, 1986; Tinto, 1980); standardized test scores (Griffiths et al., 1992; Kroc et al., 1995; Saupe et al., 1999); academic ability of students or high school performance (Astin, 1978, 1985; Saupe, 1988; Saupe et al., 1999; Smith, 2001); standardized test scores (Griffiths et al., 1992; Kroc et al., 1995; Saupe et al., 1999); faculty-student interaction or class size (US Congress, 1992); diversified student body and racial climate (Hurtado et al., 1998; Seymour & Hewitt, 1997); age of students (Saupe et al., 1999); better fit in values and culture with underrepresented groups vis-à-vis performance and collaboration (Seymour & Hewitt, 1997); faculty responsiveness and teaching (Seymour & Hewitt, 1997); student involvement and effort (Astin, 1985; Pascarella, 1985); student academic and social integration (Murguia et al., 1991; Tinto, 1986); availability of financial aid (DuBrock, 2000; Friedman & Kay, 1990; Huang, 2001; Seymour & Hewitt, 1997); enrichment (not remedial) programs (Seymour & Hewitt, 1997); parents' college education and their financial support (Huang, 2001); and higher confidence and aspirations for advanced STEM studies (Huang, 2001).

The fact that studies on factors related to persistence and graduation of STEM majors are few and inconclusive lend itself well to the need for this particular study. To be sure, the purpose of the study was to examine the factors related to persistence and graduation of STEM undergraduate students who remained in their STEM disciplines.

Specifically, two research questions were examined: (1) What factors were related to persistence and graduation of all STEM majors? (2) Were there any differences in these factors by race and gender? (3) What were the personal experiences of women and people of color in these fields?

The study had several important advantages. The first was that the study was multi-institutional, covering 200 institutions nationwide. The second was that the study explored quite a comprehensive list of variables potentially linked to persistence and graduation, with some attention paid to their conditional effects. The third was that a qualitative methodology checked for consistency with expected findings and uncovered details missed by the quantitative *apriori* approach.

## METHODOLOGY

A multi-method approach, consisting of both quantitative and qualitative methodologies, was used. To get answers to the first two research questions, the quantitative approach was used. Stepwise multiple regression was used to estimate the relationships between the dependent variables (persistence and graduation) and the sixteen independent variables. Three subgroup analyses were performed for each of the two dependent variables: all students regardless of race or gender, racial-ethnic cohorts, and gender cohorts.

In order to get answers to Research Question 3, the qualitative (phenomenological) approach using the focused interview was used. A purposive sample of eighteen students in STEM disciplines at a public research university in the Southwest was interviewed for their views regarding their personal, social, and academic experiences on campus. These students ranged in age from 19 to 23. A total of seven females and eleven males were interviewed. By race-ethnicity, four were European-Americans, one African-American, two bi-racial, and eleven Hispanics. Some of Eccles' extensive work (1987) particularly related to educational and occupational choices of students guided the qualitative interviews.

On the quantitative part of the study, the following variables were included in the study:

1. Persistence (C2YR): Continuation rates among STEM majors to the second year.
2. Graduation (GRAD6): Graduation rates among STEM majors within six years of enrollment.

3. Race (RACE): 0=European-American and Asian-American; 1=minorities (African-American, Hispanic, Native American)
4. Gender (GENDER): 0=male and 1=female
5. Standardized Scores (SDTEST): Mean standardized test scores of STEM majors (ACT scores were converted to SAT equivalence using a concordance table. The equivalent SELECT is computed based on ACT or SAT scores (0=ACT>21 or SAT>990; 1=ACT<21 or SAT<990)
6. Part-Time Enrollment (PART): Percentage of undergraduates who are attending college part-time.
7. Control (CONTROL): 0=private; 1=public
8. Carnegie: 0=Research I & II, Doctoral I & II; 1=Masters I & II, Bachelor's I & II, and others.
9. Institutional size (TENROLL): Total graduate and undergraduate enrollment.
10. Percent Poor GPA (POORG): Percent of all students with first-semester grade-point-average below 2.0
11. Percent Age (AGE): Percent of undergraduate students who are 24 years or older.
12. Percent Housing (HOUSE): Percent of undergraduate students who lived in university housing.
13. Percent Minority (MINOR): Percent of underrepresented undergraduate minorities on campus.
14. Percent STEM Minority (SMINOR): Percent of women or underrepresented minority STEM majors of the total STEM majors.
15. Percent High School Rank (HS10): Percent of undergraduate students who graduated in the top 10% of their high school classes.
16. Percent Financial Aid (FINAID): Percent of all undergraduate students receiving all forms of financial aid in 2000-2001.
17. Student-faculty ratio (SFRATIO): Ratio of the number of students to faculty in 2000-2001.

18. Percent Small Classes (SMALLC): Percent of classes with fewer than 20 students in 2000-2001.

Data on these variables came primarily from the only known national retention STEM databases compiled by the Center for Institutional Data Exchange and Analysis (C-IDEA) (Hayes, 2002). The Center, with funding from National Science Foundation, is in its third year of operation. From 120 participating institutions during its first year, the number is now 200. The sample consisted of public and private institutions nationwide, ranging from doctoral to baccalaureate institutions. Data on the last three variables came from the *US News and Report* (2002). Despite persistent controversies associated with institutional and program rankings from this publisher and others, the data for the three variables were judged to be appropriate since they were not collected based on subjective evaluations.

C-IDEA maintained three databases on STEM majors. The first database contained data on students of all majors; the second on those who started out as STEM majors, switched to other majors and persisted, transferred, or dropped out; and the third on those who started as STEM majors, remained, and graduated as STEM majors. Only the third database was used since it was the most relevant to the study's research question. Each database contained information on at least six cohorts, beginning with 1994 to 2000. The 1994-95 cohort year was chosen since this group had stayed the longest in higher education, and data on this group were the most complete.

Stepwise multiple regression was used to estimate the relationships between the dependent variables (persistence and graduation) and the sixteen independent variables. Persistence was measured by the proportion of the 1994-95 student cohort who continued to the second year, and graduation was measured by the graduation rate of the same students over a six-year period. Three subgroup analyses were performed for each of the two dependent variables. The first group consisted of all students; the second consisted of racial-ethnic cohorts; and the third group consisted of gender cohorts. Sub-group analyses were necessary since the data on race and gender were kept separately. The racial-ethnic cohort analysis was carried out by adding the RACE variable (0=non-minority; 1=minority) to all the existing variables. The minority group included

Hispanics, African-Americans, and Native Americans. The non-minority group included European-Americans, Asian-Americans, resident aliens, and others (including who did not identify a race). Likewise, the gender cohort analysis was administered by adding the GENDER variable (0=male; 1=female) to the list of existing variables.

## FINDINGS

### Persistence

The two significant correlates of second-year persistence among all STEM students, including non-minorities, was their institution's student-faculty ratio (negative coefficient) and institutional size (accounting for an R-Square of 17%) (Table 1). In the race-ethnic cohort analysis, the significant correlates were high school performance (percent of graduates in the top 10% of high school graduation class), student-faculty ratio (negative coefficient), and standardized test scores (R-square was 26%). It is significant to note that race had no bearing on persistence. In the gender cohort analysis, standardized test scores and percent of students with first-semester grade-point-averages below 2.0 (negative coefficient) were significant correlates (R-square was 13%). Gender was also not a significant factor related to persistence (Table 1).

[INSERT TABLE 1 ABOUT HERE]

A simultaneous examination of all three sub-groups revealed some interesting similarities and differences. One of the similarities was that for both race-ethnic and gender cohorts, pre-college performance variables were important correlates—high school graduation rank and standardized test scores—although not exactly in the same order for both groups. To be sure, high school graduation rank was more important to the race-ethnic cohorts whereas standardized test scores were more important to the gender cohorts. Pertaining to college variables, the campus academic rigor (represented by the percent of all students with first-semester grade-point-average less than 2.0) was important to the gender cohorts whereas student-faculty ratio was more

important to the race-ethnic cohorts. Overall, regardless of race or gender, student-faculty ratio and institutional size were related to persistence (Table 1).

## Graduation

The significant correlates of graduation for all STEM majors, regardless of race or gender, were high school grades, percent of underrepresented minorities on campus (negative coefficient), student-faculty ratio, and institutional size—the R-square was 37% (Table 2). For the race-ethnic cohorts, the significant correlates were standardized test scores, percent of students with first-semester grade-point-average below 2.0 (negative coefficient), percent of students older than 24 years, race (negative coefficient), institutional size, and student-faculty ratio (negative coefficient) (R-square was 46%). For the gender cohorts, standardized test scores, housing arrangement, student-faculty ratio (negative coefficient), institutional size, percent of students who received all forms of financial aid, and the percent of students older than 24 years (negative coefficient) were significant correlates (R-square was 28%). Gender was not an issue (Table 2).

[INSERT TABLE 2 ABOUT HERE]

A simultaneous examination of all three sub-groups revealed that student-faculty ratio and institutional size were commonalities. Another notable commonality was that standardized test scores was a significant variable to both the race-ethnic and gender cohorts. At the same time, there were at least four notable differences. One, academic rigor (the percent of students with grade-point-average less than 2.0) was important to the race-ethnic cohorts but not to the gender cohorts whereas housing arrangement was important to the gender cohorts but not to the race-ethnic cohorts. Two, financial aid was important to the gender cohorts but not to the race-ethnic cohorts. Three, the percent of older students was a significant variable to both cohorts, except that this variable carried a positive coefficient for the race-ethnic cohorts but a negative one for the gender

cohorts. Perhaps the most significant difference was that race was related to the graduation rates whereas gender was not (Table 2).

### Qualitative Interviews

Some common themes emerged from the qualitative interviews conducted with the eighteen undergraduate STEM students. When asked for the reasons for choosing STEM majors, many of them indicated an anticipation of a high economic return on their education, that they were advised by their high counselors and parents to major in STEM, that they had received targeted scholarships to major in STEM, and they thought it was prestigious to major in STEM. When asked why they specifically chosen this institution over another one, most of them cited their targeted scholarship awards, geographical proximity of the campus to their hometowns, friends they had who were already attending the same institution, and the cost of attending (it was cheaper). Interestingly, many of them had heard about the reputation of the institution and had indicated that they “were not going to be scared off” by the rigor and challenges of the place.”

When asked about the factors related to their persistence, many cited their social integration with other students of similar ethnicity (this was particularly true among Hispanic students). Many also cited assistance in the form of tutoring they received from their peers. Other cited that they had no choice but to continue with their educational path due to scholarship obligations or that they did want to be recognized as “failures” by their parents. This was particularly true of male students. This was in contrast to the female students who said that if they did not like their majors, the parents would say to them: “whatever you want to do is fine.” Assistance received from study groups (usually consisting of members from the same ethnic groups) was cited as an important factor related to their persistence. While most of the students thought their STEM experience has been challenging and rigorous, many who stayed had come to accept that reality well.

When some of the students were asked about why they had decided to change their majors or to drop out completely from college, they cited these reasons: “my grades were not good

enough”; “foreign or non-native English-speaking teaching assistants” (they cannot understand their accent; usually this is a scapegoat for their overall weak performance); “regular faculty were inaccessible to them for personal consultation”; “too many students assigned to one faculty”; “faculty did not have the time for students”; “the competitive nature of the disciplines do not breed appreciation for diversity”; “I felt lost out in the collegiate experience (because I had to study so hard)”; “we could never get remediation because it is not a part of the culture”; “we could get no personal help from faculty.” Many of the students felt that the challenges and barriers they faced as STEM students were based more on their ethnicity rather than on their gender. While many female students talked about a strong sense of “girls not welcome” on the part of both faculty and students (even though they claimed they were usually done humorously), the more serious concern with the students of color who received different treatments from their students and professors. Many students of color felt that they had to work harder than their non-minority counterparts and that faculty and other students seemed “surprised” when they did well. Another interesting theme was that the concerns raised by the female students were not strikingly different from the male students regardless of race or ethnicity. Both male and female students said that they changed majors because “studying engineering would take up too much time”; “the work is too isolated for someone who tends to be people-oriented”; “it is not a very ‘social’ major”; “many of the faculty do not really want to help students (any students, not just women or students of color).” The faculty, many cited, appeared to be more interested in seeing how the students can “figure it out” from the lectures and textbooks. Many female students thought that asking for help would show weakness which they recognize to be a part of the traditional male culture.

## DISCUSSIONS AND IMPLICATIONS

There is persistent evidence of a lower participation rate in STEM disciplines among women and underrepresented minorities. Persistence remains a critical issue as well considering the fact that more women and people of color do not stay in their STEM disciplines. Of those who

remained, only about a third would ultimately graduate in six years with degrees in STEM disciplines.

Among those who remained in their STEM disciplines (the focus of this study), only a few variables were related to their persistence and ultimate graduation. The variables found to be related were standardized test scores, student-faculty ratio, institutional size, high school performance, academic rigor on campus, percent of underrepresented minorities on campus (rather than the percent of same represented among STEM majors), percent of older students on campus, housing arrangement, and the percent of undergraduates receiving all forms of financial aid. These findings should not be too unfamiliar since they are consistent with those reported by previous researchers (e.g. Astin, 1985; Huang et al., 2000; Saupe et al., 1999). The most important finding was that gender and race were unrelated to persistence. However, race was a factor related to graduation in the race-ethnic cohorts. Just because race was a factor did not mean that it was causal in nature. By strength of association, the students' pre-college performance and their college's academic rigor were more important variables. To be sure, when students of color were academically prepared prior to college and were challenged by the academic rigor of college, they were more likely to graduate than be impeded by barriers associated with their race or ethnicity on campus (as pointed out by students in the qualitative interviews). If the institutional or STEM culture cannot be changed, many students of color and women just learned to cope by organizing and joining their own study groups and support mechanisms. Consistent with the importance of academic and social integration, these concepts were especially important to students of color and women in their quest to persist and ultimately graduate from college with their STEM degrees.

Also revealing in this study were the variables that did not turn out to be significant in this study. For example, institutional type (Carnegie classifications), institutional control (private or public), class size, percent of part-time students, and percent of underrepresented STEM majors were unrelated to both persistence and graduation. Given the rather prevalent viewpoint among underrepresented minorities in STEM majors that faculty had too many students assigned to them or were generally inaccessible to them, class size would have been predicted to be an important

factor related to their persistence and graduation, but that was not the same. The fact that structural institutional characteristics such as institutional type and control were found to be unrelated to persistence and graduation can be interpreted as either a warning or a challenge that a lot more can be done to alleviate the problems of change of majors and student drop-outs.

## CONCLUSIONS

Although this study discussed and provided some important national benchmark information about some factors related to the persistence and graduation rates of STEM majors, it has limitations. Perhaps the most important limitation was that the study did not have quantitative data on the direct variables related to the student collegiate experiences, particularly those pertaining to their level of involvement, engagement, and integration on campus. The study also did not consider the type and extent of retention programs that might have made a difference in reducing the magnitude of student dropout. Also not explored in full were experiences uniquely associated with women and students of color in STEM disciplines, such as the varying value placed on personal success and satisfaction. On this point, Seymour and Hewitt (1997) had argued that since women and students of color were likely to favor or value people and teamwork over individual success or performance normally associated with the STEM culture, this conflict could lead to student departure. While this issue explored in this study, it needed further and more detailed examination. The issue of culture remains an important one, as reflected succinctly in this statement made by Barber (1995, p. 232): “Transforming the culture of science is the key to narrowing the science and engineering gap.” In the author’s assertion, intervention strategies can be successful if they are focused on widening the cultural norms and expectations of the profession rather than on successful assimilation of students into the existing culture.

The fact that the persistence and graduation rates of women and people of color are still problematic does suggest that much more can be done to create a more supportive institutional and social cultures that treat all students fairly, encourage and support them to do their best work, provide a better and more personal sense of belonging and meaning on campus, provide them with

a more engaging collegiate experience, and recognize diversity and alternative learning modes and performance indicators. Of course no plan can be complete unless it includes strategies to encourage greater participation in science and mathematics classes in high school or even earlier, particularly among students of color and female students, and to persuade them to pursue degrees in STEM disciplines in college.

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**TABLE 1: Regression Results for Predicting Second-Year Persistence  
STEM Students Who Remained in their Disciplines**

Variables	All Students			Race-Ethnic Cohorts			Gender Cohorts		
	Unstd. B	Std. B	p	Unstd. B	Std. B	p	Unstd. B	Std. B	p
N	172			329			342		
R	.414			.510			.356		
R-Square	.171			.260			.126		
(Constant)	.996		.000	.450		.012	.184		.340
Race	NA						NA		
Std. Score				3.08e-04	.203	.033	5.04e04	.265	.004
Gender	NA			NA					
% part-time									
Control									
Carnegie									
Total enrollment	5.51e-06	.305	.038						
% gpa<2.0							-.585	-.201	.027
% age 24>									
% univ. housing									
% minorities									
% top10% hs rank				.599	.327	.001			
% minority STEM	NA								
% financial aid									
Stud-fac ratio	-2.89e-02	-.459	.002	-1.69e02	-.236	.007			
% classes 20<									
	Predictors: (Constant), SFRATIO, TENROLL			Predictors: (Constant), HS10, SFRATIO, SDTEST			Predictors: (Constant), SDTEST, POORG		

**TABLE 2: Regression Results for Predicting Six-Year Graduation  
STEM Students Who Remained in their Disciplines**

Variables	All Students			Race-Ethnic Cohorts			Gender Cohorts		
	Unstd. B	Std. B	p	Unstd. B	Std. B	p	Unstd. B	Std. B	p
N	172			334			346		
R	.610			.681			.688		
R-Square	.372			.463			.473		
(Constant)	.593		.000	.232		.141	-.186		.024
Race	NA			-9.77e-02	-.294	.001	NA		
Std. Score				3.22e-04	.252	.006	5.849e-04	.392	.000
Gender	NA			NA					
% part-time									
Control									
Carnegie									
Total enrollment	4.142e-06	.331	.022	5.01e-06	.304	.001	4.674e-06	.355	.000
% gpa<2.0				-.489	-.174	.022			
% age 24>				.293	.233	.003	-.181	-.173	.025
% univ. housing							.146	.265	.000
% minorities	-.364	-.270	.021						
% top10% hs	.325	.289	.025						
% minority STEM	NA								
% financial aid							1.588e-03	.191	.019
Stud-fac ratio	-1.94e-02	-.438	.001	-1.24e-02	-.206	.023	-1.969e-02	-.401	.000
% classes 20<	Predictors: (Constant), HS10, MINOR, SFRATIO, TENROLL			Predictors: (Constant), SDTEST, POORG, AGE, RACE, TENROLL, SFRATIO			Predictors: (Constant), SDTEST, HOUSE, SFRATIO, TENROLL, FINAID, AGE		