How Effective are Undergraduate Educational Enrichment Experiences Designed to Increase SEMCS[1] Study and Graduate and Professional Participation by Women and Underrepresented Minority Students?

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[1] Science, Engineering, Mathematics, and Computer Science

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Abstract

At each progressive educational transition, a disproportionate number of minority students are lost resulting in extreme under-representation among terminal degree awards, especially in science and engineering. Pioneering undergraduate student intervention programs designed to ameliorate these deficits experienced early success and local programs proliferated. Facing constrained resources, the institution now asks for demonstrated outcomes. This study followed participants in six enrichment programs designed to improve minority student transition rates to graduate or professional programs. Results compared the effectiveness of interventions and the relative performance of alumni search strategies, especially National Student Clearinghouse's (NSC) EnrollmentSearch. In sum, each of the six programs was found to be relatively successful in at least one important outcome: graduation rate, postbaccalaureate enrollment, persistence in SEMCS, or attraction to SEMCS fields. And, while there were significant limitations to NSC records, they presented a highly efficient opportunity to learn new information.

The Problem

The factual problem is straightforward and has been called the constricted pipeline. As reported by NSF (1999) and NCES's *Digest of Educational Statistics* (Tables 104, 107, 185, 209, 237), underrepresented minorities (Hispanic and African American) were 26% of the high school population, 21% of the undergraduate population, 14% of the graduate school population, and 13% of professional school population. Underrepresented minorities are about 8.4% of all full-time faculty. The problem is worse in science and engineering where about 16% of bachelor degrees, 9% of masters, and 6% of doctorates went to underrepresented minority students (Barlow & Villarejo, 2004).

Underrepresentation is a large problem. The good news is that it is such a large problem that modest improvements can have dramatic effects. For example, Kulis et al. (2000) note that for each one percent increase in the African American academic labor supply, the odds of an African American holding a faculty position improve by 26% or that a proportional increase of 2.5% in earned doctorates by African Americans would result in a doubling of representation among faculty. To increase flow in this currently constricted pipeline requires that we better understand the constrictions and better evaluate the success of intervention programs.

The most comprehensive examination of transitions from high school to college and beyond was reported by Huang et al. in August of 2000 and concentrated on gender and racial/ethnic gaps in science and engineering. In addressing postsecondary entrance into

[2] Science, Engineering, Mathematics, and Computer Science

science and engineering majors, they found that racial/ethnic gaps closed substantially when comparisons were made for students with similar motivations, aspirations, and confidence regarding math and science, who had earned similar advanced credits in these areas, and who had parents with similar educational attainment and expectations for their children. The gender gap remained, but women who initially majored in science and engineering both persisted in science and engineering majors and graduated at higher rates than males.

When comparing percentage representation in the 18-29 age group with representation in science and engineering associate's and bachelor's degrees, racial/ethnic differences largely disappear except for African Americans. For example, Hispanic students were 8.1% of the age group, 7% of science and engineering associate's degrees, 6.2% of bachelor's degrees and 5.5% of science and engineering bachelor's. In contrast, African Americans were 14.3% of the age group, 9.1% of associate's degrees, 7.8% of bachelor's degrees and 6.2% of science and engineering bachelor's. These differences expand considerably at graduate levels for both groups. Hispanics were 3.6% of graduate school enrollment, 3.9% of science and engineering master's, and 2.2% of science and engineering doctorates. African Americans were 3.8% of graduate school science and engineering, 3.9% of science and engineering master's and 2.2% of science and engineering doctorate's.

Review of Literature

Theoretical Foundation and Known Correlates

One area of substantial research has been the development of degree aspirations couched in the established association between aspirations and subsequent behavior (Astin, 1977) and consistent with Carter's integration of degree aspiration development as the result of five sets of variables: pre-college characteristics; initial aspirations and plans; institutional characteristics; academic and nonacademic experiences; and external contexts (Carter, 2002). Those who have examined these factors have found very interesting racial/ethnic differences, some that are within an institution's purview to influence and many that are not. One observation that becomes clear is that interventions have been driven first by intuition and good intentions, not evidence (Gandara, 2001). Relevant research will be briefly reviewed in order to avoid assumptive pitfalls.

Pre-college Characteristics

Much has been written about the causes and associated factors of underrepresented minority's failure to succeed academically. Perhaps a contrasting perspective would be helpful. Gandara (1994) attempted this qualitative study for the educationally least advantaged groups, Chicanos. She identified characteristics of Chicanos who survived poverty and disadvantage to become academic achievers. She interviewed 50 Chicanos who had achieved MD, Ph.D., or JD degrees in spite of being raised in families where neither parent had completed high school or been employed at any job with more social prestige than skilled laborer. Characteristics of these resilient people included personal

independence and remarkable parents. There parents were: supportive of educational goals whether they understood those goals or not, especially mothers; reading advocates who modeled reading; protective in that they kept the children from the labor force; respectful of educational credentials; and greatly respectful of school and teachers. In sum, they conveyed the hard work ethic and education as social mobility principle that is apparently more common in immigrants (Ogbu, 1987). Gandara suggested that motivation was fostered through family stories of prior wealth, prestige, and position. Perhaps for this reason or others, these exceptional Chicanos possessed great personal drive. Two last crucial elements were uncovered: exposure to a college preparatory peer set and recruitment programs.

Aspirations

Do aspirations vary by race/ethnicity? Huang et al. (2000) examined the 1988 National Education Longitudinal Study (NCES) and found by 12th grade there were only modest (<3%) and inconsistent differences between underrepresented minority students and whites and Asians regarding expected educational progression: high school completion, attending college, graduating college and attending a higher level school after college. Tracking science and engineering majors over a bachelor's program found fluctuations by class level, but that all groups except Asians were similarly represented in science and engineering majors (p. 78). For students who began as science and engineering majors, underrepresented minority students were less likely to complete with a degree in the initial major. They were no less likely to persist and graduate but they were more likely to change to another major area.

Pascarella et al. (2004) conducted a longitudinal study using 18 four-year National Study of Student Learning institutions but were not limited to science and engineering fields. Their study tracked 3,331 students over a 3-year period (1992-1995) and the study experienced 67% attrition of students in the study. Findings included a lowering of aspirations overall, but that after three years, Hispanic and African American student had higher aspirations (more than twice the White odds) because they had been less likely to lower their aspirations than Whites. Differences by race/ethnicity included: African Americans differentially benefited from full-time enrollment and suffered from employment. Hispanic students benefited with increased study time, exposure to arts and humanities courses, and intercollegiate athletic participation. Years living on campus had a negative impact on higher educational plans for African Americans and Hispanics but positive effect for Whites. There was a positive effect for African-Americans attending Historically Black Colleges and Universities (HBCU's).

Institutional Characteristics

Wolf-Wendel et al. (2000) examined the interplay between institutional and personal characteristics with an accountant's shaded eye toward efficiency. Using the NRC Doctoral Records File in a retroactive study they asserted that doctoral productivity was a function of institutional resources and institutional characteristics for students with a given record of prior academic performance. They found that institutional selectivity and

resources were predictive for white women. Selectivity was not important for African American and Hispanic women. For African American and Hispanic women, only instructional expenditures were predictive. Also, for all three groups, women's colleges, former women's colleges, and smaller colleges were more likely to produce women doctorates. For African American women, additional measures associated with doctoral productivity were HBCUs, instructional expenditures per student, private colleges, and comprehensive institutions. For Hispanic women, positive factors were HSIs[3] and comprehensive institutions. For White women, positive associated factors were selectivity, instructional spending per student, and endowment per student. Negatives for White women, but not minority women, were former men's colleges, doctoral-granting institutions, comprehensive institutions, liberal arts II colleges, and specialized institutions. Consistent with these findings is Perna's finding (2000) that African Americans attending segregated high schools were more likely to matriculate to a four-year college.

Using Wolf-Wendel's work (2000, Table 3, p. 176) and restricting analysis to women progressing to the earned doctorate in a science field, little overlap was found among women in the three race/ethnic groups: African American, Hispanic and White. The only variable common to all three was institutional size and the effect was negative. The positive factor for Hispanic women was HSI and the negative factor was enrollment. Positives for African American women were public control, and women's college or former women's college. The one negative was enrollment. Positives for white women included private, selective, and women's college. Negatives were former women's college, enrollment, and the Carnegie classifications of doctoral granting, liberal arts II, and special.

In sum, there is a body of research regarding the differential development of degree aspirations and of institutional characteristics associated with successful outcomes, but much of this work has greater implications for broadly directed policy than for the design of local interventions. Using Carter's five sets of relevant variables: precollege characteristics, initial aspirations and plans, institutional characteristics, academic and nonacademic experiences, and external contexts (Carter, 2002), only academic and nonacademic experiences are realistically within an institution's purview. So, what can be done at the institutional level to change the pipeline and can it be proved that it is successful?

Academic and Nonacademic Experiences--Intervention Programs

Programmatic interventions are fairly common and include academic remediation, applied research experiences, advising and counseling. What is uncommon is objective evaluation of these programs (Gandara & Maxwell-Jolly, 1999) linked to outcomes after graduation. One notable exception is a NIH funded biological sciences intervention at a major public research institution.

[3] Hispanic Serving Institutions

Barlow and Villarejo (2004) evaluated an intervention program, BUSP[4], designed to ameliorate disproportionate attrition by minority students in science majors through instructional enrichment, peer support, and mentorship and exposure through research laboratory experiences. The initial part of their program was modeled after others designed to address skill deficits in required entry courses. The idea behind the design was that minority students enter with deficits in science and math, that these deficits decrease likelihood of persistence, and that the deficits can be overcome through curricular changes and academic support activities (Fullilove & Treisman, 1990; Carmichael et al., 1993). These activities facilitated development of peer networks to help students overcome isolation (Wilson, 2000) and have been associated with increased persistence in science majors (Astin & Astin, 1992). However, BUSP's research engagement component proved to be remarkably effective. Controlling for input variables, research experience increased odds of graduating in biology with a 3.0 GPA by a factor of 7.3 and participants were twice as likely as the better prepared campus average to pursue the Ph.D. (8% versus 4%).

The six programs examined in this study were BUSP, Clinica Tepati, ESP[5], Imani Clinic, MURALS[6], and MURPPS[7]. The six programs are targeted at improving the skills and enriching the educational experiences of students. Three of the programs explicitly state postbaccalaureate study in SEMCS fields as a goal. Another program focuses on introductory calculus because it is a gatekeeper course in SEMCS fields. Three of the programs are directed at lower division students and award stipends. Two of the six are voluntary programs where students serve in various capacities at student run free health clinics primarily serving specific ethnic communities. These programs provide real experience in primary healthcare delivery and interaction with medical students and physicians. A description of each program is listed below but the programs will be anonymous in subsequent tables.

- BUSP encourages disadvantaged lower division students to develop problem-solving and study skills through instruction and work in small groups. Students learn about the research by doing work in laboratories with mentors and earn stipends.

- Clinica Tepati is a student run primary healthcare provider to the disadvantaged Hispanic community. Volunteers apply and, if selected, serve in a variety of unpaid capacities.

- The Emerging Scholars Program helps students acquire a firm foundation in calculus by providing supplemental instruction for the freshman calculus series through homework guidance, clear expectations, and mandatory work labs.

[4] Biological Undergraduate Scholars Program
[5] Emerging Scholars Program
[6] Mentorships for Undergraduate Research in Agriculture, Letters and Science
[7] Mentorships for Undergraduate Research Participants in the Physical and Mathematics Sciences

- Imani Clinic is a student run primary healthcare provider to disadvantaged African Americans.

- The MURALS program offers junior and senior students the opportunity to work with faculty on the faculty member's research or on independent research activities. Students produce research products. It is a two quarter program and students receive academic credit and a stipend.

- MURPPS extends from freshman through senior years and offers disadvantaged students a chance to work with faculty on research projects. It offers seminars, academic guidance, and tutoring through the Learning Skills Center. The express goal of the program is to create a diverse post-graduate population in physical and mathematical sciences. Students receive a stipend.

Methodology

The analysis plan was outcomes driven and focused on three critical questions. First, was the likelihood that program participants continued to graduation higher than would be expected? Second, were program participants more likely than expected to attend graduate or professional school? Third, were program participants more likely to be retained as science, engineering, mathematics or computer science majors? Each question has framed the issue in terms of expected performance given individual differences. The plan was to use admissions measures commonly available at enrollment to establish an expectation for progression to graduation and to graduate or professional school and then compare observed and expected rates for underrepresented minority and female students.

This study was expected to make two contributions. The first was toward understanding the relative value of undergraduate educational enrichment activities designed to increase the rate of participation by underrepresented minority students in graduate and professional schools. The second expected contribution was an evaluation of the relative performance of tracking tools in locating alumni (alumni surveys, National Student Clearinghouse, program follow-up). These resources were used to locate program participants to compare their success rates. The University conducts a census survey of recent graduates triennially. The University is a National Student Clearinghouse participant and has used NSC with success to confirm self-reports of enrollment after the baccalaureate. In addition, at least one program has made a concerted effort to track program participants after graduation through informal and formal means of personal contact. Collectively, these resources were expected to yield a mutually supporting and reasonably complete system. Given the large differences in associated effort and expense, evidence of relative accuracy and cost would be highly beneficial.

Subjects

The research database for this project was comprised of four sources: undergraduate institutional records, the records of mentorship and enrichment programs, graduate enrollment records from the National Student Clearinghouse (NSC), and responses to a

local alumni survey. The institutional records were all undergraduate students beginning as first-time college students at UC Davis from fall of 1993 through fall of 1999. The 1999 cutoff was imposed to provide a reasonable time in which students could complete an undergraduate program. The identifying elements of graduating students were sent to the NSC and the Enrollment Search application was used to find subsequent enrollments. When it was learned that the NSC file returned did not include subsequent enrollments at UC Davis, a request was made that local records be included to facilitate processing. It was true that this institution could determine which of its undergraduates enrolled in its graduate and professional programs, but creating and merging these records into the file returned by the NSC would be difficult but necessary if all subsequent enrollment records were to be treated uniformly. The NSC understood the concern and made the necessary change. The third source was an alumni survey conducted every three years of students about 12 months after graduation. The fourth source was local records of participants provided by each intervention or enrichment program. One of the programs also provided information about post baccalaureate enrollment of its participants based on a variety of means that they had employed to track program participants. Please note that postbaccalaureate enrollment will be determined using NSC records for the most part. Only in later analysis of agreement of NSC and other sources will those other sources be considered. In determining whether there was subsequent enrollment, community college NSC enrollment records were eliminated, the records were temporally ordered, and the last record was used to establish the institution of enrollment. In other words, a student who after graduation enrolled in a community college, college A for a masters, and college B for a doctorate; would in this analysis be identified as enrolled in College B.

Results

The first step was to determine which admissions measures were associated with degree completion and graduate school enrollment. A recent local study had found that SAT1, SAT2, and high school grade point average were all significantly correlated with four- and five-year degree completion (Chatman, 2004). The single measure showing the strongest association with completion in four years was SAT2 Writing score (r=0.20). Based upon this earlier work, it was assumed that admissions measures would be helpful in establishing likelihoods of completion and of progression to graduate or professional schools. That result was not found (see Table 1 at end of report).

Only one measure available at admission, high school grade point average, was correlated with degree completion and its correlation was weak, accounting for less than 2% of variance (r=0.14, n=23,267). The correlations for SAT1 and SAT2 scores were each 0.06 or smaller. Clearly, the strength of correlations noted in the earlier study dissipated with increasing time to degree until they were of little if any use in predicting the likelihood of undergraduate completion. Table 1 also reports correlations with graduate or professional school attendance as determined from NSC records. Again, the strongest positive correlation was with high school grade point average (r=0.05, n=18,291) but that association explained less than 1% of variance.

This first result was surprising as it supported the occasionally heard statement that admissions scores tell us nothing about which students will graduate and supported the extension of that statement to include knowing nothing about which students will progress to graduate and professional school. Within the limited range of admissions measures evidenced by UC Davis freshmen, it appeared to be true that the scores were neither predictive of graduation in six or more years nor progression to graduate or professional school.

To explore the possibility that point-biserial correlation was ineffective in identifying a relationship, the graduation and postbaccalaureate enrollment rates were examined for decile groups formed on the basis of standardized scores. Each of the admissions measures were converted to standard scores, the standard scores were added together, students were ranked based on the total, and decile groups were formed. This technique exaggerated academic differences in that students in the top and bottom deciles were students near the top and bottom, respectively, on all admissions measures. Even with this enlargement of individual differences, there was clearly little association with graduation rate or rate of progression to graduate school (Table 2 at end of report).

Because there was no foundation upon which to establish a logistic model to predict likelihoods of graduation and postbaccalaureate enrollment, the campus rates of 81% and 25% were used. In this case, all that was required was to determine graduation and postbaccalaureate progression rates for students in the programs and compare those with each other and a group of students who were in none of the programs. In all cases, a simple standard of an observed difference of 5% or more from the campus rate was used to identify important differences. Note that these were not parametric statistics from population samples. To the extent possible, they were census values. The recognition of a 5% difference is a rule-of-thumb standard. The conventional wisdom problem is that most of these programs targeted under-represented minority or first-generation students and students with lower admissions scores. It is difficult to accept that there was no *a priori* reason to expect these students to graduate or go on to postbaccalaureate study at lower rates.

Table 3 reports the results of comparing underrepresented minority students (African-American, Latino, Chicano, and American Indian) with all other U.S. citizen students. All six programs were successful in increasing graduation rate of underrepresented minority students. Four of the programs also improved graduation rate for other students while other students from one program were less likely to graduate. Participation in the program targeted at upper-division students was associated with the highest graduation rates but graduation rate the least appropriate relative outcome for that reason. Perhaps the more important contribution of this table was to show that progression to graduate school was slightly higher for underrepresented students at UC Davis. In fact, given a lower graduation rate, it was actually substantially more common for underrepresented minority students to progress to graduate or professional school. It was true that the

majority of these programs increased the likelihood that a student would graduate and go on to a graduate program and that participation in any program was better than none. There was also an advantage for the programs serving upper-division students or students at all levels. The fact that one program targeting lower-division students had higher postbaccalaureate progression was important. (See Table 3 at end of report.)

Table 4 was prepared in anticipation of questions that would have been raised in its absence. It reports differences by sex in whether students graduated and went on to graduate or professional school. Overall, a higher rate of females than males graduated (83% v. 78%) and went on to a postbaccalaureate program (27% v. 22%). Both males and females in three programs graduated at higher rates than the overall student body. Females were more likely to graduate in one of the remaining programs and males in another. There was only one program in which neither group graduated at higher than expected rates. The programs proved to be more successful in encouraging postbaccalaureate enrollment. Five of the six programs demonstrated higher rates of underrepresented minority progression to graduate or professional schools and four demonstrated higher rates for other students. (See Table 4 at end of report.)

While progression to graduate school SEMCS fields could not be determined using the sources available for this study, it was possible to determine whether program participation was associated with behavior as undergraduates. The two statistics emphasized were tendency to remain in SEMCS fields (persistence) and movement from an undeclared major or a major in a non-SEMCS field to an SEMCS field (attraction). Those patterns are shown in Tables 5 and 6. Table 5 compares underrepresented students to all students and Table 6 compares male and female students. These outcome measures had several limitations. Neither was very useful for the program directed at upper-division students. (See Table 5 at end of report.)

Several interesting patterns were apparent. For students at UC Davis overall, the initial major for 49% was a SEMCS field. The final major for 42% was SEMCS. For the 49% who were initially SEMCS, 75% remained SEMCS. For the 51% whose initial major was not SEMCS, 10% became SEMCS. These two statistics, persistence in SEMCS and attraction to SEMCS from other fields, are shown at the top of the table as key indicators. An interesting pattern was that these programs tended to be more successful at attracting students to SEMCS than converting initial SEMCS majors to final majors in SEMCS. It is important to note that program participation could have been the result of a change in interest or one of the reasons that interest changed – causality can not be assumed. That was especially a problem for the program targeting upper-division students. For that program, persistence and attraction were not good outcome. For students overall, the programs were split between those associated with persistence and attraction.

The patterns for underrepresented minority students were more uniformly positive. Program participation was more often associated with persistence at the overall rate and with attraction. Consistent with the literature cited at the start of this paper, underrepresented minority students were less likely to major in SEMCS fields initially (43% v. 49%), were less likely to persist in an SEMCS field (66% v. 75%), and were less likely to move from another field to an SEMCS field (6% v. 10%). The culmination of these differences was that underrepresented minority students were less likely to finish with a SEMCS major (32% v. 42%).

Based on the statistics presented here, the two most successful programs in retaining and attracting SEMCS students were the program focusing on first-year calculus and one of the programs supporting faculty engagement and mentorship activities. Underrepresented minority students in these programs persisted at high rates and program participation was associated with movement from majors in other areas to SEMCS majors. The patterns for these programs were uniformly high for females and males. All programs were associated with higher graduation rates and four of the six were also associated with higher rates of post baccalaureate study. Surprisingly the two programs that were most successful in holding onto and attracting students to SEMCS fields were least successful in encouraging postbaccalaureate study.

Table 6 contrasts the experiences and behaviors of male and female students. Consistent with research literature, females were less likely to major in SEMCS fields initially (44% v. 56%), were less likely to persist in SEMCS fields (69% v. 80%), and were less likely to change majors to a SEMCS field (9% v. 12%). The end result of these differences was that 36% of females and 50% of males ended with a major in SEMCS. As noted in the discussion of underrepresented students, program participation was much more likely to be associated with attraction – movement from a non-SEMCS major to a SEMCS major – than with persistence in an SEMCS major. Persistence results were discouraging.
(See Table 6 at end of report.)

The last analyses return to the issue of the accuracy of NSC EnrollmentSearch records for this purpose. Throughout the results section, determination of postbaccalaureate enrollment has relied on NSC record hits. More specifically, the strategy has been to array enrollment records in order to select the last record that is not from a community college. That record was treated as the graduate or professional school enrollment record. In regard to this project, there were two other sources of information to which some of the NSC records could be compared: a survey of recent alumni and the local records maintained by one of the study programs. The distribution of hits and misses is displayed as Table 7 and the results will follow the table arrangement of agreement with surveys of recent alumni followed by agreement with local program records.

A quick review of Table 7 suggests a marked lack of agreement between the NSC EnrollmentSearch and responses to a survey of recent graduates. Of the 44% who responded to the survey, 38% reported subsequent enrollment. Of that 38%, NSC did not report matches for most (78% of the 38%). In the relatively small number of cases where both the NSC and survey responses indicated enrollment, agreement happened in 60% of the cases. In other words, there were 2,487 graduates in 1999 and 1,098 responded to the survey. Of the 1,098, 413 reported that they were continuing their education. NSC could not confirm the fact for 322 but did confirm subsequent enrollment for 91. Even for those 91, however, the two sources agreed as to the school attended only 55 times. Therefore, on one hand, the two sources appear to provide very different information. The difference in timing could explain some differences, but the discrepancies appear to be larger than expected. Before discounting NSC records for this purpose, it is important to note that new information about subsequent enrollment was found for 83 alumni – they reported no enrollment on the survey but NSC found records. More importantly, NSC records found graduate enrollments for 273 who did not respond to the survey. There may be reasons to use multiple sources but whether the postbaccalaureate attendance rate is 18% (NSC) or 38% (survey) is of importance to the University. (See Table 7 at end of report.)

Discrepancies between NSC and local records for program alumni present a similar picture to that seen for the survey of recent graduates. There were 824 program participants over the period. Local program records reported postbaccalaureate enrollments for 159 (19%). NSC and program records agreed for only 56 alumni. A major contribution of NSC was again new information learned. NSC found postbaccalaureate enrollment records for 161 program participants for whom the local program had no record of subsequent attendance. It is interesting to note that the rate of graduate and professional school attendance as reported from the local program's records was much closer to the rate from NSC records than from the records of the survey of recent graduates (19% from local records and 28% from NSC).

There are many explanations for differences in the postbaccalaureate enrollment records of graduates. Many students invoke their right to privacy and their records are not shared. Several universities do not permit sharing of their students' records and professional schools seem to be more inclined to invoke confidentiality universally, especially professional schools in the geographic region where UC Davis graduates are more likely to attend. Recent alumni might report educational plans that do not come to fruition and much of the disagreement about institution of attendance could be due to the time when the data were collected. NSC EnrollmentSearch records do not include all institutions nor do they include institutions outside the U.S. And last, NSC enrollment records do not necessarily reflect sustained postbaccalaureate study. All in all, there are reasons to use multiple sources but the ability of NSC records to uncover new information and to support mass tracking with no direct expenditure supports its role as a primary resource that can be supplemented. It would be interesting to pursue a similar analysis using the NSC service DegreeVerify, but this institution does not currently have access to DegreeVerify.

Discussion

This paper began by acknowledging the increasing disparity between underrepresented minority students and others at principal educational transitions and for science, engineering, mathematics and computer sciences fields (SEMCS) and between female and male students in SEMCS fields. When Huang et al. (2000) controlled for motivation, aspiration, ability and confidence in science and math, and parental education; the racial/ethnic gaps closed but the gender gap remained. It was also reported that the racial gap was much more pronounced for African American students than the ethnic group, Hispanics. To summarize, there are real differences in the rates at which underrepresented minority students, especially African Americans, progress educationally and enroll in SEMCS fields. Women are also less likely to enroll in SEMCS fields. The review then examined research about the effect of individual differences in motivation, aspirations, independence and parental encouragement. One of the most striking results was a lack of difference in aspirations and, in fact, relatively higher aspirations for African American and Hispanic students over time. Following individual differences were the mixed results linking institutional characteristics with differences in progression to the doctorate by sex and race/ethnicity. In sum, women and underrepresented minorities, especially African Americans, are less likely to major in SEMCS fields and to earn doctorates. Individual differences in educational progression and attainment show much similarity across groups and educational aspirations of underrepresented minority students are very high. Higher education professionals can find much encouragement in the literature. So what might they do? The research suggests that programs targeted at undergraduate students can be effective in encouraging students to remain in SEMCS fields and to pursue the highest degrees. Engagement in research was shown to be especially effective. Unfortunately, the effectiveness of programs targeting undergraduate students has too seldom been evaluated using standards more rigorous than sharing positive anecdotes and relying on the superficial certainty of conventional wisdom.

One of the barriers to more appropriate evaluation of undergraduate enrichment programs that encourage pursuit of SEMCS study and postbaccalaureate degrees has been the difficulty of determining subsequent enrollment. The advent and expansion of National Student Clearinghouse (NSC) tracking services has created an opportunity to efficiently follow the continuing education of students after graduation. In particular, the EnrollmentSearch service provided cursory information about the continuing education of UC Davis students beginning as freshmen at Davis from 1993 through 1999. Rates of progression were examined by underrepresented minority classification, sex and participation in various undergraduate enrichment opportunities in SEMCS areas. Also examined were rates of graduation, persistence, and graduation in SEMCS fields. It was assumed that individual differences in academic ability at admission would be associated with degree completion and progression to graduate and professional schools and would therefore be useful covariates. That was not the case. Likelihood of graduation and of post baccalaureate enrollment was only slightly associated with admissions scores for this selective university. Therefore, the expected rates with which to compare observed rates were the campus values.

Each of the six programs evaluated was at least somewhat successful in increasing graduation rate and the rate of postbaccalaureate study for underrepresented minorities and women. Engagement in research with faculty was shown to be especially effective. Participation in undergraduate enrichment and medical volunteer activities was associated with higher rates of graduation and post baccalaureate enrollment for women and men and for underrepresented minority and other students. Whether these programs increased likelihood of graduation and progression or whether participation in programs was the result of higher aspiration and motivation, or whether the two were mutually supportive is unclear.

Persistence in SEMCS majors and movement from other majors to SEMCS majors found results less uniformly supportive of the undergraduate programs. Participation in several of the programs was associated with higher loss of SEMCS interest by students overall and two with higher loss for underrepresented minorities. Program participation was more uniformly associated with attracting undergraduates to SEMCS fields. The results comparing male and female persistence showed much variance. Attraction to SEMCS fields was generally positive. It should be noted that SEMCS attrition is not necessarily failure in that increased understanding of the research process in a science or mathematics field of study can make clear to a student that they should pursue other interests. Most importantly, each of the six programs can point to outcomes where program participants exceed university base rates.

The last contribution of this paper was in reporting agreement between NSC and other sources of postbaccalaureate enrollment information. The results offered mixed support for NSC when compared to results from a survey of recent alumni or to longitudinal information managed by one of the programs in this study. In both comparisons, the ability of NSC records to find new information was obvious. In addition, the cost of data collection greatly favors NSC. The downsides were that there was often disagreement between data sources and that institutional and that individual use of the NSC confidentiality flag affects matches. The fact that EnrollmentSearch provides little information about the educational record, especially about degree completion, is not a criticism of NSC services. NSC does offer a DegreeVerify service for which UC Davis does not currently subscribe. Recognizing the limitations of NSC records, the differences between self-reported survey results and enrollment information provided by institutions, and individual differences in the willingness of past program participants to maintain contact over time; NSC is a viable and arguable preferable resource. It was certainly a useful tool for this project.

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Table 1
Correlation Matrices

Correlations with Graduation

	Degree Completion	N
Degree Completion	1.00	
HSGPA	0.14	23,267
SAT Math	0.06	23,267
SAT Verbal	0.05	23,267
SAT2 English	0.06	23,267
SAT2 Math	0.06	23,267

Correlations Among Admission Measures

	HSGPA	SAT Math	SAT Verbal	SAT2 English	SAT2 Math
Degree Completion	0.14	0.06	0.05	0.06	0.06
HSGPA	1.00	0.21	0.15	0.20	0.27
SAT Math	0.21	1.00	0.43	0.43	0.81
SAT Verbal	0.15	0.43	1.00	0.74	0.36
SAT2 English	0.20	0.43	0.74	1.00	0.39
SAT2 Math	0.27	0.81	0.36	0.39	1.00

Correlations with Graduate School Attendance

	Grad School Enrollment	N
Graduate School Enrollment	1.00	
HSGPA	0.05	18,291
SAT Math	-0.01	18,291
SAT Verbal	0.01	18,291
SAT2 English	-0.07	18,291
SAT2 Math	-0.01	18,291

Table 2
Graduation Rate and Progression to Graduate School by Admissions Measures Decile

	Mean	Standard Deviation	#
HSGPA	3.72	0.36	23,267
SAT Verbal	562	93	23,267
SAT Math	599	80	23,267
SAT2 Composition	520	97	23,267
SAT2 Math	583	88	23,267

	Graduation				Graduate School			
	Percentages		Frequencies		Percentages		Frequencies	
Decile	Yes	No	Yes	No	Yes	No	Yes	No
Lowest 10%	66%	34%	1,535	793	29%	71%	444	1,092
Second	73%	27%	1,703	623	30%	70%	518	1,186
Third	77%	23%	1,781	546	31%	69%	546	1,237
Fourth	81%	19%	1,874	453	28%	72%	525	1,349
Fifth	81%	19%	1,890	435	28%	72%	538	1,352
Sixth	81%	19%	1,893	435	30%	70%	561	1,332
Seventh	83%	17%	1,909	398	29%	71%	548	1,363
Eight	81%	19%	1,906	439	27%	73%	520	1,386
Ninth	82%	18%	1,899	428	28%	72%	535	1,365
Highest 10%	81%	19%	1,893	434	29%	71%	544	1,350
Total	79%	21%	18,283	4,984	29%	71%	5,279	13,012

Decile ranking accomplished by converting each admissions measure to a standard score, summing the standard scores, then determine decile rankings for the summary measure.

Table 3

Impact of Undergraduate Enrichment Programs on Underrepresented Students' Progression to Degree Completion and Graduate School -- By Minority Status

	Program A	Program B	Program C	Program D	Program E	Program F	No Program	All Unduplicated
	656	55	531	52	584	349	49,692	51,778
Degree Completion								
				Percentages				
Underrepresented Minority								
Davis Degree	**78%**	**84%**	**78%**	**89%**	**97%**	**81%**	71%	73%
Other Outcome	22%	16%	22%	11%	3%	19%	29%	27%
Other Students								
Davis Degree	**76%**	**100%**	86%	**94%**	**99%**	**96%**	82%	82%
Other Outcome	24%	0%	14%	6%	1%	4%	18%	18%
All Students								
Davis Degree	78%	**89%**	84%	**92%**	**97%**	**86%**	81%	81%
Other Outcome	22%	11%	16%	8%	3%	14%	19%	19%
Underrepresented Minority				Frequencies				
Davis Degree	352	32	133	17	290	149	4,177	5,122
Other Outcome	97	6	37	2	10	35	1,699	1,873
Other Students								
Davis Degree	144	16	301	31	147	76	35,901	36,766
Other Outcome	45	0	48	2	2	3	7,915	8,017
All Students								
Davis Degree	496	48	434	48	437	225	40,078	41,888
Other Outcome	142	6	85	4	12	38	9,614	9,890
Progression to Graduate School After Receiving a UC Davis Degree								
				Percentages				
Underrepresented Minority								
Grad School	**33%**	**41%**	28%	**41%**	**41%**	28%	26%	28%
Other Outcome	67%	59%	72%	59%	59%	72%	74%	72%
Other Students								
Grad School	26%	**31%**	24%	26%	**40%**	**42%**	25%	25%
Other Outcome	74%	69%	76%	74%	60%	58%	75%	75%
All Students								
Grad School	**31%**	**38%**	25%	**31%**	**41%**	**33%**	25%	25%
Other Outcome	69%	63%	75%	69%	59%	67%	75%	75%
Underrepresented Minority				Frequencies				
Grad School	116	13	37	7	119	42	1,116	1,416
Other Outcome	236	19	96	10	172	107	3,143	3,722
Other Students								
Grad School	37	5	71	8	59	32	8,875	9,076
Other Outcome	108	11	231	23	88	44	27,290	27,781
All Students								
Grad School	153	18	108	15	178	74	9,991	10,492
Other Outcome	344	30	327	33	260	151	30,433	31,503

Source: The cohort is UC Davis matriculating freshmen from fall 1993 to fall 1999. They must have HSGPA, SAT1 and SAT2 scores.
UC Davis degree completion came from University records.
Program participants were provided by program representatives.
Graduate school enrollments came from the National Student Clearinghouse.
Figures in bold differ from the marginals by at least 5%.

Table 4
Impact of Undergraduate Enrichment Programs on Underrepresented Students' Progression to Degree Completion and Graduate School -- By Sex

	Program A	Program B	Program C	Program D	Program E	Program F	No Program	All Unduplicated
	656	55	531	52	584	349	49,938	51,777
Degree Completion								
					Percentages			
Female								
Davis Degree	80%	85%	**88%**	**90%**	**98%**	**88%**	83%	83%
Other Outcome	20%	15%	12%	10%	2%	12%	17%	17%
Male								
Davis Degree	73%	**95%**	80%	**100%**	**97%**	**83%**	78%	78%
Other Outcome	27%	5%	20%	0%	3%	17%	22%	22%
All Students								
Davis Degree	78%	**89%**	84%	**92%**	**97%**	**86%**	81%	81%
Other Outcome	22%	11%	16%	8%	3%	14%	19%	19%
Female					Frequencies			
Davis Degree	345	28	204	36	325	99	22,167	23,139
Other Outcome	85	5	27	4	8	13	4,470	4,605
Male								
Davis Degree	151	20	230	12	112	126	18,151	18,747
Other Outcome	57	1	58	0	4	25	5,132	5,268
All Students								
Davis Degree	496	48	434	48	437	225	40,320	41,888
Other Outcome	142	6	85	4	12	38	9,618	9,889
Progression to Graduate School After Receiving a UC Davis Degree								
					Percentages			
Female								
Grad School	**32%**	**39%**	25%	**33%**	**38%**	**34%**	27%	27%
Other Outcome	68%	61%	75%	67%	62%	66%	73%	73%
Male								
Grad School	**27%**	**35%**	24%	25%	**47%**	**32%**	22%	22%
Other Outcome	73%	65%	76%	75%	53%	68%	78%	78%
All Students								
Grad School	31%	38%	25%	31%	41%	33%	25%	25%
Other Outcome	69%	63%	75%	69%	59%	67%	75%	75%
Female					Frequencies			
Grad School	112	11	52	12	125	34	5,963	6,281
Other Outcome	234	17	153	24	201	65	16,258	16,915
Male								
Grad School	41	7	56	3	53	40	4,028	4,211
Other Outcome	110	13	174	9	59	86	14,173	14,586
All Students								
Grad School	153	18	108	15	178	74	9,991	10,492
Other Outcome	344	30	327	33	260	151	30,435	31,503

Source: The cohort is UC Davis matriculating freshmen from fall 1993 to fall 1999. They must have HSGPA, SAT1 and SAT2 scores.
UC Davis degree completion came from University records.
Program participants were provided by program representatives.
Graduate school enrollments came from the National Student Clearinghouse.
Figures in bold differ from the marginals by at least 5%.
NSC supplemented by UC Davis records when UC Davis students used confidentiality flags.

Table 5
Interest and Persistence in Science, Engineering, Math and Computer Sciences by Minority Status

	All Students								Underrepresented Minority							
	Overall	Program A	Program B	Program C	Program D	Program E	Program F	No Program	Overall	Program A	Program B	Program C	Program D	Program E	Program F	No Program
Overall																
Persistence	75%	**66%**	71%	**85%**	**69%**	**64%**	**91%**	75%	66%	62%	63%	**85%**	**50%**	**58%**	**88%**	65%
Attraction*	10%	**32%**	**62%**	**38%**	**42%**	**4%**	**26%**	10%	6%	**32%**	**57%**	**30%**	**55%**	3%	**54%**	5%
Number	52,060	656	55	531	52	584	349	49,939	6,995	449	38	170	19	300	184	5,945

All Students

		Final Major						Final Major					
		Percentages			Frequencies			Percentages			Frequencies		
		Other Majors	SEMCS	Sum	Other Majors	SEMCS	Sum	Other Majors	SEMCS	Sum	Other Majors	SEMCS	Sum
Overall													
	Initial Major												
	SEMCS	25%	75%	49%	6,414	19,197	25,611	34%	66%	43%	1,006	1,969	2,975
	Other Majors	90%	10%	51%	23,740	2,709	26,449	94%	6%	57%	3,778	242	4,020
	Total	58%	42%		30,154	21,906	52,060	68%	32%		4,784	2,211	6,995
Program A													
	Initial Major												
	SEMCS	34%	66%	70%	156	300	456	38%	62%	70%	118	195	313
	Other Majors	69%	32%	30%	137	63	200	68%	32%	30%	93	43	136
	Total	45%	55%		293	363	656	47%	53%		211	238	449
Program B													
	Initial Major												
	SEMCS	29%	71%	62%	10	24	34	38%	63%	63%	9	15	24
	Other Majors	38%	62%	38%	8	13	21	43%	57%	37%	6	8	14
	Total	33%	67%		18	37	55	39%	61%		15	23	38
Program C													
	Initial Major												
	SEMCS	15%	85%	63%	50	284	334	15%	85%	73%	19	105	124
	Other Majors	62%	38%	37%	122	75	197	70%	30%	27%	32	14	46
	Total	32%	68%		172	359	531	30%	70%		51	119	170
Program D													
	Initial Major												
	SEMCS	31%	69%	50%	8	18	26	50%	50%	42%	4	4	8
	Other Majors	58%	42%	50%	15	11	26	45%	55%	58%	5	6	11
	Total	44%	56%		23	29	52	47%	53%		9	10	19
Program E													
	Initial Major												
	SEMCS	36%	64%	27%	57	101	158	42%	58%	30%	38	53	91
	Other Majors	96%	4%	73%	409	17	426	97%	3%	70%	202	7	209
	Total	80%	20%		466	118	584	80%	20%		240	60	300
Program F													
	Initial Major												
	SEMCS	9%	91%	59%	18	188	206	12%	88%	78%	17	126	143
	Other Majors	74%	26%	41%	106	37	143	46%	54%	22%	19	22	41
	Total	36%	64%		124	225	349	20%	80%		36	148	184
No Program													
	Initial Major												
	SEMCS	25%	75%	49%	6,135	18,352	24,487	35%	65%	39%	819	1,528	2,347
	Other Majors	90%	10%	51%	22,932	2,520	25,452	95%	5%	61%	3,434	164	3,598
	Total	58%	42%		29,067	20,872	49,939	72%	28%		4,253	1,692	5,945

Note: Used NSF degrees for biological sciences, physical sciences, mathematics and computer science and engineering.
From Survey of Graduate Students and Post doctorates in Science and Engineering crosswalk between NSF and NCES codes.
No program may include UCDC.

* Attraction is movement from a non-SEMCS initial major to an SEMCS final major.

Table 6
Interest and Persistence in Science, Engineering, Math and Computer Sciences

	Men								Women							
	Overall	Program A	Program B	Program C	Program D	Program E	Program F	No Program	Overall	Program A	Program B	Program C	Program D	Program E	Program F	No Program
Overall																
Persistence	80%	78%	**87%**	**90%**	**57%**	**68%**	**92%**	80%	69%	**59%**	**58%**	**78%**	74%	**62%**	**90%**	69%
Attraction*	12%	**39%**	**100%**	**48%**	**40%**	8%	**61%**	11%	9%	**33%**	**50%**	**33%**	**43%**	5%	**71%**	9%
Number	24,015	208	21	288	12	116	151	23,283	27,744	430	33	231	40	333	112	26,637

All Students

		Final Major						Final Major					
		Percentages			Frequencies			Percentages			Frequencies		
		Other Majors	SEMCS	Sum	Other Majors	SEMCS	Sum	Other Majors	SEMCS	Sum	Other Majors	SEMCS	Sum
Overall													
	Initial Major												
	SEMCS	20%	80%	56%	2,635	10,700	13,335	31%	69%	44%	3,779	8,496	12,275
	Other Majors	88%	12%	44%	9,410	1,270	10,680	91%	9%	56%	14,031	1,438	15,469
	Total	50%	50%		12,045	11,970	24,015	64%	36%		17,810	9,934	27,744
Program A													
	Initial Major												
	SEMCS	22%	78%	78%	36	126	162	41%	59%	68%	120	174	294
	Other Majors	61%	39%	22%	28	18	46	67%	33%	32%	91	45	136
	Total	31%	69%		64	144	208	49%	51%		211	219	430
Program B													
	Initial Major												
	SEMCS	13%	87%	71%	2	13	15	42%	58%	58%	8	11	19
	Other Majors	0%	100%	29%	0	6	6	50%	50%	42%	7	7	14
	Total	10%	90%		2	19	21	45%	55%		15	18	33
Program C													
	Initial Major												
	SEMCS	10%	90%	69%	20	179	199	22%	78%	58%	30	105	135
	Other Majors	52%	48%	31%	46	43	89	67%	33%	42%	64	32	96
	Total	23%	77%		66	222	288	41%	59%		94	137	231
Program D													
	Initial Major												
	SEMCS	43%	57%	58%	3	4	7	26%	74%	48%	5	14	19
	Other Majors	60%	40%	42%	3	2	5	57%	43%	53%	12	9	21
	Total	50%	50%		6	6	12	43%	58%		17	23	40
Program E													
	Initial Major												
	SEMCS	32%	68%	48%	18	38	56	38%	62%	31%	39	63	102
	Other Majors	92%	8%	52%	55	5	60	95%	5%	69%	219	12	231
	Total	63%	37%		73	43	116	77%	23%		258	75	333
Program F													
	Initial Major												
	SEMCS	8%	92%	78%	9	109	118	10%	90%	79%	9	79	88
	Other Majors	39%	61%	22%	13	20	33	29%	71%	21%	7	17	24
	Total	15%	85%		22	129	151	14%	86%		16	96	112
No Program													
	Initial Major												
	SEMCS	20%	80%	55%	2,553	10,270	12,823	31%	69%	44%	3,582	8,081	11,663
	Other Majors	89%	11%	45%	9,271	1,189	10,460	91%	9%	56%	13,644	1,330	14,974
	Total	51%	49%		11,824	11,459	23,283	65%	35%		17,226	9,411	26,637

Note: Used NSF degrees for biological sciences, physical sciences, mathematics and computer science and engineering.
From Survey of Graduate Students and Post doctorates in Science and Engineering crosswalk between NSF and NCES codes.

Table 7
Agreement / Disagreement Between NSC and Other Sources

Between NSC and Survey of Recent Alumni					
2,487 in all					
Responded to Survey	1,098	44%			
Reported in Grad/Prof School		413	38%		
Survey yes, NSC no			322	78%	
Survey yes, NSC yes			91	22%	
Institution Agreed				55	60%
Institution Disagreed				36	40%
No grad info from survey		685	62%		
NSC found grad school			83	100%	
Did not respond to Survey	1,389	56%			
NSC found in Grad School		273	20%		
NSC Did not find grad school		1,116	80%		
Between NSC and Local Program Records					
824 in all					
Had a NSC Hit	230	28%			
Matched local record		56	24%		
Does not match local record		13	6%		
No local record		161	70%		
No NSC Hit	594	72%			
Local record found		90	15%		
Neither local nor NSC		504	85%		