Race, Gender and First Generation Status in Computing Science, Engineering and Math Persistence

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Abstract - **The NSF sponsored Scientific Leadership Scholars (SLS) program at Humboldt State University (HSU) provides scholarships to a diverse cohort of students in Computing Science, Environmental Resources Engineering or Mathematics. The program targeted financially eligible Native American and first generation students. The SLS group persisting into year three remained more diverse than earlier corresponding major cohorts: 22 (59%) were either women and/or underrepresented minority (URM) students in STEM. In the 2007-08 academic year, 36 Cohort 1 students entered the program. Of the Cohort 1 freshmen, 23 (66%) persisted into their second year and 12 (33%) persisted into their third year as SLS majors. White and Asian Cohort 1 students were more likely to persist than STEM URM students (47%, n= 8 compared to 21%, n=4). In 2008-09, 15 additional SLS students were added. Of these students, 12 (80%) persisted into their third year as an SLS major. While all white students (6) in Cohort 2 persisted, 67% (6) of the underrepresented students persisted. All 4 women in Cohort 2 persisted. There was no significant difference in the persistence based on gender or first generation status. Recommendations are included.**

Index Terms – American Indian, Retention, Persistence, Postsecondary Education, Underrepresented Minority

INTRODUCTION

The Scientific Leadership Scholars (SLS) program at Humboldt State University was designed to increase the number and diversity of science, technology, engineering and math (STEM) professionals through recruiting and retaining a diverse cohort of students in Computing Science (CS), Environmental Resources Engineering (ERE) or Mathematics (Math). The program design drew on STEM persistence research, as well as institutional and programmatic self study. STEM recruitment is important as the U.S. faces STEM labor force shortages and declines in competitiveness [1]. Race and gender equity are also a concern in STEM fields that remain predominantly white and male.

Between 2007 and 2009, we recruited 51 students who were financially eligible as defined by the U.S. Department of Education as the Cost of Attendance (COA) for an institution minus the Estimated Family Contribution (EFC) and determined by the Free Application for Federal Student Aid (FAFSA). We also prioritized first generation students, women, American Indian & other STEM URM students. Awardees received scholarships that covered most of their tuition and fees and participated in an enhanced academic program.

We built local diversity strengths and needs, as well as accreditation and strategic planning related initiatives linked to HSU diversity and URM retention. Among non-white students, American Indian and Latino students have been most likely to have the best experience at the institution [6]. The HSU Indian Natural Resources, Science and Engineering Program (INRSEP) had been particularly successful in shaping a positive experience for American Indian students and often serves Latino students given links forged through the Society for Advancement of Chicanos and Native Americans in Science (SACNAS). Faculty members and students also had a tradition of working with local tribes in addressing community needs.

This article presents SLS as a case study in the application of retention theory to STEM majors. We use second and third year data to assess the HSU case and explore challenges and insights.

PROGRAM MODEL

The SLS program model was based on practice and theory on general institutional retention [2,3] a growing movement for first-year experiences [4] and retention theory specific to STEM majors [5]. The theoretical foundation and details of the model are reported elsewhere [6], and are summarized below.

The first semester of college calls for successful separation, transition and integration into a campus community [2]. Tinto found that the level and frequency of peer group interactions are significant to successful social integration and related retention outcomes.

Students received significant scholarship monies and assistance securing their full financial aid package. Financial strain and needs to work or incur debt are a drain on student abilities to persist [7,8,9]. Work, particularly work off-campus, not only detracts from students academic focus, but also from opportunities to socially bond on campus [10,11]. So we also worked with students to

identify on-campus work opportunities, preferably in their majors.

The SLS program structured social and academic community building through common residence hall living assignments, common course scheduling, a specialized SLS seminar, time management and study skills training [12], supplemental academic advising [10], professional development and social events [4]. Research tells us that formalized mechanisms for structuring this integration are significant for many students of color and those from lower socioeconomic backgrounds whose prior social and academic experiences are less closely aligned with the structure and culture of university life [7 p.54, 13].

The second author as PI and Program Director encouraged students to enroll each semester in an interdisciplinary service learning seminar focused on professional skills development and collaborative problem solving with local American Indian communities. "Hands-on" experience has been particularly important for STEM women and students of color inviting them to see themselves in the college curriculum [14,15,16]. Most students experienced hands on curriculum in their first semester computer science and engineering courses. All students participating in the SLS seminar began in their second semester a long-term project with tribal collaborators on the development of a community healing center on Yurok land.

METHODS

This article is based largely on quantitative data aggregated from scholarship applications and institutional sources. We also introduce some evidence from small group and one-to-one interview data, as well as participant observation.

Quantitative Data Aggregation and Measurement

We compiled a quantitative data set that aggregated data from multiple sources. We extracted demographic data on measures such as ethnicity, parent education and intentions for academic major from scholarship application materials. When questions arose, Virnoche confirmed data through informal conversations and email correspondence with students and the grant team. We confirmed test scores through existing student records maintained in the university student records system and available to faculty members. Similarly, we reviewed academic transcripts to gather course and related major progress information and final grades.

Student persistence data is usually reported in snapshots that communicate a percentage of a cohort that returns to begin the next year of study. In this paper we report on two cohorts. Corresponding to local institutional measures of persistence, we counted a student as "persisting" if she enrolled in and began coursework in a given academic year. Likewise, if a student enrolled in coursework for a given term, but dropped before the term began, his status is reflected in our reporting of attrition for a given period. This operationalization of persistence and attrition is consistent with both NCES measures, as well as HSU institutional research. In addition, we operationalized "STEM" persistence as course taking consistent with the curriculum of one of the SLS majors. If a student became ineligible for a scholarship due to a change in financial aid eligibility or poor academics, we counted them as "persisting" if their course taking indicated intention to complete an SLS major. These measures are reasonable given the purpose of the program to graduate students in STEM majors – regardless of their scholarship status.

Scholarship Participant Demographics

More than two thirds (67%) of scholarship recipients identified with statuses underrepresented in STEM fields. Almost one-third were women and more than half (57%) identified with non-white ethnicities. Most (86%) came from within the state of California with 35% from the local Humboldt, Del Norte & Trinity Counties: Each of these counties have documented high need for student educational opportunities and advancement. In addition, 73% (37) students were first generation college students: neither parent held a college degree (Table I).

TABLE I: DEMOGRAPHICS OF ALL SLS PARTICIPANTS

	% (N)
Gender	
Women	31% (16)
Men	69% (35)
Ethnicity/Race	
Chinese	2% (1)
Filipino	6% (3)
Hispanic/Latino	22% (11)
American Indian	28% (14)
White	43% (22)
Geographic Origins	
Local Counties	35% (18)
California	85% (44)
Underrepresented in STEM*	67% (34)
First in Family	73% (37)
Chinese	0% (0)
White	59% (13)
Filipino	67% (2)
White	59% (13)
American Indian	86% (12)
Latino	91% (10)
Total SLS Participants	100% (51)

* Either women or ethnic minorities underrepresented in STEM

Of the students who came into SLS in the first cohort, (20%) enrolled in remedial math classes that did not count toward their degrees. Half of Cohort 1 enrolled in PreCalculus, with the remaining students (30%) enrolled in Calculus or more advanced classes.

DIVERSIFYING COMPUTING SCIENCE, ENGINEERING AND MATH

SLS increased the diversity of the three targeted SLS majors. As a point of comparison, we provide data on the 30 students who entered the program in the first semester

(Table II). (To map all the students against the majors would overestimate the diversity that SLS brought to the majors at any given point in time as new students came into the program as others left.)

Three out of the four Computing Science scholars came from groups underrepresented in that field. One was a woman and two of the men were American Indian. To date, no American Indian students have ever completed a degree in Computing Science at HSU.

Half of the Environmental Resources Engineering SLS scholars identified with groups underrepresented in their field of study. ERE American Indian enrollment through SLS represents the most noticeable gain in diversity. While the ERE major in the past averaged three (2%) American Indian students, the SLS cohort alone enrolled four (22%) American Indian students.

Mathematics showed the most noticeable gain in diversity through American Indian and other minority student recruitment. Six out of the eight students recruited to mathematics through SLS represent ethnic minority groups. Three of those students identified as American Indian. Recruitment and selection efforts have maintained, but not advanced institutional enrollment trends for women in SLS majors. Future graduation data on SLS students will be the final litmus test on the extent to which the program diversified the SLS majors.

OVERALL PERSISTENCE

There is little national research available on major retention. Major retention is challenging to measure as students declare majors and never begin coursework. Others begin coursework yet only formally declare majors in their second or even third year of study. According to the American Society of Engineering Education, schools collect that information individually, but there have been no recent studies that have looked at the national trends [17]. A 1988 Engineering Deans' Council reported wide variability in institutional data from four-year engineering schools with overall major retention through graduation ranging from 70 percent to as little as 30 percent [5].

In the 2007-08 academic year, which was the first year of scholarship funding, 36 students received financial awards to study one of three SLS majors. Thirty (30) students received funding in Fall 2007, the first semester in which scholarships were offered. An additional 6 students were added to this "cohort" as 6 of the initially funded students left the scholarship program and freed up funding for new students. To align with other research that reports persistence from year one to year two, we have consolidated these two groups to represent a single "cohort."

SLS students from Cohort 1 were less likely than the average HSU student to persist into year two and year three. The first to second year freshman persistence rate for SLS Cohort 1 was 6% below the overall mean rate for HSU 2007 freshmen. Of the 35 "freshmen" in Cohort 1, 66% (23) began their second year compared to 72% of the overall HSU 2007 freshmen cohort. All those who left SLS before their second year also left HSU. (One of our SLS award recipients continued her major at another university and is counted as "retained".)

By the third year, while half (50%) of Cohort 1 remained at HSU (11% below the 2000-06 mean institutional persistence rate of 61%), 33% (12) actually remained SLS majors enrolling in the appropriate coursework in Fall of 2009.

In 2008-09, the second year of scholarship funding, an additional 15 students at sophomore or above status were identified as eligible for SLS funding. Of these students, 12 (80%) persisted into their Third Year as an SLS Major enrolling in the appropriate coursework in Fall of 2009.

One would expect persistence differences between the cohorts for several reasons. Primarily, the second cohort was comprised of students who had already persisted prior to selection at least to year 2. Second, we were able to be more selective in awarding scholarships to Cohort 2 students; these students had exhibited commitment to their majors through successful coursework completion and had been identified by disciplinary faculty members for SLS scholarship consideration. For these reasons, it is important to keep separate our analysis of outcomes for each cohort and the results may indeed inform future award making practices.

TABLE II: COMPARISON OF SLS FALL 2007 AND AVERAGE HSU MAJOR DEMOGRAPHICS

	Computing Science		Environmental Resources Engineering		Mathematics	
	SLS (N)	HSU* (N)	SLS (N)	HSU* (N)	SLS (N)	HSU* (N)
Women	25% (1)	13% (4)	28% (5)	26% (45)	38% (3)	43% (38)
American Indian	50% (2)	--	22% (4)	2% (3)	38% (3)	5% (4)
Ethnic Minority	75% (3)	20% (5)	39% (7)	19% (33)	75% (6)	28% (25)
Underrepresented	75% (3)	--	50% (9)	--	75% (6)	--
First In Family to Attend College	50% (2)	--	38% (6)	--	13% (1)	--
Total	100% (4)	100% (30)	100% (18)	100%(173)	100% (8)	100% (88)

* Based on 2001-2005 Major Enrollment Data

ACADEMIC INDICATORS AS EARLY ALERTS

Remedial math placement and first term probation proved early alerts for attrition danger as noted in the literature [18]. Cohort 1 SLS students who placed in their first semester into college-level math were more likely to persist than those requiring remedial math: None of the 7 students requiring remediation persisted into their third year. Though URM students were more likely to require remediation, this relationship was not statistically significant.

Cohort 1 SLS students were more likely than the average HSU student to end their first term on probation, and more likely to leave than the average HSU student on first term probation. While 23% of Cohort 1 SLS students ended that first term on probation, on average 20% of HSU students end that term on probation. Yet while half the HSU students who end their first term on probation return for a second year, almost none of the first term probation SLS students returned for year two. Neither URM status nor first generation status had a significant relationship to likelihood of remediation needs or probation.

RACE AND PERSISTENCE IN THE MAJOR AND AT THE INSTITUTION

SLS students who were White or Asian were more likely to persist into the third year in their STEM major than STEM URM students, though these differences were not statistically significant. In Cohort 1, 47% of White & Asian students persisted compared to 21% of STEM URM students. In Cohort 2, 100% of White and Asian students persisted compared to 67% of STEM URM students. (Table III).

TABLE III: RACE AND MAJOR PERSISTENCE INTO THIRD YEAR

	Third Year Persistence	
Race	White/Asian	STEM URM
Cohort 1	47% (8)	21% (4)
Cohort 2	100% (5)	67% (6)

The three American Indian students of Cohort 2 account for all the URM major attrition in that cohort. While 28% of all scholarship recipients across both cohorts identified as American Indian, only one American Indian student began a third year as an SLS major: four other American Indians students remained at HSU and switched majors. We do not have comparison HSU major switch data.

Cohort 1 SLS third year institutional outcomes were about as good or better than HSU overall outcomes, with the exception of Latino students. The SLS Chinese and Filipino students were more likely to persist than their HSU peers (66% compared to 57%). American Indian and White students were almost as likely to stay at HSU: American Indian – SLS 46%, HSU 52%; and White – SLS 56%, HSU 61%. Yet SLS Latino students in Cohort 1 were half as likely as their HSU peers to stay at HSU into their third year: 33% compared to 61%.

FIRST GENERATION AND MAJOR PERSISTENCE

First generation college students from Cohort 1 were less likely to enter their third year as STEM majors than their SLS peers with a parent who held a four-year degree. About 26% (6) of Cohort 1 first generation students persisted compared to 50% (5) of Cohort 1 peers. For Cohort 2, there was almost no difference based on first generation status. While the differences noted were not statistically significant due to small cells sizes, other research continues to point to first generation status as a strong predictor for institutional retention [19,20]. This research suggests the first generation status may also be linked to STEM major retention.

As noted earlier (Table I), STEM URM students were more likely to be first generation than their White and Asian peers. Yet first generation STEM URM students from Cohort 1 were only slightly less likely to enter Year 3 than their first generation Asian and White peers: 20% (3) compared to 38% (3). Again, the cell sizes are far too small to make any statistically significant claims about these differences.

GENDER AND ETHNICITY IN PERSISTENCE

Our quantitative data suggests gender did not affect persistence. In addition, women of color underrepresented in STEM fields were just as likely to persist as their white and Asian women peers in the program: 8 of 16 women across both cohorts entered year three (3 white women, 1 Chinese American woman, 3 Latinas and 1 Filipina). The one local Chinese American woman transferred to Cornell University's Computer Science program and credits the Eschenbach's mentoring and SLS.

Yet while gender did not statistically affect the final outcomes, and we see evidence that *gender and ethnicity intersect in the nuanced experiences of the pathway to the SLS majors*. For example, the process of assessing self-efficacy in the face of poorer academic grades is complicated. There is the grade itself and then there is the interpretation of what that grade means to your future success. At least one student was unnecessarily lost from the program in this meaning making process.

Monica was an 18-year old American Indian woman majoring in Engineering. She and other SLS students struggled with a PreCalculus class that suffered from organizational and pedagogical shifts. While Eschenbach had carefully secured particular instructors for the cohort, several weeks into the semester the PreCalculus class was assigned a new instructor. This change was accompanied by changes in grading structure and teaching style. The latter included a shift from what students reported as a supportive climate to one where students were afraid to ask questions. Most earned poor grades. Two other women who identified as White and Latina successfully petitioned the Department chair for passing grades based on the original grading structure. Yet Monica did not take that path of resistance.

Monica's math experience in PreCalculus fueled her general uncertainty about attending college: Like many

other underrepresented students in the SLS scholarship program, Monica had been recruited heavily by university faculty and staff. Monica's family had encouraged her to come, despite her interest to stay closer to home. In trying to make sense of her math experience, Monica met separately with Eschenbach and another advisor who worked with her through a separate support program on campus. Eschenbach encouraged Monica to meet with the Department Chair about the PreCalculus grade. Based on many conversations over the course of the semester, Eschenbach also knew that Monica had been uncertain about college all along. Eschenbach provided what she thought was good advising as she spoke to Monica about commitment. She said that Monica needed to decide if she was committed to college or not. According to her other advisor, Monica "heard" – "you're not college material," which confirmed her self doubt. By this time, Monica had failed most her courses and withdrew from the university.

Devin was the only American Indian student remaining in the program by the third year. Devin was part of Cohort 1 and had dogged determination. He was a sports star in high school and brought that competitive -- get back in the game when you're down – orientation to his academics. Devin had to take multiple courses more than once on his path to a Computer Science major. He has a real commitment to having his own computer business, as well as to his mother. So while Monica fled the institution as she came to understand herself as an outsider, Devin laughs at the struggles he has had. That same bravado is found in the focus group narratives of all the engineering male students, including the men who were involved in the infamous PreCalculus class that had become folklore among SLS students. We might understand then that Devin drew his tenacity for persistence, not only from embracing the hegemonic male culture – but perhaps also from embracing his own ethnicity and family and the role that his success would play in their collective well being and pride.

DISCUSSION

We conclude that the SLS Program did as well, if not better, than the university on a whole in retaining a group of students who faced multiple structural disadvantages for college persistence. All SLS students faced considerable financial challenges that qualified them for the scholarship program. SLS students were also far more likely to be first and URM students. And finally, the SLS disciplines of Computer Science, Mathematics and Engineering face high attrition rates that challenge direct comparison to institutional rates. Another study that tracked only HSU engineering students reported 50-53% first year retention rates and overall major retention (compared to 66% for SLS) [21].

Nevertheless, there are likely several factors complicating the first year SLS major persistence outcome data. First, there was great financial incentive to begin and stay the course of study in a STEM field. We could see in the course taking patterns, and in discussions, that students were making plans to leave STEM majors even as they continued some coursework in their second year.

Many of the SLS students experienced a common first-semester in college. They had difficult transitions with time management and study needs between high school and college. They were disappointed with their performance. Yet in written essays and conversations, most communicated a plan to return with strong commitments to "do better" in their second term. Yet they were selective in their general education coursework laying groundwork for the switch to other majors: the reasons for the switch included interest, poor academic performance and a perception (or experience) that STEM majors were just too much work.

In conversations with our scholarship recipients at the opening retreat, the drive to "make a difference" and help the environment (and others) was a common theme as the new students described themselves and their goals. Yet as the months passed by, many found other avenues for making this difference.

LESSONS LEARNED

Elsewhere we have noted particular lessons shaped by the first year of the grant and related to recruiting and scholar selection processes [6]. There we recommended to program leaders at institutions like HSU *a more focused and local recruiting effort and the selection of a smaller initial cohort* size (15 versus 30). Both these changes would likely have produced positive outcomes for our program as we faced time-intensive advising and support needs of students coupled with unanticipated financial cut backs on the existing diversity recruiting and support infrastructure, as well as time constraints on the core SLS faculty PI team.

Given poor retention outcomes for SLS students placing in remedial math, *scholarship awards should be made contingent upon successful placement in college-level mathematics.* This means that if lower achieving students are to be considered for scholarships, their acceptance must be coupled with financial support for intensive summer mathematics training and success in those programs that bring them to college level math before they begin their freshmen year. Programs like SLS could partner with institutional and national programs that provide that training.

Yet for those evaluating applicants to scholarship programs, identifying remediation needs can be problematic. In California, advanced high school math course taking has not directly translated to college level math placement [22]. In addition, math placement exams come late in the overall admissions process: too late for making decisions about scholarship selections. So program leaders may need other strategies for gauging likely math placement and remediation needs.

Evaluation of noncognitive retention factors such as leadership experience and goal orientation may be less helpful in predicting major retention than institutional retention. We did collect information on these factors through student essays and letters of recommendation and took them into account before admitting students. Yet these

sources are subject to desirability bias in a situation with clear rewards for particular response sets. This same bias may influence even reference letters, where teachers and counselors are well-aware of the significance of scholarship money for college attendance. Yet some evaluation of noncognitive retention factors is clearly helpful in assessing the general likelihood for an applicant to stay in college.

SLS has produced more diverse cohorts of students very likely to graduate in their STEM (those remaining are unlikely to drop out). *The overall program of cohort building and wrap around support has mitigated for these students the challenges of attending a predominantly White institution and even more so White and male majors.*

Yet we look at these outcomes with both caution in light of small numbers, and hope found in unlikely cases of success and the nuances of decisions to leave we saw in bright students like Monica. Cases like Monica's alone, suggest we must deal holistically with the nature of STEM education. Those of us in engineering are particularly vulnerable to the gateway classes often beyond the control of our own departments. As institutions look closely at overall attrition, and particularly attrition in STEM fields, our attention must be drawn to reshaping those earliest college experiences in disciplines like Mathematics and Chemistry, upon which most STEM fields depend.

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