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Modeling Minority Opportunity Programs: Key Interventions and Success Indicators

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Abstract

MORE R.E.S.U.L.T.S. (Minority Opportunities in Research; Research and Evaluation of Students Using Long-Term Studies) is a multi-institutional research study to assess the effectiveness of diverse interventions in Minority Opportunities in Research (MORE) programs at three universities. These programs increase interest, motivation, and preparedness for careers in biomedical research among underrepresented minority students. This paper presents research on the efficacy of MORE academic interventions. Aggregated data across three MORE institutions enhances the ability to understand multiple academic interventions. These results have the potential of impacting program design and execution at the institutional, national, and international level.

Introduction

The primary objectives of this study are to develop a greater understanding of effective MORE programs and second, to document the outcomes or impact of these interventions. Knowing the impact of interventions will allow universities and funding agencies to more effectively distribute their resources in supporting underrepresented minority students in pursuit of science careers.

The goal of the present research study is to document the system of interventions employed at three public universities to support science students, and then examine students' career paths to discern how they reflect upon the general efficacy of various interventions. In the process, the research seeks to answer questions regarding the comparative value of specific interventions, including supplemental instruction, mentoring, laboratory experiences, financial assistance, graduate school preparation**,** as well as program management and infrastructure. The study investigates both intervention elements and combinations of elements that are individually understood to be beneficial for most students.

The Context

The investigators studied Minority Opportunities in Research (MORE) programs at three state universities, New Mexico State University (NMSU); California State University, Los Angeles (CSULA); and San Francisco State University (SFSU). The programs at all three universities have been in place for at least twelve years. Historically, the programs have had a high enough success rate in preparing Hispanic, Native American and African American biomedical researchers to be repeatedly funded by two US federal agencies: the National Institutes of Health and National Science Foundation. The following questions drive the research:

1. How do MORE programs function and what do they have in common?

2. How successful are the three MORE programs in promoting science students in their careers?
3. Which MORE interventions are the most effective?

Effective interventions are defined as those that assist the students in achieving success in their degree programs and encouraging them to pursue advanced study. This study will report the findings of emerging research based on the study of over 250 biomedical/science major students and graduates. In particular, we are interested in identifying the key correlates of success in biomedical and science degree programs at the undergraduate and graduate levels. The significance of this research is that it could allow institutions and expenditures to tailor programs to the best benefit of the individual students.

Background

At the National level in the US, non-Asian minority students (Black, Hispanic, Native American, Alaska Native, and Pacific Islander) are significantly underrepresented in the STEM fields of Science, Technology, Engineering, and Math (National Science Foundation, 1999; 2000). Upon entering college, these students are typically less prepared than their peers (Campbell et al., 2000; National Assessment of Educational Progress, 2001), have greater difficulties obtaining bachelor's and graduate degrees (National Science Foundation, 2000) and on average take more time to graduate. Recent data (as of 2003) show the magnitude of the underrepresented minorities Ph.D. productivity in science and engineering, compared to the US population (see Figures 1 and 2 below). In 2003 27% of the population consisted of underrepresented minorities (URMs) while only 9.39% earned Ph.D.s in science, technology, engineering, and math (STEM) fields.

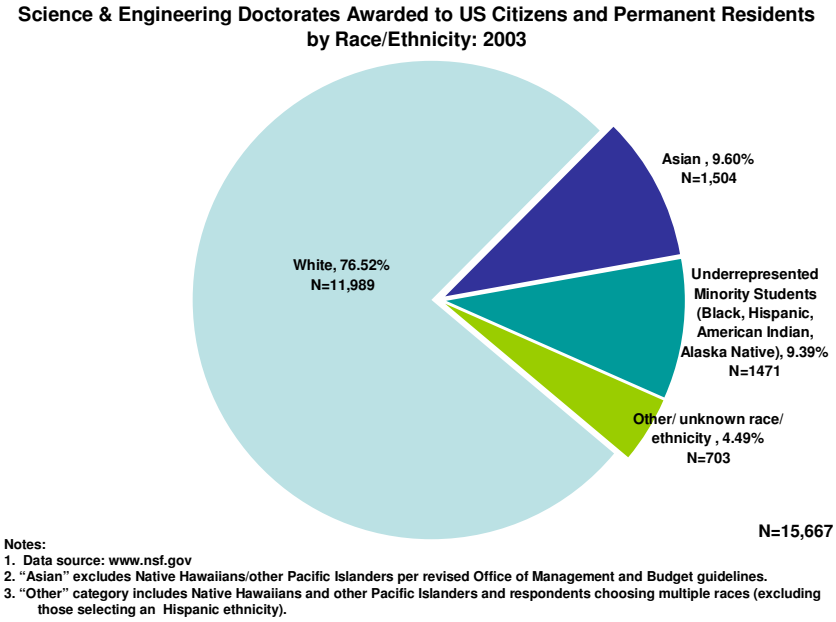


Figure 1: Doctorates Awarded by Race

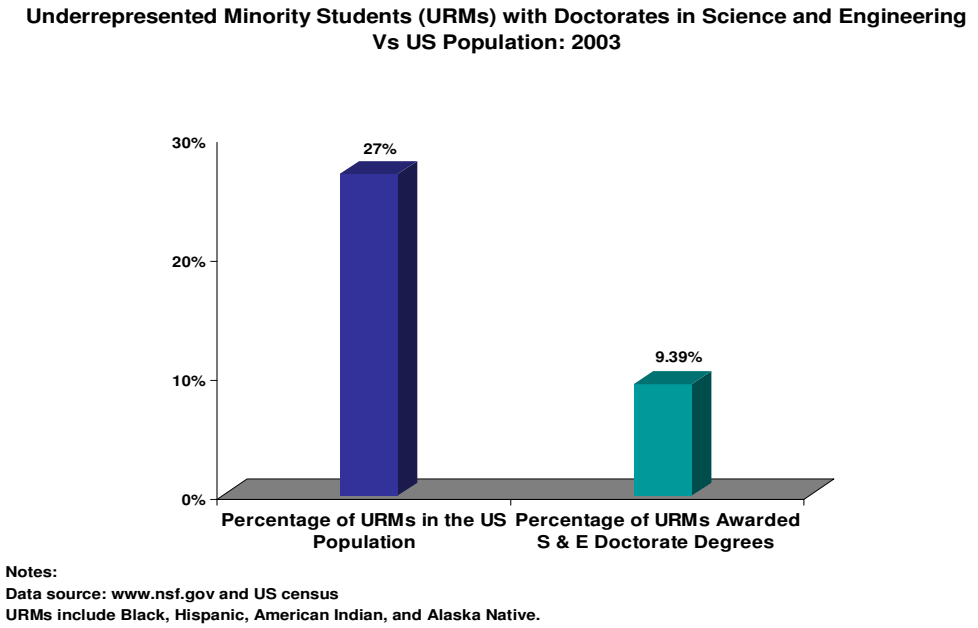


Figure 2: Doctorates Awarded; URM vs. General Population

To reverse this chronic under-representation, the National Institute of General Medical Sciences (NIGMS) in the United States created Minority Opportunities in Research (MORE) and similar academic interventions. The scope of the problem and the desire to address it are reflected in the significant expenditures on such programs. NIGMS alone spends more than $160 million in American dollars annually on its MORE programs, including $112 million on the Minority Biomedical Research Support-Research Initiative for Scientific Enhancement (MBRS-RISE) program; $31 million on Minority Access to Research Careers-Post baccalaureate Research Education Program (MARC-PREP); and $10 million on the Bridges initiatives. The current study examines the components and the effectiveness of large MORE programs at three public universities which have been supported by a variety of NSF and NIH sources.

Previous Studies

Past studies have generally focused either on individual program evaluations or on researching the effects of broad combinations of interventions. To date, few comparative studies have been published indicating which programs or interventions are most beneficial or if there is a differential effect across diverse student populations.

Table 1 below indicates four pertinent interventions that have been examined in the literature, along with the studies that have presented evidence to support their effectiveness**.**

Table 1. Sources for successful interventions for improving college student performance

Intervention	Source	Date
Academic Advising	Harter & Szurminski	2001
Developmental/Remedial Courses	Easterling, Patten, & Krile, Illinois Community College Board	1998 1998
Mentoring	Fernandez, Whitlock, Martin, & VanEarden	1998
Supplemental Instruction	Harter & Szurminski, Wolfe, & Zanitsky	2001 1991 1994

Few studies have looked specifically at the effects that interventions have on minority students. Springer et al. (1999) found that smaller classes benefited minority students to a greater degree than their peers. Researchers such as Quintana-Baker (2001) have shown that large support and intervention programs, when available, lead to enhanced minority student performance when compared to students for whom these interventions are not available. Lacking in both of these studies, however, are discussions of multiple interventions.

Lewis (1991) found that students enrolled in an undergraduate research program were more likely to continue on to graduate school than those who were not, but his study only examined a single program. Another study by Barlow and Villarejo (2002) found similar results, but with similar restrictions.

In his exhaustive survey of more than a million students over a period of years, Alexander Astin (1993) showed that environmental variables can have significant effects on student experience: support from grants and scholarships, as one example, result in improved satisfaction with faculty members over those who work or who rely on savings to pay for college. Social activism and tutoring other students can result in marked scholastic improvement. Increased student interaction with faculty members, particularly outside of the classroom, was shown to improve scholarship. When faculty showed a strong interest in the students as individuals the benefit was even more acute with rising academic self-concept and intellectual self-esteem. Grade point average was positively associated with faculty interaction, but the relationship could be complex. Faculty members who were believed to be "student-oriented," (showing interest in personal matters or individual scholastic improvement, or exhibiting cultural sensitivity), improved student perceptions of their academic experience; those believed to be strictly "research-oriented" had a measurably negative effect. These findings reinforce the need for further investigation into the effects of mentors and research programs as influencers of student success.

While previous research strongly suggests that research based interventions can have a positive impact on student achievement, the focus up to the present has been relatively broad. Little research has been done on multiple, simultaneous interventions. The significance of studying multiple interventions is that it could allow institutions and expenditures to tailor programs to the best benefit of the individual students and maximize system resources.

Method

This study contains more than one sub-unit of analysis, which includes student demographics, advisors, directors, departments, and institutions as a whole. Because the research questions focus on multi-dimensional mediating factors (e.g., Academic Advising, Developmental or Remedial Courses, Mentoring, Supplemental Instruction) within complex contextual institutional environments, an embedded case study method was selected. Moreover, this mixed method approach is particularly appropriate for descriptive and exploratory studies that seek to grasp the "how" and "why" elements of the three sites (Merriam, 1998; Owen & Lambert, 2001; Yin, 2003). Quantitative data was culled from surveys, program records, and institutional data along with qualitative data from interviews with program directors, faculty, and research advisors.

MORE students were surveyed at least once a year regarding their attitudes towards the MORE programs and the effectiveness of specific interventions within those programs. The data from these surveys was combined with program records detailing demographics, specific program participation, graduation and enrollment, and post-graduation plans (career, Master's program, PhD, etc.). A number of non-MORE students were also surveyed to form a basis for comparison. Follow-up contacts and resume analysis were made with MORE program graduates to gather data on their subsequent career paths.

MORE program directors were interviewed one-on-one regarding program implementation variables. Their input, along with previous surveys with MORE students and faculty, were used to develop a model of effective MORE program implementation. This model was then vetted by the research team and program staff to ensure a valid representation of those factors most important for program success. Subsequent feedback loops to review results were used to verify the program models in place.

Sampling strategy

The three institutions involved in this study were chosen for their consistently long history of involvement with MORE programs (all had at least ten years of experience in implementing MORE

programs), and for the diversity of interventions supported by these institutions. All three universities supported access to student and alumni databases, as well as prior research studies involving these MORE programs and students. Additionally, all three universities boast high science degree completion rates, with NMSU graduating more than 90% of their science undergraduates, and an average PhD placement rate of over 80% across all three institutions. Students are interviewed by program faculty to ascertain commitment to science.

Data Collection Sources and Instruments

Table 2 summarizes the instrumentation and schedule of administration. The surveys were developed using a collaborative approach involving the research team and the MORE program directors, who advised the research team on language and terminology to insure the instruments were applicable and understandable by the students. The various surveys and instruments were administered over a three year period. Student data were collected using three surveys: a portfolio survey which gathered data on students backgrounds prior to entering the MORE program, and was administered in both the fall and spring, followed by two surveys, one in the fall and the second in the spring, which examined students' attitudes towards the program and their plans for the future. Alumni from previous years were also surveyed regarding their attitudes and their current career situations. Interviews with MORE program directors began in 2004 and continued to the completion of the study.

Table 2. Instrument Schedule

Research Instruments	Date Administered
Alumni database	Fall 2004
Alumni survey	Fall 2004
Interviews with MORE Directors'	Fall 2004, Spring 2006, Summer2006
Portfolio Data Form for students	Fall 2005, Spring 2006
Student surveys	Fall 2005, Spring 2006
MORE Graduate placement template	Summer 2006

Additional demographic and instructional data was collected from institutional records at the three universities, as well as MORE program records.

Results

The research questions dealt with the effective implementation of MORE programs and the indicators of their success. Using the information gathered from interviews with the program directors, the model below (Figure 3) was developed using a structured coding system to analyze data and identify discrete indicators, themes and patterns shaping program success (Ryan & Bernard, 2003). Indicators and factors that were initially derived through two cycles of interviews with program directors and context analysis of the three programs which were then used to construct the surveys of students to test and validate causal relationships between four key indicator categories: 1) leadership/philosophy factors, 2) recruitment/intake process (including selection criteria), 3) student characteristics including motivation and interest in science, and 4) talent development/program infrastructure (interventions).

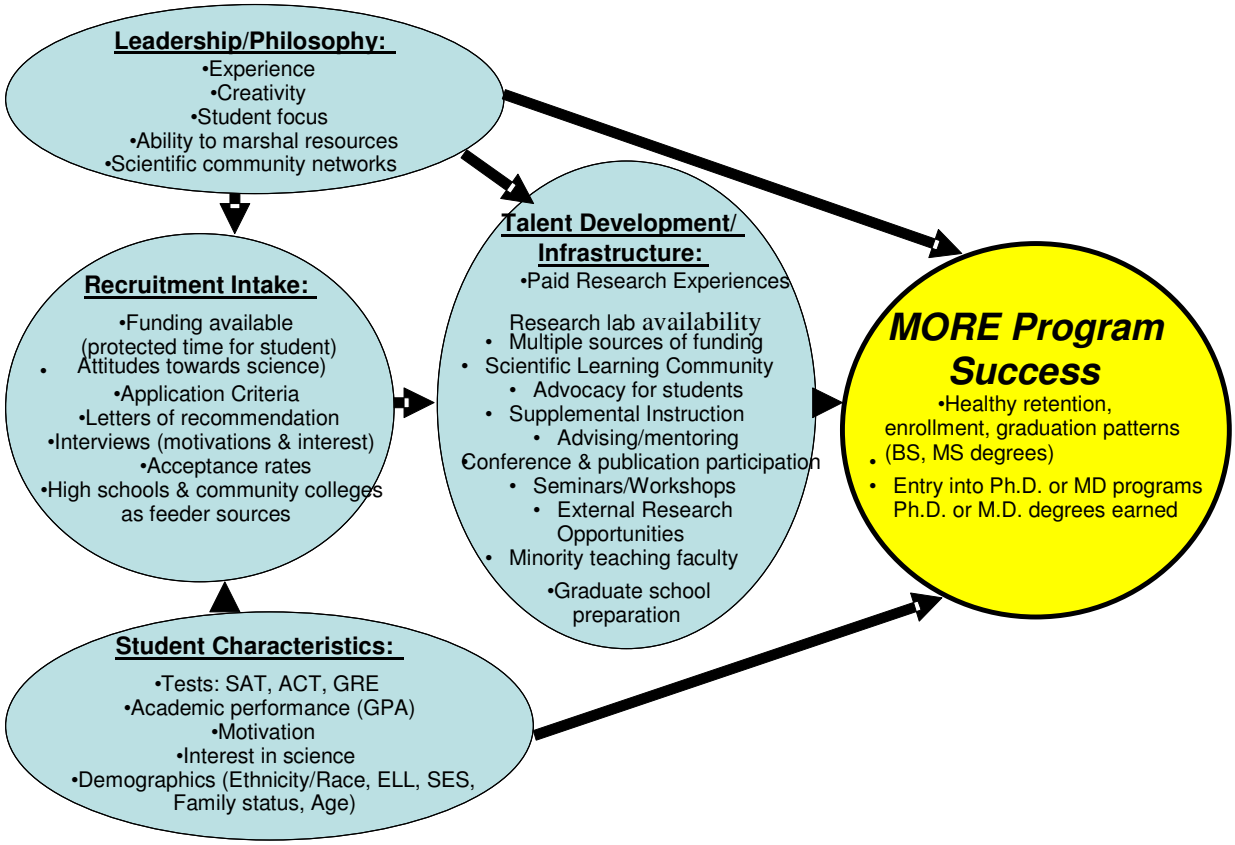


Figure 3: MORE R.E.S.U.L.T.S Model

Table 3 delineates the key indicators in the model above which can be analyzed in three phases read from left to right: inputs, formative processes, and ultimate outcomes.

Table 3: Key Inputs, Processes, and Outcomes			
Inputs & Antecedents	**Mediating Processes**	**Outcomes**	**Figure**
Leadership: faculty experience, creativity, student focused, ability to marshal and anticipate resources, network to scientific communities, conceptual framework **Recruitment/Intake**: Funding (protected time), Referrals, Application/Acceptance Criteria: attitudes (toward science); letters of recommendation; interviews (motivation & interest) **Student Contexts &**	**Talent Development:** research experiences including labs on campus, advocates for students, supplemental instruction, advisors and advising, tutoring & mentoring, conference and publication participation, external research opportunities, seminars and workshops, grad school prep, resume preparation & job placement, cohorts **Infrastructure**: sequential sources of funding (multiplicity & continuity),	**Success Indicators:** Placement & retention rates Completion rates from "gatekeeper courses" and Graduation patterns and degrees earned Time to completion, dropout and stopout rates Entry into PhD programs Post-doc placements Life after post-docs research careers.	4 4, 5 6-8 9 4

Table 3: Key Inputs, Processes, and Outcomes			
Inputs & Antecedents	**Mediating Processes**	**Outcomes**	**Figure**
Characteristics: Performance: SAT, ACT, GRE's; academic performance (GPA esp. science courses), motivation, interests, demographics (ethnicity/race, English language learner, socio economic status, family status, age, gender)	scientific learning community, student advisory committee voice, MORE program management, URM teaching and research faculty, internal advocacy (to solve student problems)		

The significance of these factors is described in Table 4.

Table 4: Description of Indicators	
Indicator	**Practical Significance**
Leadership/Philosophy Experience Creativity Student Focus Ability to marshal resources Network to scientific communities	The program directors involved have between 12 and 30 years experience, and actively pursue research-based interventions for their students. There exists a strong focus on student success (rather in just content mastery), and in marshalling resources (i.e. success in grant writing) to support the students. The directors' connections with scientific communities, specifically PhD granting institutions, enable them to aid students in transitioning into PhD programs.
Recruitment Funding available (protected time for students) Attitudes (Strong Interest Inventory) Application Criteria Letters of recommendation Interviews (motivations & interest) Acceptances High schools & community colleges as Feeder schools	These indicators refer to the recruitment efforts undertaken by the program directors and selection committees. These efforts include ensuring a maximum amount of funding available, so that students are not forced to work outside of the university to support themselves. Attitudes refer to seeking students with a genuine passion for science and research. Other important factors include the application criteria and letters of recommendation, as well as the presence of high schools and community colleges that feed into the universities.
Student Characteristics Tests: SAT, ACT, GRE Academic performance Motivation Interest in science Demographics (ethnicity/race, ELL, SES, family status, age)	The salient student characteristics identified by the program directors include standardized test scores, GPA in science courses, and the students' interest and motivation in science. Given that MORE programs target underrepresented minorities, ethnicity and race are not large factors, however socioeconomic status, age, and family support all play a role in MORE success.
Talent Development/Infrastructure Research Experiences Research labs Multiple sources of funding Scientific learning community Advocacy Supplemental Instruction Advising Conference & publication participation Seminars/workshops	The presence of funded research experience and the availability of biomedical research labs in which to conduct research are critical in ensuring student success. Ensuring that there are multiple sources of funding means that students can be continually supported through a variety of programs. Advocacy refers to directors being willing to cut through 'red tape' to ensure students are able to, for instance, get into the courses they need. Supplementary instruction involves aiding students in difficult courses. Faculty advising

External Research Opportunities Minority teaching faculty Graduate school preparation	MORE students and serving in a mentor capacity was also identified as very important, particularly in the case of minority faculty, who could serve as role models for students. Program directors also found support for attending conferences, co-publishing with faculty, and seminars given by faculty as positive factors. They also found that students were helped by external research opportunities, such as internships, and aid in preparing for graduate school (such as test preparation and help in crafting statements of purpose).

Together, these indicators or factors contributed to MORE program success. Current evidence of success is summarized in Figures 4 and 5 below. Since the MORE programs support degree programs at the bachelor's and master's level, the primary success indicator is further study at the Ph.D. level of MORE graduates and post-doctoral research placements. As can be seen in Figure 4, during 2005-2006 there were 236 students in the MORE programs at the three institutions. Of those, 111 graduated while the rest continued their studies. The key outcome variable then for these 111 students is how many continued along the career path toward earning their doctoral degrees in the sciences.

Tracking MORE Students **CSULA + NMSU + SFSU** (Academic Year '05-'06)	
# of current funded students	236
# of graduates this year	111 (100%)
# going straight into Ph.D. programs*	**70 (63%) (Total attending grad school :**
# going to Masters programs (many plan to pursue Ph.D.s later)	**22 (20%) Ph.D.s and Masters = 83%)**
# with other plans* ***(many state they plan to pursue Ph.D.s later)***	3 - Research fellowships 2 - Peace Corps 3 - BS -> Post Baccalaureate 3 - BS -> Research Associate 1 - BS -> MD programs 2 - Post Bac -> MD programs 2 - MS -> MD programs 2 – Unknown
# going into the workplace	5
TOTAL Ph.D. 's + MD 's + MS	**97 (87%)**

Figure 4: Placement in Advanced Degree Programs of More Graduates 2006

Nearly all students eligible to graduate in the 2005-2006 did so, and 63% of those students went directly into PhD programs, with an additional 20% entering into Master's programs. Combined, 83% of all MORE graduates at the three universities entered into graduate STEM programs or 87% including medical degrees. Among those students who did not go on to pursue Master's or PhD's, several took research positions, and a few additional students entered MD programs. Of the 111 total graduates, only five entered the workforce instead of continuing their education.

The progress of alumni on the scientific researcher career paths was assessed mainly through the institutional databases and the MORE programs' records. Figure 5 illustrates the cohort analysis of 111 MORE students who graduated with either a BS or MS degree in 2005-2006.

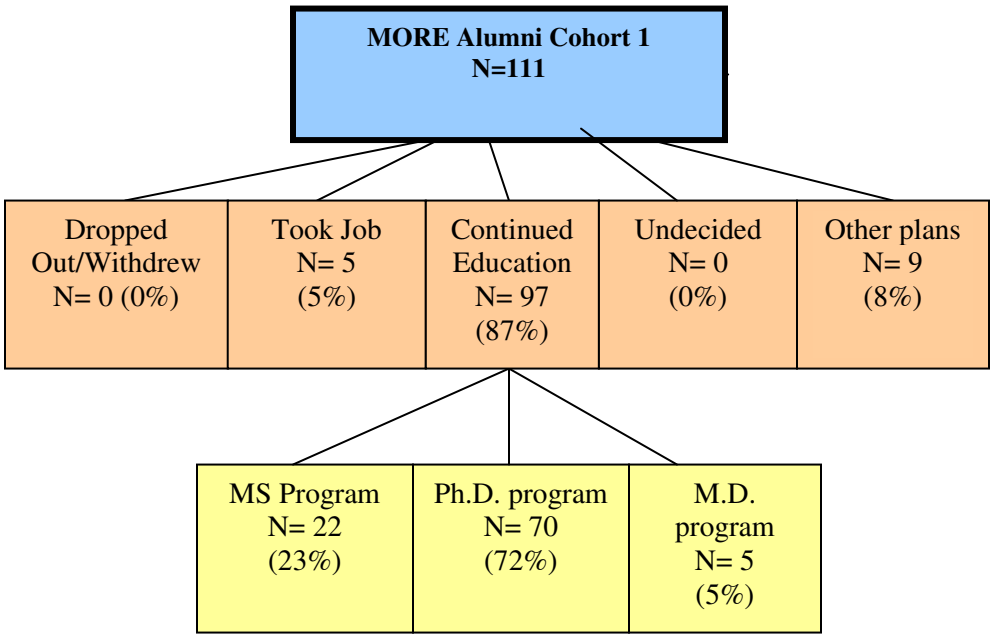


Figure 5: Career Paths for MORE Alumni

The high rate of degree completion and pursuit of advanced degrees seen above is echoed in historical data of MORE programs at the institution level.

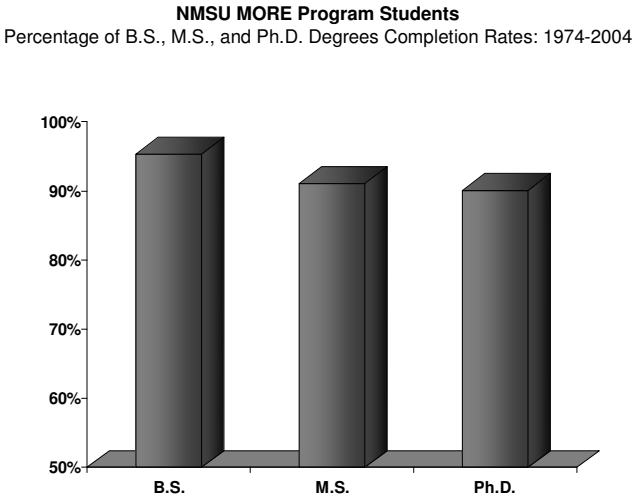


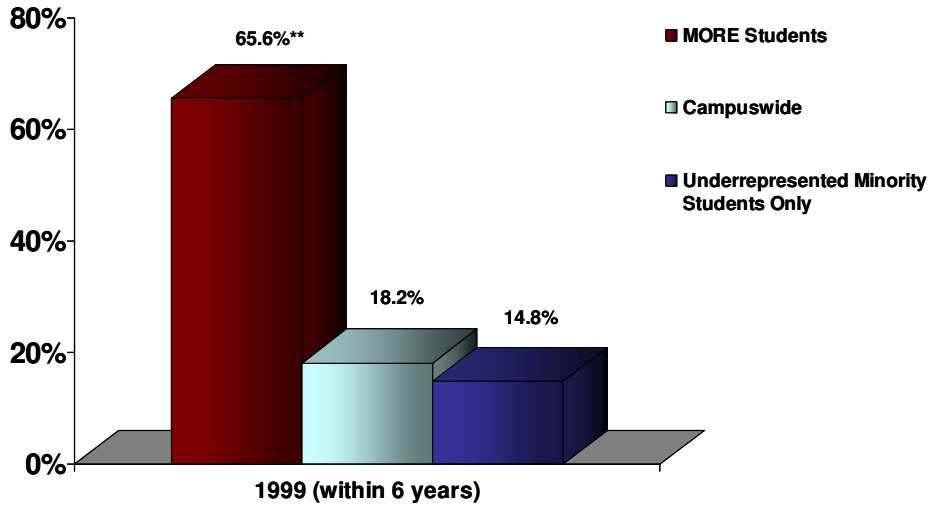
Figure 6: Degree Completion Rates of MORE students

The most mature MORE program (NMSU) reported the highest degree of completion. Degree completion rates from New Mexico State University between 1974 and 2004 reveal close to 90% of MORE graduates completing Ph.D.s (Figure 6).

In addition to undergraduate and graduate STEM degrees completed, overall graduation rates and retention rates are other indicators of MORE program success. The data from Cal State LA demonstrates that MORE participants are more likely to have graduated within 6 years than both the campus as a whole rate and the underrepresented minority students in particular rate. Figure 7 below compares the progress of MORE students to other non-MORE students who began as freshmen at the university. Two explanations for this dramatic difference may help understand these disparities. One explanation comes from the students themselves who indicate the importance of paid research jobs in helping their progress toward degrees. The activity students cited most frequently as helping with their educations involved (paid) research lab jobs. Also, since many students study part-time on this predominately commuter campus, a campus-based job eliminates the need to work off-campus and reduce students' time for academics.

CSULA*

Percentage of STEM 1999 Freshmen Graduating in 2005 MORE Students versus Campuswide versus Underrepresented Minority Students



Note: *Average student retention rate campuswide ~30%

** MORE students estimated graduation rate ~65.6% based on annual retention rates (excludes engineering and math majors

Figure 7: Time to completion at CSULA

Together these results provide validation of the success in achieving the outcome indicators as listed in the model in Figure 3 above.

Oh and Slovacek (2004) and collaborators measured student achievement through the Minority Opportunities in Research (MORE) programs relating to dropout and stop out rates. The investigation measured the effectiveness of CSULA's two largest programs, MBRS and MARC, in terms of science majors' success. The programs succeeded in enhancing the education of minorities through their expanded interaction with science faculty and other biomedical scientists as well as participation in research experiences. As can be seen in Figure 8, MORE programs effectively reduced the annual dropout and stop-out rate from approximately 20% for all freshman students at the university to 1.7% for MORE students over a one-year period. Student surveys indicated that the program was effective in raising grade point averages (GPAs) to a level significantly higher than the university average. Surveys also showed that the program was effective in improving students' educational skills, inspiring academic careers in the sciences, and boosting competitiveness in the field for further study. 81.8% of MARC students and 90.9% of MBRS students aspired to obtain a Ph.D.

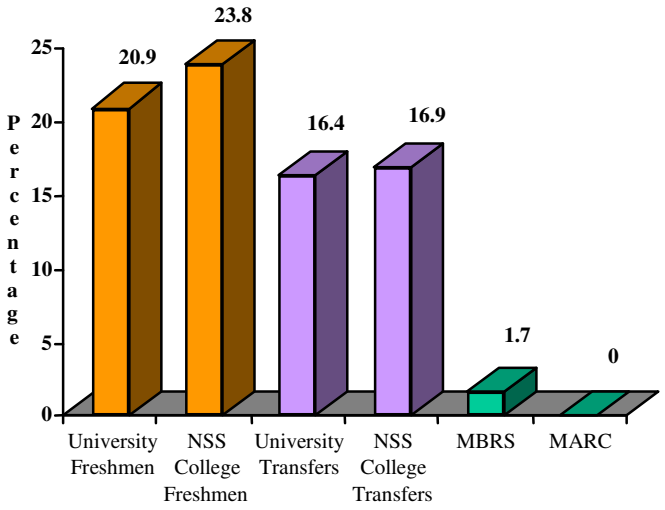
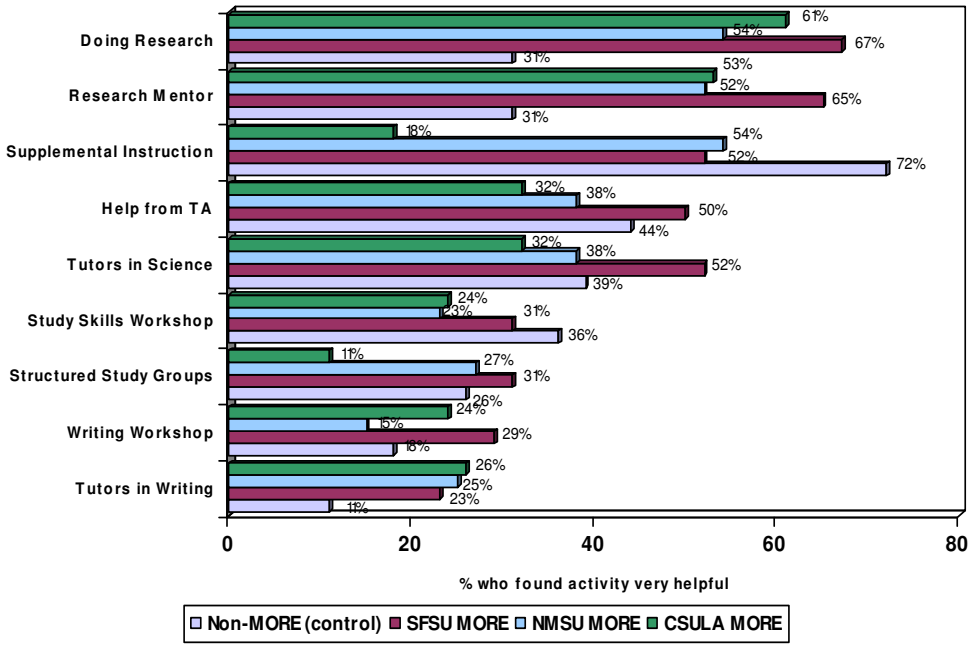


Figure 8: Dropout/Stop-out Rates (2000-2001) at CSULA: University, College, and MORE Students Compared

While the first two research questions deal with the program as a whole, the last question focuses on the effectiveness of specific interventions. Effectiveness, again, was determined by students' perceptions regarding the interventions utility in supporting their coursework and preparing them for advanced study.



Note: n=174. Source: Fall Survey, Fall 2005 (MORE RESULTS)

Figure 9: Factors Found to be Very Helpful to Science Students

When asked in Fall 2005 about factors they considered "very helpful" in their programs, 61% of students at CSULA, 54% at NMSU, and 67% at SFSU responded with "doing research." It should be noted that the research students engaged in consisted of paid laboratory positions (research assistants). Other interventions identified by a significant number of students as "very helpful" were research mentors

and supplementary instruction. Those interventions that were less very helpful included study groups and writing workshops. Figure 9 above details students' responses.

Conclusions

The results of the study are most applicable for those looking to implement or restructure their own support and intervention programs for minority students in the sciences. The study provides informative data on both the general effectiveness of MORE programs (as carried out using the comprehensive model employed at the three institutions) in increasing graduation rates while at the same time reducing dropout/stopout rates and transfers (to other majors) of science students. Specific information on the most effective interventions was provided.

It can be said with confidence that a synthesis of diverse intervention and support programs implemented at the three universities advanced the educations and progress toward science careers of under represented minority students. Furthermore, MORE students in the study found three interventions or mediations to be the most effective for their success: a) the research-based interventions, such as working in research labs and research internships, b) being supported regularly by STEM faculty research mentors/advisors, and c) participating in supplemental instruction. Students in MORE programs were clearly interested in being able to perform research during their undergraduate and master's level studies. Also noted were also those interventions that students did not feel were as helpful. While students expressed moderate support of tutors in science, they were somewhat less enthusiastic about tutors in writing, although about a quarter of the students found writing workshops helpful.

Taken together these findings are of use to those looking to design or reform student support programs in post-secondary science education, in particular with regards to which interventions or support activities should be offered to the minority students.

In addition to the results on interventions, the MORE program model depicted in Figure 3 provides a structure or framework to evaluate the efficacy of other intervention and support programs. The model identifies multiple critical indicators of success as well as the inputs and processes that lead into them. Furthermore, as the model was constructed by examining three successful MORE programs, the model can also serve to illustrate those processes and elements that should be considered for implementation in future science degree support programs for underrepresented minority students.

Further Research

While this study indicates which specific interventions minority science students felt were most valuable as well as some promising outcomes measured by academic degree progression, longer term follow-up studies of these students to ascertain their completion rate of Ph.D.s would add greatly to understanding the full impact of MORE programs. Also, more research needs to be done into the effects of combinations and "dosages" of interventions on student success. Given that MORE programs typically employ multiple interventions, data relating to how those interventions interact and complement one another would be very useful.

Finally, while this study looked at underrepresented minority students as a whole, it did not have sufficient power to detect reactions to interventions within specific minority groups or genders. It is possible that different minority groups or genders respond differently to various interventions. Knowledge of these differences would be of use to MORE program directors and science educators.

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