

## **Charting a Course towards Hispanic Success in Science, Engineering and Mathematics**

Katherine A. Friedrich  
Graduate Project Assistant  
Center for the Integration of Research, Teaching and Learning  
Diversity Team  
University of Wisconsin-Madison  
552 Educational Sciences Building  
1025 West Johnson Street  
Madison, WI 53706  
Email: [friedrich@wisc.edu](mailto:friedrich@wisc.edu)

Alberto F. Cabrera  
Professor, EPI Senior Scholar & WISCAPE Senior Researcher  
Department of Educational Administration  
University of Wisconsin-Madison  
1250 Educational Sciences Building.  
1025 West Johnson Street  
Madison, WI 53706  
Telephone: 608-262-3771  
E-mail: [cabrera@education.wisc.edu](mailto:cabrera@education.wisc.edu)

This manuscript was prepared for the HACU Hispanic Higher Education Research Collective Conference: Setting the Research Agenda for Hispanic Success in Higher Education.

## **Charting a Course towards Hispanic Success in Science, Engineering and Mathematics**

Latinos are close to 3% of the science, technology, engineering and mathematics labor force, even though they accounted for 14.1% of the U.S. population in July, 2004 (not including Puerto Rico) (U.S. Bureau of the Census, 2005; Walters, 1997). The Hispanic population had a growth rate of 57.9% from 1990 to 2000 – the fastest of any population group in the U.S (U.S. Bureau of the Census, 2000).

As of July 1, 2004, the U.S. Census Bureau estimated that there are 41,322,070 Hispanics in the United States (not including Puerto Rico). The one-year growth rate – 3.6% – was the largest rate of all population groups. (U.S. Bureau of the Census, 2005b). The number of Hispanic youth in the U.S., particularly of Mexican origin, is increasing (Eamon, 2005).

Because of a shortage of locally trained employees, the U.S. now imports highly-skilled workers in many science-related specialties (although there have been fewer work visas granted in recent years, due to international political issues). Although there is a growing need for a highly native skilled labor force, Hispanics, the fastest growing subpopulation in the country, are not being trained for these jobs. Hispanics currently are likely to work in food service-related occupations, construction, cleaning, and in factories, while Asians, many of whom are recent immigrants, are much more likely to work in medical fields, in specialized professional fields such as engineering and law, and at universities (Wilson, 2003). Science, engineering and mathematics-based careers could offer Latino youth a path out of dead-end employment. Job growth is occurring in

scientific fields, and the pay offered is high in comparison to that of the occupational niches Latinos currently occupy.

The low income of Hispanics in the U.S. can be mainly explained by their educational attainment (Council of Economic Advisers, 2000). However, simply telling young people to “remain in school and study science” is not enough. A complex constellation of factors works to keep young Hispanics out of technical fields, and, until we address them thoroughly, we will not succeed.

The purpose of this manuscript is to provide a review of the key factors on the path to success in science, engineering and mathematics, and to discuss Latino success in this field. Finally, we will summarize areas in which more research is needed.

### ***Science Pathways for Majority Students***

To give context to the influences that constrain Latino student success in science fields, it is useful to begin with the professional development of majority students, starting in K-12 and continuing through university graduation (which many do not complete). We will use the “path to college model” (Cabrera, Burkum & La Nasa, 2005) to describe what matters most for all students first. Then, we will discuss what matters most for Hispanics.

There are a variety of possible pathways from K-12 education to a college degree. Many students do not follow the traditionally accepted model of entering college directly after high school and completing a four-year program. According to Cabrera, Burkum and La Nasa (2005), students with high socioeconomic status are most likely to go directly from high school to pursuing a four-year degree, while students from less

affluent backgrounds are more likely to enter community colleges. This is partly a function of differences in their degree aspirations; students from low-income backgrounds are less likely to expect to attain a college degree. They are also much less likely to be encouraged by peers and family.

Students begin to make decisions about their future starting in the eighth grade (Cabrera, Burkum & La Nasa, 2005). Intervention programs should provide students and their families with resources about college options from before the beginning of high school. A student's choice of courses in high school can determine his or her academic future. Math preparation is especially important (Swail, Cabrera, Lee & Williams, 2005).

Science and mathematics course taking appears to play a pivotal role in the success of community college students. When low-income community college students take science courses and achieve high grades, they are much more likely to continue on to a four-year institution (Cabrera, Burkum & La Nasa, 2005).

A filtering process takes place in primary, secondary and higher education which separates students who are equipped to study science from students who are not. To enter an accredited degree program in a technical field, students must have high-quality math and science preparation in high school, culminating in pre-calculus, if not calculus. Both pre-calculus and calculus courses taken during high school increase the probability of Latino students' graduation from a four-year college significantly (Swail, Cabrera, Lee & Williams, 2005). If students experience academic tracking out of college-preparatory classes, low school quality, lack of communication with parents about college requirements, adversarial relationships between students and school staff, stereotypes that

they cannot become scientists, or personal difficulties that make it hard for them to study, they may not persist.

Although majority students have higher rates of entering science, engineering and mathematics than Latinos do, their situation is not ideal. The general science literacy of the U.S. population is low, which implies that the quality of science education through high school is not as high as it could be. Most young people are likely to grow up with little understanding of concepts such as photosynthesis, DNA, and even the fact that the earth goes around the sun. Understanding of the scientific method is also low in the general population (National Science Foundation, 2004). Science teachers may be unaware of subtle misunderstandings that students bring into the classroom. Students then attempt to memorize information that contradicts their existing beliefs, and do not grasp the material conceptually.

Although improved science education may be available in college, not all majority students continue on to graduate from high school and enter postsecondary education. The table below (Cabrera & La Nasa, 2000) summarizes factors influencing students' decisions about college attendance.

Table 1

College Choice Process: Stages, Factors, and Outcomes

STAGES	FACTORS	OUTCOMES
Predispositions: Grades: 7 <sup>th</sup> -9 <sup>th</sup>	Parental Encouragement & Support Parental Saving for College Socioeconomic Status Parental Collegiate Experiences High School Academic Resources Student Ability Information About College Student Ability	Reading, writing, math & critical thinking skills Career/Occupational Aspirations Educational Aspirations Enrollment in College-Bound Curriculum
Search Grades: 10 <sup>th</sup> -12 <sup>th</sup>	Parental Encouragement & Support Educational Aspirations Occupational Aspirations Socioeconomic Status Saliency of Potential Institutions Student Ability High School Academic Resources	Listing of Tentative Institutions Narrowing List of Tentative Institutions Securing Information on Institutions
Choice Grades: 11 <sup>th</sup> -12 <sup>th</sup>	Educational Aspirations Occupational Aspirations Socioeconomic Status Student Ability Parental Encouragement Perceived Institutional Attributes (quality/ campus life/majors availability/distance) Perceived Ability to Pay (perceived resources/perceived costs)	Awareness of College Expenses & Financial Aid Awareness of Institutional Attributes & Admission Standards Attaining Scholastic Aptitudes & Attitudes Perceived Support from Family & Friends Institutional Commitment Submission of Applications Pre-Registration Attendance Application for Financial Aid

Source: Cabrera, A. F., & La Nasa, S. M. (2000).

According to the Pew Hispanic Center (2004), almost 70% of white high school graduates are academically prepared to enter a four-year college. The number qualified to study science, engineering and mathematics is probably smaller.

Once students enter college, they self-segregate by major. Asian students are more likely than their peers to major in the sciences, while women are generally less likely than men to enter the field (Simpson, 2001). Women and underrepresented minority students who enter technical fields are less likely than their peers to graduate; however, students in these majors are, on average, more likely to persist than their peers in other majors (Fenske *et al.*, 2000).

Science and math proficiency does not guarantee success in engineering. Students of all ethnicities need mentoring and support systems. They find large class sizes, learning new study and coping skills, lack of familiarity with the subject, and program difficulty to be obstacles to their success. However, students who intend to persist, are determined and mentally prepared, and have good grades and coping skills, are more likely to succeed (MacGuire & Halpin, 1995).

### ***Latino Students in the Sciences***

To explore the constellation of influences that keep young Latinos out of science, engineering and math, it is useful to follow the career path of Latino students who are successful in science. This demonstrates what Hispanic students must overcome to persist and attain a college or graduate degree in this field.

## ***Constraints on Hispanic Students' Success***

### ***Part 1: K-12***

Currently, only 1% of Hispanic K-12 students (as compared to 9% of white students) are learning higher-order analytical thinking skills (Swail, 1995). When one compares math proficiency, the statistics are equally grim. Only 4% of Hispanic high school graduates are mathematically proficient, as compared to 20% of their white peers (Barton, 2003). Performance gaps in reading and mathematics appear by age 9 and persist through later grades (T. M. Smith, 1995a). A gender gap is also apparent, with Latinas earning lower ACT scores than their male peers (Rodriguez, 1997). Cuban students are the only Hispanic group who are performing on par with white students, while Mexicans, the largest Latino group in the nation, tend to have lower achievement than other Hispanics (Eamon, 2005, Pew Hispanic Center, 2004). Longer duration of family residence in the U.S. (i.e. being a second-generation or third-generation U.S. citizen) does not statistically improve student achievement (Pew Hispanic Center, 2004).

Data from the 1988 cohort of the National Education Longitudinal Study shows minority students are equally as enthusiastic about science and math as majority students at a young age, but they face difficulties in developing their skills and pursuing their interests. Both at home and at school, they are in environments that have few resources to foster their learning of these subjects (Peng *et al.*, 1995)

Family income is a powerful influence on student success in the educational system (Battle, 2002). Several studies show that family influences such as household structure are much less important than socioeconomic status in determining student success in school (Battle, 2002; Pong *et al.*, 2005). Students whose parents have not

graduated from college are much less likely to take calculus (Harrell & Forney, 2003). Middle-class Latinos are 17% more likely to complete college than their lower-income peers are (Swail, Cabrera, Lee & Williams, 2005). And, while 36% of Latino students are from the lowest socioeconomic status category, only 6.9% of white students are within the same economic range (Cabrera & LaNasa, 2001).

High school quality is crucial for students to develop an interest in math (Eamon, 2005). However, educational quality is not consistent within and across schools in the U.S.. School segregation leads to less-than-adequate preparation of students (Lee, 2004). Because of the current system of school funding, which is not equal across districts, Hispanic students are less likely to have access to challenging, high-quality math instruction, computers and calculators (Berry, 2005; Chacon, 2000; Triana & Rodriguez, 1993). The practice of tracking is also problematic: it tends to perpetuate social inequality. Tracking is particularly prevalent among Latinos, who are more prone to be tracked into vocational routes than their white counterparts (Peng *et al.*, 1995; Sosa, 1993; Triana & Rodriguez, 1993). Students may be aware of the unequal treatment they receive, and may develop oppositional cultural attitudes about education which make it difficult for them to succeed (Simpson, 2001). Attending disorderly schools may also interfere with the learning of Latino students (T. M. Smith, 1995a). Disorganized schools may discourage students' interest in learning. A study of schools in Chicago found that overcrowding is also a problem (Valdez & Espino, 2003). When schools are overcrowded, it is more difficult for students to have individual attention from teachers or staff, and educators may be more likely to experience cynicism and burnout. In general, the quality of courses suffers when schools are overcrowded.

Students who experience conflict, trauma or other hardships outside of school may have difficulty excelling in class (Rumberger & Larson, 1992; Sosa, 1993). Many current immigrants to the U.S. are refugees. Their children must compete academically with peers who have not experienced traumatic events. When this situation takes place in a disadvantaged school, it is more difficult for overworked school personnel to intervene and help students individually.

Often, school administrators are unsympathetic to what they perceive as excuses for poor performance, a lack of empathy which fosters an environment of miscommunication and mistrust towards Latino students and their families (Rumberger & Larson, 1992). This mistrust may have important consequences for the way school engages students and their families. For instance, sometimes, families are not informed that their children are in trouble academically, and are unaware that their children are not receiving a competitive education (Chacon, 2000). Schools do not often provide individualized assistance for young people who are in trouble at school or at home (Chacon, 2000; Rumberger & Larson, 1992).

Low expectations are another challenge that students face. In a case study of a middle school Space Science Education Program, Sorge (2000) found that Hispanic students had difficulty perceiving themselves as scientists, even though they were interested in science. They believed that they would have to be geniuses to succeed in the field. The study did not determine where the students had learned that they could not be scientists.

Although Latina students are 20% more likely to complete college than their male peers, they face stereotypes and gender-based differences in communication when they

enter math and science courses. In these courses, collaborative learning styles and holistic perspectives are often discouraged (Ramirez et al, 1999; Swail, Cabrera, Lee & Williams, 2005). Female-only lab environments may make science courses more welcoming for Latinas (Ramirez *et al.*, 1999).

High school outcomes for Hispanic students could benefit from programs designed to reduce dropout rates. 30% of Hispanic students drop out of high school; the dropout rate for Chicanos is 40%, as compared to 12% for white students (Lockwood & Secada, 1999; Sosa, 1993). These completion rates have improved slightly, but there is a long way to go (Barton, 2003).

## ***Constraints on Hispanic Students' Success***

### ***Part 2: College***

Throughout the college application process, choice of a major, and acclimation to the expectations of demanding science programs, complex issues face Latino students who persist in science.

The challenges begin with the SAT. The relationship between SAT scores and success in college is debatable. However, students whose parents have attended college appear to be more successful on the SAT (Harrell & Forney, 2003). There has also been a long history of biases in standardized testing that favor English-speaking students. Spanish-speaking and bilingual students have been tested inconsistently or not at all (Figueroa & Hernandez, 2000). Several researchers recommend that minority-serving institutions should not rely on standardized tests for admission, but should focus on other factors, such as student talent and years of math taken, since students who do not score highly on the SAT can still be successful (Marwick, 2004; Swail, 1995).

Hispanic students are less likely to attend college than majority students are. Currently, Latino college attendance rates have dropped to under 50% (Nevarez, 2001). Chacon (2000) found that only 26% of Latino high school graduates in his study in the San Francisco Bay Area had completed California's college-prerequisite courses. The Pew Center found somewhat more encouraging results; 53% of Hispanic high school graduates were minimally qualified for admission to a four-year college. However, only 19% were highly qualified, as compared to 35% of majority students. 23.2% of Latino college students graduate with a four-year degree; this is less than half of the persistence rate of their white peers (Swail, Cabrera, Lee & Williams, 2005).

Over half of Hispanic college students pursue a two-year degree. In general, students at 2-year schools are less likely to attain their baccalaureate (Nevarez, 2001). Retention rates at community colleges are low; the reason for this is unclear (Nora *et al.*, 1997). When Latino students experience career mentoring, counseling and academic support, they are more likely to transfer to four-year institutions (Avalos & Pavel, 1993).

Santa Fe Community College is one two-year institution which has been successful in supporting students in the sciences. The college offers tutorial labs, a Hispanic STEM (science, technology, engineering and math) student organization, a faculty mentoring program, work-study positions in math and science, and a bridge program (Pantano, 1994).

Once Hispanic students enter college, they are less likely to complete their degrees than their white or Asian peers are. Retention of Latino freshmen is 72%, compared to the 81% retention rate of white and Asian students (T. Y. Smith, 1995b).

Overall, approximately half of Hispanic 25- to 29-year-olds who have some college education did not complete their degrees (Barton, 2003).

The highest predictor of college graduation is a rigorous high school curriculum (Barton, 2003; Cabrera, Burkum & La Nasa, 2005; Swail, Cabrera, Lee & Williams, 2005). Hispanic students are 30% more likely to graduate from college when attending a highly selective institution than a less-selective institution (T. Y. Smith, 1995b). This may be related to the students' academic achievement and courses taken during high school, which can lead to recruitment by selective institutions. According to Swail, Cabrera, Lee and Williams (2005), a strong high school math curriculum which includes calculus can have a powerful effect on Latino student success in college.

Although high school rigor is important, social integration also plays a role in student success at college. According to Tinto's model of educational integration, students must feel included both socially and academically at college. Role models and peer support are essential for the success of minority students (Swail, 1995).

Latino students do not always feel welcome at the colleges they attend (Cabrera & Nora, 1994). Segregation, discrimination, and difficulties with cultural adaptation often face ethnic minority students at majority-serving schools. Cultural incongruence sometimes places Latino students in a position where they feel they must choose between the campus and their community (Hurtado *et al.*, 1999). Over 2,000 hate crimes were recorded on college campuses in 1999 (Nevarez, 2001). Often, hate crimes are reported in the local press. This can lead to greater ethnic tensions.

In addition to hate crimes, institutional racism affects the performance of Latino college students. Minority college students tend to perform less well academically than

their white peers, and are aware that their professors stereotype them as less capable and less interested than white students (Madkins & Mitchell, 2000). In some cases, majority universities recruit minority students aggressively and then do not fully support their transition to campus life (Madkins & Mitchell, 2000). Sometimes, majority institutions provide assistance for minority students, but do not educate majority students and faculty about racism and stereotypes.

The presence or absence of financial aid also has a strong effect upon retention. The Pell Grant system, for example, increased college enrollment by 20% in the 1970s. Many of these students were minority students or had low socioeconomic status (Nevarez, 2001).

Some minority students prefer grants to loans because they do not want to incur debt. If students must work to support themselves, providing opportunities for them to work at their university, preferably in their field of interest, can improve their chances of persistence (Nevarez, 2001; Swail, 1995). Also, sufficient financial aid should be made available so that students do not have to work over 20 hours a week (Swail, 1995). Maintaining low tuition at public institutions is crucial for minority student success (Swail, 1995).

### ***Science Pathways for Hispanic Students***

Little research exists on the factors that lead Hispanic students to choose non-science majors during college. However, educational expectations and social and cultural capital may play a role. Once students choose a science, engineering or math major, the campus climate, teaching quality, difficulty of the academic program, and financial

resources can aid or hinder their retention. In general, Latino graduate students tend not to choose the sciences (Rodriguez, 1997).

Educational expectations have a powerful effect on student achievement in mathematics (Yan & Lin, 2005). High grades in math are necessary for persistence in technical fields. Parental expectations are particularly salient for Latino students (Swail, Cabrera, Lee and Williams, 2005). Also, some Latino students have difficulty perceiving themselves as scientists (Sorge *et al.*, 2000). This may affect their expectations of success in math and/or science courses, as well as their career aspirations.

Cultural and social capital may also play a role in students' choice of major. Latino students with middle- or upper-class backgrounds may make professional connections through social networks. However, students with lower socioeconomic status may not have access to these resources. Research shows that bilingualism, rather than speaking Spanish, is socially advantageous for students (Stanton-Salazar & Dornbusch, 1995).

Familiarity with white middle-class and upper-class cultural norms is important for success in the academic mainstream. This may act to filter out students who are unfamiliar with unspoken expectations. Often, students' academic merit is judged by their level of acculturation (Stanton-Salazar, 1997). Science and math-based professions usually require middle-class, majority cultural behavior, particularly during job interviews.

Stanton-Salazar's observations are supported by a study of Chicana career aspirations (Reyes *et al.*, 1999). Chicanas tended to aspire to male-dominated careers

more often if they were more acculturated, more aware of their job options, and had higher aspirations and GPAs.

Even acculturated students with high expectations may find the climate in science courses unwelcoming. Affirmative action controversies, often discussed by students, may make the climate less friendly for minorities. In 1996-1997, the enrollment of Hispanic graduate students in science and engineering dropped by 17% after a steady increase of 66.5% from 1989 to 1995 (Malcom *et al.*, 1998). The critical mass for stability of a minority group in the classroom is 15% (Walters, 1997). In many science classrooms, the numbers are much smaller.

Two studies of underrepresented minority engineering students found that they reported that faculty teaching was generally of poor quality (Sondgeroth & Stough, 1992; Stough & Songeroth, 1994). High-performing students tended to have better problem-solving ability and study skills (Sondgeroth & Stough, 1992; Stough & Songeroth, 1994). Many students felt overwhelmed by the difficulty of their program (Sondgeroth & Stough, 1992). Group studying was helpful for them (Stough & Songeroth, 1994).

Because science, engineering and mathematics degrees often take longer to complete than other college majors, more financial aid is needed to retain students in these programs (Barton, 2003; Fenske *et al.*, 2000). It is not clear that this need is being addressed, particularly in graduate school. Graduate students need financial support to attend conferences, and assistance with finding fellowships and assistantships (Brazziel & Brazziel, 1995).

In a study of one program to assist beginning graduate students in the life sciences at the University of Minnesota, Walters (1997) found that information about

opportunities, advanced research experience, peer relationships and mentoring were helpful. These last two factors relate to Tinto's integration model.

Parental expectations also play a role in determining Latino student persistence. Specifically, if parents expect a student to attain an advanced degree, he or she is more likely to complete college (Swail, Cabrera, Lee & Williams, 2005).

## ***Recommendations for Change***

### ***Part 1: K-12***

Latino students face serious deficits in educational opportunity, an educational opportunity that is tied to the schools they attend. In Chicago, for example, the schools are overcrowded, students tend to have low socioeconomic status, and dropout rates are high. Not surprisingly, Latino students attending those schools have low reading and math scores (Valdez & Espino, 2003). In Chacon's (2000) study of Latinos in the Bay Area, low expectations were creating problems for students. Parents were unaware that their children were not receiving an equal chance to pursue higher education, and teacher quality was low.

How can K-12 schools address these situations, given the fact that they often lack resources? A change of attitude appears to be the first fundamental step. The Hispanic Dropout Project recommends that educators connect with students and their families, make course content interesting, hold high expectations for students, and value Hispanic language and culture. They also recommend educators let go of beliefs that students are deviant, criminal, unwilling to learn, undeserving, or are victims (Lockwood & Secada, 1999).

Instituting high expectations for Latino students and providing them with quality math education, from algebra through calculus, improves their chances of college graduation. Guidance counselors should also encourage students to plan for college from a young age (Swail, Cabrera, Lee & Williams, 2005).

A study of the Escalante Math Project yields similar recommendations for rigorous coursework. Connecting math to prior knowledge and emphasizing its relevance for future employment can help to capture students' interest. Thorough explanation of problems, collaborative learning, and teaching study skills can help students develop their mathematical thinking. Mentoring students in character development and helping them discover their talents can help improve the climate. Educators must also be comfortable dealing with behavior problems and managing class time (Kester, 1993).

On a larger scale, the research literature also provides recommendations for institutional, national and regional change. Tracking should be eliminated, and steps should be taken to equalize school financial resources (Simpson, 2001). Award programs can be established for teachers who excel in working with bilingual populations, and Hispanic educators can be included in award programs and review boards (Triana & Rodriguez, 1993). Handbooks of Hispanic role models and organizations can be distributed in school districts (Triana & Rodriguez, 1993). School districts could also offer workshops on culturally relevant teaching (Triana & Rodriguez, 1993). When schools do not have sufficient resources to offer advanced math and science courses, they can encourage students to enroll in college courses. Admissions offices could take students' numbers of math and science courses taken into account, rather than exclusively relying on grades or SAT performance (Adelman, 1999).

Schools should institute increased learning time and accelerated learning, become more accountable for education, and engage in early intervention with students who are having difficulties (Chacon, 2000). Communication with families about college options and requirements is essential for improving the persistence of Latino students, and strategies can be developed to improve this dialogue (Chacon, 2000; Harrell & Forney, 2003). Verbal communication with parents is especially important (Rumberger & Larson, 1992).

## ***Recommendations for Change***

### ***Part 2: College***

Many Latino students perceive, in their college science courses, that doors are closed to them because of poor teaching and a chilly climate. Creating a welcoming and supportive environment for students, and improving the climate and teaching methods in gatekeeper courses, is critical (Triana & Rodriguez, 1993). One technique that has shown promise in reducing student isolation is collaborative learning (Swail, 1995). Cabrera, Crissman, Bernal, Nora & Pascarella (2002) found that students working in collaborative learning settings not only improved their cognitive development, but became more open towards diversity.

Rewarding professors for teaching, rather than focusing exclusively on research, may aid in improving the classroom environment. Also, professors should be encouraged to take a personal interest in students, and to be accessible (Swail, 1995, Quality Education for Minorities Network, 1997). Faculty can also take an active role in mentoring minority future faculty (Brazziel & Brazziel, 1995).

Programs that offer Hispanic students various types of support and outreach can be helpful. These include leadership activities, financial aid, research experience and work experience (Brazziel & Brazziel, 1995; Morrison & Williams, 1993; Nevarez, 2001; Swail, Cabrera, Lee & Williams, 2005; Triana & Rodriguez, 1993). Also, personal counseling, intervention, individualized advising, peer tutoring, academic assistance, study groups, mentoring (especially by alumni in the sciences), and social integration are valuable (Brazziel & Brazziel, 1995; Morrison & Williams, 1993; Nevarez, 2001; Swail, 1995, Quality Education for Minorities Network, 1997; Swail, Cabrera, Lee & Williams, 2005). The importance of communication about educational opportunities and requirements with parents, high schools and the Latino community should not be underestimated (Nevarez, 2001, Quality Education for Minorities Network 1997).

Tinto's integration model can be used to develop institution-wide retention programs (Swail, 1995). Such programs may address the climate concerns of Latino students more effectively.

Partnering with high schools to improve science education and recruit students, as well as to develop bridge programs, can aid students in making the transition to college (Brazziel & Brazziel, 1995; Morrison & Williams, 1993; Nevarez, 2001; Swail, 1995, Quality Education for Minorities Network, 1997). Effective bridge programs provide long-term support for students, place them in challenging courses, provide them with a mentor and a supportive peer group, offer financial assistance, and value their cultural background (Gandara & Bial, 2001).

Latino students are more likely to complete four-year degrees if they enroll initially at a four-year college or university rather than a two-year institution. They are

also more likely to persist if they do not take breaks during college to explore other work opportunities (Swail, Cabrera, Lee & Williams, 2005).

It is also crucial to assess the status of Latinos in education and the long-term effects of retention programs (Morrison & Williams, 1993). Triana (1993) recommends developing a system of assessment and accountability for retention, while Nevarez (2001) suggests studying the academic and social climates at high schools and colleges and communicating the findings to the community, Latinos, and government agencies.

Hiring Latinos at high levels within an institution can aid in changing the environment for students. For example, employing Hispanic faculty and administrators and creating research programs that hire Hispanic scientists may improve institutional climates (Morrison & Williams, 1993; Triana & Rodriguez, 1993). Simpson (2001) recommends neutralizing institutional racism by moving minority persons into positions of power on campus.

Addressing diversity issues, committing ample funding and staff time to minority initiatives, instituting a minority student office, and encouraging students to set up chapters of Minorities in Science and Engineering (MSE) organizations can create a more positive environment (Brazziel & Brazziel, 1995; Morrison & Williams, 1993, Quality Education for Minorities Network, 1997). These institutional frameworks can become a platform for Latino students to advocate for themselves.

### ***Further Research***

To develop successful retention programs for Latinos in the sciences, more data is needed on what students are currently experiencing on their career paths. The following questions are particularly salient:

1 ) What influences Latinos' choice of college majors? Is it educational preparation? Awareness of science as a degree option? Knowledge about science careers? Formal or informal mentoring? Attitudes of teachers? Discouragement during gatekeeper courses? The presence of stereotypes?

2 ) What would Latino science students themselves recommend to improve the educational experiences of the next cohort of their peers?

3 ) What communication strategies are most effective in connecting with Latino parents, high school students and communities? How can schools with limited resources implement these strategies? How can universities implement them?

4 ) To what degree do science professions demand acculturation? How can undergraduate advisors, counselors and minority program staff assist students in moving between cultures without being alienated? How can students learn to understand scientific culture?

5 ) How can we foster high expectations and quality teaching in schools with limited resources?

6 ) Why are some Latino students, even from a young age, unable to see themselves as scientists, mathematicians, or engineers? What interventions can change this discourse?

7 ) Would a sustained program of collaborative learning improve educational outcomes for Latino students in the sciences?

8 ) What are the retention effects of providing personalized counseling and advising?

9 ) What are effective ways to dispel myths about Latino student ability that teachers and professors may hold? How can teachers who work with Latino students become more culturally competent?

10 ) Why are Latinos choosing not to attend graduate programs in science, engineering and mathematics?

Improving the educational outcomes of Hispanic students in science, engineering and math is both urgent and important.

Technical fields are creative, and benefit from a diversity of ideas. Science, engineering and mathematics will be better equipped to serve the international community if practitioners are comfortable working in multicultural settings and understanding the needs of underserved communities. Therefore, science, engineering and mathematics would benefit from increased Latino representation.

Without access to high-paying work which requires technical degrees, Hispanic students in the United States may not be able to succeed economically, and may remain confined to low-paying, often seasonal or temporary work, which is less likely to offer benefits and more likely to pose health risks.

It is in the interests of educational institutions, government and the Latino community to connect and begin a dialogue about how to support the next generation of Latinos in taking rigorous science courses, pursuing college and graduate degrees, and believing that they can succeed.

In conclusion, if Latino students are given the message that they are expected to succeed in science and math, and are given quality math instruction and a supportive environment during high school, as well as social, academic and financial support in making the transition to college, they will be much more likely to excel. Making science, engineering and math classroom climates more welcoming is also essential for improving the environment for Latino college students.

DRAFT

## REFERENCES

- Adelman, C. (1999). *Answers in the tool box: Academic intensity, attendance patterns, and bachelor's degree attainment*: U.S. Department of Education.
- Avalos, J., & Pavel, D. M. (1993). *Improving the performance of the Hispanic community college student*. Los Angeles, CA: ERIC Clearinghouse for Junior Colleges.
- Barton, P. E. (2003). *Hispanics in science and engineering: A matter of assistance and persistence*. Princeton, NJ: Educational Testing Service.
- Battle, J. (2002). Longitudinal analysis of academic achievement among a nationwide sample of hispanic students in one- versus dual-parent households. *Hispanic Journal of Behavioral Sciences*, 24(4), 430-447.
- Berry, R. Q. (2005). Introduction: Building an infrastructure for equity in mathematics education. *The High School Journal*, April/May, 1-5.
- Brazziel, W. F., & Brazziel, M. E. (1995). *Distinctives of high producers of minority science and engineering doctoral starts*. Mansfield Center, CT: Brazziel (Marian) Associates.
- Cabrera, A. F. & Nora, A. (1994). College students' perceptions of prejudice and discrimination and their feelings of alienation: A construct validation approach. *Review of Education/Pedagogy/Cultural*, 16(3-4), 387-409
- Cabrera, A. F., & La Nasa, S. M. (2000). Understanding the college choice of disadvantaged students. In *New directions for institutional research*. San Francisco, CA: Jossey-Bass.

- Cabrera, A.F., Crissman, J. L., Bernal, E. M., Nora, A., P.T. & Pascarella, E. T. (2002). Collaborative learning: Its impact on college students' development and diversity. *Journal of College Student Development*, 43(2), 20-34.
- Cabrera, A. F. & La Nasa, S. M. (2001). On the path to college: Three critical tasks facing America's disadvantaged. *Research in Higher Education*, 42(2), 119-150.
- Cabrera, A. F., Burkum, K. R. & La Nasa, S. M. (2005). Pathways to a four year degree: Determinants of transfer and degree completion. In A. Seidman (Ed.). *College Student Retention: A Formula for Student Success* (pp. 155-209). ACE/Praeger series on Higher Education.
- Census 2000 PHC-T-1. Population by race and Hispanic or Latino origin for the United States: 1990 and 2000. (2000). Retrieved July 21, 2006, from <http://www.census.gov/population/cen2000/phc-t1/tab04.pdf>
- Chacon, M. (2000). *The state of Latino education in the San Francisco Bay Area: A crisis in student performance*. San Francisco, CA: Hispanic Community Foundation.
- Eamon, M. K. (2005). Social-demographic, school, neighborhood, and parenting influences on the academic achievement of Latino young adolescents. *Journal of Youth and Adolescence*, 34(2), 163-174.
- Educational attainment and success in the new economy: An analysis of challenges for improving Hispanic students' achievement*. (2000). Washington, D.C.: Council of Economic Advisers.
- Fenske, R. H., Porter, J. D., & DuBrock, C. P. (2000). Tracking financial aid and persistence of women, minority, and needy students in science, engineering, and mathematics. *Research in Higher Education*, 41(1), 67.

- Figueroa, R. A., & Hernandez, S. (2000). *Testing Hispanic students in the United States: Technical and policy issues*: President's Advisory Commission on Educational Excellence for Hispanic Americans.
- Gandara, P., & Bial, D. (2001). *Paving the way to postsecondary education: K-12 intervention programs for underrepresented youth*: National Postsecondary Education Cooperative.
- Harrell, P. E., & Forney, W. S. (2003). Ready or not, here we come: Retaining Hispanic and first-generation students in postsecondary education. *Community College Journal of Research and Practice*, 27(2), 147.
- Hispanic population passes 40 million, Census Bureau reports*. (2005). Retrieved July 21, 2006, from <http://www.census.gov/Press-Release/www/releases/archives/population/005164.html>
- Hispanic school achievement: Catching up requires running faster than white youth*. (2004). Washington, DC: Pew Hispanic Center.
- Kester, D. (1993). *An instructional guide concerning the highly successful teaching & motivating practices of Jaime Escalante for the Escalante math project at East Los Angeles College*. Downey, CA: Los Angeles County Office of Education.
- Lee, J. (2004). Multiple facets of inequity in racial and ethnic achievement gaps. *Peabody Journal of Education*, 79(2), 51.
- Lockwood, A. T., & Secada, W. G. (1999). *Transforming education for Hispanic youth: Exemplary practices, programs and schools*. Washington, D.C.: National Clearinghouse for Bilingual Education.

- MacGuire, S., & Halpin, G. (1995, November). *Factors related to persistence in engineering: Results of a qualitative study*. Paper presented at the Annual Meeting of the Mid-South Educational Research Association, Biloxi, MS.
- Madkins, J. B., & Mitchell, C. E. (2000, February 21-26). *Establishing a "level playing field" for minority students on predominantly Anglo university campuses*. Paper presented at the National Association of African American Studies & National Association of Hispanic and Latino Studies: 2000, Houston, TX.
- Malcom, S. M., Van Horne, V. V., Gaddy, C. D., & George, Y. S. (1998). *Losing ground: Science and engineering graduate education of Black and Hispanic Americans*. Washington, DC: American Association for the Advancement of Science.
- Marwick, J. D. (2004). Charting a path to success: The association between institutional placement policies and the academic success of Latino students. *Community College Journal of Research & Practice*, 28(3), 263.
- Morrison, C., & Williams, L. E. (1993). Minority engineering programs: A case for institutional support. *NACME Research Newsletter*, 4(1).
- Nevarez, C. (2001). *Mexican Americans and other Latinos in postsecondary education: Institutional influences*. Charleston, WV: ERIC Clearinghouse on Rural Education and Small Schools.
- Nora, A., Kraemer, B., & Itzen, R. (1997, November 6-9). *Persistence among non-traditional Hispanic college students: A causal model*. Paper presented at the 22nd Annual Meeting of the Association for the Study of Higher Education, Albuquerque, NM.

- Pantano, J. (1994, May 22-25). *Comprehensive minority SEM programs at Santa Fe Community College*. Paper presented at the 16th Annual International Conference of the National Institute for Staff and Organizational Development on Teaching Excellence and Conference of Administrators, Austin, TX.
- Peng, S. S., et al. (1995). *Understanding racial-ethnic differences in secondary school science and mathematics achievement*. Washington, DC: National Science Foundation.
- Pong, S.-I., Hao, L., & Gardner, E. (2005). The roles of parenting styles and social capital in the school performance of immigrant Asian and Hispanic adolescents. *Social Science Quarterly (Blackwell Publishing Limited)*, 86(4), 928.
- Ramirez, R., Jr., Laurel, E. G., & Rodriguez-Aguilar, C. (1999, March 28-31). "*Como que no puedo!*" *Strategies for the recruitment and retention of Hispanic females into mathematics and science post-secondary programs and careers*. Paper presented at the Annual Meeting of the National Association for Research in Science Teaching, Boston, MA.
- Reyes, O., Kobus, K., & Gillock, K. (1999). Career aspirations of urban, Mexican American adolescent females. *Hispanic Journal of Behavioral Sciences*, 21(3), 366-382.
- Rodriguez, A. J. (1997). *Counting the runners who don't have shoes: Trends in student achievement in science by socioeconomic status and gender within ethnic groups*. *Research monograph*. Madison, WI: National Institute for Science Education.

- Rumberger, R. W., & Larson, K. A. (1992). *Keeping high-risk Chicano students in school: Lessons from a Los Angeles middle school dropout prevention program*: California University System.
- Science and technology: Public attitudes and understanding. (2004). Retrieved May 24, 2006, from <http://www.nsf.gov/statistics/seind04/c7/c7h.htm>
- Simpson, J. C. (2001). Segregated by subject - racial differences in the factors influencing academic major between European Americans, Asian Americans, and African, Hispanic, and Native Americans. *Journal of Higher Education*, 72(1), 63-100.
- Smith, T. M. (1995a). *The educational progress of Hispanic students. Findings from "The condition of education 1995," no. 4*. Washington, DC: National Center for Education Statistics.
- Smith, T. Y. (1995b, May 28-31). *The retention status of underrepresented minority students: An analysis of survey results from sixty-seven U.S. Colleges and universities*. Paper presented at the 35th Annual Forum of the Association for Institutional Research, Boston, MA.
- Sondgeroth, M. S., & Stough, L. M. (1992, April). *Factors influencing the persistence of ethnic minority students enrolled in a college engineering program*. Paper presented at the American Educational Research Association, San Francisco, CA.
- Sorge, C., Newsom, H. E., & Hagerty, J. J. (2000). Fun is not enough: Attitudes of Hispanic middle school students toward science and scientists. *Hispanic Journal of Behavioral Sciences*, 22(3), 332-345.

- Sosa, A. (1993). *Thorough and fair: Creating routes to success for Mexican-American students*. Charleston, WV: ERIC Clearinghouse on Rural Education and Small Schools.
- Stanton-Salazar, R. D. (1997). A social capital framework for understanding the socialization of racial minority children and youths. *Harvard Educational Review*, 67(1), 1-40.
- Stanton-Salazar, R. D., & Dornbusch, S. M. (1995). Social capital and the reproduction of inequality: Information networks among Mexican-origin high school students. *Sociology of Education*, 68, 116-135.
- Stough, L. M., & Songeroth, M. S. (1994, January 27-29). *Minority students who persist: A three-year study of undergraduate engineering majors*. Paper presented at the Annual Meeting of the Southwest Educational Research Association, San Antonio, TX.
- Swail, W. S. (1995). *The development of a conceptual framework to increase student retention in science, engineering, and mathematics programs at minority institutions of higher education*. George Washington University.
- Swail, W. S., Cabrera, A.F., Lee, C., & Williams, A. (2005). Part III: *Pathways to the bachelor's degree for Latino students*. Washington, DC.: The Educational Policy Institute. <http://educationalpolicy.org/pdf/LatinoIII.pdf>
- Table 3: *Annual estimates of the population by sex, race and Hispanic or Latino origin for the United States: April 1, 2000 to July 1, 2004*. (2005). Retrieved July 21, 2006, from <http://www.census.gov/popest/national/asrh/NC-EST2004/NC-EST2004-03.xls>

- Triana, E. M., & Rodriguez, M. G. (1993). *United-Undidos: Mathematics and science for Hispanics*. Washington, DC: American Association for the Advancement of Science.
- Valdez, V., & Espino, J. (2003). *Statistics for Latino majority schools in the Chicago public schools: A closer look. Part 2*. Chicago, IL: Joyce Foundation.
- Walters, N. B. (1997, November 6-9). *Retaining aspiring scholars: Recruitment and retention of students of color in graduate and professional science degree programs*. Paper presented at the 22nd Annual Meeting of the Association for the Study of Higher Education, Albuquerque, NM.
- Weaving the web of MSE success for minorities: Top ten colleges and universities report*. (1997). Washington, DC: Quality Education for Minorities Network.
- Yan, W., & Lin, Q. (2005). Parent involvement and mathematics achievement: Contrast across racial and ethnic groups. *The Journal of Educational Research*, 99(2), 116-127.