OVERVIEW OF HISPANICS IN SCIENCE, MATHEMATICS, ENGINEERING AND TECHNOLOGY (STEM): K-16 REPRESENTATION, PREPARATION AND PARTICIPATION

—Prepared for the Hispanic Association of Colleges and Universities—

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Currently, Latinos represent only 3% of the labor force in the areas of science, technology, engineering and mathematics even though the number of Hispanics has increased dramatically in the U.S. population (Nevarez, 2001; Walters, 1997; Young, 2005). Despite the need to train this needed work force internally *and* in spite of the demand for highly-skilled workers in science-related specialties (Oaks, 1990), efforts have not been seriously undertaken to train Hispanics for these jobs, the fastest growing populace in the country. Rather, Hispanics are more likely to be found in food service-related occupations, construction, janitorial services, and in factories, a contrast to Asians, themselves recent immigrants, that are represented more in health-related fields and in specialized professional areas such as engineering and law (Wilson, 2003).

Adding to the dilemma is the reality that a large percentage of baby boomers are nearing retirement in STEM occupations (Barton, 2003; Maple & Stage, 1991). It has been predicted that by the end of the decade STEM employment opportunities in this country will have increased by nearly 50% (National Science Foundation, 2000). Increasing the percentage of Hispanics and other non-Asian minorities in STEM occupations is not only ethnically and morally correct, as these traditionally under-represented groups deserve equal access to STEM fields, but allows minority groups to serve as role models and mentors for younger members of their own ethnic/racial group (Bonous-Hammarth, 2000; Grandy, 1998).

The importance of increasing the number of undergraduate Hispanic students completing degrees in science, mathematics and engineering has been recognized by Congress in the Goals

2000 Educate America Act (section 102, 5Biii). In response, the federal government has allocated billions of dollars to increase funding earmarked for post-secondary STEM programs (United States Government Accountability Office, 2005). Unfortunately, the majority of these programs has not been theoretically-grounded; research specific to identifying the academic, cognitive, and social factors influencing Hispanic access and persistence in STEM fields appears to be limited and largely fragmented. The following paper will summarize the literature to date regarding the encouragement, recruitment, and access of Hispanic students into STEM fields as well as their persistence in the major in an attempt to identify theoretically-sound recommendations for policy and practice. Potential areas for future research are also highlighted.

Pre-College Circumstances and their Impact on Field of Study

Science literacy among the U.S. population lags far behind that of other developed countries. Implicit in this statement is the notion that the quality of science education in our elementary and secondary schools is not as rigorous compared to Asian and European countries. Students, particularly those of racial and ethnic descents, have little understanding of science concepts such as photosynthesis and DNA, or even the simple fact that the earth revolves around the sun. Understandably, an awareness of scientific information is lacking among the general population but more specifically among minority and low-income students (National Science Foundation, 2004). Exacerbating the situation is unawareness on the part of science teachers of the subtle misunderstandings that these students bring into the classroom that make it difficult for them to conceptually grasp scientific material. Subsequently, the number of qualified students to study science, engineering and mathematics after high school graduation is exceptionally minimal.

Latino Students and the Sciences in K-12. At present, only 4% of Hispanic high school graduates are mathematically proficient, compared to 20% of their white counterparts (Barton, 2003). Gaps in reading and mathematics performance between Latinos and Whites appear as earlier as age 9 and persist through graduation (Smith, 1995a). In addition, a gender gap is also evident, with Latinas scoring lower on the ACT scores than Latinos (Rodriguez, 1997). Although Latina students may enroll in higher level math and science courses in high school, they face stereotypes and gender-based differences in communication when they enter those classes. Instructional approaches such as collaborative learning styles and holistic perspectives that are more in line with female ways of acquiring knowledge are often not used in classroom instruction (Ramirez et al, 1999; Swail, Cabrera, Lee & Williams, 2005).

Subgroup differences are also found as Cuban American students are the only Hispanic subgroup that performs on par with majority students; Mexican Americans, the largest Latino subgroup in the country, tend to score lower on standardized tests (Eamon, 2005; Pew Hispanic Center, 2004). Even among second- or third-generation minorities, scores do not significantly improve over time (Pew Hispanic Center, 2004).

Notwithstanding, data from the 1988 cohort of the National Education Longitudinal Study reveals that minority students are equally as enthusiastic about pursuing science and math careers as majority students at an early age, but face difficulties in developing their skills and engaging in those interests because oftentimes their academic and home environments have few resources to foster their learning in science and mathematics (Peng *et al*., 1995). For example, a case study of a middle school Space Science Education Program (Sorge, 2000) uncovered that Hispanic students had difficulty perceiving themselves as scientists, even though they expressed

an interest in science. They believed that it would require being exceptionally bright to succeed in that field.

Perhaps because of the poor quality of the high school curriculum in those school districts where many Hispanic students are enrolled, they do not develop or maintain an interest in science or math (Eamon, 2005). The current system used for funding school districts is not equal across those districts and Hispanic students are less likely to have access to challenging, high-quality math instruction, computers and calculators further discouraging an interest in mathematics or science (Berry, 2005; Chacon, 2000; Triana & Rodriguez, 1993).

Under-representation of Hispanic College Students in STEM Majors

Filling the pool of qualified applicants for possible employment in science and technology fields will require a growing number of Hispanics, African American, Native American and women entering and earning degrees in STEM majors, groups traditionally underrepresented in those areas (Oakes, 1990). Unfortunately, disproportionately low rates of Hispanics currently pursue and attain degrees in STEM fields (Oakes, 1990; Young, 2005). The number of under-represented students that actually graduate with a STEM degree is of even greater concern because so few Hispanic students are found in those fields. Nearly half of all students that declare majors in engineering or science do actually graduate with a degree in either area (Young, 2005).

Data from the Integrated Postsecondary Education Data System (IPEDS) Completion Survey for the 1999-2000 academic year points out that the most popular majors in which Hispanic students earned bachelor's degrees were in the social sciences, business, psychology, and education. In contrast, Hispanic students were less likely to earn undergraduate degrees in biological and life sciences, computer and information sciences, engineering, and the health

professions and related sciences. These discrepancies that exist at the undergraduate level are also seen at the master's and doctoral levels, as Hispanic students are more likely to earn degrees in education and are less likely to earn a master's degree in the health professions, engineering, computer information sciences, and business in the 1999-2000 academic year (Llagas & Snyder, 2003; add study).

Fortunately, the number of students enrolling in STEM fields is on the rise. Student enrollment in STEM fields from 1995-1996 to 2003-2004 increased 21%, compared to an increase of 11% in non-STEM areas. During that same time period, the percent of Hispanic students enrolling in STEM fields increased by 33%, representing 10% of students in STEM fields (United States Government Accountability Office, 2005). While the number of Hispanic students declaring a major in a STEM field has increased, the literature is sparse regarding what factors could possibly increase the number of Hispanics wanting to pursue a math or science career or, better still, what factors instill a desire to remain enrolled in a math or science major. There are many Hispanic students that do not persist in their majors and oftentimes settle on less demanding programs of study.

Factors Influencing the Representation of Hispanic Students in STEM Undergraduate Majors

The under-representation of non-Asian minorities and women in STEM fields as an area of research has been examined extensively (i.e., Leslie & Oaxaca, 1997) but, unfortunately, has primarily focused on women and/or graduate STEM education with limited findings on undergraduates. The following section will summarize those factors (i.e. academic, cognitive, and socio-cultural) that to date have been found to impact the access and participation of Hispanic students in STEM fields.

Academic Factors

Prior Mathematics and Science Academic Achievement. Reliably, the most convincing predictor of mathematics participation appears to be prior achievement in mathematics (Gross, 1993). With that in mind, the low level of Hispanic enrollment in college mathematics is not surprising; a mere 4% of twelfth-grade Hispanic students score at or above the Proficient level on the NAEP mathematics assessment (i.e. demonstrating an understanding of statistical, algebraic, geometric and special reasoning). The figure compares to 20% for white and 34% for Asian students. While no studies exist that identify a specific NAEP score required for students to successfully complete a STEM degree after high school, it can be assumed that it is probably not much lower than at the Proficient level. Regardless, the excessively low representation of Hispanics scoring above the Proficient level makes it difficult to increase the engagement of Hispanics in STEM fields (Barton, 2003). Correspondingly, mathematics preparation prior to enrollment in college has been found to positively impact students' interest in science as a major and future career (Astin & Astin, 1992) and has been shown to hold true for minority students specifically (Grandy, 1998).

Prior Academic Experiences. Hispanic students have fewer opportunities to develop science and mathematics skills in elementary and junior high schools in contrast to white students (Oakes, 1990). Data from the Early Childhood Longitudinal Study indicate that as early as kindergarten Hispanic students score an average of 6 points lower than white students (Swail, Cabrera, Lee & Williams, 2005), a finding attributed to the lack of participation of Hispanic children in preschool programs (Pew Hispanic Center, 2005). Cumulatively, Hispanic students with limited participation in early childhood educational programs are more likely to move through the K-8 mathematics curriculum at substantially slower rates than white students (Gross,

1993), leading to limited opportunities to participate in advanced coursework in mathematics (Clewell & Anderson, 1991; Swail, Cabrera, Lee & Williams, 2005). As a consequence, limited academic experiences in mathematics and science prior to high school negatively affects interests in and access to STEM occupations for many Hispanic students.

***Misperceptions on the Part of Students*.** Findings by Gamoran (1987) and Henig (1996) indicate that minority students use different criteria when defining an appropriate curricular program (as cited in Simpson, 2001). Non-minority students view "general coursework" as academic or college preparatory courses and begin to develop educational and occupational aspirations as early as eighth grade and begin to make occupational decisions such as taking college-prep courses and engaging in extracurricular activities (Stage & Hossler, 1989). Minorities, on the other hand, view general coursework as separate from a college-prep curriculum which can be taken at any point in time during high school.

Compounding Hispanic students' often misguided perceptions of what constitutes a "required coursework" is the disproportionate number of Hispanic and African American students assigned or incorrectly placed in lower level courses based on faulty achievement test scores. Placing students in mathematics and reading classes based on academic ability, referred to as ability grouping, is common practice in middle and high schools. As can be anticipated, white students are more likely than Hispanic or African American students to be placed in "high ability" courses and will more likely be afforded learning opportunities that prepare them for advanced mathematics courses in high school, leading to interests in STEM majors and enrollment in appropriate college-level math and science courses (Catsambis, 1994).

The number of mathematics, science, and English courses taken by high school students serves as a major predictor of choosing a college major in the sciences, technology, engineering

or mathematics, and is related to student persistence (Astin & Astin, 1992; Simpson, 2001). This fact, while positive for non-minority students, creates a barrier for minorities. Lower-achieving students, disproportionately Hispanic and African American, are forced to enroll in general curricula or are tracked into vocational programs that require a limited number of science and mathematics courses. In the end, minorities are unlikely to be prepared for high school and/or college level STEM coursework (Oakes, 1990; Peng, Wright, & Hill, 1995; Simpson, 2001).

Institutional Choice. The type of institution that a student selects to attend has been cited as a factor influencing access to and participation in STEM fields for Hispanics. Students who attend a four-year institution and arrive on campus with a strong research focus have been found to be more likely to major in engineering as opposed to majoring in business or the physical sciences (Astin, 1993). Unfortunately, because Hispanic students are unlikely to possess an appropriate academic preparation as has been previously noted, less than half of those graduating from high school qualify to enroll at a four-year institution immediately following graduation (President's Advisory Commission, 2002). The majority of Hispanic students (68%) are much more likely to attend a community college than white students (Pew Hispanic Center, 2005; Arbona & Nora, 2005). Consequently, fewer and fewer Latinos enter into STEM majors.

Cognitive Factors

Attitudes/Beliefs/Perceptions toward STEM. Cognitive dispositional characteristics are defined by psychological, emotional, physiological, and behavioral tendencies that reflect an individual's perceptions and interactions with, and responses to, his or her surrounding environment. Earlier studies established that two cognitive factors are related to the enrollment and completion of non-required (or college preparatory) science and mathematics courses - a student's interests in math and science topics and their self-efficacy regarding both (Lantz &

Smith, 1981). More recent studies indicate that all ethnic groups have equally positive attitudes and similar aspirations for STEM careers. However, as minority students progress through their academic careers their interests in science and mathematics weakens as student achievement in these classes declines (Wright, & Hill, 1995). One study (Catsambis, 1994) found, however, that Hispanic attitudes toward mathematics remained positive despite low levels of achievement during junior high and high school.

Self-efficacy. Empirical findings indicate that students are more likely to sign up for math courses if they have high levels of self-efficacy in this area (Meece, Parsons, Kaczala, Goff & Futterman, 1982). Leslie, McClure and Oaxaca (1998) found that the probability of choosing engineering or science increases with students' perceptions that they possess a solid science/math background and in the belief that he or she has the ability to perform well in those courses. The study substantiated the conclusion by Post-Kammer and Smith (1986) that self-efficacy was the strongest predictor in the consideration of mathematics as a career choice. The importance of self-efficacy in predicting performance in mathematics for Hispanics as well as their motivation has most recently been validated by Stevens, Olivarez, Lan, and Tallent-Runnels (2004). Unfortunately, Leslie, McClure and Oaxaca (1998) also observed that minority students have lower self-efficacy when it comes to science and mathematics as compared to white students. In the latter study (Stevens, Olivarez, Lan, & Tallent-Runnels, 2004), the finding was also substantiated using a Hispanic student population. In the end, Hispanic students often have difficulty perceiving themselves as scientists, even when they express an interest in science careers (Sorge, Newsom, & Hagerty, 2000).

Socio-Cultural Factors

Quality of Academic Preparation. Over and over again, studies reveal that a lack of sufficient mathematical and science training at the elementary and secondary levels negatively affect the academic preparation of students as well as their interests in high school mathematics and science coursework and in pursing a STEM career (Eamon, 2005; United States Government Accountability Office, 2005). In combination with the aforementioned prevalence of "tracking" Hispanic students into lower level mathematics and science courses, it appears that the quality of the academic preparation many Hispanic students receive is negatively impacted by disparities among teacher quality, school funding, and monies spent on instructional resources. Hispanic students are more likely to be taught science by teachers not majoring in that field or when they have earned a science degree they are inexperienced teachers. Hispanic students are also more likely than white students to be exposed to funding inequities in the K-12 educational system (Young, 2005). Overall, the current system used for funding school districts is not equal across districts and Hispanic students are less likely to have access to challenging, high-quality math instruction, further discouraging an interest in mathematics or science (Berry, 2005; Chacon, 2000; Triana & Rodriguez, 1993).

Social Experiences. Peer influence has also been shown to inspire students' decisions to major in a STEM field. Astin and Astin (1992) found that the most consistent environmental influence on a student's choice of major is the number of friends and peers that students possess or knew that were seeking a degree in that field of study. In addition to the overall influence that is exerted by peers to seek a STEM degree, among Latina students patterns of socialization differ for those aspiring toward more traditionally male-dominated careers (Reyes, Kobus, & Gillock, 1999). These female Hispanic students report a greater preference for socializing with a more

heterogeneous group when compared to Latinas aspiring toward a traditionally female-dominated career. Perhaps the exposure to a more diverse group of aspirations, career possibilities and thoughts that are not gender-restricted may offer Latinas much more options including majoring in STEM fields.

Moreover, even the anticipation of major social events in the lives of Hispanics has a consequence on their choice of majors. Leslie, McClure and Oaxaca (1998) hit upon the finding that for Hispanic men, marriage or plans for marriage had a positive effect on selecting engineering or science as a major. For Hispanic women, marriage plans were found to have the largest negative effect on the probability of majoring in the biological sciences. It could be argued that the anticipation of major family responsibilities may discourage Latinas from seeking what could be perceived as long academic careers such as medicine or doctoral programs.

Mentoring Encounters. More recently, mentoring has been noted as an instrumental force in the participation of minorities in STEM fields (United States Government Accountability Office, 2005). Although not from a formal mentoring perspective, Grandy (1998) found that the most important variable impacting high-ability minority students' science ambition and persistence in the major was the support they received from minority "mentors" which they defined as having a minority role model in college (e.g. science faculty, doctoral students), receiving different forms of support from advanced undergraduate students of the same ethnic group, and having access to a dedicated minority relations staff. One of the biggest problems facing colleges with regard to STEM fields of study is persistence in the major or keeping minority students interested in science past their first year in college. The largest effects that were exerted on a commitment to science in Latinos' sophomore years were the direct and indirect effects of minority support. Because a support system provides guidance and advice

through a process (in this case, a student's first-year experience), different aspects of mentoring are made accessible to Hispanic students that encourage their commitments to remain enrolled in the major.

Parental Support. Parental encouragement is one of the strongest influences on Hispanic students' early educational aspirations (Arbona & Nora, 2005). Not surprisingly, Hispanic males living in a household where at least one parent is engaged in engineering or physical science as an occupation are more likely to select engineering as a major (Leslie, McClure, & Oaxaca, 1998). The researchers concluded that having a parent working in an engineering or science-related field is instrumental in forming the belief among Hispanic males that a career in STEM is a realistic goal. In much the same fashion, Latina students that develop an early interest in highly male-dominated careers such as STEM fields are likely to have a better understanding of the steps needed to achieve their career goals and objectives (Reyes, Kobus, & Gillock, 1999).

The importance of a family support system for minority students in developing and encouraging a student's interest in science and mathematics as a career has previously been recognized (Catsambis, 1994). Data from the 1988 cohort of the National Education Longitudinal Study brings to light that minority students are equally as enthusiastic about pursuing science and math careers as non-minority students at an early age. In spite of this early interest, Hispanics face difficulties in developing their skills and engaging in those interests due to a lack of resources needed to foster their learning in science and mathematics (Peng, Wright, & Hill, 1995; Auerbach, 2004).

Factors Specific to Latinas

Gender serves as one of the most powerful and robust predictors of choice of college major for minority students, as female minority students are much more likely to pursue a liberal

arts, health, public service or business degree than a STEM degree program (Simpson, 2001). In turn, minority women are currently the most underrepresented group in the fields of science and mathematics. Despite this gross inequity, few researchers have attempted to understand how women of color perceive and experience science and mathematics. What is known is that differences in attitudes can be seen as early as junior high school, at which time Latina students are more afraid to ask questions during class discussions, less likely to report that they are looking forward to taking eighth grade mathematics classes, and are the least likely of any group to aspire to STEM careers (Catsambis, 1994).

Several cultural features among Latinas may also impact the choices they make as to what careers to pursue. Bowman (1993) and Marin (1993) discovered that Hispanic female students raised in a predominately patriarchal family structure are much more likely to consider STEM careers. Perhaps the encouragement from a father to his daughter to consider "male career options" may counter sexist attitudes that society might associate with specific careers in spite of displaying more traditional gender roles and adhering to loyalty and respect for family. Despite the emphasis (or adherence) to traditional Hispanic views, Reyes, Kobus, and Gillock (1999) also found that Latina students aspiring toward male-dominated careers (e.g. STEM) preferred having "American" friends and preferred using English in conversation.

Factors Influencing the Retention of Hispanic Students in Undergraduate STEM Majors

Although a major emphasis in the literature is the recruitment of Hispanic students into STEM majors and careers because of the under-representation of minority and women, an equal amount of attention should also be paid to research on Hispanic student persistence in the major (Fenske, Porter & DuBrock, 2000). Much more is known regarding those factors that impact

Hispanic students' decisions to remain enrolled in college than those factors that influence the decisions of these students to remain engaged in a STEM major. The following section is limited to findings by Astin and Astin (1992), Grandy (1998), and Barton (2003) who were among the first to attempt to shed light on some prevailing factors that have some bearing on Hispanic persistence in STEM majors.

Prior Academic Preparation. Quite often students decide that a career in science, technology, engineering or mathematics is not what they really want to pursue. The indecision to remain enrolled in a STEM major is quite likely to be influenced by a students' entering mathematics training prior to enrolling in college and his or her academic aptitude (Astin & Astin, 1992). More specifically, student achievement in the form of a grade point average and mathematics SAT scores has been found to be associated with the persistence of undergraduates in STEM majors (Bonous-Hammarth, 2000; Sondgeroth & Stough, 1992). Specific to Hispanics, data gathered from the Educational Testing Service (1989) of students who earned a SAT math score of 550 or higher (referred to as students with high abilities) reported not only higher levels of participation in science and mathematics clubs but were enrolled in decidedly more advanced placement courses and were also more involved in science and math activities in high school. Ultimately, they were more likely to remain in college and dedicated to earning an undergraduate degree in a STEM field (Barton, 2003).

***Commitment to the Major*.** The emphasis on a student's commitment to a specific major once enrolled, as in science, mathematics and engineering, is as important as developing an early interest in STEM fields in K-12. A strong commitment to a STEM major is a compelling predictor of student persistence (Bonous-Hammarth, 2000). Grandy (1998) found that minority students that expressed a deep satisfaction with engineering and science as their major (or

committed to a STEM field as a career) were more likely to persist in those majors. Interestingly enough, though, the investigator found that serving as a role model or leader on campus pulled the students away from a commitment to science. Those students that placed more value on leadership or service were actually more likely to change majors. One could speculate that the time and effort that is necessary to succeed in a science or mathematics-related field is very demanding so that it leaves very little time for a student's social integration on campus. Involvement in such organizations as student government, political groups or even athletic support groups pull students away from their studies and laboratory time.

The importance of having a personal commitment to a STEM field and its impact on Hispanic student persistence in the major has been substantiated by the Educational Testing Service (1989) (as cited in Barton, 2003). Persisting in a science, technology, engineering or mathematics major is highly dependent on the degree of commitment that Hispanic students bring with them as they enroll in college.

Quality of Instruction. Quite often, students report that they change majors to a non-STEM degree simply because of the poor quality of the instruction they receive at the university level (United States Government Accountability Office, 2005). On the other hand, a positive satisfaction with the quality of a student's academic program has been cited as a leading factor in degree attainment for both minority and non-minority students (Eimers, 2001). Findings provided by the Educational Testing Service (1989) note that when high achieving minority students perceive their science, mathematics or engineering coursework as enjoyable, those students are much more likely to persist in their chosen field (as cited in Barton, 2003).

A carryover effect of the student's commitment to a STEM field and interest in his or her field is that it assists faculty in teaching classes and it opens opportunities for students to conduct

research independently or with faculty (Astin & Astin, 1992). In return, these experiences serve to increase the student's satisfaction with their major, faculty members and their overall academic experience. Among biology science majors, the existence of a student-centered faculty is unquestionablely related to the overall satisfaction of students with the curriculum and faculty.

Satisfaction with faculty is often driven by different factors as, for example, the expectation that regardless of the major that students have chosen, the coursework is much more practical-oriented rather than theoretical in nature. Among physical science majors, the existence of a strong research faculty only serves to pull students away from the major and to be dissatisfied with their program of study. While Astin and Astin (1992) hypothesized that the finding is likely the result of the dominant use of teaching assistants among research faculty, a more acceptable speculation is that the degree of attention that is paid to scientific findings and investigation is not what the students expected in class.

Type of Institution Attended. As is often the case with other outcomes, the type of institution that students attend appears to impact student persistence in STEM fields. Astin and Astin (1992) first established that students attending small four-year institutions were more likely than not to persist in their science majors. In a later study where different student subgroups were studied, Grandy (1998) found that minority students enrolled in four-year colleges as opposed to attending a community college during their sophomore years were more likely to complete a STEM major.

Financial Aid. Because science, engineering and mathematics degrees often take longer to complete than other college majors, financial aid takes on an added importance in retaining students in those programs (Barton, 2003; Fenske, Porter, & DuBrock, 2000). As such, the importance of financial aid on keeping Hispanic students interested and enrolled in STEM

majors/careers cannot be overstated. The availability of adequate financial resources has been rated as one of the top five factors related to the persistence of minority engineering students by The National Action Council for Minorities in Engineering (Landis, 1985).

Brief Overview of Interventions, Policies and Practices

Currently, there are more than 200 education programs across the country specifically designed to increase the number of students pursuing and graduating with STEM degrees and entering STEM-related occupations or to improve programs in the areas of science, mathematics, engineering and technology (United States Government Accountability Office, 2005). Many of these programs focus on moving Hispanic students through the K-12 pipeline by impacting student achievement, promotion and graduation (e.g. No Child Left Behind Act, The College Board's Equity 2000 program, Project GRAD, Gaining Early Awareness And Readiness for Undergraduate Programs). At the post-secondary level, local, state and federal efforts provide students access to pursuing STEM occupations. Specifically, those initiatives target underrepresented populations, such as non-Asian minorities, women and students with disabilities by providing support services in addition to those found at their educational institutions and positive academic experiences (United States Government Accountability Office, 2005).

One example is the Meyerhoff Scholars Program, the nation's leading producers of minority graduates in STEM fields. The program successfully retains a large number of minority students by providing support to students beginning in their high school freshman year and extending through graduation. As part of the overall project, a Summer Bridge program provides minority students with science, math, and humanities coursework, extensive summer research

experiences, mentors from professional and academic STEM fields, merit scholarship support and advocates the use of university student services (Hrabowski, 2003).

In spite of the fact that federal agencies are spending billions of dollars to help support STEM education programs, of which nearly half are sponsored by the National Institutes of Health (NIH) and the National Science Foundation (NSF), program evaluations have been completed for only 43 programs, most of which simply report that they have met their goals and objectives but provide no empirical or scientific evidence. Moreover, evaluations have yet to be completed for more than 100 programs. The implication of this current state of affairs is that the multiple goals targeted for a diverse group of students have not been examined as to their effectiveness and efficiency in meeting those goals. These goals include the recruitment and academic preparation of minority students in STEM-related coursework, the attraction of students to pursue STEM degrees, the provision of research opportunities to STEM students, the recruitment of graduates into STEM careers, and the improvement of the overall education provided to STEM students (United States Government Accountability Office, 2005).

Sadly, not enough is known about the effectiveness of the programs on recruiting students to and retaining students in STEM majors. Of the more than 100 programs not yet evaluated, 17 have been operating for more than 15 years (United States Government Accountability Office, 2005). Clearly there is a need to carefully evaluate the effectiveness of those programs that promise so much for different student populations.

Recommendations for Policy and Practice

Although large-scale evaluations of different STEM programs are still needed to inform practice and intervention, several key recommendations are evident. The following suggestions are based on the limited research that has been conducted to date:

1. ***Early intervention.*** One clear implication of the findings presented is that interventions aimed at Hispanic students must begin as early as elementary school so that career aspirations in science, technology, engineering and mathematics fields are formed and sustained throughout the K-12 system. Specifically, issues related to career choices, student academic self-efficacy, interactions between family and the student's school, and discussions focused on the importance of math and science college preparatory courses should be addressed and engaged in as early as elementary school (Fouad, 1995).
2. ***Raise participation and achievement in math and science at all educational levels***. There is no doubt that increasing Hispanic representation in STEM fields involves improving their high school achievement, their completion rates, their entry into a postsecondary institution and, ultimately, their degree attainment (Barton, 2003). Improvement must begin by eliminating the initial achievement gaps that currently exist even at the kindergarten level. Substantial evidence establishes that early intervention in the form of preschool programs that focus on pre-literacy skills and support for healthy development effectively eliminates the achievement gap before children enter the educational system (Gandara, 2006). Participation and success in mathematics and science in middle school leads to participation and success in mathematics and science in high school. The key to increasing the number of STEM majors and graduates at the undergraduate level is to increase the overall mathematics and science competencies among all high school students, namely Hispanics and African Americans (Astin & Astin, 1992).
3. ***Family and peer influence should not be overlooked.*** Although academic preparation at all educational levels appears to be a necessary attribute for the successful entry of Hispanic students into the STEM workforce, it does not guarantee a successful outcome. The

importance of family and culture must also be recognized (Ramirez, Laurel & Rodriguez-Aguilar, 1999). Family support and encouragement in different forms are critical to the development of STEM career aspirations on the part of Hispanic students and to the commitment to persist in the major (Leslie, McClure & Oaxaca, 1998). Educators must seek and find ways to engage minority parents in math and science projects and discussions (Hrabowski, 2003). Perhaps science projects that require the student and parent to work together could be part of after-school or summer programs. As for the role of peers in influencing others to consider math and science careers, Astin and Astin (1992) found that students choose a major based on the number of peers in that field, implying that the ability to recruit and retain Hispanic students in STEM fields is in part dependent on reaching a "critical" mass of Hispanics in each of these areas.

4. ***Academic self-efficacy of Hispanic students.*** Interventions designed to guide Hispanic students toward a STEM academic preparation and, ultimately, to choose careers in STEM fields must also incorporate a component that addresses the student's academic self-efficacy in those areas. Ramirez, Laurel and Rodriguez-Aguilar (1999) suggest students' attitudes toward STEM careers should be a key focus beginning in the fifth grade. The main intent of such interventions is not to focus primarily on academic performance but to also emphasize the affective sphere of influence on student attitudes, aspirations and self-esteem related to STEM areas.
5. ***Improve and expand community college support services provided to Hispanics.*** Grandy (1998) emphatically notes that students' enthusiasm for engineering and science either builds or weakens during the freshman and sophomore years. An important part of building this enthusiasm is the existence of a minority support system that provides the social capital

necessary to maintain interest in those fields, often not present at two-year institutions. Grandy suggests that two-year colleges must link minority students interested in STEM careers with minority faculty and advanced undergraduate and graduate students at nearby universities. One means of initiating those connections is by establishing a series of brown bag seminars, lectures or presentations by research faculty (minority and non-minority) where several classes during a specific time period would be required to attend.

6. ***Amount of financial aid and length of repayment provided to Hispanic STEM majors.*** Traditionally, the total number of hours that are required to earn an undergraduate degree in STEM fields far outnumber those in many other majors. The implication is that more hours require more financial assistance to pay for tuition, fees and related educational costs. Consequently, the larger number of hours that are required in math and science majors means larger student debt when they graduate. Perhaps more students would develop or sustain an interest in those careers if they felt that additional time was provided to them before they would be required to repay their loans; time enough to establish themselves in a new job, particularly students in those fields that are highly competitive and where it is difficult to find jobs (Fenske, Porter & DuBrock, 2000).

A FINAL NOTE

A major predicament with the research on Hispanic students in STEM fields and careers and the evaluation of federal- and state-sponsored STEM programs is the extreme lack of theoretically-sound longitudinal databases and empirical studies. By and large, state and national databases are not informed by a body of scientifically-driven evidence suggesting which variables should be collected and tracked year-to-year. Databases do not exist at the institutional level that incorporate the kinds of constructs necessary to capture the underlying structural

patterns among different STEM- and nonSTEM-related variables. Although there is much information, findings and implications all focused on Hispanic student retention, achievement and degree attainment, researchers and practitioners should not simply apply that body of knowledge or conceptual frameworks to Hispanic students enrolled in STEM majors to inform practice and policy. A shortfall of that approach is the focus on persistence to graduation only and not on persistence in the major. The two, while significantly interrelated, do not represent the same issue. Moreover, it may not be prudent to cluster all Hispanic students into one STEM category as there may be significant differences among the processes affecting the persistence in the major for different majors and different subgroups of Latino students.

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