STEM

STEM Professions: Opportunities and Challenges for Latinos in science, technology, engineering, and mathematics

A REVIEW OF LITERATURE

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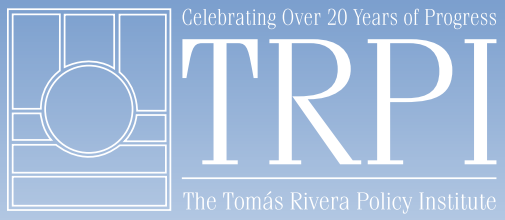

The Tomás Rivera Policy Institute (TRPI) advances informed policy on key issues affecting Latino communities through objective and timely research contributing to the betterment of the nation.

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The Tomás Rivera POLICY INSTITUTE

C·E·N·T·E·R for LATINO Educational Excellence The Tomás Rivera POLICY INSTITUTE

The Center for Latino Educational Excellence (CLEE) was established as a major initiative of the Tomás Rivera Policy Institute in the spring of 2002 to help improve educational attainment and achievement in Latino communities across the United States. Through its policy research, CLEE seeks to provide guidance for Latino leadership — across public, non-profit, and private sectors — on how to better the current systems of education that are, on many levels, failing Latino youth and adults.

Introduction

The United States has the best innovation ecosystem[1] in the world (President's Council of Advisors on Science and Technology [PCAST], 2004). Yet, current trends threaten this ecosystem. Students in the United States have weak math and science skills compared with those in the rest of the world. Even students at the top tier pursue careers in science, technology, engineering, and mathematics (STEM) at significantly lower rates in the U.S. than in other countries. There is a dramatic global shift in technical and scientific talent from the U.S. to Asia, which will have a significant impact on the research and development (R&D) global infrastructure. The (PCAST) report underscores the need to "protect the nation's innovation ecosystem" to maintain U.S. global economic leadership.

The number of U.S.-trained STEM professionals is not enough to meet the country's needs.

The number of U.S.-trained STEM professionals is inadequate to meet the nation's needs, given current pipeline and participation rates. Moreover, the diversity in race/ethnicity of the population is not reflected in the population of STEM professionals. Demographic trends reinforce this shortage and indicate that an increasing number of STEM professionals will soon be retiring. For example, half of all engineers in the United States will retire with the "baby boom" generation (U.S. Congress, 2006). Without counteracting factors, the estimated ratio of 22-year-olds who will earn scientific and engineering bachelor's degrees (out of the total number of 22-year-olds who graduate with bachelor's degrees) and could enter a STEM profession in the United States will continue to drop (National Science and Technology Council, 2000). Furthermore, the flow of international students, scientists, and engineers to the U.S. has decreased as other countries recognize the economic importance of a technical workforce and implement policies that entice their citizens to remain (National Science and Technology Council, 2000). Thus, it is imperative to encourage more U.S.-based individuals to consider STEM-related fields. This emergent need presents an opportunity for the growing population of Latinos[2] in the U.S.

This report synthesizes existing literature regarding Latino participation in STEM-related fields. It describes in detail trends in degree attainment and employment levels for these fields, and chronicles various obstacles and opportunities affecting Latino representation.

STEM Professions: An Opportunity Waiting for Latinos

The Latino population is the fastest growing ethnic group in the U.S. It has rapidly increased in the past decade and is expected to continue its growth. Latinos accounted for 14.5 percent of the population in 2005, and it is estimated that they will constitute 25 percent of the total population by the middle of this century (American Community Survey). However, Latinos are poorly represented in STEM fields in terms of degree attainment and participation in STEM professions. Additionally, among non-white races/ethnicities, Latinos also suffer from a worse gender gap in STEM careers (more men than women) compared with Asians and African Americans.

[1] The innovation ecosystem encompasses "inventors, technologists, and entrepreneurs; a motivated workforce; world class research universities; highly productive research and development (R&D) centers (both industrially and federally funded); a vibrant venture capital industry; and government funded basic research focused on areas of high potential" (PCAST, 2004).

[2] For this report we use the terms Hispanic and Latino interchangeably in reference to persons tracing their ancestry to the Spanish-speaking regions of Latin America and the Caribbean.

Trends in Degree Attainment

Latinos are underrepresented in all parts of the nation's higher education pipeline, and the degree of underrepresentation increases at higher education levels. Chapa and De La Rosa (2006) examined Latino population growth and participation in STEM higher education. Their data from the National Science Foundation showed that only 728 (4%) of all doctoral degrees in STEM fields were awarded to Latinos in the U.S. in 2001. In academic year 2002-03, Latino STEM graduates accounted for 6 percent of all graduates at the bachelor's level, one percent at the master's level, and 2 percent (544) at the doctoral level (National Science Foundation Report, *Science and Engineering Indicators*, 2006). Moreover, Chapa and De la Rosa noted that among Latinos, 43 percent of Ph.D.s in science and engineering granted in 2001 went to temporary visa holders, rather than to Latinos who were raised and educated in the United States.

Few Latinos enter the educational pathway that leads to a STEM degree, and among those who do, many fail to complete the process.

Latino underrepresentation at the graduate level is similar to trends found at the undergraduate level. The number of Latino students interested in STEM-related fields increased 33 percent from the 1995-96 to 2003-04 academic year, but this represented onlyt about 10 percent of all students in STEM fields in each academic year (GAO, 2005). However, a significant majority of freshmen STEM majors dropped out or switched to non-STEM majors (Tan, 2002). Fewer than 7 percent of the 578,000 total STEM graduates in 2003-004 were Latinos (GAO, 2006).

Trends in Levels of Employment

The proportion of Latinos employed in STEM fields almost doubled from 5.7 percent to 10.0 percent between 1994 and 2003 (GAO, 2005). However, Latino representation in STEM-related fields was still lower than Latino representation in the civilian labor force. Although Latinos accounted for 13 percent of the civilian labor force, they represented only 10 percent of the STEM workforce (GAO, 2006).

In 2006, Latinos represented only 10 percent of the STEM workforce.

Trends among Latino Women

In 2005, Latino women received 60 percent of all undergraduate degrees conferred to Latinos, but only 37 percent of STEM-related degrees (Excelencia in Education, 2007). In 2003, women accounted for about one quarter (26%) of all STEM workers (CPST 2005). Compared with the overall percentage of women in STEM careers, Latinas do not lag far behind at 24 percent of the overall Latino STEM workforce as of 2003. However, compared with other races/ethnicities, this figure is low, particularly when compared with Asians (27%) and African Americans (35%).

Challenges Faced by Latinos in Pursuing STEM Degrees

Few Latinos enter the educational pathway that leads to a STEM degree, and among those who do, many fail to complete the process. There are three major reasons for the resulting Latino underrepresentation in STEM careers: the correlated factors of student behavior characteristics, school and institution factors, and family characteristics

(U.S. Department of Education, 2000). Student behavior characteristics include attitudes, aspirations, and academic preparation. School and institution factors include pre-college curriculum and instruction, recruitment and retention programs, and financial aid. Family characteristics include socio-economic status, parent involvement, family patterns, and cultural values.

STUDENT BEHAVIOR CHARACTERISTICS

Elementary and secondary education has an impact on admission into post-secondary schools and selection of a major in college. Latinos as a minority group have been plagued by poor retention and academic preparation, and limited exposure to career information.

High School Retention

The number of Latinos ages 18-24 who are in college is much lower than that of other races/ethnicities. One of the major reasons for this is the elevated high school dropout rate of Latinos. As of 2004, U.S. dropout rates among youth ages 16-24 was 24 percent for Latinos, much higher than the 12 percent for African Americans, and 7 percent for non-Hispanic whites (Child Trends Databank, 2004). Consequently, many Latinos miss the opportunity to even consider STEM, and the high dropout rate significantly contributes to lower Latino participation rates in college and STEM fields (Tornatzky et al, 2006).

Preparation and Skill Deficits

Latino college students are more likely to have deficits in necessary skills. First, they may have inadequate preparation in math and science. Seymour and Hewitt (1997) stress that secondary school academic preparation has a direct effect on postsecondary science and engineering persistence and completion. Second, young Latinos tend to have poor study habits, critical thinking ability, and communication skills. This may be due to factors such as inadequate high school preparation, family and cultural dynamics, shortcomings in institutional policies and practices, or any combination of these. Efforts to address these deficits are usually disorganized or of a limited scope (Tornatzky et al, 2006).

Self-Confidence and Stereotype Threat

Stereotype threat is the fear that one's behavior will conform to an existing stereotype of a group with which one identifies. This fear may lead to an impairment of performance, such as performing poorly on tests of ability (Steele, 1997). In a laboratory experiment of 120 male and female college students, findings indicated that male and female Latinos evidenced ethnicity-based stereotype threat (Gonzales, Blanton and Williams 2002); their awareness of their ethnicity affected their test results.

Aside from stereotype threat, Seymour and Hewitt (1997) discuss their findings which indicate that African American and Latino students suffer from a conflict between over-confidence and poor preparation; a unique psychological difficulty, impairing their persistence in science and engineering programs. Many minority students who choose science and engineering majors come from high schools in which they were viewed as academically outstanding compared with very disadvantaged peers. As a result, they developed strong confidence without having taken any advanced placement classes. These students are often overwhelmed and are at risk of switching to less-challenging majors or dropping out of college altogether.

SCHOOL/INSTITUTION FACTORS

A. Secondary School Factors

Curriculum and Instruction

Holt (2006) conducted a regression analysis of panel data from the National Educational Longitudinal Survey 1988-2000. The number of higher-level math units taken by students in high school and their math self-esteem (that is, a student's self-confidence in math) were found to affect a student's 12th grade math achievement, which was a predictor of persistence in a STEM college major. Advanced math and science courses offer students in-depth learning in these subjects and consequently lead to higher performance (Oakes, 1990; Peng, Wright and Hill, 1995). High expectations combined with intensive curricula compel students to learn, while inferior curricula and poor instruction impair achievement, especially that of vulnerable minority students who have less access to out-of-school learning opportunities compared with their white counterparts (Ware and Lee, 1998; Smith and Walker, 1988; Catsambis, 1994).

A rigorous science and mathematics curriculum is also a requisite for entering college and succeeding in STEM fields. Yet, high schools with large minority populations tend to have less rigorous science and mathematics curricula. Additionally, underrepresented minorities disproportionately take less intensive classes and have little access to more demanding classes even when they are offered. Solorzano (2004) examined access and availability of Advanced Placement (AP) courses, which are tied to college admissions. The study analyzed data regarding various AP courses from 2001-02 Los Angeles Unified School District data and 2000-01 California Department of Education data. In 2000-01, Latinos made up only 16 percent of the student population in the top 50 AP high schools. Gandara (2006) found that Latino students were more likely to be assigned to low curriculum tracks than whites, which affected their potential for entering college and STEM. Additionally, a lack of English proficiency had a strong negative impact on academic and STEM success. Furthermore, Tornatzky et al. (2006) state that a large proportion of Latino students entering college are shunted to needed remedial course work, a situation that often serves as a deterrent to starting college at all, or results in lengthening the time required for degree completion.

High schools with large minority populations tend to have less rigorous science and mathematics curricula.

Learning Opportunities

Students are commonly grouped into three tracks: academic or college preparation, vocational and technology, and general programs. More often than not, minorities have a lesser chance to be in the first track than white students (Ware and Lee 1988; Oakes 1990). Hence, schools that provide curricula via ability grouping tend to compromise the equity of student learning, including learning in math and science (Coleman and Hoffer 1987; Lee and Bryk 1988).

Teachers and Counselors

A growing body of research suggests that schools can make a difference in student achievement, with teachers playing a major role. Studies using the Tennessee Value-Added Assessment System and a similar database in Texas found that teacher effectiveness at the classroom level is a strong determinant of differences in student learning, far outweighing the effects of differences in class size and heterogeneity (Sanders and Rivers, 1996; Wright, Horn, and Sanders, 1997; Jordan, Mendro, and Weerasinghe, 1997). Sanders and Rivers (1996) also found that students who are assigned to several ineffective teachers sequentially have significantly lower levels of achievement and fewer gains in achievement than those who are assigned to several highly effective teachers in sequence. This implies that teacher effectiveness appears to be additive and cumulative. The problem is that minority groups may be more likely to be

assigned to ineffective teachers rather than effective ones. There is evidence that shows strong bias in assignment of students to teachers of different effectiveness levels (Jordan, Mendro, and Weerasinghe, 1997), including indications that African American students are nearly twice as likely to be assigned to the most ineffective teachers and half as likely to be assigned to the most effective teachers (Sanders and Rivers, 1996). Latinos may face the same predicament.

Effective teachers have been cited as crucial in the quality of mathematics and science education. The quality of educators and the level of high school classes influence a student's ability to succeed and to choose STEM fields. However, due to a large shortage of math and science teachers, a large proportion of students are instructed by teachers unprepared in these areas. For two-thirds of all school districts and over 90 percent of districts with high numbers of minority students, the recruitment of qualified math or science instructors is a major challenge (U.S. Congress, 2006). The U.S. Department of Education (2004) revealed that 45 percent of high school students in biology/life science courses and 30 percent in mathematics, English, and social science courses were taught by instructors who had not studied these subjects. Most of these instructors were likely to teach in schools with a large number of underrepresented students. The Education Trust-West found that 44 percent of math courses at high-poverty-level high schools and over 90 percent of such courses at high-poverty middle schools in California were led by teachers without mathematics certification (U.S. Congress, 2006). This situation is exacerbated by the fact that the shortage is expected to persist; it is estimated that at least 2 million new public school teachers will be needed in 2009 (May and Chubin, 2003).

Latinos' high dropout rate contributes significantly to their lower participation in college and STEM fields.

In addition, Latinos often do not have sufficient guidance when making decisions related to college and careers, especially those related to STEM. Informal sources may not have sufficient knowledge to provide advice, and counselors are overworked in high schools and may not have full knowledge of STEM-related career pathways. For example, Tornatzky et al. (2006) suggest that few high school guidance counselors have adequate information about information technology (IT) careers and industries. Finally, there are few relatives or community members who serve as mentors.

Lack of Resources

Lack of educational technology such as computers, calculators, and other tools for math and science has also been shown to inhibit representation. For example, students attending schools with substantial media libraries have been shown to perform better academically (Tomás Rivera Policy Institute, 2002). Studies on the "digital divide" — a term used to describe the gap between individuals with and without technology access — reveal that underrepresented minorities are less likely to have such access. Between 1994 and 1999, the proportion of schools with Internet connections rose from 35 percent to 95 percent. Similarly, the proportion of public school instructional classrooms with Internet connections increased from 3 percent to 63 percent. However, schools in areas with high concentrations of poverty lagged behind. In 1999, less than half (39%) of instructional classrooms in schools in areas of high poverty were connected to the Internet (May and Chubin, 2003). Therefore, low-income minority students, who generally attend these schools, had limited access to resources crucial for understanding science and mathematics as well as access to STEM fields. The lack of resources in the 1990s may be one of the factors responsible for the lower representation of low-income college students majoring in STEM in 2007. Revisiting the data paints a more hopeful picture: as of 2005, 100 percent of public schools with minority enrollment of 50 percent or more had Internet access. Moreover, the ratio of public school students to instructional computers with Internet access was comparable for high-minority level schools (4.1 students per computer) and low-minority level schools (3.0 students per computer) (U.S. Department of Education, Fast Response Survey System, 2005).

B. Post-secondary School Factors

Recruitment, Retention and Financial Aid

Program organization, not availability, is the key to determining STEM outcomes for underrepresented groups. Friedman and Kay (1990) found that while science and engineering enrollment among women and minorities may increase due to strong recruitment programs, retention and completion depend on effective financial assistance efforts (Friedman and Kay 1990; Seymour and Hewitt 1997). Latino families are often unaware of financial aid programs that are available to reduce the cost of higher education (Tornatzky et al., 2006).

Insufficient Guidance and Mentoring

Many post-secondary schools offer inadequate advising and mentoring programs for Latinos. Tornatzky et al. (2006) state: "The colleges and universities that are more successful are more likely to tailor support services in ways that leverage the strengths of Latino culture and family dynamics. For example, there are increasing examples of institutions successfully using peer and group-based support systems with Latino students." This is especially important as underrepresented minorities commonly place primary value on people and groups, and focusing on grades as a main source of personal status may lead to students from underrepresented groups leaving STEM fields (Seymour and Hewitt 1997).

Many post-secondary schools have inadequate advising and mentoring for Latinos.

Research further cites faculty non-responsiveness, poor teaching quality associated with extensive use of teaching assistants, and lack of collaboration as challenges faced by women and underrepresented minorities in science and engineering programs (Seymour and Hewitt 1997).

Institutional Structure and Education Equity

A United States Congress study (2002) reports that, compared with large universities, small liberal arts colleges, community colleges, and historically African American colleges and universities are believed to have strongly contributed to narrowing the gaps related to both gender and race/ethnicity in selection of major and in graduation rates. The report further notes that small liberal arts colleges — with apprenticeship models of education that facilitate close interaction between faculty and students — are better able to provide all students with adequate opportunities for STEM careers. Research also shows that the nationwide community college system has expanded minorities' post-secondary education opportunities in general, and enrollment in science and technology in particular (Brazziel and Brazziel 1994; U.S. Congress 1992; Quimbita 1991).

Latinos are well-represented at the community college level. In 1996, more than half (54%) of Hispanic undergraduates attended community college (May and Chubin, 2003). Enrollment in community college has several advantages, including convenience and affordability. Two-year college institutions could potentially be a valuable source of matriculants into STEM programs. However, the transfer rate to four-year universities remains problematic. According to Adelman (1999), of those who earned science and engineering bachelor's degrees in 1995 and 1996, only 11 percent of African Americans, 15 percent of Hispanics, and 20 percent of American Indians had earned associate's degrees. These percentages are lower than the 26 percent of all students who began their undergraduate careers in a two-year college and then transferred to four-year institutions (May and Chubin, 2003). Possible explanations include miscommunication and misunderstanding regarding prerequisites for majors, degrees, and transfers (ETS, 2006). Many classes at community colleges focus on enhancing job skills and may be difficult to transfer to bachelor's programs. Also, articulation agreements are sometimes problematic (Tornatzky et al, 2006).

FAMILY CHARACTERISTICS

Student behavior characteristics and school/institution factors are not the only determinants in increasing Latino participation in STEM professions. Family characteristics may explain why many students with strong academic achievement leave the college STEM pipeline.

Socio-economic Factors and Financial Difficulties

The low socio-economic status of Latinos is associated with pressures to work and forsake higher education.

The Latino-white achievement gap is well documented in many research articles. One of the key explanations for the gap is the socio-economic factor. Pong, Hao and Gardner (2005) studied the National Longitudinal Study of Adolescent Health, a nationally representative study of 20,000 youth in Grades 7-12, and concluded that socio-economic status is responsible for the achievement gap between foreign-born Latinos and third-generation white students.

The low socio-economic status of Latinos is associated with pressures to work and to forsake higher education. Due to close familial ties, those who eventually attend college must often balance work and school in order to provide for themselves and their families (Seymour and Hewitt, 1997). Thus, financial conditions, family obligations, and demanding STEM-related courses may prolong the degree attainment process and raise the likelihood of Latinos withdrawing from school. The financial situation is heightened due to additional tuition costs involved in the pursuit of STEM degrees. One study found that students who continued in — as well as those who left — STEM fields, had more financial difficulties due to the extra time taken to pursue degrees in some STEM fields (NCES, 2000).

Latino families tend to value living in close proximity to each other. Students, particularly Latinas, are strongly encouraged to enroll in local community colleges rather than attend universities that are farther away from home.

Parental Involvement

Latino students enrolled in STEM programs tend to be the first generation in the family to pursue higher education. Their parents have a higher likelihood of possessing a lower educational level. As a result, they may not be able to provide complete academic, financial, and emotional support to their children. An analysis of 10,000 third-grade children from the Early Childhood Longitudinal Study (2004) showed that reading and math achievement suffered for Latino children living below the poverty level whose mothers had low education levels (Taningco, 2006). The study also found that Latino achievement for reading and math increased with the academic expectations of the parent for the child and the frequency with which the child read books at home. Taningco also found that the Latino-white achievement gap in math disappeared after controlling for school type, parent involvement, and other confounding variables. Meanwhile, Latino children continued to lag behind their white counterparts in reading comprehension.

Family Patterns and Cultural Values

Health care, nutrition, adequacy and stability of housing, neighborhood environment, and the number and ability of adults in a young person's life who can provide support and guidance also affect academic careers (Gandara, 2006).

In addition, families may encourage their children to uphold cultural values. For example, Latino families tend to value living in close proximity to each other. Students, particularly Latinas, are strongly encouraged to enroll in local community colleges rather than attend universities that are farther away from home (Tomás Rivera Policy Institute, 2002). Also, Latino patriarchal culture reinforces traditional gender roles. Although such beliefs are gradually diminishing, they still exist and play an important role in the choices of young students. Latinas often receive more pressure to conform to ideals that deter them from STEM fields (Villegas, 2005).

The Need to Address Challenges and Grab Opportunities

There is obviously a need to address the challenges and barriers faced by Latinos in entering STEM careers at the student, family, and school/institution levels. The good news is that the problems faced by Latinos are now out in the open and many stakeholders are involved in developing potential solutions. The problematic pipeline for Latinos entering STEM careers is being discussed at the national level. The major challenge is that the primary obstacles are not limited to STEM careers, and will require comprehensive attention to a range of issues that constrain the educational achievement and overall opportunities for Latino students.

Latinos have a unique opportunity to aim high and go for STEM careers given the high demand in this field.

Latinos are a young population, with a median age of 25.8 years in 2000 versus 35.3 years for the U.S. population overall (U.S. Census Bureau). As the youngest and fastest growing ethnic group in the U.S. today, Latinos have a unique opportunity to aim high and to strive for STEM careers, given the high demand in these fields. Additionally, the broader U.S. community has an interest in encouraging and supporting this progress in order to meet the economic demands of the nation.

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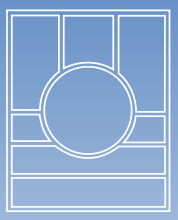

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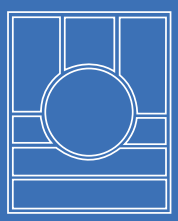

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