Hispanics in Engineering

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Hispanics in Engineering: A Review of the Literature

Hispanics or Latinos is one of the minority groups projected to grow its representation in the most dramatic way; from 15% to more than 30% by 2050. As it is known, current demographic trends in Science and Engineering do not reflect this segment of the population. Latinos constitute 3% of employed doctoral scientists, and 2.8% doctoral engineers. The American Dilemma is "this nation's failure to educate and develop a growing proportion of its potential talent base –African Americans, Latinos, and American Indians- as its need for people with skills in science and engineering is escalating."

Engineering education literature is very scant of studies addressing, in depth, the misrepresentation of Hispanics in engineering. This study reviews existing literature in this and other related areas (e.g., diversity in higher education, STEM studies) and sheds light into the causes that hinder the growth of Hispanics in the engineering field. Preliminary results are presented in this paper.

Method

This preliminary literature review consisted of using database-library resources, namely EBSCO, ERIC, Academic Search Premiere and Wilson Omnifile. Key terms such as Hispanics & Engineering and Latinos & Engineering were used to initially approach all academic literature. Given the lack of studies directly related to Hispanics/Latinos in engineering, the criteria for selecting resources involved all publications that included direct or indirect references to the lack of representation of Hispanics/Latinos in engineering. An initial screening of abstracts and conclusions yielded 44 resources, including reports of engineering trends and studies that explicitly identify the Hispanic/Latino population.

Preliminary Results

The wide variety of issues discussed in the literature but related to the misrepresentation of Hispanics/Latinos in engineering called for a categorization of themes. Three themes emerged

from this preliminary analysis: (1) The problem: Hispanic/Latino misrepresentation, (2) The possible causes, (3) The possible solutions. The following paragraphs describe these themes.

The first theme emerged as a thorough explanation of the lack of representation. Almost all reports and studies corroborated the statistical information regarding this misrepresentation. The most illustrative resources were Chapa and De la Rosa (2006), and Nettles and Millett (1999). The former included information from the associate's degree level to the doctoral level on how the pipeline becomes rather a "pipette"; from 9.9% of science and engineering associate's degrees (conferred to Hispanics in 2001) to 7.1% at the bachelor's level, 4.1% at the master's and 4.3% at the doctoral level. It also provided relevant information about the fact that the 20 institutions with the higher number of graduating Hispanic science and engineering bachelors comprise the 30% overall Hispanic enrollment in the country (concentrated in Puerto Rico, California and Texas). The latter resource provided disaggregated information regarding parental education, occupation, GRE and College GPA of doctoral engineering students and a comparison with science and math students.

Zavala (2003) pointed out the diversity of the Hispanics/Latinos, for example "Puerto Ricans are about 10 percent of all Latinos but make up 29 percent of the Latino Ph.D.'s" (p. 189). Furthermore, based on a Pew Hispanic Center report, Friedrich and Cabrera (2012) and Crisp and Nora (2006) state that "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" (p. 8). In consequence, this misrepresentation is a problem more prevalent among Mexicans.

The causes

Several are the possible causes reported in the literature. Among the most cited ones are (1) lack of pre-college preparation, (2) socioeconomic reasons, (3) institutional environment and type, and (4) psychological reasons, including culture and language.

The lack of pre-college preparation specifically High School, is the most analyzed and found attributable cause of underrepresentation of Latinos in STEM. It is also the prevalent predictor of Hispanics in engineering. Barton (2003) and Landgraf (2003) from the Educational Testing Service speak about the very low level of proficiency of Hispanics in mathematics and

science, only 4%, compared to the 20% of the White population. In addition, the drop-out problem is most prevalent among Latinos (28.1%), compared to 13.2% Black non-completion and the White rate of 7.4% within the 1996-2000 period (Barton, 2003).

However, agreeing with several authors, these deficiencies cannot suddenly appear in High School. Landgraf (2003) state that such differences are prevalent in cognitive development and performance even at the time children enter kindergarten. Zavala (2003) properly asserts that:

> Underrepresented minority children are most likely to come from families with low educational attainment and low socioeconomic status... They are more likely to attend schools where the teachers are not well prepared to teach science and mathematics and/or who have few resources to enhance their teaching and learning. These children are at a significant disadvantage from the very start of their educational careers, and they continue to fall further behind. (p. 190)

Adding to the disadvantaged position, the report to the president (2010) refers to the messages Latinos and other minorities get about not considering careers in mathematics and science during the pre-college years.

On the side of socioeconomic reasons, across most of the publications, the problem of misrepresentation of Latinos in engineering seems to stem from the overall misrepresentation of socioeconomically disadvantaged (SED) students in STEM fields (Chapa and De La Rosa, 2004; Conrad, Canetto, MacPhee, and Farro, 2009). Mervis (2013), in addition, proves how "minorities run up significant debt in earning STEM Ph.Ds." (p. 1511). More recent studies concentrate not only in the lack of financial resources but also in the lack of other resources accompanied with the SED status, such as social or cultural capital; where social capital involves the "resources embedded in a social structure" (Martin, Simmons, and Yu, 2013, p. 228), and cultural capital refers to the "familiarity and ease with which one navigates the dominant culture of society" (Cole and Espinoza, 2008, p. 287).

The institutional environment and type seem also to affect the participation of Latinos and other minorities in engineering; Hispanic serving institutions are still by far the greatest producers of Latino engineers in the country (Museus, Palmer, Davos and Maramba, 2011).

Institutions more selective and devoted to research seem to attract but not to retain Latinos (Bonous-Hammarth, 2000; Fry, 2002; Gándara, 2006; and Toulim and Groome, 2007, Griffith, 2010). Hurtado, Newman, Tran, and Chang (2010) state that "such an environment may include a highly competitive peer environment where only a few are expected to succeed, a faculty that is more focused on research than teaching, and a limited number of role models for Blacks, Latinos, and Native Americans." (p. 9)

Institutional climate and culture, where the first refers to *current* perceptions, attitudes, and expectations that define the institution and its members" and the second refers to "*deeply embedded* patterns of values, beliefs, and assumptions" (Museus, Palmer, Davos and Maramba, 2011, p. 65), are also attributable causes of misrepresentation of Latinos in engineering (Castillo, Conoley, Choi-Pearson, Archuleta, et. al., 2006).

Closely related to institutional environment there are aspects such as affirmative action and mentoring. Affirmative action, understood as "programs in the universities to attract minorities" (Matthews, 2007), have proved beneficial. Yet, affirmative action has been the target of continuous political attacks, thus creating tension and strengthening the colorblind-meritocracy culture within universities that does not recognize racial inequalities and does not promote the feeling of "welcomeness" which is crucial in the Latino culture.

The feeling of welcomeness, as related to mentoring, is the common topic of investigation of studies of Latinos and minorities (Nuñez, 2009; Bordes and Arredondo, 2005; Crisp and Cruz, 2009; Conrad, Cannetto, MacPhee and Farro, 2009). Crisp, Nora and Taggart (2009) and Museus, Palmer, Davis, and Maramba (2011) point out the mentoring support from the family, friends and peers in general in Hispanic serving institutions. Cantú (2012), in her study of Chicanas in STEM speaks of a level of mentorship of her college professors beyond school matters even to the point of lending money for rent or clothes during winter. Similarly, Museus, Palmer, Davis and Maramba (2011) report that "some faculty members at HBCUs go out of their way to teach, spend time with students outside the classroom, and even invite students into their homes and allow them to spend time with their families." (p. 62).

Psychological reasons, including self-efficacy are the topic of investigation of studies such as Hackett, Betz, Casas, and Rocja-Singh, 1992; Lent, Brown, Schmidt, Brenner et.al., 2003; Diekman, Brown, Johnston, and Clark, 2010; and Else-Quest,

Mineo, and Higgins, 2013. Self-efficacy, understood as expectations of one's confidence in career-related pursuits, has been found to play a critical role in the success of Latinos in STEM fields. Hernandez, Schultz, Estrada, Woodcock et.al. (2013) state that "researchers found that minority students who learned to tolerate problems and who learned to see failed experiments as normal, rather than a reflection of their own inadequacies, had better outcomes. "Among women, a sense of communal goal and advancement seem to play a role in the selection of a major (Diekman, Brown, Johnston, and Clark, 2010).

Language and culture seem also to play a role in the representation of Latinos in engineering (Cantú, 2013). Chapa and De la Rosa (2004) include language as part of the disadvantaged socioeconomic status among Hispanics. Lucas, Henze, and Donato (1990) enumerate the following list of factors that create a successful language-minority program:

1. Value is placed on the students' languages and cultures,
2. High expectations of language-minority students,
3. School leaders make the education of language-minority students a priority,
4. Staff development is explicitly designed to help teachers and other staff serve language-minority students more effectively,
5. A variety of courses and programs for language-minority students is offered,
6. A counseling program gives special attention to language-minority students through counselors,
7. Parents of language-minority students are encouraged to become involved in their children's education,
8. School staff members share a strong commitment to empower language-minority students through education. (p. 324-325)

Peralta, Caspary, and Boothe (2013) add to the mix of language and culture, the immigration status stating that "it was found that language, culture and immigration status each played a significant role in how these students perceived their ability to resist oppressive structures in schools." (p. 911). Else-Quest, Mineo, and Higgins (2013) also found influence of years living in the U.S. in attitudes and achievement among High School students.

The solutions

Consequently, the solutions to the misrepresentation of Latinos in engineering found in the literature are aligned with

(a) Support and preparedness at the pre-college levels, starting at very early stages of development,
(b) Grants and financial aid available for Latinos,
(c) Institutional culture and climate, involving mentoring and affirmative action programs,
(d) Sensitivity to culture, language, and immigration status as well as campaigns targeting messages given to Latinos.

Museus, Palmer, Davis and Maramba (2011) contend that more than financial aid, minorities and Latinos benefit more from grants to the point that "an additional $1,000 in grants lowered the probability of Black and Hispanic students leaving college by 7 to 8 percent" (p. 58).

In regards to messages, Varma (2010) unveils the prevalent messages Latinas get in regards to not choosing computer engineering/science majors by reproducing a Hispanic male assertion: "This is mainly because of our culture. Hispanic women are supposed to get some sort of careers so they can have enough time to be a housewife, raise children, and prioritize family'' (p. 306). Conrad, Canetto, MacPhee and Farro (2009) also refer to messages Latinos could benefit from, mainly in terms of informing about the lucrative careers and high status jobs. Oh and Lewis (2011) contribute to the discussion of economic retribution finding that "female and minority college graduates earn more relative to comparable white men in STEM than other fields" (p. 402).

Final remarks

This preliminary analysis of Hispanics/Latinos in engineering constitutes a first approximation to the problem of misrepresentation of this segment of the population. It is not intended to be a comprehensive study but a start point. As a starting point, it uncovered a series of factors that influence the engineering academic pursuits of Latinos in the United States. Most of these factors were already expected, others were a surprise and even some considerations not done in the past were adopted based on the convincing arguments of researchers and professionals whose works are included in this review.

To find pre-college preparation as a cause of low participation of Hispanics in engineering was not a surprise, it was however surprising to find an establishing group advocating for pre-college interventions at the kindergarten and even at earlier stages. Factor analyses at the level of High School were expected and confirmed considerations related to self-efficacy, lack of preparation, and interests among Latinos.

The socioeconomic factors were initially considered purely economic, the literature however called for a revision of this category because other type of resources were found to be of relevance. Social and cultural capitals were the resources that emerged as factors that contribute to the success of Latinos in engineering. In addition, a closer look into the economic factors provided one of the most important revelations of this study. This revelation was that many of the problems minorities face are shared by economically disadvantaged students, regardless of their race/ethnicity.

Another surprising cause of Latinos not graduating in engineering majors had to do with the intense research status of Universities. Climate and culture of institutions were established lines of research that were expected to emerge; however, their possible relationship to the research status of the institution was a new realization. Mentoring and affirmative action were also expected aspects but their links to the psychological reasons were a new finding. Self-efficacy, Latino culture and language were already known factors; the inclusion of immigration status, as part of the psychological factors, was also a new finding.

This study has limitations in terms of gendered differences (Latinos vs. Latinas). The few pieces of research included in this review were a relative happenstance. This however is a topic for further investigation. As a starting point, this work will be revised and refined through several iterations.

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