

THE UNITED STATES' CHALLENGES IN SCIENCE AND ENGINEERING EDUCATION: THE HISPANIC FACTOR

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ABSTRACT

Numerous statistical data indicate that science and engineering workforce in the United States is aging and nearing retirement. Moreover, various studies show that it has become increasingly difficult to attract American students to science and engineering fields. We focus in this paper on a fast growing minority segment of the American population. Accordingly, we show that the situation is particularly grim for Hispanics. They remain an untapped resource, which could either present the solution needed to overcome this challenge, or further deteriorate the situation. The challenges of recruiting and retaining Hispanic students in science and engineering disciplines is illustrated by studying the situation at Polytechnic University of Puerto Rico (PUPR), a major producer of Hispanic engineers located at the United States Caribbean island of Puerto Rico. The objective of this manuscript is to shed some light on the situation and suggest some solutions to this predicament that the nation is facing.

KEY WORDS

Science and engineering education, student retention, United States universities, underrepresented minorities, Hispanics.

1. Introduction

The United States has, in recent years, found that a high percentage of its science and engineering workforce is nearing retirement age. According to the U.S. National Science Foundation [4], in 2005 about 26% of Science and engineering degree holders were age fifty or more. Accordingly, one out of four science and engineering related workforce is eligible for retirement by 2017. The situation is more grim for specific fields such as nuclear science and engineering. For instance, according to a 2004 report by the Department of Energy [5], by 2012, "about three-quarters of the workforce in nuclear engineering will reach retirement age." Accordingly, the nation is facing an aging workforce and is in danger of

losing most of its expertise as such talented workforce retires. Therefore, the United States is in dire need for a young and diverse workforce in all areas of science and engineering.

A major part of the solution to the national need is at the university level. Fortunately, the nation is well equipped to tackle the problem at this level. Indeed, the United States and its territories have 4,391 degree granting institutions of higher education (IHE) with a total student enrolment of 17,570,569 [9]. Of these institutions, there are 1,730 or 40% that have only programs of study that are at least two years but less than four years. These two-year institutions have 37% of the total student enrolment. These institutions typically offer associate degrees, but they also provide a pipeline of students to IHEs that offer Bachelor degrees or higher. Out of all IHE, there are 1,737 or 40% that are public with 74% of the total student enrolment, while the rest of the institutions are private. Of these private institutions, 908 or 52% are for-profit with 20% of the total private student enrolment, while the rest of the private institutions are not-for-profit. The United States higher education gained an international reputation largely due to the activities of 96 institutions, classified by the Carnegie Foundation for the Advancement of Teaching as RU/VH, or research universities with very high research activity [9]. However, these institutions constitute only 2% of the U.S. IHE, and 13% of the total student enrolment.

The other predicament is that it has become increasingly difficult to attract and retain students into the scientific and technical fields necessary for the nation to compete in a global arena. According to a report by the U.S. National Science Foundation [4], in 2005, the U.S. institutions conferred 640,910; 1,437,200; 567,875 and 52,588 associate, bachelor, master and doctoral degrees, respectively. In other words, total degree conferral is less than 15% of the total U.S. student population, which hints to a low retention rate. For example, ideally for a successful four-year program, this rate should be around 25% of the student population. The corresponding

percentage of degrees in science and engineering was 7%, 32%, 21%, and 54%, associate, bachelor, master and doctoral degrees, respectively. However, the proportion of these degrees awarded to students on temporary visas was 3%, 4%, 28% and 36%, respectively.

Indeed, since its birth the United States has been a nation of immigrants and its success is largely attributed to attracting the best talent and brains from all around the world. This led to the quick and easy solution to fixing national needs in every domain by admitting more immigrants who eventually become Americans. Accordingly, the U.S. Census Bureau points out that in 2004 about 11% of the U.S. population aged 25 to 44 was naturalized citizens [2]; that is citizens who obtained U.S. citizenship by means other than parent or birth in the United States or its territories. The other traditional approach to solving the national need was by taking jobs beyond U.S. borders to gain from the expertise of foreign nationals at a cheaper cost, which is referred to as outsourcing.

Using 2005 data, [4] points out that 25% of science and engineering graduate student enrolment in the U.S. was on temporary visas. In addition, 4%, 28% and 36%, of science and engineering bachelor, master and doctoral degrees, respectively, were awarded to students on temporary visas. Many foreign students tend to stay in the U.S. after graduation however. For example, according to [4], 74% of Ph.D. awardees on temporary visas tend to stay in the U.S. after graduation. However, this situation is changing due to global demand and various restriction that were introduced in response to 9/11 events. Nevertheless, in 2004 the U.S. accounted for 22% of internationally mobile students [4]. This percentage is decreasing though according to the same resource.

The nation has an untapped in resource to solve the country's shortage in science and engineering expertise. Many minority segments of the population are traditionally underrepresented in science and engineering fields. Most notably are African Americans and Hispanics. Nationally, the underrepresentation of minorities in science and engineering careers has been a topic of research and concern for educators and policy makers. Research has consistently shown the benefits of a workplace that reflects the diversity of the broader community [8]. Many national committees are formed to help focus on removing obstacles preventing minority and women participation in science and engineering careers [4]. This prompted various federal agencies to allocate a variety of scholarships, fellowships, and other incentives specifically designed to attract minorities to science and engineering disciplines. Many universities utilize pipeline models to help carry students interested in a science and engineering domain from one level of participation to more advanced levels in order to help students gain experience and knowledge; see [7] for a detailed discussion on this topic.

Unfortunately, minority participation in science and engineering related disciplines remains a serious challenge. For example, while African Americans and Hispanics make up 12.8% and 15% of the U.S. population, respectively [3], they each only account for 5% of the science and engineering workforce [4]. Furthermore, the annual increase rate of representation of Hispanics in science and engineering education is less than half of their annual population increase rate. Thus, although the situation may seem slightly improving, looking at the bigger picture more needs to be done to avoid certain catastrophic results. Accordingly, in this paper we focus on the Hispanic underrepresentation in science and engineering coupled with their growing percentage of the United States population. We present various data to illustrate these challenges and indications of improvement of the situation. Thus, in the next section we present and analyze Hispanic student's demography in the United States. In Section 3, we discuss the situation at Polytechnic University of Puerto Rico; which produces about one out of ten Hispanic engineers annually. In Section 4, we suggest some solutions to mitigate the situation and transform failures to successes. Section 5 presents summary and concluding remarks.

2. Hispanics' Underrepresentation

The United States Census Bureau considers Hispanic to mean a person of Latin American descent (the Caribbean and Central and South America) living in the United States who may be of any race or ethnic group (white, black, Asian, etc.). Based on the 2000 census data [1], Hispanics constitute 15.5% of the U.S. population aged 19 to 28. However, this percentage is expected to increase to 17.6% and 19.4% by 2015 and 2020, respectively. Thus, their average annual increase is around 0.4 percentage point. Hence, Hispanics are the fastest growing ethnic group in the United States.

According to the U.S. Census Bureau, between 2000 and 2006, Hispanics accounted for one-half of the nation's growth and their growth rate was 24.3%, which is more than three-times the total U.S. population's growth rate, which was 6.1% [6]. Thus, the 15.5 percentage is expected to increase dramatically. Yet Hispanics are well underrepresented in science and engineering, in comparison with the other ethnic groups. Although their percentage representation is improving as illustrated in Figure 1, the increase is too small compared to the Hispanic population growth rate. Therefore, they are getting more and more underrepresented in science and engineering. Yet Hispanics still remain a valuable resource to address the nation's shortage.

Hispanics representation in graduate school has doubled from 3.4% in 1989 but is still less than half of their representation in the society. Since 2000, it is increasing at an average annual rate of less than 0.2 percentage point.

However, this is much less than their average annual increase in population aged 19 to 28, which is around 0.4. Thus, their underrepresentation in science and engineering is getting worse. Their associate degree percentage doubled from 1985 to 1995, but it is slowly fluctuating between 11.0 and 11.8 since 1997. Their bachelor degree representation has increased steadily since 1977; it doubled to 5.9 in 1995, and continued its slow increase at an average of 0.2 points a year. This is also the average annual increase for their master degree representation since 1989, which reached 6.2% in 2005. At the doctoral degree level, their representation has tripled since 1977, reaching 4.7 in 2005, however their average annual increase since 1995 is less than 0.2 points a year.

3. Polytechnic University of Puerto Rico

3.1 Overview

Polytechnic University of Puerto Rico (PUPR) is a Hispanic Serving Institution (HSI) with an enrollment of about 6,000 students, and is the largest private Hispanic Serving Engineering School in the United States. PUPR's student enrollment is Hispanic U.S. citizens of which about 90% are undergraduates and about 25% are females [11]. PUPR is located on a ten-acre piece of land in the heart of the financial district of the capital San Juan of the Caribbean island of Puerto Rico, which is a U.S. territory, about the size of the state of Connecticut, and with a population of about four million, the vast majority of which are Hispanic U.S. citizens.

PUPR operates on a semester-hour-equivalent trimester in which 45 contact hours corresponds to three credits. Accordingly, a three-credit-hour undergraduate (graduate) course meets twice (once) weekly for a total of four contact hours. The minimum number of credit hours that an undergraduate (graduate) student can take to be considered a full-time student is twelve (six) per trimester. Classes are taught in Spanish or English, but textbooks are in English, and it is expected that students present most of their written work in English.

PUPR offers baccalaureate degrees in engineering (civil, chemical, computer, electrical, environmental, industrial, and mechanical), computer science, architecture, business administration, management, and land surveying. PUPR also offers masters in engineering (civil, computer, electrical, manufacturing), computer science, engineering management, manufacturing competitiveness, environmental management, landscape architecture, and business administration.

3.2 National Recognition

The quality of PUPR's academic programs is

demonstrated by the accreditation and recognition from the following agencies:

- The Middle States Association of Colleges and Schools (MSACS).
- The Council of Higher Education of Puerto Rico (CHE-PR).
- The Accreditation Board for Engineering and Technology (ABET) accredits all of PUPR's undergraduate engineering programs (civil, chemical, computer, electrical, environmental, industrial, and mechanical), and land surveying and mapping program.
- The National Architectural Accrediting Board (NAAB) accredits PUPR's Architecture undergraduate program.
- The International Assembly for Collegiate Business Education (IACBE) accredits PUPR's school of management.
- The National Security Agency recognizes PUPR as one of the nations Centers of Academic Excellence in Information Assurance Education.
- PUPR is an associate member of Oak Ridge Associated Universities.

In addition, in May 2008, the Chronicle of Higher Education reported that "The nation's top producers of Hispanic engineers are the public University of Puerto Rico at Mayagüez and the private Polytechnic University of Puerto Rico. Together they account for about a fifth of the 4,614 bachelor's degrees in engineering that American institutions awarded to Hispanic students in 2005. Most of the other institutions with high rankings on that list are public universities in Florida and Texas," [12]. Thus, given the fact that PUPR produces one out of ten Hispanic engineers, it is of great importance to support such

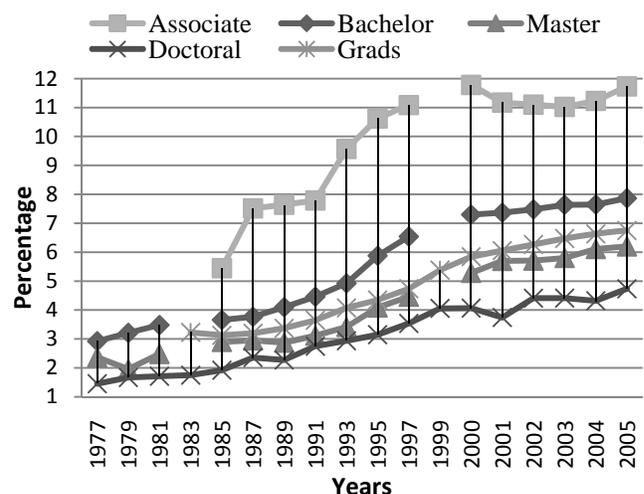


Figure 1. Yearly percentage of science and engineering degrees obtained by Hispanics at U.S. institutions based on [4].

institution to fulfill the national need.

PUPR's five-year undergraduate and two-year graduate programs have gained an outstanding reputation in Puerto Rico over the years for producing highly skilled and workforce-ready talent. Consequently, PUPR graduates are placed in graduate schools, while others join government or private sector scientific facilities. PUPR graduates progress well in their chosen careers. Accordingly, numerous fortune 500 and fortune 100 companies, federal agencies such as Federal Highway Authority, Patent and Trademark Office, Army Research Office, Department of Defense, NASA, NSA, to mention a few, and local industry and government are recruiting PUPR graduates every year.

3.3 Geopolitics

The geopolitical state of Puerto Rico makes it harder for students to relocate to the US Mainland. The fact that it is an island makes it harder and more expensive for its residents to visit the US Mainland and increases the isolation. Moreover, Puerto Rico is a US territory and not a state, which makes it unable to access federal funds that are otherwise available for states. Furthermore, the first language in Puerto Rico is Spanish, which makes the students hesitate to communicate in English as it is not their language of daily use. In addition, unlike the case in the U.S. Mainland, in Puerto Rico lower socio-economic income students generally attend private colleges and universities and middle and upper middle class students attend the public university system. As a result, private higher education institutions on the Island have historically provided access to higher education for lower income students. This has been both a source of pride and challenge for the University. As a result, PUPR serves students from a target area that is characterized by economic deprivation, large concentration of disadvantaged population, and a low educational attainment.

3.4 Retention Rate

The geographic and socio-economical conditions of the region present barriers against completion of high school and subsequent college enrollment and graduation. Accordingly, PUPR's students typically have to struggle to pay for their school and other expenses which force them to work full-time outside the University campus while being registered as full-time students. This hardship forces other students to register part-time while working full-time to support their education and make ends meet. Thus, about half of PUPR's student enrolment is part-time [11]. The tendency of the students to work outside campus negatively impacts their grades, time to perform any research-related task and their inclination to join a

graduate school. This is if students were able to stay in school and continue their education.

The grim reality is that the undergraduate retention rate at PUPR is less than 35% [13]. According to an institutional report [13], the average annual withdrawal for first year students (1995-2005) is 22%, for second year students (1995-2004) is 20%, for third year students (1995-2003) is 10%, for fourth year students (1995-2002) is 7%, and for fifth year students (1995-2001) is 5%. Therefore, with some support, PUPR can double or triple its production of Hispanic engineers from one out of ten to fulfill the national need and better serve the local population of Puerto Rico.

4. Suggested Solutions

It is clear from the analysis set forth in this paper that Hispanics represent almost one-sixth of the U.S. population aged 19 to 28 and climbing, yet with the exception of associate degrees (less than 12%); they are only represented by less than 8% in science and engineering education. Moreover, the situation for Hispanics may seem improving at an average annual rate of 0.2 percentage point. However, in comparison with their population's average annual increase rate of 0.4 percentage point, their underrepresentation in science and engineering is only getting worse. Thus, more attention needs to be given to Hispanics and more aggressive approaches need to be implemented to not only mitigate this predicament, but to utilize them as a valuable resource for solving the nation's need.

There are various federal programs and initiatives designed to improve the situation [10], however as the presented data show, the progress is very small. Thus, due to their current demography and population growth, Hispanics are a resource that can either bridge the gap for national need or deteriorate the situation further. They remain an untapped in resource to improve the situation in the future. Accordingly, students at associate degree programs can be a good resource to improve the situation if they are motivated to continue their education and obtain higher degrees. The fact that Hispanics are much better represented at the associate degree level, shows that they have some interest in science and engineering, yet other factors prevent them from continuing their education to obtain a higher degree. These obstacles include but are not limited to their previous education at K-12, financial constraints, language and cultural barriers, many are first in their families to seek a college degree, etc. Although it is tempting for a privileged person to claim that different segments of the population are good at different domains, the nation cannot afford to continue such attitude and ignore this growing minority segment of the population.

More scholarships and fellowships should be available to attract students to such fields. In addition, serious collaboration between U.S. national laboratories and universities should be established through internships, coops, and research collaboration that include both students and faculty. Various strategies need to be implemented to motivate students and faculty to benefit from such opportunities. Such strategies should include e-collaborative initiatives in the research and education presented to minority serving institutions [10] by research institutions and universities, national laboratories, educational entities, and federal agencies. Such institutions can provide weekly remote lectures to expose minority students to the thrill of science and engineering and facilitate their recruitment by the corresponding institution. The students need to be exposed to cutting edge research to feel excited about their field of study and the vital role they can play in the future for the development of the society at large. These e-collaborative efforts could incorporate Internet2 (www.internet2.edu) and GENI project (www.geni.net) to increase the bandwidth and make such collaborative efforts more feasible, enjoyable and productive.

5. Conclusions

The United States is facing an aging workforce and is in danger of losing most of its expertise as such talented workforce is due to retire soon. It has also become increasingly difficult to attract students into the scientific and technical fields necessary for the United States to compete in a global arena. Although the situation has improved from the past, Hispanics remain untapped in resource to remedy the situation. The percentage improvement in the representation of Hispanics in science and engineering education is less than half of their percentage population increase with respect to the rest of the population. Thus, various strategies need to be implemented to attract and retain students in science and engineering. In addition, serious collaboration between U.S. national laboratories and universities should be established through internships, coops, and other research collaborations that include both students and faculty. By this manuscript, we hope that we have shed some light on the grim situation and rung an alarm bell so that policy makers take aggressive strategies to avoid catastrophic results.

Acknowledgements

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