

**AC 2008-2165: PATHS TO DISCOVERY: CHICANAS IN MATHEMATICS,
SCIENCE, AND ENGINEERING.**

Lupita Montoya, Rensselaer Polytechnic Institute

Cleopatria Martinez, Phoenix College

Paths to Discovery: Chicanas in Mathematics, Science, and Engineering.

Abstract

Lack of participation in Science, Technology, Engineering and Mathematics (STEM) fields from underrepresented minority students is a recognized problem in higher education. Institutions around the country have developed a plethora of plans and strategies to promote these fields and attract this population. Participation from minority women in STEM often poses additional challenges, and however well intentioned these efforts, we are still not seeing much improvement in this area. Often, policies are put in place to “encourage” these students to pursue these majors at the undergraduate and even graduate levels. The success of any such efforts, we propose, must be linked to an acknowledgement that these students have their own life circumstances that may affect not only their choice of major, but the very decision of whether to pursue a college degree. Ignoring these important circumstances and evaluating these students with the same standards of achievement that mainstream students with many fewer obstacles to overcome, often eliminates highly capable students from opportunities that are solely based on quantitative evaluations. Even more unfortunate is the fact that many bright young minds still get turned away from these fields by careless comments or erroneous assessments of their intellectual abilities. Our goal is to make reference to experiences as identified by the authors of a book titled *Paths of Discovery: Chicanas in Mathematics, Science, and Engineering*. These authors wrote autobiographical essays addressing simple but critical issues they had to face on the road to their chosen fields. What determine the character of a person are her experiences. A person able to work and solve problems on her own and without direction, we propose, has the distinctive characteristics that contribute to innovation, learning, and creativity. Our most important goal, however, is to urge the engineering and scientific community to engage in an honest and substantive discussion of what is truly necessary if we are to level the playing field in higher education and harness all the potential in our young students.

Introduction

The Adelante! Project originated as a focused effort in 2003 from a group of dedicated veteran Chicana Scientists and within the context of the annual meeting of *Mujeres Activas en Letras y Cambio Social (Women Active in Literature and Social Change -MALCS)*. This initial effort resulted in a book describing the career paths of nine Chicanas in STEM fields; the book was titled *Flor y Ciencia: Chicanas in Mathematics, Science, and Engineering*. The 2006 publication of this book was sponsored by the American Association for the Advancement of Science (AAAS) and a second edition is expected for the summer of 2008 under the auspices of the Chicano Studies Research Center at the University of California, Los Angeles. The authors wrote autobiographical essays addressing simple but critical issues such as mentorship, childhood and interest in their chosen fields. Authors illustrated the diverse paths that may lead to a career in science, engineering and ultimately, academia. Important turning points in these paths are

highlighted so as to demonstrate when it is particularly important to persevere. Issues of balancing family and career are also discussed. Readings of this book have been done at various venues focused on Chicana and Latina recruitment and students have been able to relate to at least one of the roads taken by one of the featured scientists.

Much of learning is a function of attitude and motivation, thus this book appeals to a broad audience including teachers and students from K-12 public schools through the postsecondary level. Education administrators may find this book as a valuable resource for the promotion of STEM fields amongst young Chicana and Latina students. There is no more powerful tool than that of an example. In fact, that is how engineering is usually taught. The authors' goal is to use their own experiences, however humble or even painful, as a means to reach and inspire those who are meant to follow us. Notably, these women are primarily first generation college-educated and rarely had a role model to follow. For the most part, they created their own models and did it in a variety of ways that illustrate the diversity of our experiences. Our final message to our young sisters is: "Sí se puede! (Yes, it can be done!) and we are happy to show you how."

Preface

***by Dr. Norma E. Cantu,
Professor of English, UTSA***

The preface provides a short history of the events that lead to the creation of this book project. The origin of this enterprise has its roots in the 2003 conference of *Mujeres Activas en Letras y Cambio Social (MALCS)*. A year after this event, a small group of Chicanas in Science and Mathematics who participated in that conference met to discuss the possibility of writing a book. This book started to take shape in August 2004, and progressed through several subsequent meetings. These gatherings became special occasions to share the joy and challenges of being survivors in a world not designed for them. They also became a place to air differences and recognize similarities in their commitment to their communities, regardless of what professional sectors they now occupy. For example, although most of the contributors are professors at U.S. universities, some work in a community college, public school, government or in civil service. They are also geographically diverse and at various stages of their careers, including some who have reached retirement. All of the contributing writers are committed to their community and to promoting Chicanas in science, math and engineering.

Un Cuadro – A Framing

***by Dr. Aida Hurtado,
Professor of Psychology, UCSC***

Professor Hurtado provides a scholarly introduction to the notion that success in this society is often attributed to individual perseverance and will. The Horatio Alger story is alive and well in the US imagination as a way of explaining our acceptance of meritocracy. The fields of mathematics and natural sciences are fertile grounds for exploring the myth of individual success and how it may mask other possible explanations for why individuals outside the mainstream flourish and make impressive contributions to their field's knowledge base.

Chicana scientists, given their small numbers and relative obscurity, are often thought of as individuals of extraordinary individual strength who have succeeded against all odds. In the

autobiographical essays included in this book, however, the stories are much more complicated and nuanced. If there is one overarching similarity among them, it is that individual perseverance alone is not sufficient to succeed in male-dominated fields. Instead, what the stories uncover is a web of caring and support that propel these Chicanas into spheres previously uninhabited by people like them: predominantly working class, first generation in college, of color, and women. The ways in which they are embedded in the social relations that contributed to their success are much more complex and textured than individual explanations would lead us to believe. So what can be gleaned from these Chicana scientists' narratives of their life trajectories that will help guide the next generation of pioneers in such fields as mathematics, engineering, chemistry and biology? The themes of their childhoods and adult lives hold valuable lessons worthy of closer examination.

Book format

Among important topics that the book contributors agreed to explore in our individual narratives, we included: 1) the role that parents, extended family and community played in our academic life; 2) the importance of teachers and mentors; and 3) the importance of reading. Additional important issues include 4) how to overcome obstacles and 5) negotiation of stigmas: racism, sexism, classism. The book was divided into three sections: *Abriendo Caminos* (Opening roads), *Al Norte* (To the North), and *Pasos con Veredas* (Established tracks). Each section contains three contributed chapters. The sections are not intended to be mutually exclusive, but to provide a means for the reader to connect with the writings in an overarching way.

The main theme of the section titled *Abriendo Caminos (Opening Roads)* is the daunting task faced by the three contributors. Like some of the other contributors to this book, these were the first in their families to finish high school, to attend college, to obtain advanced degrees, and ultimately to become academics. *Abriendo caminos* is about opening roads that were previously closed to them and their families.

Almost all of the contributors to this book, in one way or another, have experienced migrating *al Norte (to the North)* to work in the farm fields or in academia. The phrase *el Norte* is used both in Latin and Central America and in Mexico, as well as the United States, to designate the departure of individuals and families from their homelands to pursue employment, opportunities and, in the case of our contributors, education in *el Norte*.

The contributors featured in the section titled *Pasos con Veredas (Established Tracks)* had educational experiences that were less stressful than those of the other contributors. However, despite their easier routes to education and career, they have always felt a strong commitment to helping others succeed educationally. They understand that their paths were somewhat anomalous when compared with other Chicanas and Chicanos and are as committed as the other contributors to facilitating students' access to higher education.

The topics that were explored in each of the narratives in this book constitute, in our opinion, the most important in determining our ability to persevere and ultimately achieve our academic and professional aspirations. In most cases, these aspirations were not clearly delineated or facilitated by the educational system; in the worst cases, obstacles and discouragement were

actively thrown our way. Fortunately, critical characters and events played positive roles in enabling us to reach our potential. These positive and critical factors are discussed in more detail in the next sections. Such discussions should provide a starting point for people interested in promoting diversity in STEM fields, particularly among young Latinas. We propose that in order to better understand and eliminate obstacles to achieving diversity, we need to look at minority students as individuals with personal dimensions that go beyond a GPA, GRE or SAT scores.

We fail these minority students by not taking into consideration their background, which often develops the very qualities (such as creativity and independent thinking) needed to do exceptional research. This paper is an effort to convey this message to students (so they will know they are not alone) and to higher education personnel (so they can establish better standards of achievement and serve as effective mentors).

Overcoming obstacles

There are many obstacles faced by Chicanas that need to be overcome in order to succeed. Such obstacles include prejudice, sexism, discrimination, and evaluative standards that overlook strength of character. This strength of character, in turn, arises from prevailing over those very obstacles but rarely appears in any objective evaluation of achievement. Several of these obstructions are mentioned in the book in addition to various adaptations to manage them. They are presented and discussed from the vantage point of the student and the university professor or other personnel.

Traditionally, we fail to recognize that creativity requires both initiative and self-sufficiency. We do not take into consideration what a great achievement it is that a student – who was raised by a single mother, in poverty – managed to stay out of trouble with the law, helped raise her siblings, and still continued to get good grades in school. This required the student to be imaginative and resourceful in solving the myriad of problems that come to pass in such an environment. Such demonstrations of creativity and initiative – character-building experiences in the background of the student – are traditionally not considered when we institute standards of achievement to measure aptitude. Instead, we continue to establish qualifications based on much narrower schemes, which are easily measured, such as GRE scores and the GPA. These schemes may be preferred because they require no original or insightful effort on the part of the evaluator, but these schemes don't capture important, valuable information about the ability of a student to think creatively and independently. It is important to recognize that the GRE score or GPA of students with these personal responsibilities cannot be compared with those of students from affluent and stable homes. Performing such a comparison is analogous to comparing the race time of two champion swimmers – one whose feet were tied together and the other whose feet were free.

Negotiation of stigmas: racism, sexism, classism

Through television, the printed media, and the educational system in the United States, we are taught about the contributions of great Americans who are typically white and male. The same type of message is presented in History classes where the contributions of Mexicans and other minorities in American society are rarely mentioned. Stigmas involving race, sex, and class are heartily developed. It is very difficult to do extremely well in science, mathematics, or

engineering feeling the stigmas of being poor, women, and Mexican while living without a positive self-image. Dr. Elizabeth Rodriguez-Johnson poignantly reveals that “negative stereotypes only added” to her low self-esteem. It was not until her freshman year in college that her self-esteem was finally lifted when she heard a History professor make a positive comment regarding Mexicans. In order to excel, the contributors to this volume (*Paths to Discovery: Chicanas in Mathematics, Science, and Engineering*) had to overcome this type of oppression. The book discusses the various roads taken by the women writers to negotiate these stigmas. Dr. Lupita Montoya states that “having self-confidence can make or break an academic career,” and she feels fortunate to have developed that aspect of her personality in Mexico because it has helped her emerge “more confident than before.” Each woman who contributed to the book devised a means for overcoming prejudice and discrimination, and we hope to share some of these insights with the audience. We also plan to acknowledge the cost the authors paid to take the “road less traveled” and discuss any regrets and other feelings experienced at the end of their journeys toward becoming scientists, mathematicians, or engineers.

Role of parents, extended family and community

The role of parents and extended family, and to some extent the general Latino community can play a very crucial role in the career of budding minority scientists and engineers. As depicted in several of the essays in the book, parents in particular, played an important role by providing the moral and even intellectual support these women needed to pursue their careers. Since most of them are first generation college-educated, the intellectual support came primarily during childhood. The moral support continued throughout their careers, even when their own paths had diverged quite a bit from their own families.

In the case of Dr. Elsa Ruiz, for example, working on the rooftop with her father using a measuring tape may seem like an inconsequential event; however, for her, it meant that she was able to explore a world often reserved for boys. Having access to that knowledge and tools gave her an early appreciation for the usefulness of mathematics that later translated into a career in math education. For Dr. Zavala, having a mother who nurtured her experimental incursions into biology also eventually transformed that curiosity into a life-long career in botany research; this happened in spite of recurrent discouragement along the way. In her very poignant section, Dr. Martinez talks about the principles her single mother taught her concerning accuracy, pride in her work, persistence, and willingness to learn on her own. All of these principles were quite helpful in her development as a mathematician.

Role of teachers and mentors

While the importance of teachers is widely recognized, it is particularly crucial for minority women who often do not have role models at home who can help them navigate the educational system, or recognize and seize opportunities. In more than one occasion, the authors speak of a teacher or mentor who said or did the right thing to enable their advancement. Sadly, there are also examples of the opposite. In some cases, a teacher “took a chance” with one of these women and found that they would perform at the top of their class, once given that initial chance (as in the story told by Dr. Zavala and her Spanish class). In other cases, teachers took a special interest in the success of the student and provided better alternatives as in the case of Dr.

Montoya and her English as a Second Language teachers. Overall, these characters were instrumental in providing the support needed for them to make it successfully to the next level. In her chapter, Dr. Rodriguez-Johnson speaks about the negative effect that misrepresentation of history in the Southwest had in her own self-esteem. Luckily, through a better education, she was able to shake off the stigma and her insecurities. Unfortunately, not all minority students will reach that level of education and will continue to believe and accept the bad stereotyping of these communities. To fight these stereotypes and ignorance requires an inner strength that has to be developed and nurtured by good intentioned and informed people. These people can be a teacher, a counselor or any administrator.

Importance of reading

While having books available at home was not always an option for them, these women recognized the importance of reading. In some cases, it allowed for the exploration of worlds that were very different from their own as well as provided the door to discovery and scientific curiosity. Dr. Elma Gonzalez tells her touching childhood story about the wonderful book she encountered while working as a migrant worker. This was a discarded book that she was not allowed to keep but became a strong memory. As an adult, she re-encounters a picture in that book and the memories returned. Dr. Marinez mentions how she was an avid reader, using both her school and public library books to satisfy her thirst.

Status of Chicanas in STEM Fields

According to the National Science Foundation *Report on Women, Minorities, and Persons with Disabilities in Science and Engineering: 2002*, the number of bachelor's degrees awarded in science and engineering increased from 1990 to 1998 for women in each racial/ethnic group. In the case of Hispanics, the numbers increased from 6000 to 14,000.¹ According to the NSF Science and Engineering Indicators 2006, Science and Engineering Bachelor's degrees usually constitute about one third of all Bachelor's degrees in the last two decades.² The number of such degrees in Engineering and Mathematics have stayed fairly flat between 1992 and 2002. In the case of engineering, this flattening happened after a downward trend in the late 1980's. Individual numbers for Mathematics and Engineering, however, continue to constitute a very small fraction of these degrees. These numbers increased from 640 in 1990 to 1250 in 1998.¹ There is no further break down of data to look at how Chicanas (or Mexican Americans), in particular, fair in this scheme.

At the Master's level, Hispanic women earned 48 percent of the total master's degrees awarded to all Hispanics.¹ At the Doctoral level, Hispanics earned 468 of the Science and Engineering doctoral degrees awarded in 1990 and 688 of those awarded in 1999. They comprised 4 percent of the S&E doctorate recipients in 1999, up from 3 percent in 1990. Coincidentally, the youngest of the contributors to this book, Dr. Montoya, received her doctorate in Civil and Environmental Engineering in 1999, becoming the first Chicana in her department to receive a PhD. Since there are in excess of fourteen million Hispanics in the USA, it is no surprise then that these women feel so committed to changing these bleak statistics.

Status of *Path to Discovery* (previously *Flor y Ciencia*)

The Chicana scientists who wrote this book, *Flor y Ciencia*, are dedicated to encouraging Latina students to complete undergraduate and graduate work leading to doctorates in STEM fields. With this in mind, several of the co-authors have presented excerpts of their writing at various conferences in 2005 and 2006, and each presentation has been received with great enthusiasm.

The first time we had a panel presentation of the stories in *Flor y Ciencia* was at the annual SACNAS (Society for the Advancement of Chicanos and Native Americans in Science) Conference in October 2005. The stories in the book are wide-ranging and inspiring to a lot of people with different experiences and backgrounds. This panel presentation was extremely well received even though we did not yet have the book. We had an audience of over 100 people and there was standing room only. Many audience members related directly with the stories given in as much as they too, were studying to be engineers and scientists or were themselves professors who had similar experiences.

We next traveled to Guadalajara, Mexico, in July 2006 where we again presented our narratives and engaged in dialogue with participants at the National Association of Chicana/o Studies Conference (NACCS). This presentation allowed us to speak to people who had not seen Latinas in these non-traditional roles of engineer or scientist.

The first time we were able to talk about the book with the book in hand was at the conference of MALCS, the early spring of 2006 in Santa Cruz, California. Six of the authors were able to be present for a panel appearance to read a short excerpt and talk about the writing of the book. The audience was comprised of women only, which provided an interesting dialogue for the authors.

Finally, in October 2006, we were able to present the book at the annual SACNAS Conference and were able to give away dozens of copies of the book. The conference participants from all levels of the educational continuum -undergraduate, graduate, post-doctorate, professional, government employees - again received us with eagerness to learn more about how Latinas could manage to become engineers and scientists, particularly at the PhD level. Each of the presentations was met with great interest and we plan to continue to share these experiences so every young student of any background and ethnicity knows becoming an engineer or scientist is very achievable. It is possible! *Sí se puede!*

References

- ¹ National Science Foundation, Report, Women, Minorities, and Persons with Disabilities in Science and Engineering: 2002.
- ² National Science Foundation, Science and Engineering Indicators 2006, Volume 1.