# Using a research center-based mentoring program to increase the participation of African Americans, Hispanics and Native Americans in engineering

**Dr. Eduardo Santillan-Jimenez, University of Kentucky Center for Applied Energy Research**

Dr. Eduardo Santillan-Jimenez is the director of a mentoring program based at the University of Kentucky Center for Applied Energy Research (UK CAER) – and funded by the Broadening Participation in Engineering program of the National Science Foundation – designed to increase the number of African Americans, Hispanics and Native Americans graduating with engineering degrees and pursuing academic careers. Originally from Mexico, Dr. Santillan-Jimenez joined UK first as an undergraduate research intern and then as a graduate student performing his doctoral research at UK CAER and at the University of Alicante (Spain). After obtaining his Ph.D. in 2008, he worked as a postdoctoral fellow at Utrecht University (The Netherlands) prior to retuning to UK CAER, where he now holds the position of Principal Research Scientist. His current research focuses on the application of heterogeneous catalysis to the production of renewable fuels and chemicals, with emphasis on the upgrading of algae oil to drop-in hydrocarbon fuels. His synergistic activities include participating in a number of K-20 educational initiatives designed to increase and broaden participation in STEM fields.

**Mr. William Henderson III, University of Kentucky**

Mr. William Henderson III is the co-director of the mentoring program as well as the Director for Diversity Programs and Diversity/Out-of State recruitment for the University of Kentucky (UK) College of Engineering. Originally from Lexington, Kentucky, William obtained his bachelor's and master's degrees in Math Education and Secondary Math Education, respectively, from UK. He has performed a number of functions at UK including: grant writing, strategic planning for the university in general and for diversity in particular, coordinating student affairs, advising, and outreach programming.

William currently creates and conducts programming for K-12 and post-secondary Science, Technology Engineering and Mathematics (STEM) initiatives. He is the founder and director of the UeducateU Career Advisory Council. It serves as a think-tank designed to improving diversity in STEM fields by connecting corporations, educators, stakeholders and students while solving issues related to becoming more involved with prominent careers.

# Using research center-based mentoring to increase minority participation in engineering

*Minority underrepresentation in engineering:* Minorities continue to be underrepresented in science and engineering both at the undergraduate and graduate levels as well as in the workforce (National Science Foundation, 2013, 2014). This can be partially attributed to the fact that the loss of science and engineering college majors is disproportionate among minorities (Maton, Hrabowski, & Schmitt, 2000; Seymour & Hewitt, 1997).

*Improving higher education outcomes through mentoring:* Mentoring can improve retention and academic performance (Gershenfeld, 2014; Lee, 1999; Nora & Crisp, 2007) and many theories have been put forward to explain this. One theory contends that mentoring promotes the involvement of students in the educational process, which correlates with graduation and academic achievement (Astin, 1984). Another theory holds that retention is the outcome of the academic and social integration of the student in the educational environment (Tinto, 1975). A third theory suggests that mentoring provides the social support that allows students to better cope with the demands of college (Pearson, 1990; Vaux et al., 1986). Another theory states that mentoring provides the developmental support necessary for students to reach their potential (Chickering, 1969; Thomas, Murrell, & Chickering, 1982). However, using a single theory is inadequate and all theories should be acknowledged given the range of outcomes in mentoring programs (Gershenfeld, 2014).

*Mentoring for minority students:* Discrepancies between mentoring opportunities available to minority and Caucasian students is of concern (Jacobi, 1991). Mentoring for minority students used to be rare (Haring, 1999; Johnson, 1989), albeit recent efforts have investigated the impact of mentoring on this group (Bernier, Larose, & Soucy, 2005; Bordes & Arredondo, 2005; Campbell & Campbell, 1997; Collier & Morgan, 2006; Gershenfeld, 2014; Ishiyama, 2007; Kador & Lewis, 2007; LaVant, Anderson, & Tiggs, 1997; Lee, 1999; Zalaquett & Lopez, 2006). Mentoring has been recommended to offer minority students the support needed to succeed in an environment that may appear alienating or hostile (Johnson, 1989; Moore & Amey, 1988; Sedlacek, 1983; Ugbah & Williams, 1989). Albeit some reports exist on the mentoring of science and engineering students (Frierson Jr, 1996; Hoyte & Collett, 1993), work on the mentoring of minority engineering students is still inchoate. This is unfortunate, since attrition among minorities has been attributed to academic and cultural isolation, lack of peer support, low motivation, low expectations, and discrimination (Allen, 1992; Gándara & Maxwell-Jolly, 1999; Garrison, 1987; Nettles & Thoeny, 1988; Seymour & Hewitt, 1997; Steele & Aronson, 1995). These issues can be addressed by mentoring, which can increase the number of students that earn science and engineering degrees (Maton et al., 2000) and join graduate programs (Hrabowski & Maton, 1995; Maton & Hrabowski III, 2004).

*Challenges for mentoring in academic engineering departments:* Unfortunately, mentoring in academic engineering departments is rendered difficult by several factors, faculty role strain having been identified as a chief concern (Bowen & Sosa, 1989; Boyer, 1990; Fairweather, 1996; Geisler & Rubenstein, 1989).

*Opportunities for mentoring in research centers:* Some research centers display a number of attributes conducive to mentoring (Bozeman & Boardman, 2003). Specifically, research centers staffed with non-faculty researchers – who typically have lower teaching and administrative workloads than faculty – may be particularly amenable to mentoring, since student retention is enhanced by the amount and frequency of student-mentor non-classroom contact (Pascarella, Terenzini, & Feldman, 1991). Moreover, the research focus of research centers tends to be entirely problem driven and not to closely track disciplines or established scientific and technical specialties (Bozeman & Boardman, 2003). However, research centers that require for its affiliates to be full-time tenured or tenure track faculty may not favor mentoring, as research center association exacerbates faculty role strain (Boardman & Bozeman, 2007; Bozeman & Boardman, 2004).

*Mentoring of minority engineering students at a center for applied research (CAR):* Since the mentoring literature is lacking in terms of the potential benefits of housing mentoring programs in research centers relative to traditional engineering departments, the prospect of broadening participation in engineering through a CAR-based mentoring program is now being investigated. The CAR involved is staffed by full-time non-faculty scientists and engineers researching topical subjects. Students involved in the CAR research projects have access to ancillary services, facilities and support staff. Besides gaining laboratory experience, students working at the CAR receive credit towards a degree and/or compensation. In addition, students gain authorship in journal articles, attend scientific conferences to present their results, and participate in a number of outreach efforts. The CAR offers student researchers a supportive environment, as students experience a sense of permanence and community in the organization.

*Goals of CAR-based mentoring:* The CAR-based mentoring initiative is designed to accomplish three main goals: 1) to motivate minority students to study engineering and help them graduate with engineering degrees; 2) to help these students acquire the skills they need to become engineering professionals, academics, leaders and role models; and 3) to investigate if mentoring in research centers offers advantages over mentoring in traditional engineering departments.

*Description of CAR-based mentoring program:* 10-15 minority engineering students are recruited each fall. Students meet right away with a College of Engineering counselor and a CAR point of contact. This establishes a connection between university personnel and students from the moment they arrive on campus, a critical component of any successful mentoring program (Astin, 1982; Fleming, 1981; Flemming, 1988; Parker & Scott, 1985; Pounds, 1987). A first meeting is immediately held to explain participants the goals and benefits of the mentoring program, as students seem unable to press mentoring to its fullest potential when they lack this understanding (Haring, 1999). In this way, students are placed in a supportive environment and meet other students like them at an early stage, which are vital initial steps of mentoring programs shown to improve retention (LaVant et al., 1997). Participants are also asked about their needs to be successful in college, as need assessment represents a desirable first step because needs vary widely (Haring, 1999). Early on their engineering studies, students tour the CAR and learn about its research groups and projects. Based on their interests and preferences, students are then matched with a CAR mentor. Throughout their college years, students receive support and guidance from the aforementioned counselor, a CAR point of contact and mentor.

These individuals help students develop the skills they needed to pursue a successful career in engineering.

*Skills to be developed through mentoring:* Students are helped to develop their academic and study skills, research skills, communication skills, teaching skills, funding procurement and project management skills, and outreach skills by their counselor, their CAR point of contact and their mentor, who also make use of a variety of resources available at the university. This arrangement avoids understaffing, a design flaw commonly found in mentoring programs (Haring, 1999).

*Types of mentoring expected and observed:* Given that mentoring roles can also be assumed by senior student and peers (Haring, 1999; Kram & Isabella, 1985; Zalaquett & Lopez, 2006), authors have identified several types of naturally occurring mentoring relationships in addition to classic mentoring, namely, individual-team, friend-to-friend, and peer-group (Philip & Hendry, 2000). Since this provides each student with an extended support network, this program incorporates elements of network mentoring (Haring, 1997; Swoboda & Millar, 1986). Moreover, the mentoring program includes both formal mentoring relationships, which are structured and managed (Chao, Walz, & Gardner, 1992), and informal mentoring relationships, which develop naturally (Campbell & Campbell, 1997; Chao et al., 1992).

*Assessment of previous mentoring studies:* Research on mentoring has been limited by data collection at a single point in time, as well as by the fact that most studies display a pre- and post-design and limited sample sizes (Jacobi, 1991). Moreover, two common threats to internal validity have been identified in previous mentoring reports, namely the lack of control groups and of reliable measurement instruments (Crisp & Cruz, 2009; Gershenfeld, 2014; Paglis, Green, & Bauer, 2006). Thus, a quasi-experimental design including cross-sectional and longitudinal components is needed (Cook & Campbell, 1979).

*Assessment of the present mentoring study:* The 4-year duration of this mentoring program allows for the acquisition of valuable longitudinal data, which will be collected at multiple and regular intervals to determine the amount of time it takes for mentoring effects to emerge and the length of time that these effects persist (Jacobi, 1991). Cross-sectional information is being acquired in the form of data that will allow a comparison between mentored and unmentored students as well as between students mentored at a research center and those mentored at traditional engineering departments. Both objective and subjective measures are being used, since the latter has been deemed to hold the greatest promise to achieve internal, external and social validity (Gershenfeld, 2014). Objective parameters include both retention and performance data, while subjective parameters include feelings of integration to the university environment and perception of mentoring relationships, which are being gauged through survey instruments. Notably, the size of the population sample is within the range employed in some of the foremost studies on mentoring in a college setting published to date (Frierson, Hargrove, & Lewis, 1994; Gershenfeld, 2014). This approach offers important advantages over a true randomized experiment, which has been associated with ethical concerns (Gershenfeld, 2014).

*Initial results of assessment:* In terms of academic performance, participants in the research-center based broadening participation in engineering (BPE) mentoring program belonging to the

cohort recruited in the fall of 2015 had a higher average cumulative GPA at the end of the fall 2015, spring 2016 and fall 2016 semesters than underrepresented minority (URM) engineering students from the same cohort not participating in the BPE mentoring program, this improved performance for BPE program participants being observed irrespective of ethnicity, i.e., across both African American and Hispanic students (see Figure 1).

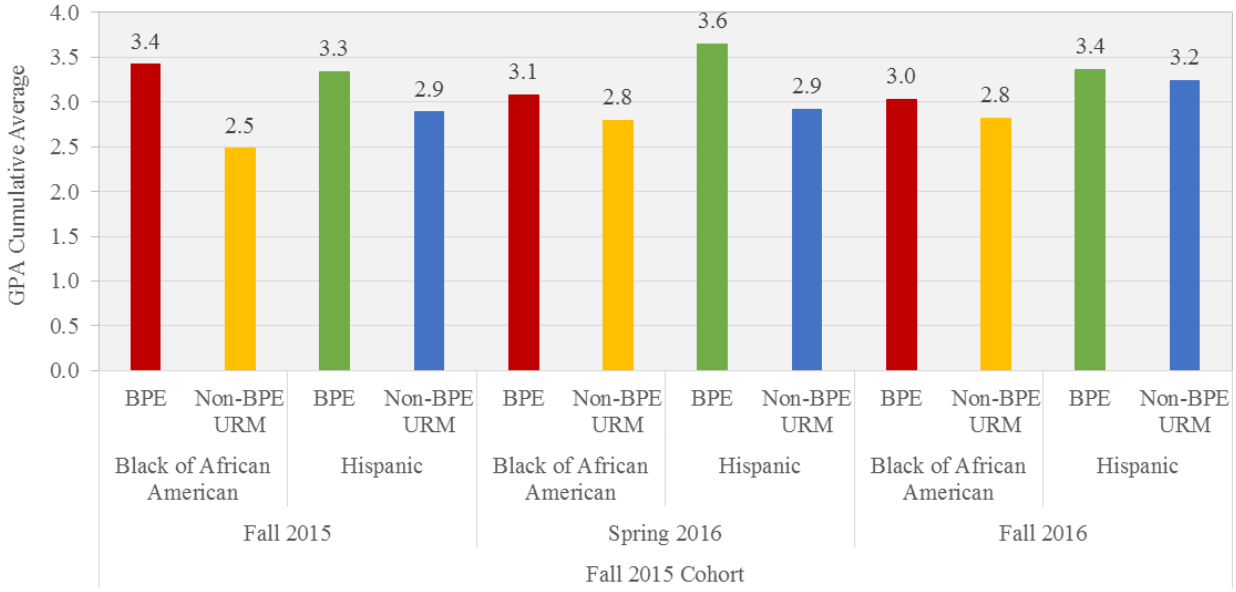


**Figure 1. Academic performance of BPE and non-BPE URM engineering students**

In terms of retention, 80% of the BPE and non-BPE URM engineering students recruited in the fall of 2015 remained students in good standing within the College of Engineering by the spring of 2016; however, while the aforementioned value remained unchanged in the next semester for BPE students, only 57% of non-BPE URM engineering students remained students in good standing within the College by the fall of 2016. Subjective measures have been studied through the use of surveys, a first survey being employed to assess the needs and expectations of participating students. Recurrent answers included assistance improving both study and time management skills, help deciding on major and career path, as well as support accessing opportunities to attain hands-on experience in the field. A second survey was employed to probe the feelings of integration to the university environment and the importance attributed to having mentors of the same gender or ethnicity. Students reported feeling very well integrated to the university environment thanks to the mentoring program. However, ambivalent answers were given to having mentors of the same gender or ethnicity, albeit gender was identified as a more important criterion and academic interests were identified as an equally or more important matchmaking parameter. A third survey focused on the perception on the part of mentored students of different mentoring relationships, students invariably ranking research center-based and mentoring program-associated mentoring relationships more positively.

*Acknowledgement and disclaimer:* This material is based upon work supported by the National Science Foundation under Grant No. 1444779. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

**References**


Allen, W. (1992). The color of success: African-American college student outcomes at predominantly white and historically black public colleges and universities. *Harvard Educational Review, 62*(1), 26-45.

Astin, A. W. (1982). *Minorities in American higher education: Recent trends, current prospects, and recommendations.* San Francisco, CA: Jossey-Bass.

Astin, A. W. (1984). Student involvement: A developmental theory for higher education. *Journal of College Student Personnel, 25*(4), 297-308.

Bernier, A., Larose, S., & Soucy, N. (2005). Academic mentoring in college: The interactive role of student's and mentor's interpersonal dispositions. *Research in Higher Education, 46*(1), 29-51.

Boardman, C., & Bozeman, B. (2007). Role strain in university research centers. *The Journal of Higher Education, 78*(4), 430-463.

Bordes, V., & Arredondo, P. (2005). Mentoring and 1st-year latina/o college students. *Journal of Hispanic Higher Education, 4*(2), 114-133.

Bowen, W. G., & Sosa, J. A. (1989). *Prospects for faculty in the arts and sciences*. Princeton, NJ: Princeton University Press.

Boyer, E. L. (1990). *Scholarship reconsidered: Priorities of the professoriate*. Princeton, NJ: Carnegie Foundation for the Advancement of Teaching.

Bozeman, B., & Boardman, C. (2003). *Managing the new multipurpose, multidiscipline university research center: Institutional innovation in the academic community*. Washington, DC: IBM Endowment for the Business of Government.

Bozeman, B., & Boardman, C. (2004). The NSF engineering research centers and the university–industry research revolution: A brief history featuring an interview with Erich Bloch. *The Journal of Technology Transfer, 29*(3-4), 365-375.

Campbell, T. A., & Campbell, D. E. (1997). Faculty/student mentor program: Effects on academic performance and retention. *Research in Higher Education, 38*(6), 727-742.

Chao, G. T., Walz, P., & Gardner, P. D. (1992). Formal and informal mentorships: A comparison on mentoring functions and contrast with nonmentored counterparts. *Personnel Psychology, 45*(3), 619-636.

Chickering, A. W. (1969). *Education and identity*. San Francisco, CA: Jossey-Bass.

Collier, P., & Morgan, D. (2006). *Students first mentoring project: Using role-theory to improve low-income, first generation student retention*. Paper presented at the Annual Meeting of the American Sociological Association, Montreal, Quebec.

Cook, T. D., & Campbell, D. T. (1979). *Quasi-experimentation: Design & analysis issues for field settings*. Chicago, IL: Rand McNally.

Crisp, G., & Cruz, I. (2009). Mentoring college students: A critical review of the literature between 1990 and 2007. *Research in Higher Education, 50*(6), 525-545.

Fairweather, J. S. (1996). *Faculty work and public trust: Restoring the value of teaching and public service in American academic life*. Boston, MA: Allyn and Bacon.

Fleming, J. E. (1981). The opening of white colleges and universities to black students. In G. E. Thomas (Ed.), *Black students in higher education: Conditions and experiences in the 1970s*. Wesport, CN: Greenwood Press.

Flemming, J. (1988). *Blacks in college: A comparative study of students' success in black and in white institutions*. San Francisco, CA: Jossey-Bass.

Frierson, H. T., Hargrove, B. K., & Lewis, N. R. (1994). Black summer research students' perceptions related to research mentors' race and gender. *Journal of College Student Development, 35*(6), 475-480.

Frierson Jr, H. T. (1996). *Comparing science and non-science minority students' perceptions and satisfaction with a short-term research and mentoring program*. Paper presented at the Annual Meeting of the American Educational Research Association, New York, New York.

Gándara, P., & Maxwell-Jolly, J. (1999). *Priming the pump: Strategies for increasing the achievement of underrepresented minority undergraduates*. New York, NY: College Entrance Examination Board.

Garrison, H. H. (1987). *Undergraduate science and engineering education for blacks and native americans.* Paper presented at the Minorities: their underrepresentation and career differentials in science and engineering conference. Proceedings of a workshop. National Academy Press, Washington, DC.

Geisler, E., & Rubenstein, A. H. (1989). University-industry relations: A review of major issues. In A. N. Link (Ed.), *Cooperative research and development: The industry-university-government relationship* (pp. 43-64). Boston: Kluwer.

Gershenfeld, S. (2014). A review of undergraduate mentoring programs. *Review of Educational Research, 84*(3), 365-391.

Haring, M. J. (1997). Networking mentoring as a preferred model for guiding programs for underrepresented students. *Diversity in Higher Education, 1*, 63-76.

Haring, M. J. (1999). The case for a conceptual base for minority mentoring programs. *Peabody Journal of Education, 74*(2), 5-14.

Hoyte, R. M., & Collett, J. (1993). "I can do it": Minority undergraduate science experiences and the professional career choice. In J. Gainen & R. Boice (Eds.), *New Directions for Teaching and Learning* (Vol. 1993, pp. 81-90). San Francisco, CA: Jossey-Bass.

Hrabowski, F. A., & Maton, K. I. (1995). Enhancing the success of African-American students in the sciences: Freshman year outcomes. *School Science and Mathematics, 95*(1), 19-27.

Ishiyama, J. (2007). Expectations and perceptions of undergraduate research mentoring: Comparing first generation, low income white/caucasian and African American students. *College Student Journal, 41*(3), 540.

Jacobi, M. (1991). Mentoring and undergraduate academic success: A literature review. *Review of Educational Research, 61*(4), 505-532.

Johnson, C. S. (1989). Mentoring programs. In M. L. Upcraft & J. Gardner (Eds.), *The freshman year experience: Helping students survive and succeed in college* (pp. 118-128). San Francisco, CA: Jossey-Bass.

Kador, J. T., & Lewis, C. W. (2007). The role of mentors/advisors in the doctoral training of African American students at predominantly white universities: Implications for doctoral training. *Essays in Education, 19*, 100-118.

Kram, K. E., & Isabella, L. A. (1985). Mentoring alternatives: The role of peer relationships in career development. *Academy of Management Journal, 28*(1), 110-132.

LaVant, B. D., Anderson, J. L., & Tiggs, J. W. (1997). Retaining African American men through mentoring initiatives. *New Directions for Student Services, 1997*(80), 43-53.

Lee, W. Y. (1999). Striving toward effective retention: The effect of race on mentoring African American students. *Peabody Journal of Education, 74*(2), 27-43.

Maton, K. I., Hrabowski, F. A., & Schmitt, C. L. (2000). African American college students excelling in the sciences: College and postcollege outcomes in the Meyerhoff Scholars Program. *Journal of Research in Science Teaching, 37*(7), 629-654.

Maton, K. I., & Hrabowski III, F. A. (2004). Increasing the number of African American PhDs in the sciences and engineering: A strengths-based approach. *American Psychologist, 59*(6), 547.

Moore, K. M., & Amey, M. J. (1988). Some faculty leaders are born women. *New Directions for Student Services, 44*, 39-50.

National Science Foundation. (2013). *Women, minorities, and persons with disabilities in science and engineering: 2013. Special report NSF 13-304*. Arlington, VA: National Science Foundation.

National Science Foundation. (2014). *Doctorate recipients from U.S. Universities: 2012. Special report NSF 14-305*. Arlington, VA: National Science Foundation.

Nettles, M. T., & Thoeny, A. R. (1988). *Toward black undergraduate student equality in American higher education* (Vol. 25). Westport, CT: Greenwood Publishing Group.

Nora, A., & Crisp, G. (2007). Mentoring students: Conceptualizing and validating the multi-dimensions of a support system. *Journal of College Student Retention: Research, Theory and Practice, 9*(3), 337-356.

Paglis, L. L., Green, S. G., & Bauer, T. N. (2006). Does adviser mentoring add value? A longitudinal study of mentoring and doctoral student outcomes. *Research in Higher Education, 47*(4), 451-476.

Parker, W. M., & Scott, J. (1985). Creating an inviting atmosphere for college students from ethnic minority groups. *Journal of College Student Personnel, 26*(1), 82-84.

Pascarella, E. T., Terenzini, P. T., & Feldman, K. A. (1991). *How college affects students*. San Francisco, CA: Jossey-Bass.

Pearson, R. E. (1990). *Counseling and social support: Perspectives and practice*. Newbury Park, CA: Sage.

Philip, K., & Hendry, L. B. (2000). Making sense of mentoring or mentoring making sense? Reflections on the mentoring process by adult mentors with young people. *Journal of Community & Applied Social Psychology, 10*(3), 211-223.

Pounds, A. W. (1987). Black students' needs on predominantly white campuses. *New Directions for Student Services, 1987*(38), 23-38.

Sedlacek, W. E. (1983). Teaching minority students. *New Directions for Teaching and Learning, 16*, 39-50.

Seymour, E., & Hewitt, N. M. (1997). *Talking about leaving: Why undergraduates leave the sciences* (Vol. 12). Boulder, CO: Westview Press.

Steele, C. M., & Aronson, J. (1995). Stereotype threat and the intellectual test performance of African americans. *Journal of Personality and Social Psychology, 69*(5), 797.

Swoboda, M. J., & Millar, S. B. (1986). Networking-mentoring: Career strategy of women in academic administration. *Journal of NAWDAC, 49*, 8-13.

Thomas, R., Murrell, P. H., & Chickering, A. W. (1982). Theoretical bases and feasibility issues for mentoring and developmental transcripts. *New Directions for Student Services, 19*, 49-65.

Tinto, V. (1975). Dropout from higher education: A theoretical synthesis of recent research. *Review of Educational Research, 45*(1), 89-125.

Ugbah, S., & Williams, S. (1989). The mentor-protégé relationship: Its impact on blacks in predominantly white institutions. In J. C. Elam (Ed.), *Blacks in higher education: Overcoming the odds* (pp. 29-42). Lanham, MD: University Press of America.

Vaux, A., Phillips, J., Holly, L., Thomson, B., Williams, D., & Stewart, D. (1986). The social support appraisals (SS-A) scale: Studies of reliability and validity. *American Journal of Community Psychology, 14*(2), 195-218.

Zalaquett, C. P., & Lopez, A. D. (2006). Learning from the stories of successful undergraduate latina/latino students: The importance of mentoring. *Mentoring & Tutoring, 14*(3), 337-353.