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Texas versus California: Trends in Gender Diversity and Impacts by Engineering Discipline

Prof. Keith J Bowman, Illinois Institute of Technology

Keith J. Bowman became Professor and Chair of the Department of Mechanical, Materials and Aerospace Engineering at Illinois Institute of Technology (IIT) in August, 2011, immediately following nearly five years of experience leading the Purdue School of Materials Engineering as Interim Head and Head. His first faculty appointment was as an Assistant Professor at Purdue University in 1988 after receiving degrees from Case Western Reserve University (CWRU), (B.S. 1981, M.S. 1983) and the University of Michigan (Ph.D. 1987). He was promoted to Associate Professor in 1992, and then promoted to Professor in 1996. Keith Bowman served as a visiting professor and received Alexander von Humboldt stipends for research at the Technical University of Darmstadt, Germany in 1996 and again in 2002. He served as a visiting professor at the University of New South Wales in Sydney, Australia in 2003. From 1996 to 2004 he served as graduate program chair of the Purdue School of Materials Engineering (MSE) during a substantial retooling of the program to more strongly emphasize doctoral degrees. In 2005-06 he served a one-year appointment as Interim Head of MSE and in 2007 was named Head of the Purdue School of Materials Engineering (MSE). He was named a Fellow of the American Ceramic Society in 2000, and has held several division and society positions, including becoming a member of the Board of Directors in 2012. In ASME, known as the American Society of Mechanical Engineers, he is a member of the executive committee of the mechanical engineering department heads and chairs (MEDHC). Awards at Purdue University include receiving the MSE Best Teaching Award in 1992 and 1995 and Purdue's highest teaching award, the Charles Murphy Undergraduate Teaching Award in 1995. In 2003 Professor Bowman's name was added to the Purdue Book of Great Teachers. In 2007 he received the Purdue College of Engineering Mentoring Award and he became a Professor of Engineering Education (by courtesy). In 2012 he was invested as the first Duchossois Leadership Professor in the IIT Armour College of Engineering.

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Introduction

Across the past decade, there has been tremendous growth in Bachelor's (BS) degree attainment in US engineering schools coupled with clear challenges towards advancing gender diversity. The focus of this assessment is to explore trends in gender diversity for engineering BS degrees produced by public universities in our two largest states. In 2013, California represented about twelve percent of the US population and the public systems in California provided an education to approximately ten percent of engineering BS degree recipients for that year (US Census, 2015, ASEE, 2014, ASEE 2015). In the same year, Texas represented about eight percent of the US population and the public university systems in Texas provided an education to approximately six percent of the engineering BS degree recipients (US Census, 2015, ASEE, 2014).

The two largest US states, Texas and California, both have multiple public university systems that educate engineers in accredited programs that include universities with strong reputations for research and education. Both states have a large number of public colleges and schools with ABET-accredited engineering bachelor's (BS) degree programs as shown in Table 1 (ABET, 2015).

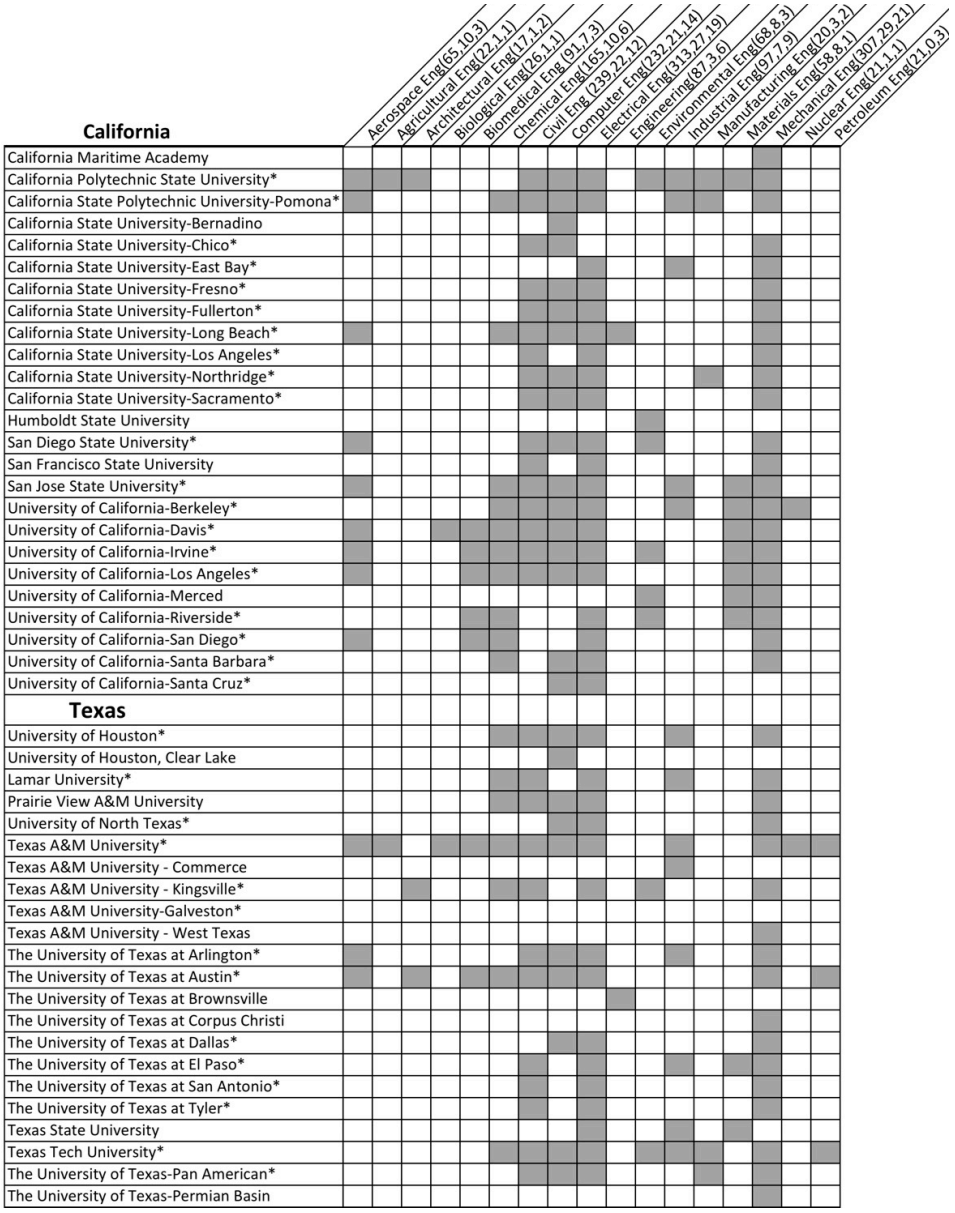
The 1960 Donahue Higher Education Act, considered more broadly as California's Master Plan for Higher Education (1960), established the course for California's community colleges, the California State University System and the University of California System . The Master Plan considered cost, access and faculty quality while enabling the top 12.5% of high school graduates admission to a University of California (UC) campus and the top 33.3% admission to a California State University (CSU) campus (CPEC, 2007; PPIC, 2010; The Economist, 2012). As of this writing, there are 10 UC and 23 CSU campuses. As shown in Table 1 all UC campuses have two or more engineering degree programs with four UC campuses having eight or more degree programs. For CSU, sixteen of the campuses have at least one ABET-accredited engineering degree program with three CSU campuses, Cal Poly, Cal Poly Pomona and CSU, Long Beach, having seven or more engineering degree programs. Factoring in all adult residents, including those who moved to California, fifty years after the inception of the Master Plan the fraction with a bachelor's degree is 31%. By some estimates, a higher rate of BS degree attainment will be required to keep up with employment demand and the expectation is that STEM BS degree attainment will need to increase at higher rates.

One notable aspect of California's college eligibility is the gender gap. Across all races and ethnicities women are much more likely than men to qualify. In the last published study on admissions eligibility (CPEC, 2007), the gap reached a rate of eligibility for males that is only about 70% that of females for both the UC and CSU systems. Eligibility, however, is not the entire story since students must first apply, enroll and then complete degrees.

Texas (THECB, 2015) has six university systems as well as a number of independent state universities with a total of forty universities. Since 2000, Texas has been engaged in a program called "Closing the Gaps: The Texas Higher Education Plan," an initiative of the Texas Higher Education Coordinating Board (THECB) (THECB, 2014; Tienda & Sullivan, 2015, Rankin, 2013). The goal of the plan is to reduce gaps in "participation, success, excellence, and research" between Texas and other states by 2015. Texas made some progress towards meeting the expected goals, including exceeding goals for overall degrees to African Americans and

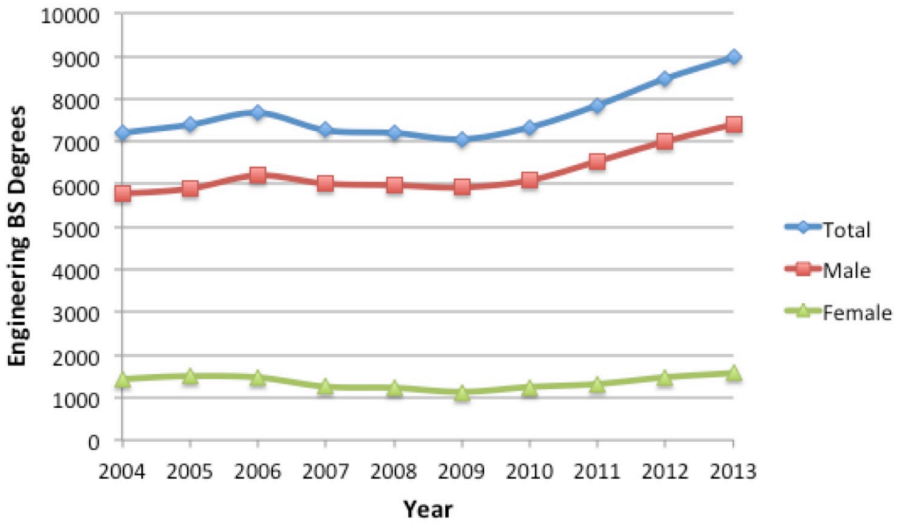
Hispanic Americans. For degrees in Science, Technology, Engineering and Mathematics (STEM) the growth in Hispanic Americans has been quite strong. At the same time, the fraction of STEM degrees earned by women declined from one quarter to one fifth of all degrees.

Table 1 ABET Accredited Engineering Degree Programs (ABET, 2015)

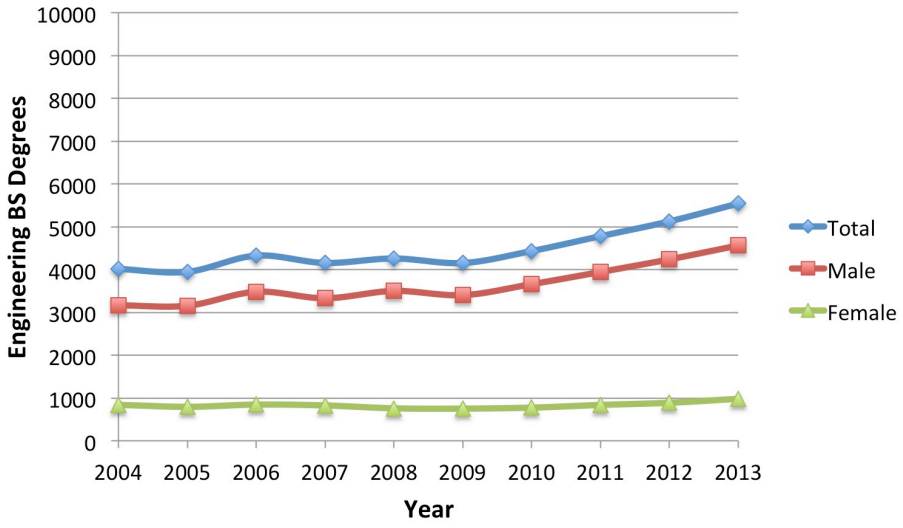


The number of accredited programs is noted for each category after the degree category by (US, CA, TX). The table does not include the following engineering disciplines: Construction Engineering, Ceramic Engineering, Construction Management, Engineering Management, Engineering Technology, Metallurgical Engineering and Ocean Engineering, all quite small disciplines, are not included in this table due to space and program size limitations. Computer science programs are not included as they often lie outside of engineering colleges and some colleges in this sample are colleges of engineering and science or technology.

Data for the remainder of this paper was obtained using the ASEE (2015) Data Mining Tool and relies upon data voluntarily submitted by engineering colleges and schools. The database enables sorting on the basis of a large number of categories with separate demographic categories for race and ethnicity coupled with gender since 2005. Nearly all large and well-established programs provide this data, but smaller and recently-established programs are more variable in participation.



(a) California



(b) Texas

Figure 1 Engineering BS degrees for (a) California and (b) Texas (ASEE, 2015). Programs with an * in Table 1 were included in this data. The remaining programs either had limited data across the ten years, repeat or unusual entries or very small numbers of programs or students.

Figure 1 shows that California and Texas are fairly consistent with the pattern of engineering BS degree production that has dominated the last decade. Both states showed flat or slightly declining total degree production corresponding to effects of both the dot com bubble and the late 2000s recession for the first half of the decade. For California, wherein a stronger proportion of industry is in electronics and computing, engineering degree production overall parallels, albeit with a softer profile, the large peaks and valleys seen for computer science degrees (Zweben & Bizot, 2014). Both states show a rapid increase in BS degree production from 2009. For California, the year-on-year growth rate averages 6.2% for the past four years and for Texas, the growth rate is averaging 7.4%.

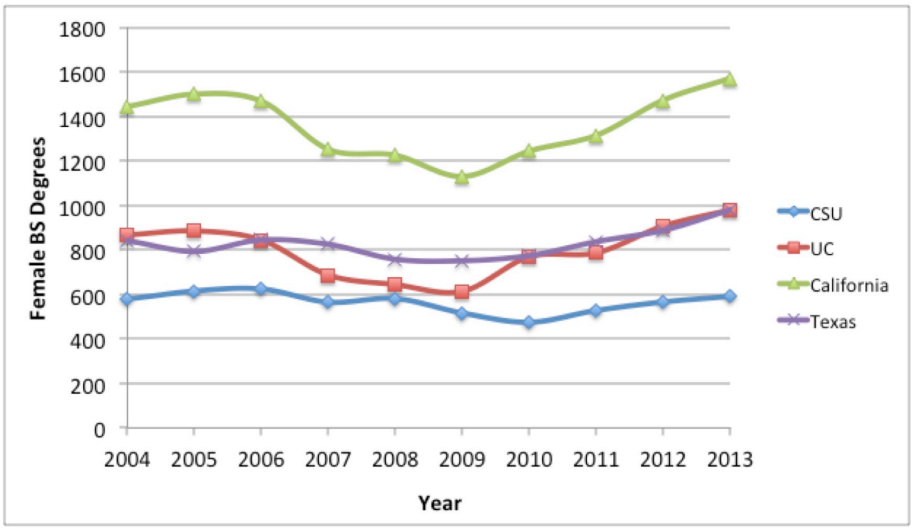


Figure 2 Female engineering BS degrees by year for CSU, UC, California and Texas (ASEE, 2015). Programs with an * in Table 1 were included in this data. The remaining programs either had limited data across the ten years, repeat or unusual entries or very small numbers of programs or students.

Figure 2 shows the changes in female engineering BS degree production across the past ten years for California and Texas universities. Degree production for California, the sum of the CSU and UC values, has undergone a much more extreme range of changes across the decade than US degrees overall. After a long period of overall increase, the number of reported female BS degrees peaked at 1500 in 2005 and then declined to 1130 in 2009, representing a decrease of nearly 25%. Since then, the number of female BS degrees has increased by 39%. But, across the two systems, CSU and UC the magnitude of change is substantially different. For CSU engineering programs, the initial decrease from 2005 to 2009 was only 10% and the increase since 2009 has been about 15%. For the UC system a large decrease from 2005 to 2009 of 29% has been followed by an increase of nearly 60%.

Although the numbers are somewhat volatile due to the small size of some programs, the CSU programs Cal Poly, Fresno and Fullerton experienced healthy growth of 36%, 43%, and 64%, respectively, in the number of female BS engineering degrees. On the other hand, East Chico, Los Angeles and Sacramento had substantial declines of 43%, 46% and 50%. The growth is

consistently positive for the UC programs, with Riverside, Santa Barbara and Santa Cruz more than doubling the number of female engineering BS degrees. Berkeley, in most years the largest producer of engineering BS degrees in the UC system, strongly trailed all other UC programs with an increase in female BS engineering degrees of only 19.2%. Across the same time period male BS engineering degrees at Berkeley increased by about 35%.

In 2005, Berkeley had the highest fraction of female BS engineering degrees among California public institutions at 28.5%. For 2013, the female fraction of BS engineering degrees at Berkeley was fourth in California at 20.1%. Among all California public engineering programs only Irvine and Riverside have made clear positive improvements in BS degree gender diversity since 2005, with Irvine increasing from 19.5% to 23.4%.

Texas' two A&M campuses, the flagship and Kingsville, have made modest progress across the nine years. UT Austin, as the second largest producer of BS engineering degrees has declined slightly to exactly match Texas A&M in gender diversity. As the third largest BS engineering degree producer, Texas Tech (TTU), trails most Texas institutions at a consistently low female fraction of about twelve percent. Prairie View A&M and UT-Pan American, both Minority Serving Institutions (African American and Hispanic American, respectively) have experienced strong declines of over eleven percent in female fraction. The strong decline in female fraction for Prairie View A&M is consistent with a national trend for African American female engineers and Historically Black Colleges and Universities (HBCUs) across the same period (Bowman, 2014a).

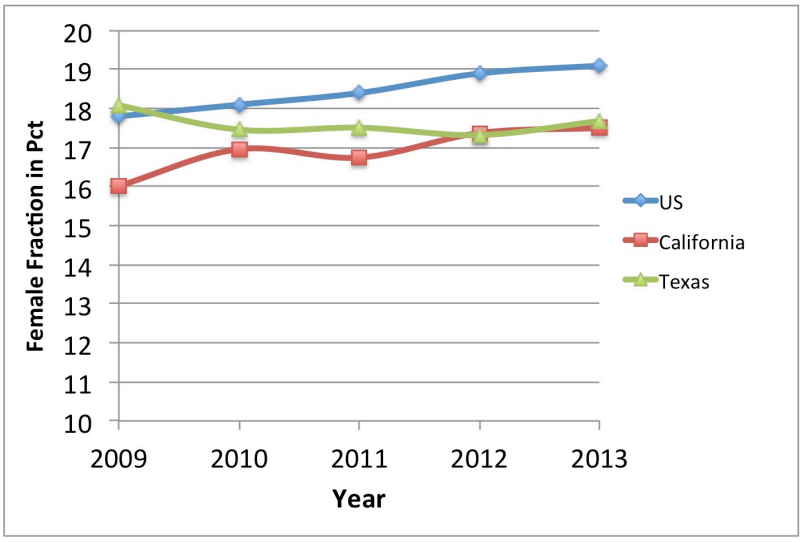


Figure 3 Female fraction for California, Texas and the US (ASEE, 2015). Programs with an * in Table 1 were included in this data. The remaining programs either had limited data across the ten years, repeat or unusual entries or very small numbers of programs or students.

In context, Figure 3 shows that the five-year trend for female fraction for California is somewhat encouraging. California overall is tracking with the US fairly well. On the other hand, Texas has shown a fairly flat or slightly declining trend across the past five years.

As shown by Table 1, an additional difference between the states and the individual universities and university systems is the difference in availability of engineering disciplines. Because the engineering disciplines vary considerably in gender distribution, a different mix of disciplines can also result in a different gender mix. Table 2 addresses this by showing the number of reported degrees, the fraction of the total number of engineering degrees and the gender fraction for each of the five largest engineering disciplines for the US and both states (ASEE, 2015).

California produces a smaller fraction of ME and ChE BS degrees than it does engineering degrees overall, but produces a substantially larger fraction of ECE, CE and BME BS degrees. The slightly smaller fraction of ME degrees may result from a stronger emphasis on electronics and computing. The smaller fraction of ChE degrees may result from a relatively limited number of ChE degree programs, particularly in the CSU system. If California produced ChE degrees proportional to the rate it produces engineering degrees overall and if this change did not negatively impact the numbers of degrees and gender diversity in the other engineering disciplines (Bowman, 2011) the net female fraction of engineering degrees would be equal to the national female fraction. Only three CSU campuses, Poly Pomona, Long Beach and San Jose State have ABET-accredited ChE degree programs.

Table 2 BS Degrees, Degree Fractions and Female Fractions for the US, California and Texas

2013	Degrees	Fraction of Total	Female Fraction
US Engineering	93,423	~	19.1%
California	8976	9.6%	17.5%
Texas	5542	5.9%	17.7%
US ME	21707		12.5%
California	1824	8.4%	11.8%
Texas	1298	6.0%	12.0%
US ECE	17149	~	12.2%
California	2051	**12.0%**	12.2%
Texas	1085	6.3%	10.3%
US CE	12464	~	21.0%
California	1732	**13.9%**	23.0%
Texas	739	5.9%	23.3%
US ChE	7717	~	32.3%
California	549	7.1%	30.1%
Texas	469	6.1%	30.9%
US BME	4709	~	38.9%
California	649	**13.8%**	34.1%
Texas	190	4.0%	36.8%

Texas produces ME, ECE, CE and ChE BS degrees nearly in proportion to engineering degrees overall, but produces a much smaller fraction of BME degrees. The smaller fraction of BME degrees is due to the limited availability of BME degrees at Texas universities. Only Texas A&M and UT Austin offer BME degrees. If Texas produced BME degrees proportional to the rate it produces engineering degrees overall and if this change did not negatively impact the numbers of degrees and gender diversity in the other engineering disciplines (Bowman, 2011) the net female fraction of engineering degrees would be equal to the national female fraction.

In most instances, the female fraction by BS degree discipline for both states equals or lags slightly the national female fraction for that discipline.

Discussion

As the two largest states, California and Texas have a significant impact on engineering degree production and engineering diversity (CPEC 2007, THECB (2014)). Although the states are demonstrably different in approaches to higher education systems, both states have factored diversity and inclusion into their higher education planning.

For California, the UC system has recently recovered quite aggressively towards having growth in female BS engineering degrees match the strong growth of male engineering degrees. Student admissions, recruiting and the broad range of degree options, including degree programs such as BME, ChE, bioengineering and environmental engineering appear successful in ensuring that the female fraction for BS engineering degrees will at least approach national levels. But, for the CSU system, potential competition with the UC system for some students, the reliance on student pathways that begin with community colleges and the limited number of degree options may limit gender diversity. Because CSU campuses offer one new, as yet not ABET-accredited, BME program (San Jose State, 2015) and only three ChE degrees, students with these interests may not be attracted to these campuses even though faculty in other disciplines teach courses, mentor projects and do research in related topics. Recently, CSU Los Angeles (2015) announced an undergraduate minor in biomedical engineering that will start in Fall, 2016. Some students at CSU campuses who might otherwise have interests in biomedical engineering can choose science disciplines such as biology, chemistry, environmental science and biochemistry instead of engineering disciplines. Five CSU campuses do offer industrial engineering (IE), manufacturing engineering (MfgE), or both. Nationally, both IE and MfgE produce BS degree female fractions of nearly 30% (ASEE, 2014). But, the small program size and the somewhat lower gender diversity (~23%) of the CSU IE/MfgE programs does not have a significant positive effect on the overall gender diversity of CSU engineering colleges and schools.

For Texas little progress has been made in gender diversity of BS engineering degrees across the past five years. Limited availability of BME degrees may contribute, as does the persistently low female BS degree production of the third largest undergraduate engineering program at TTU. TTU produced only 7.6% of 2013 Texas female BS engineering degrees while producing 12.5% of male BS engineering degrees. Ten Texas campuses offer industrial engineering (IE), manufacturing engineering (MfgE), or both. But, small program size and the somewhat lower gender diversity (~24%) of the Texas IE/MfgE programs does not have a significant positive effect on the overall gender diversity of Texas engineering colleges and schools. Texas A&M produced nearly half of Texas' IE/MfgE degrees in 2013, but the female fraction was only 16%.

With the exception of Hispanic Americans, growth in BS degree attainment in US engineering schools has been coupled with relatively limited increases in underrepresented groups, including African Americans and Native Americans (ASEE, 2014; Bowman 2014b; 2014c). As the two largest US states, Texas and California have multiple public university systems that educate engineers in ABET-accredited programs. Public universities in both states include some of this country's highest ranked engineering colleges or schools. The states also have been involved in some competitive debates in recent years, including efforts to lure or retain industry (Kirkham, 2014). Nearly one third of California residents hold an undergraduate degree, whereas in Texas about one fourth do. But, as much as these two states lead the US in many ways, they have not been successful leaders in advancing gender diversity for undergraduate education in engineering. I believe that success in advancing gender diversity requires breaking down the challenge into coherent pieces, including state, conference/association, industry and disciplinary pieces wherein we can all dig in and address the challenges piece-by-piece. I hope that with this assessment of the two states, and some healthy competition, education commissions and engineering educators in both states will be inspired to more effectively advance diversity and inclusion. Coupled with K-12 outreach, admissions and recruiting and program changes, Texas and California could both advance towards the national leadership expected by citizens in each of these largest of US states.

References

ABET, (2015) http://abet.org/

ASEE (2014) 2013 ASEE Profiles of Engineering and Engineering Technology Colleges, Engineering Statistics, pages 11-47 http://www.asee.org/papers-and-publications/publications/14_11-47.pdf

ASEE (2015) The ASEE Data Mining Tool, http://edms.asee.org/session/new

Bowman, Keith J. (2011) "Potential Impacts of Creating Biomedical Engineering (BME) Programs on Gender Distribution within Leading Engineering Colleges." *Journal of Diversity in Higher Education,* 2011, Vol. 4, No. 1, 51–64.

Bowman, Keith J. (2014a) "Disturbing Decline in Engineering Degrees for African American Women" September 21, 2014. https://www.linkedin.com/pulse/article/20140921062338-161640750-disturbing-decline-in-engineering-degrees-for-african-american-women

Bowman, Keith J. (2014b) "Rapid Growth in Engineering Degree Production- Sustainable?" July 5, 2014 https://www.linkedin.com/pulse/article/20140705041849-161640750-rapid-growth-in-engineering-degree-production-sustainable

Bowman, Keith J. (2014c) "Texas vs California: Hispanic American Engineers" October 25, 2014 https://www.linkedin.com/pulse/article/20141025070316-161640750-texas-vs-california-hispanic-american-engineers

California Master Plan for Higher Education (1960) http://www.ucop.edu/acadinit/mastplan/MasterPlan1960.pdf

CPEC (2007), California Postsecondary Education Commission University Eligibility Study for the Class of 2007
http://www.cpec.ca.gov/completereports/2008reports/08-20.pdf

CSU Los Angeles (2015) http://www.calstatela.edu/ecst/biomedical-engineering

Kirkham, Chris, "California vs. Texas in fight to attract and retain businesses" LA Times, August 24, 2014 http://www.latimes.com/business/la-fi-california-vs-texas-economy-20140824-story.html

PPIC (2010) public policy institute California
http://www.ppic.org/content/pubs/report/R_410HJR.pdf

Rankin, D. (2013). A comparison of Texas' Closing the Gaps by 2015 undergraduate retention and graduation policy to SREB-member states(Doctoral dissertation, TEXAS A&M UNIVERSITY-COMMERCE).

San Jose State University (2015) https://bcme.sjsu.edu/BME%204%20Year%20Plan

The Economist (2012) "One State Two Systems", August 11, 2012
http://www.economist.com/node/21560290

THECB (2014) Closing the Gaps 2014 Progress Report
http://www.thecb.state.tx.us/reports/PDF/5924.PDF?CFID=20361408&CFTOKEN=17353582

THECB (2015)
http://www.txhighereddata.org/Interactive/Institutionsshow.cfm?Type=1&Level=1

Tienda, Marta and Sullivan, Teresa, (2015) "Texas Higher Education Opportunity Project"
http://texastop10.princeton.edu/project.pdf, http://theop.princeton.edu/
US Census (2015) http://quickfacts.census.gov/qfd/states/00000.html

Zweben, S., & Bizot, B. (2014). 2013 Taulbee Survey, Computing Research News, *26*(5). http://www.cra.org/uploads/documents/resources/crndocs/2013-Taulbee-Survey.pdf