US-China Education Review, ISSN 1548-6613
March 2011, Vol. 8, No. 3, 323-332

A Multicontextual Model for Broadening Participation in STEM Related Disciplines

Edward E. Brown Jr.
Rochester Institute of Technology, Rochester, USA

This paper argues that the "pipeline", leading to the production and increase of undergraduate engineering and STEM (science, technology, engineering and math) related degrees by underrepresented student populations (which include female and AALANA (African American, Latin American and Native American) students), has become more of a "funnel". After five decades of affirmative action-oriented programs and laws, there is still a disconnect at most major research colleges and universities between the number of these students entering into the various STEM related disciplines as freshmen and the total number that successfully complete the baccalaureate STEM degree. Current programs address superficial/peripheral issues related to diversity (i.e., recruitment), but not the underlying sociological and anthropological aspects that lead to real solutions with permanent results (i.e., increased retention and graduation rates along with a more pluralistic campus environment where diversity is respected, celebrated and embraced in the STEM disciplines). Thus, this paper suggests that a "multicontextual" model that emphasizes the latter will ultimately bridge this disconnect and achieve the more desirable "affirmative outcomes" that previous affirmative-action-oriented initiatives were originally put in place to accomplish.

Keywords: diversity, pluralism, broadening participation in computing, underrepresented student populations, STEM disciplines, rehabilitation robotics

Introduction

According to the US Census Bureau, in 2004, females made up 50.8% of the total US population; African Americans made up 12.2% of the population; Latin Americans made up 14.1% of the population; and Native Americans (including Native Hawaiians and Pacific Islanders) made up 0.9% of the population (United States Census Bureau, 2004). In the same year, there was a total of 64,675 bachelor degrees awarded to students majoring in engineering fields in the US. Out of that total, females received 20.5% of the total degrees awarded; African Americans received 5%; Latin Americans received 6.9%; and Native Americans received approximately 0.5% (National Science Foundation—Women, Minorities, and Persons with Disabilities in Science and Engineering, 2004). White males, in comparison, received 53% of the total degrees awarded in engineering, even though they only made up approximately 40% of the total US population in that year (National Science Foundation—Women, Minorities, and Persons with Disabilities in Science and Engineering, 2004). These statistics persist even until today.

This paper is based upon work supported by a grant from the Semiconductor Industry Association, and the National Science Foundation under Award No. IIS-0748418 and Award No. IIS-0705130.

Edward E. Brown Jr., Ph.D., assistant professor, Biomechatronic Learning Laboratory, Department of Electrical and Microelectronic Engineering, Kate Gleason College of Engineering, Rochester Institute of Technology.

Consequently, the year 2004 was a very significant year in the US history. It represented the 50th anniversary of “Brown vs. Board of Education”, the US Supreme Court landmark decision to integrate public schools for black and white students which declared that “Separate educational facilities are inherently unequal”. In 2004, the country celebrated the 40th anniversary of the “Civil Rights Act of 1964”, which outlawed discrimination in the US based on race and gender. And lastly, in 2004, it represented approximately 30 years of “affirmative action” initiatives in the US (Bell, 2005; Wise, 2005). Therefore, given this history, the question arises: Why are the numbers of minority and female students graduating from American undergraduate engineering programs disproportionate compared to their total numbers within the US population described above? What is wrong with the engineering and STEM (science, technology, engineering and math) “pipeline”?

Background

In most colleges and universities in the US, in order to improve diversity within the undergraduate schools of science and engineering, the approach to increasing the number of students from underrepresented populations, i.e., female and AALANA (African American, Latin American and Native American) students, involves an “add and stir” methodology (Bauer-Dantoin & Ritch, 2005; Tobias, 1992). The approach is simple in its implementation. University officials submit an edict to the academy ordering the increase in the affirmative recruitment and placement of female and minorities into the various science and engineering programs. And the numbers do increase. The problem with this approach is that while there are “affirmative actions” taking place, with many improvements being made in terms of the general “enrollment” of female and minority students in science and engineering majors, the approach can still be deliberate, at best, in its intended goal: the successful and timely graduation of female and AALANA students in science and engineering majors with the baccalaureate degree. To bridge this disconnect in the so-called “pipeline” within American engineering programs, university administrators and engineering academicians need to focus more on “affirmative education” programs that are student-centered and concentrate on the quality of the educational experience for female and minority students (Tobias, 1992). In this way, they can ultimately achieve the more desirable “affirmative outcomes” that their affirmative action initiatives were originally put in place to accomplish.

Academic Culture

A large part of an engineering student’s success in college is due not only to how well they perform academically, but also to how well that student adapts to the culture of their department. For female and minority students, the problem lies in the fact that while they are aggressively recruited into science and engineering programs to begin their undergraduate careers, they are usually brought into environments that are not conducive to their cultural and educational needs. In many cases, the traditional culture that existed prior to the students’ enrollment into an engineering department is usually still firmly in place, which means that there is a strong possibility that the obstacles and barriers that created the initial lack of diversity in these programs to begin with may not have been fully addressed. These obstacles may include gender, ethnic, cultural and socioeconomic biases within the academy. While they may not necessarily be blatant, they can still pose subtle but lasting emotional and psychological impediments for students from underrepresented populations including feelings of fraudulence (McIntosh, 1985; Watson, Terrell, Wright, Bonner II, Cuyjet, Gold, …, & Person, 2002; Foor, Walden, & Trytten, 2007; Seymour & Hewitt, 1997; Margolis & Fisher, 2001; Margolis, 2008).

Even in the best academic situations, female and AALANA students are required to conform to environments where they have been traditionally marginalized. They have to adapt and succeed in engineering departments where they see very little of themselves in the classroom, in the laboratory, in the textbooks, in the faculty, and in many cases, the staff. These issues are further compounded by the fact that there exists "behavioral nepotism" within the science and engineering academy. When searching for the next generation of scientists and engineers, most researchers look for students who are essentially younger versions of themselves (Tobias, 1990). These students often have similar contextual learning and communication styles as these professors and, unsurprisingly, do well (if not excel) in that environment. They are dubbed the "good" students, the "best" students, and sometimes, the "top-tier" students. If these students decide to go into the professoriate, they will be more than likely to develop a similar teaching style as the professors that once taught them. This personality type ultimately reproduces itself into each generation of science and engineering faculty and their respective students, thus creating and perpetuating a culture of this singular personality type. In other words, the behaviors, values and personal attributes of these faculty members are constantly reinforced by the like-minded students they produce. So the science and engineering classroom risks becoming an elite club. But what happens to students who do not think or learn like these professors? What is the message being sent to these students, particularly if they are from underrepresented populations?

Objective

The objective of this paper is to discuss the design of a "multicontextual" model for bridging the disconnect in the "pipeline" of underrepresented students pursuing STEM baccalaureate degrees (Ibarra, 1999). This paper argues that the solution lies in examining and addressing the culture of the engineering classroom and the engineering laboratory. Underrepresented students (and students as a whole) succeed in environments that are conducive to how they learn both culturally and contextually (Trenor, YU, Waight, Zerda, & Sha, 2008). Thus, "how" engineering faculty proceed in teaching and mentoring these students (and the mechanisms they use) is just as important (if not more so) as "what" they teach or research. The current political climate has prompted various media outlets to suggest that the US is entering into a "post-racial" era where issues related to race will be minimized, and US gradually becomes "race-blind" (Givhan, 2008; Harris-Lacewell, 2009). But it can be debated that the country is actually entering into a "pro-racial" era where it will be increasingly detrimental to American educational institutions to ignore issues related to diversity and cultural context, specifically, where learning and STEM education is involved. If it is important for university faculty to understand the needs of students from the so-called "Millennium Generation" (Pew Research Center, 2010), then it is also important to understand the needs of students from diverse ethnic, socioeconomic and gender backgrounds that may have even more diverse learning styles in addition to those of their generation. For these reasons, the author has created a rehabilitation robotics research laboratory known as the BLL (Biomechatronic Learning Laboratory) (2011) as the primary mechanism for studying "multicontextual learning", as it relates to engineering education, diversity and pluralism (see Figure 1). Preliminary findings and observations from this endeavor will be discussed in this paper as well as the engineering research projects pursued to achieve the author's stated objectives.

The major research questions addressed by this paper are: (1) What are the components necessary to create and sustain a successful academic model that encourages underrepresented student populations to complete the engineering baccalaureate degree and enter into STEM-related field? (2) How do science and engineering faculty implement those components in order to move beyond the "add and stir" college recruitment/retention paradigm for increasing diversity? (3) What are the teaching and research methods required to address the needs of a diverse student population with diverse learning styles? and (4) How do science and engineering faculty develop these methods into a formalized pedagogical system in order to cultivate a pluralistic engineering educational environment?

Figure 1. BLL.

Reframing the Context of an Engineering Education

In Learning and Cultural Context

A major objective of the proposed model is to reframe the context of the engineering educational experience by focusing on a student-centered approach to teaching and research versus the traditional content-centered approach. How this approach impacts students from underrepresented populations (as well as those students from diverse socioeconomic backgrounds) and how it makes their environment more conducive to learning are of particular interest in this study. There have been several papers and books written describing the various teaching and learning styles of students majoring in engineering and STEM-related disciplines (Kapadia, 2008; Wankat & Oreovicz, 1992). This literature focuses on whether a student is a "sequential learner" or a "global learner", and if an instructor's teaching style should be "visually" or "verbally" based. But many times a student's cultural background is not given sufficient relevancy in determining their particular learning style. A lack of understanding about a student's culture could result in a series of miscommunications, distrust, possible isolation and marginalization, and any other combination of social backlashes that will greatly impact a student's performance in the classroom as well as in the research laboratory.

For this reason, disciplines related to education, the social sciences, liberal arts, the humanities, biology and health-care tend to be more attractive to female and AALANA students because of their proclivity for including cultural context and social sensitivity as a basis for scholarship. These disciplines are "applied" in their orientation which means that they allow students to focus their studies on immediate political, cultural and societal issues occurring within their communities as opposed to abstract and theoretical hypotheses they are more likely to encounter in the "hard" sciences. They get to help and interact with real people and not abstract concepts. For students in these disciplines, who they are personally and culturally is valued and validated (Seymour & Hewitt, 1997). In order to create an environment that is conducive to students from diverse backgrounds, the proposed model for increasing the "pipeline" must take these cultural inclinations among diverse groups into consideration (Cairncross, Gordon, Ratcliffe, Tizard, & Turnbull, 2008).

Theory of Multicontextuality

The “theory of multicontextuality” is a theoretical construct proposed by Ibarra (1999) for explaining the academic performance differences among female and various ethnic groups majoring in college science and engineering programs. It suggests that the context in which all individuals learn and interact with their surroundings is based on their culture. It builds on Hall’s research demonstrating that all people can be categorized according to their cultural context (Hall, 1981). Hall (1981) categorized individuals from “high” to “low” context to indicate the significance of certain behavioral patterns among various ethnic and gender populations.

“High context cultures” are described by Hall (1981) as individuals who focus on streams of information surrounding an event (or situation) in order to determine the meaning of the event from the circumstances and conditions in which that event occurs. Ethnic minorities and females are typically identified as being affiliated with “high context cultures”. “Low context cultures” are recognized as individuals who ignore the circumstances and conditions surrounding the event (or situation) so they can focus as much as possible on objective facts, words and details which represent the content describing the event. Northern European ethnic groups and majority males are typically identified as being affiliated with “low context cultures”. Most individuals are a combination of both context cultures, however (Ibarra, 1999). Thus, in order to create a more pluralistic engineering laboratory environment that is conducive to diverse populations of students with diverse learning styles, understanding the cultural context in which they learn is an important first step towards assisting them in becoming successful academically.

The Biomechatronic Learning Laboratory

Objectives of the Biomechatronic Learning Laboratory

The BLL (Biomechatronic Learning Laboratory) was established as a vehicle for promoting a multicontextual academic model for broadening participation in computing and increasing the graduation rates of underrepresented undergraduate student populations in STEM-related disciplines. In the BLL, multicontextual learning is addressed with respect to: (1) engineering practice and application; (2) ethnicity and culture; (3) gender; and (4) socioeconomic background.

The BLL is a unique and innovative rehabilitation and assistive robotics research laboratory with a decidedly different agenda than most robotics research centers. In those centers, the focus is on the development of new robot technologies. The major objective of the BLL is not explicitly new product research and development in the field of rehabilitation robotics, but rather it emphasizes research which contributes to the development, training, and apprenticeship of diverse undergraduate engineering students into the next generation of biomechatronic and rehabilitation robotic engineers. To achieve this objective, research in the BLL falls into two categories: (1) rehabilitation robotics; and (2) engineering education.

Rehabilitation robotics. Research in this area involves using robot technologies to develop assistive devices that aid individuals with physical disabilities, e.g., those individuals who have suffered strokes, major spinal cord injuries, neuromuscular diseases, etc. In the BLL, the overall engineering objective is to use robot technologies to develop an intelligent orthotic/wearable robotic system for patients having muscular atrophying diseases and disabilities, such as muscular dystrophy. Patients who have muscular atrophying diseases like muscular dystrophy have extremely weak muscles that waste away over time. These individuals experience difficulties in the simplest of physical tasks, e.g., picking up a cup or holding a spoon. An externally powered, upper-limb, intelligent orthotic system, which takes advantage of the patient’s residual strength (and other useful physiological information), can be used to augment the patient's abilities and provide the patient with increased dexterity and movement. Thus, the primary engineering application research in the BLL focuses on the design and development of multi-modal, human-robot interfaces for a rehabilitation robot.

Engineering education. Research in this area involves researching and developing new pedagogical systems that assist in increasing the "pipeline" of students majoring in engineering and STEM-related disciplines. In the BLL, the overall educational objective is to investigate diverse teaching and research styles that address the needs of an increasingly diverse student population with diverse learning styles. In the process of developing the intelligent orthotic system described above, it is extremely important to understand what social and anthropological mechanisms are involved in maintaining a healthy and pluralistic laboratory environment where students from diverse backgrounds do not just survive, but thrive. This is a dynamic process that is continuously monitored and adjusted when and where needed, which means moving beyond the "add and stir" method of increasing diversity in engineering disciplines, and moving more towards an "add and stew" philosophy. Therefore, we wish to reframe the context of the engineering educational experience by focusing on a student-centered approach to teaching and research versus the traditional content-centered approach.

The integration and intersection of these two areas of study form the core principles of the BLL, which are teaching, learning, research, discovery and diversity.

Components Necessary to Maintain a Pluralistic Laboratory Environment

In the BLL, the themes or "components" that are emphasized in order to maintain a pluralistic laboratory environment are: (1) valuing diversity; (2) providing solid mentoring; (3) engaging students in professional development activities; and (4) framing research objectives in a relevant cultural context.

Value diversity. As Moore (2002, p. 88) stated, "Marginalized students are not the problem; the system that marginalizes them is the problem". Gender, ethnic, cultural and socioeconomic biases still exist in the academy (Bombardieri, 2005; Rey, 2001). While they are not necessarily blatant, they still can pose subtle but lasting emotional damage to students from underrepresented populations. This is an unfortunate reality that is still felt today. Female and AALANA students continue to deal with hidden issues of sexism and racism (i.e., stereotyping, discrimination, etc.) as well as issues that are sexual and racial in nature (e.g., gender and cultural insensitivity by faculty and students, lack of female and AALANA faculty as role models, etc.). These issues can cause feelings of inferiority, self-doubt and low self-efficacy that may ultimately deter AALANA students away from science and engineering majors (Bandura, 1997; Concannon & Barrow, 2009; Marra, Rodgers, Shen, & Bogue, 2009).

In the BLL, diversity is valued (see Figure 2). Students performing research in the BLL come from diverse gender, cultural, ethnic and socioeconomic backgrounds. Many are the first in their families to attend college and/or to major in an engineering discipline. Undergraduate and graduate students are actively recruited from underrepresented populations. In addition, engineering seminars by leading female and AALANA researchers in the robotics and engineering field are sought out to give talks to students on their research and to encourage students to continue pursuing engineering as a career (see Figure 3). The message is that in any engineering, research-oriented and learning organization, diversity is strength towards bringing about true technological innovation as well as an affirmative educational research experience for all students involved (Loftus, 2004).

Figure 2. Students are performing robot control experiments.

Figure 3. A senior robotics engineer with NASA's (National Aeronautics and Space Administration) Jet Propulsion Laboratory presented a talk on the Mar's Rover project.

Provide solid mentoring. Supportive relationships are important in retaining students from underrepresented backgrounds, particularly in engineering. The mentoring component of the BLL is one of the strongest aspects of the lab (Brown, 2007). In the BLL, lower class students are paired with upper-class students with similar academic and personal backgrounds. The goal is to have upper-class students act as mentors and role models for incoming freshmen and lower-class students. These upperclassmen assist the freshmen in their understanding of the electrical engineering discipline as well as how to navigate through the electrical engineering program. In addition, the program PI (principal investigator) acts as a mentor to the upperclassmen. In the end, a professional (as well as a social) network is formed among the students as a direct consequence of this novel style of tiered/peer-mentoring. This proves to be essential, since most 1st and 2nd year engineering students (particularly from underrepresented populations) struggle in identifying a network of students within their major that they can associate with professionally and socially. This mentoring strategy has met with much success.

Consequently, students receive additional academic and professional mentoring via participation in several student organizations that emphasize diversity and engineering (see Figure 4). Students in the BLL are encouraged to participate in organizations, such as NSBE (National Society of Black Engineers), the SWE (Society of Women Engineers), the SHPE (Society of Hispanic Engineers) and the IEEE (Institute of Electrical and Electronic Engineers).

Figure 4. Students from the BLL attend the SWE Conference.

Engage students in professional development activities. Students are also engaged in professional development activities that link the above-mentioned components of valuing diversity and providing solid mentoring. These activities provide growth and enrichment in their chosen discipline/research area. In the BLL, these activities include participation in the Richard Tapia Celebration of Diversity in Computing Conference, whose aim is to provide a supportive networking environment for underrepresented groups across the broad range of computing and information technology, from science and business to the arts and computing infrastructure (Tapia, 2009); attending the Georgia Institute of Technology's FOCUS (Focused Recruitment) program, whose goal is to increase the number of master's and doctoral degrees awarded to minorities not only at Georgia Tech, but also nationwide (FOCUS, 2011); and presenting their research projects at several biomedical engineering conferences and symposiums including the IEEE (Institute of Electrical and Electronic Engineers) Engineering in Medicine and Biology Conference (see Figure 5).

Figure 5. BLL students are presenting a poster at an undergraduate Biomedical Engineering Symposium.

Frame research objectives in a relevant cultural context. All research activities in the BLL center around the rehabilitation of individuals with physical disabilities. Most people have someone in their family with a disability or know someone who has a disability and can easily identify with the need to provide assistance for these individuals. Current target patient populations in the BLL include individuals with spinal cord injuries, muscular dystrophy and populations that are disproportionately affected by diseases and disabilities, such as African Americans with diabetes. This goal forms a context for students in the BLL pursuing rehabilitation robotic research, including those students who did not originally have an interest in robotics or biomedical-related research, but they have a sincere desire to use their engineering skills and talents in a meaningful way to create solutions for these patient populations (see Figures 6 and 7).

Figure 6. BLL students are testing their senior design project: An upper extremity motion capture system.

Figure 7. Spinal cord injury patient is controlling the BLL robotic arm.

Conclusion

This paper describes a multicontextual model for improving the participation and graduation rates of underrepresented student populations in STEM-related disciplines. It argues that the "pipeline" leading to the production and increase of undergraduate engineering-related degrees by underrepresented student populations needs to be improved. In order to realize this affirmative outcome, the author offers four components necessary for improving this "pipeline". Those four components are: (1) valuing diversity; (2) providing solid mentoring; (3) engaging students in professional development activities; and (4) framing research objectives in a relevant cultural context. A description of a rehabilitation robotic laboratory which incorporates these four components is presented along with the successful activities resulting from this implementation.

While some of these components are instituted in many college and university undergraduate enrichment programs for all students regardless of race, gender or socioeconomomic background, the reality is that students from underrepresented groups receive a disproportionately lower level of this type of support. And the available support may not be appropriate or sufficient for those students. This point is emphasized in the literature. In addition, the universities and colleges that do provide this level of student support and programming usually do so with the program being external to the engineering school itself. That is, the support program is not explicitly connected or integrated into a student's engineering academic life. Nor are the administrators of these programs. This is in contrast to the BLL, which integrates research, education, mentoring and professional development within the students' academic environment. In the BLL, there is a vested interest in each student's success. Basic scientific research, student development and diversity are not considered to be mutually exclusive.

Finally, this project is ongoing. Future work involves constantly assessing the value of the BLL activities on participating students' academic and professional performance even beyond graduation.

References

Bandura, A. (1997). *Self-efficacy: The exercise of control*. New York: W.H. Freeman and Company.

Bauer-Dantoin, A. C., & Ritch, D. (2005). Moving beyond the add and stir approach to increasing diversity in the sciences: Design and implementation of an undergraduate course entitled ethnic minorities in science. *Journal of Women and Minorities in Science and Engineering, 11*(4).

Bell, D. (2005). *Silent covenants: Brown v. board of education and the unfulfilled hopes for racial reform*. New York: Oxford University Press.

Biomechatronic Learning Laboratory. (2011). Retrieved from http://www.rit.edu/kgcoe/electrical/bll/

Bombardieri, M. (2005, January, 17). *Summer's remarks on women draw fire*. Boston: The Boston Globe.

Brown, Jr., E. E. (2007). The ST@R Project: An initiative to increase the retention rates of 1st and 2nd year underrepresented students enrolled in electrical engineering. *2007 American Society of Engineering Education (ASEE) Annual Conference*, Honolulu, HI, June 24-27, 2007.

Cairncross, S., Gordon, K., Ratcliffe, D., Tizard, J., & Turnbull, C. (2008). Valuing diversity: Development of a student support forum for females. *38th ASEE/IEEE Frontiers in Education Conference*, Saratoga Springs, New York, October 22-25, 2008.

Concannon, J. P., & Barrow, L. H. (2009, April). A cross-sectional study of engineering students' self-efficacy by gender, ethnicity, year, and transfer status. *Journal of Science Education and Technology, 18*(2), 163-172.

FOCUS. (2011). Retrieved from http://www.focus.gatech.edu/

Foor, C. E., Walden, S. E., & Trytten, D. A. (2007, April). I wish that I belonged more in this whole engineering group: Achieving individual diversity. *Journal of Engineering Education, 96*(2), 103-115.

Givhan, R. (2008, March 16). Edging (at times clumsily) toward a post-racial America. *The Washington Post*.

Hall, E. T. (1981). *Beyond culture*. Garden City, NY: Anchor Books.

Harris-Lacewell, M. (2009, July, 7). The notion: Skip gates and the post-racial project. *The Nation*.

Ibarra, R. A. (1999, October). Multicontextuality: A new perspective on minority underrepresentation in SEM academic fields. *Research News on Minority Graduate Education, 1*(3).

Kapadia, R. J. (2008). Teaching and learning styles in engineering education. *The 38th ASEE/IEEE Frontiers in Education Conference*, Saratoga Springs, New York, October 22-25, 2008.

Loftus, M. (2004, January). Paving the way. *ASEE Prism*.

Margolis, J. (2008). *Stuck in the shallow end: Education, race, and computing*. Cambridge, MA: The MIT Press.

Margolis, J., & Fisher, A. (2001). *Unlocking the clubhouse: Women in computing*. Cambridge, MA: The MIT Press.

Marra, R. M., Rodgers, K. A., Shen, D., & Bogue, B. (January 2009). Women engineering students and self-efficacy: A multi-year, multi-institution study of women engineering student self-efficacy. *Journal of Engineering Education, 98*(1), 29-38.

McIntosh, P. (1985). Feeling like a Fraud. *Work in Progress, 18*. Wellesley, MA: Stone Center for Developmental Services and Studies, Wellesley College.

Moore, R. (2002, February). Our apartheid. *The American Biology Teacher, 64*(2).

National science foundation—Women, minorities, and persons with disabilities in science and engineering. (2004). Retrieved from http://www.nsf.gov/statistics/wmpd/tables.cfm

Pew Research Center. (2010, February). *Millennials—A portrait of generation next: Confident, connected, open to change*.

Rey, C. M. (2001, August, 31). Making room for diversity makes sense. *Science, 293*.

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

Tapia. (2009). Retrieved from http://tapiaconference.org/2009/

Tobias, S. (1990). *They're not dumb, they're different: Stalking the second tier*. Tucson, AZ: Research Corporation.

Tobias, S. (1992). *Revitalizing undergraduate science: Why some things work and most don't*. Tucson, AZ: Research Corporation.

Trenor, J. M., YU, S. L., Waight, C. L., Zerda, K. S., & Sha, T. L. (2008, October). The relations of ethnicity to female engineering students' educational experiences and college and career plans in an ethnically diverse learning environment. *Journal of Engineering Education, 97*(4), 449-465.

United States Census Bureau. (2004). Retrieved from http://www.census.gov

Watson, L., Terrell, M. C., Wright, D. J., Bonner II, F. A., Cuyjet, M. J., Gold, J. A., …, & Person, D. R. (2002). *How minority students experience college: Implications for planning and policy*. Sterling, VA: Stylus Publishing, LLC.

Wankat, P. C., & Oreovicz, F. S. (1992). *Teaching engineering*. New York: McGraw Hill.

Wise, T. J. (2005). *Affirmative action: Racial preference in Black and White*. New York: Routledge.