Increasing Diversity Within the Field of Engineering: Closing the Minority Gap

Rebecca P. Blust
University of Dayton

Abstract

Although minorities have broadened their career choices in the past few years, they have not increased their numbers in science and technology. The current US workforce is comprised of 77% White, 4% Asian and 19% Minority, but these numbers do not hold for engineering professionals. The Bureau of Labor Statistics in conjunction with the National Science Foundation states that among engineering professionals, 88 % are White, 6% are Asian and only 6% are minority. Studies indicate that both industry and society benefit from diversity; furthermore, teams function at higher levels when there is diversity among colleagues. This optimization enhances competitiveness within companies, enabling them to outperform their competitors. However, even though there are many benefits from increasing diversity, the fact still remains that a minority gap exists within engineering.

This paper will explore philosophies and provide methods and recommendations to promote an increase of minority participation within science and technology. The main discussion will focus upon the "minority gap" model, which is a triad. Each side - personal, education, and industry - represents a different element of support needed to foster and stimulate growth in the individual. Understanding items presented in the model will help companies foster future participation of minority engineers and scientists in today's technological environment.

I. Introduction

Traditionally, the white male has dominated science and engineering professions. Although minority participation has increased in the past twenty years, the numbers are still not where they need to be. For example, the current US workforce is comprised of 77% White, 4% Asian and 19% Minority. However, according to the Bureau of Labor Statistics and the National Science Foundation, statistics reveal that among engineers, 88% are White, 6% are Asian and only 6% of the current engineering professionals are minority.[1] Thus a minority gap clearly exists within engineering.

Statistics show that cross-culturally, first graders' interest in the disciplines of math and science are very similar no matter what ethnic group they belong to. However, as time goes on, a larger gap in the level of interest is noted. By the time the students reach the eighth grade, a high percentage of minority students tend to lose interest.[2] Considering this trend, it is no wonder that minority students select careers in other fields.

It is obvious that increasing the diversity in the science and engineering professions would result in improved technological advancements, which, in turn, might result in advanced research that would contribute to the global competitiveness and future economic security of our country. We must foster more diversity within this industry.

Losing potential scientists and engineers has ramifications for both industry and society. In order for a qualified member of a minority group to be successful, intervention and support must occur on three legs of the Minority Gap Triad Model (Fig. 1). The first leg of the triangle, *Personal Participation*, is composed of the minority candidate, parents, extended family and friends. Together, these individuals have a responsibility to recognize the child's talent and curiosity as well as coordinate intellectual interests in science or technical fields.

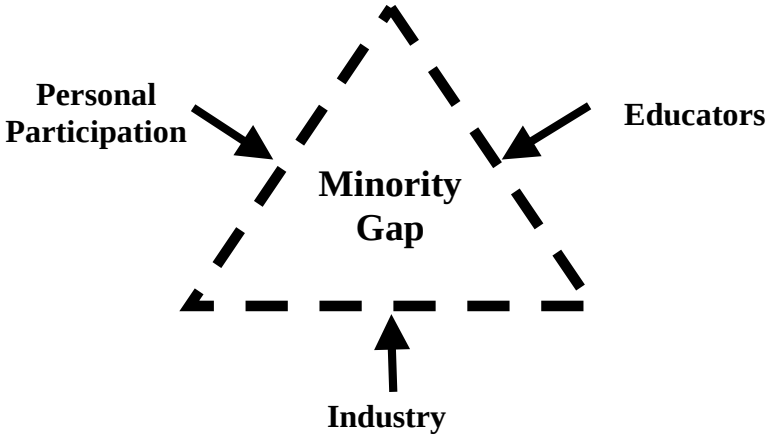

Figure 1. The Minority Gap Triad

The second leg of the triangle, *Educators*, includes primary, secondary and collegiate education. An Educator's role may be twofold. First, this person is responsible for encouraging and challenging interested students. This includes keeping abreast of new technology and being able to convey technological changes to the student in an interesting manner. Second, this role model should provide guidance and foster growth.

The third leg of the triangle, *Industry*, is responsible for encouraging participation within science and technology. Corporate America understands the benefits of diversity. It seems only right that it plays a large part in increasing the interest level of students through such programs as corporate mentoring, sponsoring "special needs" offerings such as summer camps, and encouraging industry tours.

The role that each supporting leg of the triangle provides is critical to the goal of shrinking the minority gap. The information presented in this paper will provide methods and recommendations based on the triad concept to increase minority participation within the science and engineering fields.

II. Personal Participation

In order to improve the trend of minority involvement in the scientific and engineering professions, we must first understand the role peers play in the individual's life. The strongest peer pressure most minority students face is oddly, the pressure to fail. Minority students who excel academically report that being smart makes them feel like an outsider at their own schools.[3] While mainstream students are generally proud of their academic abilities, the minority student is being rewarded by peers for NOT excelling in school. Since membership in the scientific community relies on a strong academic foundation, intervention in this leg of the triad is of utmost importance. We must convey to our minority students that it is NOT cool to fail. But how can this trend be altered? To change the attitudes of students it is necessary to intervene on three levels: Parent, Church and Individual.

Parents

Interest in the field of science and engineering comes from one of three domains; family influence, self interest, or just "hearing about it". Students that have been influenced by the family are proven to be the most successful at achieving a degree in a scientific field. If a student just hears about engineering with little or no exposure, the individual is unlikely to enroll in engineering courses in college. To increase a child's interest and understanding, parents need to make an effort early to expose their children to the influence of science and technology during daily social functions. A parent's interest in the subjects of math and science will send a clear message to the child that these things are important and are utilized in all aspects of daily life. Early experiences with these subjects positively influences children's interests in creative thinking and problem solving.[4]

Parents need to support and encourage their child to perform well in math and science classes. Simply interacting with the child by reviewing homework assignments, fostering good study habits, and discussing final grades, conveys to a child that the schoolwork is important. Another means to ensure success is to review a child's schedule in high school and be sure math and science courses are taken each semester. It is critical that the parent understand the importantance of each class as part of a larger structure that will support the student in collegiate studies and future career success.

Parents must also get actively involved in creative educational programs in the community that foster "hands-on" experimentation and exploration. Involvement in local museum activities, community science centers, and university/college summer engineering programs is important to foster an attitude that technology and science are fun and intriguing. Local libraries can also help. They provide free books and magazines that give exposure to science concepts for inquisitive minds. In addition, parents can check out science books from the library to conduct "do it at home" science experiments. Research shows that this type of cooperative learning reinforces scientific concepts and has a positive impact on the student. Parents can also encourage interest in math and science is by increasing active involvement as children watch television and critically discuss the merits of a program. Watching programs such as *NOVA*, *National Geographic* Specials, and *Bill Nye - The Science Guy* together reinforces a child's view that learning is fun. Providing toys like Zany Brainy and items from Nature's Wonder, Museum

Gift Shops and bookstores that foster interest in math and science promote scientific learning. Finally, parents need to encourage natural curiosity. This can start as early in a child's life as possible. Since babies are inquisitive by nature, this method of learning is very comfortable for them.

Finally children can experience science when traveling, vacationing, visiting the public zoos, state parks, or local industries. As the child matures, the level of detail can change but the main influence is parents taking an active part in the child's education to encourage learning and problem solving.

Church

Young minority students are influenced by pastors and ministers in the local congregations where the need for a strong education is reinforced, according to Bruce Carr, Director of the Minority Engineering Program at the University of Dayton.[5] "However," Carr states, "in order for this influence to be truly effective, church leaders must have a strong dedication to educational commitment themselves". It is not only enough that they are successful Christian leaders, but they also must attain high levels of education excellence. Carr also states that ministers and pastors may also be doctors, surgeons and lawyers. They make sure that successful students get recognized publicly within the church when students gain academic achievements. The members of the church also serve as strong role models or mentors for students. The cohesiveness and a sense of belonging in the religious community help the student stay focused on the productive behaviors that encourage academic success from elementary school through college.

Participant

According to The International Encyclopedia of Education, the circumstances a child is exposed to early in life will affect the knowledge and skills that the child will develop later on.[6] Thus, minority students can be divided into two classifications: independent and interdependent. Independent students by necessity have accepted responsibility outside the classroom in areas such as providing childcare for younger siblings, working part time or performing domestic responsibilities for the family. These experiences forge similar decision-making traits when a student makes decisions about future education or career choices. This student is able to make decisions with little or no input or support from family or friends. It is critical to note that there are few individuals in this category, and even fewer students who are able to succeed without additional support.

Interdependent students differ from independent students by the amount of involvement and influence that family and or friends may have in decision-making. These students are strongly influenced by parents or friends who direct them toward tasks that increase their chances of success. These students have a strong support system. In many cases, if interdependent students select a career in science or technology, they have a better chance of graduating because of the additional encouragement and support.

III. Education

One of the root causes for minorities being underrepresented in the fields of science and engineering is the lack of an effective educational program. Previously, educational curricula developed to increase the number of minorities enrolling in science and engineering have had little or no success. In order to change the downward trend, the system must restructure to meet the real needs of qualified individuals. Critical pathways to success are found through effective high school and college programs that focus on exposure to science and engineering careers and the retention of students who have selected that field.[7]

High School

Interest levels in math and science for grade school students is virtually the same regardless of ethnic background. However, after grade school, interest for minority students plummets. It is important to mention that there is disagreement among resources on the subject. Some studies show that minority middle school students develop a noted disinterest or fear in math and science classes even though they shared the same interests as other non-minority students in elementary school. Understandably, they finish high school only taking the minimum requirements in science and math. Other sources state that the interest level of students may not be the sole problem. For example, The Office of Educational Research and Improvement cite the many barriers at the high school level:

- Understaffed and underequiped schools
- Inequities in school funding (especially in urban areas with high numbers of economically disadvantaged families)
- Less access to science and mathematics education.
- Less access to qualified teachers in mathematics and science courses.
- Instructional emphasis in minority classrooms focus upon preparing students for standardized tests rather than for further study in math and science curriculums. [4]

Recognizing these problems, schools must make changes in teaching styles and informational programs that target student interest at the middle and high school levels. For example, educators must ensure that minority students receive the same quality of education in math and science courses. The design intent and curriculum of math and science courses should reflect teaching styles that encourage cooperative learning and accommodate a variety of students with different skill levels. Course content should engender enthusiasm, interest and competence needed for future involvement in science and math. Utilization of these types of learning techniques fosters a more interactive classroom environment. Increased communication among students who share a common interest enhances the learning process. The classroom becomes more supportive, so students feel more at ease to ask questions and accept help from their peers. Some suggestions include:

- Incorporate hands-on activities as a regular part of daily instruction.
- Keep expectations of student abilities high since students will perform to the standards set by their role models.
- Challenge students

- Actively involve them in discussions and classroom experiments.
- Apply theories learned in class to real life situations.
- Involve appropriate role models from industry with students to participate in classroom learning.
- Encourage teamwork and group learning styles. [4]

By focusing on these issues, students will become more comfortable with math and science. Also, the student will enter college with an increased comfort and skill level, which will better prepare them for college level challenges.

College

At several successful universities, the retention efforts are centered in the Dean's office. This signals the institution's level of commitment and sends a clear message to minority students and industry that diversity is an important part of the academic environment. Many universities have adopted a Minority Engineering Program (MEP). The intent of the MEP is to recruit, retain and graduate minority individuals interested in the field of engineering. Over half of the schools with successful minority retention programs have a full time person dedicated to this program. [8]

The University of Dayton supports an MEP with the elements needed to support minority-engineering students. The university takes pride in its retention and graduation figures that are more than double the national average. The program is designed to enhance the student's professional and academic development. The MEP provides encouragement and support for minority students well beyond the classroom. The MEP focuses on professional development, mentoring, academic success, and promoting a sense of community.

The professional development segment requires first year students to attend a weekly seminar for the first year that they attend the university. During the first semester seminar, minority engineers from local industries give presentations to these students. They discuss the profession, different job functions and any other topics that pertain to the field of engineering. During the second semester, human resources representatives from local industries speak to students regarding cooperative education and intern programs. The university career placement service personnel also meet with students to discuss various job skills and presentation skills necessary to attain successful employment.

Another part of UD's MEP is mentoring. Minority engineering professionals serve as role models for students during the student's four or five years at the university.
The goal of the mentoring program is to promote active dialogue about engineering and foster relationships between students and engineering professionals. Developing this relationship between the engineering student and the engineer provides the student with a mentor outside the academic environment for additional guidance and support.

To enhance the academic success, first year minority students must attend two mandatory "study sessions" a week. Non-minority students attend once a week. These study periods promote collaborative study with other engineering students and are supervised by faculty and

student mentors. After a while, students begin to realize that group learning can be dynamic, productive and fun. Additionally, students learn how to function successfully in groups, invaluable experience for the future. Engaging in teamwork also lessens the feelings of isolation for minority students while encouraging the positive aspects of community.

In addition to academic workshops, another method used to enhance academic success is course clustering which puts minority students together in large general education courses in order to increase diversity and reduce academic isolation. Increasing the number of minority students within classrooms and laboratories diminishes any feelings of seclusion that traditionally many minority students have had.. Facilitating a diverse environment increases the comfort zone for minority students. When a person does not feel conspicuous, the classroom is perceived as non-threatening. Clustering minority students together creates an environment where they communicate freely and feel comfortable. Increasing the number of minority students in classrooms also enhances the learning experience for non-minority students by adding diverse perspectives and experiences.

The goals of the University of Dayton Minority Engineering Program are to develop a talented, educated, diverse work force, to create an optimum learning environment for minorities, and to increase the number of minority students in the engineering pipeline which ultimately will increase the number of minority graduates.[9] Comprehensive programs of this type promote involvement and enthusiasm among minority students by offering a variety of methods to develop the skills needed to have a successful engineering career.

IV. Industry

Traditionally, engineering was viewed as a "white male" profession. Although today's society has made strides in shattering such stereotypes, the engineering profession, in contrast to most others, still remains predominately white male.

Corporate America recognizes this lack of minority participation in engineering and actively pursues hiring minority graduates. They recognize the many advantages to creating a diverse workplace. However, even if a company successfully recruits minority engineers, the problem of retaining them remains a problem. In order to combat these problems and reap the many benefits that having a diverse work pool brings, companies are developing programs that increase awareness of the problems in recruiting and retaining minority engineers. These programs promote a supportive environment for both potential minority engineering students and engineering professionals.

Grade School Level

Corporate influence is important even at the elementary school level to kindle and support technical interests that minority youngsters may develop. Simple programs are sometimes the most effective. For example, although many companies sponsor "Bring Your Child to Work Day," many do not promote the program with enthusiasm. Many companies fail to see the day's potential for exciting future employees, but view it instead as an unproductive day.

However, structured programs geared to young children could do much to foster curiosity and excitement in engineering fields.

Other companies have focused specifically on increasing the development of minority engineers by offering a "Sponsorship Day." Students are invited to spend this day with an engineer who offers the student exposure to wide variety of what engineers do. Students can also rotate from engineer to engineer for an even broader exposure to experiences in engineering. Participating in experiences like these, young minority students are provided with the encouragement and understanding they need to pursue a career as a future engineer.

Middle and High School Level

For many corporations, involvement in the schools begins at the high school level. They sponsor programs that provide job opportunities and mentoring for potential engineering students. For instance, the IBM Corporation has created a program that provides job opportunities for high school students interested in a technical profession[10]. Recognizing the importance of a strong background in calculus for engineers, the company commits the first two hours of every student's day to calculus instruction. The need for calculus is reinforced as they spend the rest of the day working with engineers who are using these math skills to solve problems that create better products.

Another company that has developed a successful program for recruiting more minorities is United Technologies Corporation. UTC encourages engineers to mentor local high school students. The mentors work with students on various research projects. They provide the leadership, direction, and guidance necessary to foster a successful research project. Many of these volunteer mentors are alumni of the local high school. They state that their motivation for involvement is to create a future workforce that reflects the diversity that they would like to see within their own corporation. [10] Other corporations such as the Goodyear Tire and Rubber Company get involved by sponsoring industrial tours for interested high school students. These tours expose students to a variety of technical and research opportunities in local industries.

College Level

As mentioned previously, industrial involvement at the college level for minority students is very important to retain engineering students. The Minority Engineering Programs supported by many universities solicit the participation of local industries to act as partners in retaining and graduating minority-engineering students. Another form of active participation is to hire these students for summer internship programs and cooperative job opportunities. Thousands of minority engineering students take part in these corporate-sponsored programs each year. Xerox Corporation can attest to its success in offering these job opportunities. It has noted an increase in the number of fulltime minority-engineering students who go to work for them after graduation. These new employees credit their participation in minority summer internship programs for choosing to work for Xerox. [11] Recognizing that there are intercultural differences that may exist when recruiting fulltime minority engineering students can also help companies increase technical diversity. For instance, in a job interview it is customary to look

your interviewer in the eye when responding to questions. This candidate is viewed as confident and respectful. However, this may not be the case for some cultures. For example, in the Asian culture, making direct eye contact is discouraged. If this is not understood, a potentially good engineer may not be hired because of cultural differences. Therefore, it is important that companies take the time to train employees to understand cultural differences.[12]

Professional Level

Although the minority student has successfully been hired as an engineer, the chances of staying in the field are less than average. New minority hires must learn to deal with corporate politics and protocol. Many get frustrated and leave the profession. To improve retention, larger corporations encourage minority networking within the company. Minority networking is a formal program initiated by employees. For example, Shell Oil Company states that minority networks help remove barriers and build a sense of inclusion among minorities. Many other companies view minority networks as critical to resolving diversity issues and offering opportunities for minorities to grow professionally. These programs may encourage professional development of current associates by offering classes in communications and management. Companies are willing to support these networks because they are good for business. By increasing diversity, a corporation expands its global competitiveness. A broader base of employee experiences and cultural insights will also inspire a broader spectrum of ideas, potential clients, and products. In addition, having a more diverse population enhances the company's ability to hire other minority professionals. Getting a minority-networking program started involves just a few simple steps according to John K. Borchardt, Ph.D. Listed below are a few suggestions:

- Members must share common values and norms to promote coherent actions on organizational goals.
- Associates should initiate groups. To promote enthusiasm among its members.
- Get management buy-in. A program that is supported by management has a high chance of success. Support from management exists in many forms such as availability of meeting rooms, access to photocopy equipment, funding and the utilization of company communication channels to announce meeting times and places.
- Involve a member of management that is a minority. This will affirm upper level management's commitment to the program.[11]

Creating an environment supported by employees and management alike is beneficial for the success of the company as well as the individual.

V. Conclusion

The Minority Gap Triad Model forms is comprised of three sides that form an equilateral triangle. Each leg represents a different support group's involvement in promoting the expansion of minority participation in engineering. The sides represent *Personal Participation, Educators and Industry*. Although contribution from each support group is critical, the degree of involvement during the participant's different stages of growth may vary.

Personal Participation has its greatest influence during the candidate's primary stage (birth to adolescent). As a young minority candidate progresses through adolescence into young adulthood, he or she is most influenced by the roles that *Educators* play. Finally, the candidate's last stage is the adult stage. As a minority engineer begins to mature and grow in a career, his or her largest support member comes from *Industry*.

As demonstrated in this article, the attitude toward selecting a career in engineering starts at a very young age and progresses through adulthood. The trend for minority students enrolling in engineering programs is improving. However, to continue this trend, new methods need to be explored and strong commitments made by family, friends, educators and industry. To ensure optimization of our resources, future technological success depends upon society's ability to embrace and utilize diversity.

Bibliography

1. Borchardt, John, Ph.D.Unequal Compensation for Unequal Representation. *Graduating Engineer and Computer Careers.* September 2000.
2. Lasley, Tom, Ph.D. Department Chair, Department of Education, University of Dayton. Interview. December 5, 2000.
3. Crawley, Patricia. Extracurricular Opportunities Broadening Student Horizons by Encouraging Scientific Success. *The Science Teacher*. March 1998.
4. Clark, Julia. Minorities in Science and Math. *Educational Resources Information Clearinghouse Digest.* May 1999.
5. Carr, Bruce. Director of Minority Engineering Programs, University of Dayton. Interview. December 12, 2000.
6. The International Encyclopedia of Education. 2nd Edition. *Elsevier Science Inc*. Tarrytown, NY. 1994.
7. Horelco, Janet. Professor, Education Department, University of Dayton. Interview. December 12,2000.
8. Absher, Martha. Taking Another Look at Educating African American Engineers: The Importance of Undergraduate Retension. *Journal of Engineering Education.* July 1997.
9. Minority Engineering Program Progress Report. University of Dayton. Fall 2000.
10. Lipp, Paula. Clearing the Hurdles. *Graduating Engineer.* August 31, 1999.
11. Borchardt, John, Ph.D. Common Ground. *Graduating Engineer.* August 8, 1999.
12. Carranza, Richard. Minorities in the Engineering Workplace '99: Overcoming Barriers to Success. *Graduating Engineer.* September 15, 1999.

REBECCA P. BLUST

Rebecca Blust is currently an Assistant Professor at the University of Dayton after a 12 year career with The Goodyear Tire and Rubber Company. While working for Goodyear, she has held many management positions including; Automotive Business Center Manager, Production Manager and Interim Plant Manager for the world's largest conveyor belting facility. Rebecca's extensive industrial background facilitates excellent learning for students by combining practical experiences with technical knowledge.