Surviving Engineering:
From a Minority Female Perspective

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Abstract – As a practicing female under-represented minority in the field of engineering, I have wondered what I could do to help in the retention and development of minority and women engineering students. I have always felt that I represented a unique perspective as one who has lived through the struggle and survived. This paper highlights my struggles through one of the most respected engineering programs in the country. By using a timeline format, I strive to demonstrate the pitfalls and triumphs along with key turning points which brought an aspiring overachieving high school student to an unsupported struggling undergraduate student with low self esteem and to a successful professional engineer today.

Keywords: minority, female, under-represented, professional engineer, diversity

PRE-COLLEGE YEARS

My name is Jackie Mobley and I am a non-Hispanic Black female. In 1975, I graduated from the newly integrated John I. Leonard High School in Lake Worth, Florida with a 4.2 out of a possible 4.4 GPA. I was a straight "A" student throughout middle and high school having taken honors mathematics (through Pre-Calculus) and science courses the last three years. I was a member of the National Honor Society, a cheerleader and track statistician for all of my middle and high school years. I was also in the 4 -H club and had participated as a Girl Scout from a Brownie to Senior Scout.

Family Life
I am the first born of three girls, raised solely by my mother, a math middle school teacher working two to three jobs throughout my grade school years. I was an over-achiever who recognized at an early age that I got more attention from my Mom when I brought home good grades. She taught me that hard work would not kill me.

It is because of my mother that I never acknowledged the color of a person's skin. We never had conversations in our home regarding race. From my perspective, it was a non-issue…until I graduated from college. So if anyone treated me unfairly, I didn't notice. Looking back, it might have happened. But I've found that it was to my advantage that I didn't see color. It kept me from judging others motives. It kept me focused on my studies. I've known many minority students who allowed the perceived indiscretions of others to distract them to the point of not completing their educational goals. It never crossed my mind to blame someone else for my difficulties. I thank my Mom and God for putting it in me to retain my innocence for so long.

Lack of Guidance
One would think that with so much potential, I would have been afforded every opportunity to succeed after I graduated. However, this was not the case. My consistent trips to the Guidance Counselor's office only left me more confused and anxious with each visit. By the beginning of my senior year, I was so gripped with fear of my unknown future that I dropped out of many of the extra-curricular activities I had been participating in during the previous few years. Teachers began contacting my mother to find out what was wrong with me because they had observed a tremendous change in my behavior. I had become very quiet and withdrawn. Even I did not know why at the time. I understand now that this was my way of coping with the looming questions that everyone kept asking me: "Where are you planning on going to college? What are you going to major in?" Every time I was asked, I would cringe because they made me

feel as though I should know these answers, but I didn't know how to get the answers. The process paralyzed me with fear.

Finally, my high school Chemistry teacher sat me down and recommended that I consider majoring in Chemical Engineering. It had been his major in college and he felt that it would be a good fit since I had excelled in my math and science courses.   I grabbed hold of it, gratefully for the guidance. I was later accepted to attend the University of Florida for the fall 1976 term.

Reflecting back, I am amazed that I was never given the opportunity to evaluate the range of career options. I never took the battery of assessment tools used to help students narrow down their career choices. I was never presented with career choices. I had choices??? This was a failure on the administration's part to track my progress, recognize my potential and desire to gain the necessary information and provide competent professional career guidance. I strongly believe that this was an injustice that went unnoticed. And I wonder how many other highly capable individuals go without proper guidance at such a crucial time in their lives.

COLLEGE YEARS: THE ACADEMIC PRISON

Getting acclimated into the University of Florida environment was very difficult my first academic year. I noticed right away that the way I studied and completed my class work in middle and high school was not going to be enough to succeed at this school. It scared me. I remember telling my mother after I received my first quarter grades that if I didn't do better the next term, I was going to leave. Several factors were contributing to this resolve: 1) I did not want to suffer the embarrassment; 2) I did not want to disappoint my family who went around bragging about me to everyone; 3) I had not made any friends yet and I was homesick; and 4) the place was just too BIG. I always felt like I was just a Social Security number. I felt that no one cared what my name was or whether I was enjoying this experience.

Pressures to Succeed
The pressure placed on under-represented students to succeed in the field of engineering is immense. Everyone in your family is excited for you. They mean well but they have no clue of the anxiety it causes inside when you're afraid that you really won't be able to complete the journey. They want to see you do well and any time you visit home, they want you to go visit their friends so they can gloat over you as well. One really is on exhibition.

What's worse, is that everyone proclaims how because you are a minority in a predominantly White field that you will not have any problem finding a job once you graduate. This too adds more pressure when you realize that no one is ringing your telephone off the hook to interview and hire you after you graduate.

Culture Shock
Stepping onto the University of Florida campus would be intimidating to any student unfamiliar with such a large academic system. I considered myself lucky at the time because I had at least attended a predominantly White middle and high school. But nothing can prepare one for the vastness of the administrative process of financial aid, finding your way around campus and such large numbers of White people.

Isolation
I was a loner growing up. I was considered a "nerd" by my peers and rarely interacted with crowds of people unless I was cheerleading. I credit this character trait for the struggle I experienced socially-in and out of class. I simply had a hard time letting people know me. Because of the pain this isolation caused me, today, I look for these individuals when I visit campuses to see if I can help. I know what they are going through. It is hard to watch your fellow students make plans to get together to study and do the homework and want so badly to ask if you can tag along. I tried once to just check one of my homework answers with a fellow student and they looked at me with such contempt, I didn't try again. I've even heard awful stories this year where fellow engineering students would share homework knowing it was

wrong. Then when that individual finds out, they provide wrong answers to another person because they had been tricked.

I think the engineering faculty and staff should assume a healthy responsibility for ensuring the successful completion of each student's academic curriculum. The engineering administration should be alert to those students who do not appear to be assimilating well with their peers (any peers!). We must acknowledge the growing boil which festers when individual students are alone, withdrawn or self-preoccupied in an engineering environment where one can only succeed when inter-relationships are formed. These students are missing out on a very important developmental process which will manifest itself (whether well-developed or not) in all future professional environments. The ability to communicate on equal footing in your professional circle is essential to any respected engineer.

Students may feel isolated for many reasons: 1) poor social skills; 2) lack of practice in taking risks; 3) not being used to asking for help; 4) being a minority in a predominantly White university; 5) being a minority in a predominantly White academic program; 6) lack of self-knowledge.

Past research studies have shown that even if an under-represented minority has strong critical thinking skills, attending White engineering schools can be problematic for them. Predominantly White colleges are less supportive of minority intellectual development in general [4]. I have not found this to be the case at Historically Black Colleges and Universities (HBCU).

Stress Factors
"Stress is essentially a response mechanism to one's experiences and expectations that is comprised of both physical and mental components. Numerous factors are attributed to stress in the university setting. These factors may range from one or a combination of: financial problems, pressures related to academic achievement, extra-curricular activities, employment, socialization, responsibilities, relationship problems and sleep deprivation [8]."

When you add to that, the stress related to being in a new city environment, a new housing environment (residential hall), a new campus environment, a new academic routine and program, the stress associated with new freedom and independence, and the pressure from family to succeed, you've got the formula for a highly stressed individual.

The Feeling of Helplessness
How do I express to you the feeling of powerlessness? How do I explain the pain of embarrassment when I discovered that I was really not up to par for this academic program? I just was not doing well in my core courses at all. Little did I know at the time, that the dropout rate among minorities in engineering schools was as high as 70% nationwide [4]. All I knew was that I was hurting and spiraling downward. What happened? How did I all of a sudden become dumb? Something was missing. There was a missing link and since I was in the thick of the downward spiral, I was not able to evaluate my circumstances effectively. I was just drowning with no one seeming to care.

Rejection
One day I was asked to meet with the Chair of the Chemical Engineering. He told me that he felt that I needed to consider looking for another major; that he did not believe I would succeed in this program. For the next few weeks, I visited different departments on campus searching for something I would like to do. None of them interested me enough to make the switch. So I went back to the Chair and told him that I was going to try and stick it out. He suggested that I consider an Engineering Technology degree instead. But since I would still need to take the same core courses as the Chemical Engineering curricula, I told him that I may as well go for the real thing. The Chairman of the Department then made a statement that would stick with me for the rest of my life. He said, "OK, but I would recommend that you not get an engineering job when you graduate because we would not want companies to think we were turning out inferior engineers." He did not want me to reflect a negative light on the Department and risk losing their research grants from companies like Dow Chemical or DuPont.

Because I didn't know any better, I believed him. I never told a soul what he said to me for about ten years. My Mom still doesn't know. I remember spending a good hour or two sitting on this hill every day crying and praying to God to get me out of this prison of a program. It was a very humbling time of my life.

I must say that if it were not for my faith in God, I would have succumbed to a deep depression and become another dropout statistic. God gave me the tenacity to stay, in spite of the pain and embarrassment. He gave me one guy, a Black student one year ahead of me, to help me study and complete my homework. He gave me favor with the Department administrators. They saw that I wouldn't quit and over time approached me with a solution that led to my successful completion. After eight years, I graduated in August 1983. I didn't get my first engineering job until 1993.

What I Really Needed?
Reflecting back on it now, the following support would have been helpful: 1) better academic guidance in junior and senior year of high school; 2) a practical awareness of the career resource center services early in my freshman year. This is where I could have researched "how I learn" using the available assessment tools; 3) an awareness of available tutorial services; 4) an engineering peer support group; 5) Tours to different manufacturing plants and water/wastewater treatment facilities to gain visual knowledge to link with the textbook knowledge. 6) I am a firm believer in the value of therapeutic counseling; 7) I think is would have been very valuable to have been assigned a Personal Career Coach to evaluate my academic progress and make suggestions for improvement; occasionally this individual would serve as champion for the students to facilitate communications and act as an agent on their behalf.

I just felt that if I just had some help I could do this. But usually I was so depressed and embarrassed that I mostly just escaped mentally.

POST-COLLEGE
When I graduated, I received stacks of rejection letters from companies, most of them stating that I was "over-qualified." They would share that they felt I would leave as soon as I found a better offer. I had to take my degree off of my resume to obtain any kind of work. I had to promise my first employer that I would stay at least a year before he would hire me and that was for a government scientist position.

It was difficult meeting people because when they found out that I had a degree in Chemical Engineering, they always assumed it was from an HBCU. When I told them where I did obtain the degree, they would just stare at me speechless and just change the subject.

I was very apprehensive for a long time after becoming an engineer. I often felt inferior and questioned my abilities and professional decisions; most of the time my concerns were unfounded. It was then that I grew angry with myself that I had allowed one man to create so much grief in my life. I knew there had to be a better way. I never wanted anyone else to experience the pain I had gone through. I began to seek out ways to help other minority and women engineering students. I sought my Masters degree in Educational Leadership to obtain the background information and understanding of the university process to determine how I could make the best impact in the lives of these individuals. I enjoyed the research. I became more indignant at the injustices taking place. I chose to release the anger in a productive manner for the good of others.

Five years ago I passed the Engineering Principles and Practices examination and obtained my Professional Engineering license in the State of Florida. I had a supervisor ask me with contempt, "How did you get that license anyway?" I looked at him and had to acknowledge that disrespect still had not ended. Later, I found out that one of my subordinates had contacted the Board of Professional Engineers to verify that I had actually passed the exam. They thought I had falsified my certificate hanging on the wall.

Today, I am a respected engineer among most of my peers. They seek out my advice on engineering issues and when I feel I can contribute, I do so. However, there are some White engineers who resent the fact that

a Black female has the authority (if needed) to shut their engineered systems down potentially causing them to lose hundreds of thousands of dollars. Over time they at least acknowledge that I am fair in my judgment, whether they like me or not. I have learned that I do not have to prove myself to them. I have learned that I was just as capable of learning as any other engineer. I understand now that I simply "learn differently." I thank God for His stamp of approval on me and for me when I was unable to obtain it here on earth.

OUR DELIMMA

I have heard that since 9/11, the field of "engineering has a diversity problem"[3]. The resulting quagmire of paperwork needed to obtain visas has discouraged many foreign students from considering United States (U.S.) universities for their engineering studies. It is unfortunate that it took such a catastrophic event for this nation to consider the available future workforce here on U.S. soil. However, the U.S has a far deeper problem. In my opinion, the field of engineering in the U.S. has a "cultural competence" problem. Cultural competence is "the willingness and ability of a system to value the importance of culture in the delivery of services to all segments of the population…. In particular, it is the promotion of quality services to underserved, racial/ethnic groups through the valuing of differences and integration of cultural attitudes, beliefs, and practices…" [2].

I believe that many professionals in engineering are on an elitist power trip; unwilling to share their knowledge with anyone not like them. I also believe that there are some who are just unable to do so because they don't know how to make the concepts practical. All they really know is the same lecture they've taught over and over again. And I believe these individuals are afraid of being exposed, so they hurl insults and derogatory comments to protect themselves. I believe it has become for them a badge of honor. It hasn't matter on an individual level that our country is in an economic and technological crisis.

The Facts
Based on the National Science Foundation (NSF) 2003 data source presented in Table 3, Whites represent at least 75% of the scientists and engineers in the United States [9]. "STEM [science, technology, engineering, and mathematics] workers are overwhelmingly white, male, and disability-free, while the available pool of talented women, minorities, and persons with disabilities remains significantly underutilized. In contrast, these groups together constitute a little more than two-thirds of today's U.S. workforce. The current and projected need for STEM skills compels policies, programs, and resources that support greater participation by these groups in STEM education and careers" [2].

Table 1. Scientists/Engineers Demographics by Sex & Race, 2003

Race/ethnicity (% distribution)	Both Sexes	Female	Male
White	77.4	75.1	79.1
Asian	9.6	9.3	9.7
Black	5.8	7.7	4.3
Hispanic	5.2	5.6	4.9
American Indian/Alaska Native	0.4	0.5	0.4
Other race/ethnicity	1.6	1.8	1.5

Data Source: NSF, Div. of Science Resources Statistics, SESTAT.

These facts become even more daunting when we acknowledge that up to "25% of the current engineering workforce will be eligible for retirement in the next five years" [7]. Who will replace them and how will the new technical generation look demographically?

Some Successful Programs
Recently I've become aware of several programs specifically designed to assist underrepresented minorities students in STEM fields. It has been very encouraging to read of their success in retaining and graduating these students. Two programs serve as models today demonstrating that minorities can achieve STEM academic success if given the support: 1) The University of Maryland, Baltimore County's Meyerhoff Program; and 2) Yale's Science, Technology, and Research Scholars (STARS) Program.

The University of Maryland-Baltimore County is a public, predominantly white research campus where minority student retention rates are higher than those of whites. "Since the Meyerhoff Program was created in 1988, it has become one of the nation's leading producers of minority graduates, particularly African-Americans, who go on to postgraduate study and research careers in science and engineering. Approximately 500 competitively selected undergraduates have enrolled in the program from its inception, and since the first group of graduates in 1993, nearly 300 Meyerhoff students have earned degrees in science and engineering, with 85 percent matriculating into graduate and professional programs nationally. These students are now part of a pipeline that has begun to produce a stream of minority Ph.D.s, M.D.s, and M.D./Ph.D.s" [5].

Their success is attributed to several factors: 1) successfully recruiting minorities with grade point averages of 3.5 or higher and with SAT scores approaching 1220; 2) a summer bridge program for incoming freshmen including training in analytical problem solving and study skills; 3) removing financial concerns by offering comprehensive merit scholarships; 4) involving faculty with a genuine interest in recruiting, teaching and mentoring the students; 5) "emphasizing strong programmatic values, including outstanding academic achievement, study groups, collegiality, and preparation for graduate school"[5]; 6) involving students in summer research projects; 7) encouraging students to take advantage of university and departmental tutorial services; 8) ensuring university administration involvement and support; 9) providing academic and personal counseling; 10) providing networking and mentoring opportunities for the students from the professional and academic communities; 11) providing a sense of community; 12) encouraging civic duty within the larger community; 13) providing opportunities to involve the students' parents and relatives in their academic progress and special counseling, if needed. The program's distinguishing operating assumption is "that every student selected has the ability to succeed in science and engineering, given appropriate opportunities and resources"[5].

Yale's Science, Technology, and Research Scholars (STARS) Program "provides first year students through seniors with an integrated experience in research, course-based study and the development of mentorship skills. More than 100 students each year participate in STARS programs"[10].

The STARS program encompasses: 1) study groups to assist with the first and second year core courses; 2) department faculty advisors and graduate students as group supervisors; 3) undergraduates who have previously taken the core courses facilitate the development of mentoring skills; 4) summer independent research projects with a Yale faculty member; 5) financial support for juniors and seniors who participate in up to ten hours a week of research in the laboratory of a faculty mentor; 6) summer stipend support for juniors and seniors to continue research); 7) juniors and seniors participate in the STARS II Symposium where they present their research to student and faculty STARS program participants.

"STARS students enjoy a number of structured enrichment activities during term-time. Special dinners bring together scientists in various disciplines from Yale and other schools, graduate and medical school panels provide guidance in career development, and scholars are encouraged to attend national and regional science conferences"[10].

The University of California-Berkeley has a Biology Scholars Program (BSP) which has shown success as well in helping minorities succeed in STEM fields. The BSP is an undergraduate program "designed to

promote the success of students from economic, gender, ethnic and cultural groups historically underrepresented in the biological sciences. Its goal is to diversify who participates in science, thereby benefiting the discipline and our larger society:" [1]. BSP provides students pursuing their interest in biology with a comprehensive program of support including: 1) academic workshops and study groups promoting success in "gateway" introductory science courses; 2) tutoring for the lower and upper division science and math courses; 3) reading and writing coaches to develop reading and comprehension skills; 4) pre-calculus, pre-general chemistry, pre-physics, and pre-biology courses for students needing remedial assistance; 5) professional seminars, research internships, and community service opportunities whereby students gain practical insight into what it means to be a biologist and how to best plan their college experiences to prepare for careers in science; 6) faculty and student mentors; and 7) a community environment which serves to propagate the individual's success and unifies the students so they establish lifelong connections and friendships.

A study was conducted by Uri Treisman at the University of California-Berkeley whereby Black and Latino students demonstrated the ability to become high achievers in introductory calculus courses by changing their study habits. Treisman noticed that the Black students were not performing nearly as well as the Asian students. Upon close observation of how they studied, he observed that the Asian students 'first studied individually and then gathered together to discuss their work. Then they separated and worked alone again. However, when Treisman visited his African American students he found that they usually worked alone rather in groups. Treisman encouraged his African American students to study in groups, which they agreed to do, and their grades improved dramatically…It produced a marked change in behavior and an increase in achievement" [14]. Treisman's model is now also used at the University of Michigan and UT Austin (Emerging Scholars Program).

I believe the most important factor aiding towards minority student success is the active involvement of administrators and faculty members in the students' lives. Since this served as the most detrimental factor for myself, I am personally sensitive to it. "Researchers Richardson and Skinner noted 15 years ago what holds true today: In addition to academic preparation, personal contact with faculty members in the major is a key factor in academic success. Furthermore, students who become 'planted' in their major early on seem far more likely to graduate" [14]. "Faculty members are an extension of the institution; one can even advance the notion that faculty are the institution. Research has revealed that they provide a needed outlet, a support system for students, especially minority students, one that is often missing in majority environments. For minority students on the majority campus, these relationships prove to be more critical aspects in their educational experiences. A study by Allen proved that for Black students on predominantly White campuses, relationships with faculty are one of the most effective predictors of student outcomes" [13].

Seeing the strategies implemented that I felt I needed has been extremely healing for me – it reaffirms to me that I was not going crazy or just having a "pity party." To think that others were and still are experiencing the things I went through hurts all the way down into my gut. I truly believe that anyone who has the aptitude and desire to take on the challenge of a STEM program deserves our 100% support.

CONCLUSION

Economist Lester Thurow, author of *Head to Head*: *The Coming Economic Battle among Japan, Europe and America,* stated that "In the 21st century, the education and skills of the workforce will end up being the dominant competitive weapon.[12]" "If this nation fails to prepare citizens from all population groups to participate in the technology-driven economy, we risk losing our economic and intellectual preeminence...Today, when the U.S. economy requires more STEM workers, the largest pool of potential workers continues to be isolated from STEM careers" [2].

I am in no way advocating the lowering of ABET accreditation standards to provide a portal for those who may think differently or learn differently. But I do question the sincerity of the engineering academic and professional communities when they say they are doing everything they can to help retain minorities and

women in this field. What I have experienced and researched strongly indicates lip service more than proactively establishing a means to improve this diversity pipeline. Bridging this gap will require more than coming to conferences and going back to your environment with the same mindset. You will have to make a personal commitment and acknowledge that "while traditional instructional strategies appear to support the students who are traditionally successful in engineering programs, they fail to provide the same opportunities to their more diverse students" [3].

What I am advocating is an asserted effort on your part to identify at least one under-represented student among you that you know is struggling to fit in or struggling with their grades. I am asking you to go beyond the norm to see how you can be of assistance to them. Help them to see practical ways to use the concepts hidden in those boring textbooks; show them the contribution they can make on a community; offer to go with them to visit a local manufacturing or utility plant. Like me, they may need to actually see the workings of the systems large scale; contact one of your professional peers in industry and ask if a student can job shadow them for a day; offer to meet with them weekly to answer any homework questions they may have one-on-one. You never know what will be the thing that inspires them.

Most importantly, offer them you. It only takes one person to care, open up your life so that a student can see that engineering really can be a reality for them. It only took one person, my Chemistry teacher, to assess that I could become a Chemical Engineer. It only took one woman, my mother, to show me that hard work would not kill me. It only took one friend to help me study. And it only took the one God to give me the strength to keep going. It's time to share. Haven't you ever had a difficult time doing something and you knew that if you just had some help, you could do it? Remember how you felt. Remember the frustration. I am only asking you to be a fair human being.

"Creating a workforce that is capable of thinking and working across diverse perspectives is imperative to the future of engineering. To achieve this goal, we must characterize diversity, build communities that value diversity, and develop programs and initiatives to leverage diversity" [11]. "By offering students a variety of classroom and learning environments, students with different learning style preferences and skills may have a better opportunity to discover what best fits their own strengths, needs, and weaknesses" [6]. At the same time, by giving, you will also receive. I am so grateful to those individuals who supported me and made a deposit into me. I was worth the investment.

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