

Reaching Back to Look Ahead

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Abstract – Graduate school offers several avenues for students to discover or confirm their career plans. One such avenue is the Student and Teacher Enhancement Partnership (STEP) program, funded by the NSF GK-12 program and coordinated by the Georgia Institute of Technology. This program links K-12 and graduate education by teaming graduate students with high school teachers and students for 10 hours per week. In this paper, four engineering doctoral students, all African American women who participated in STEP, share the impact of this program on the development of their career interests.

Keywords: Minority, K-12 outreach, Mentoring, Graduate education, Pipeline

INTRODUCTION

The graduate school experience has the unpredictable and oftentimes unexpected ability to cause one to not only reflect on his/her present and future, but it also demands that one weigh both periods against the past. It is during these reflective moments that one asks him/herself: “What do I really want to gain as a graduate student other than a master’s or doctorate degree?” “For what reason did I choose to pursue a graduate degree?” “What responsibility, if any, comes with my earned degree?” and “Who or what will be most impacted by my career choice?” There is no one correct answer to any of these questions, as discovered by the four African-American engineering student authors of this paper. Each student, while from similar yet different backgrounds, concluded that she would explore these questions as Fellows in the Student and Teacher Enhancement Partnership (STEP) program.

STEP, coordinated by the Georgia Institute of Technology (Georgia Tech) in Atlanta, Georgia, is sponsored by the NSF GK-12 program. The program seeks to partner Georgia Tech graduate and undergraduate students with teachers at local high schools. The three primary goals of the STEP program are: to use the unique talents and energy of the Georgia Tech students to help address the pressing needs at the schools; to promote long-term, mutually beneficial, and multi-faceted partnerships at these schools; and to provide the Georgia Tech students with a teaching internship experience that would benefit their professional growth and subsequent career, whether in academia, industry, or education. The partner schools that were served by the authors had student populations of 1231, 1585, and 1893 students, where 52%, 100%, and 94%, respectively, were under-represented minorities. The data reflects the demographics of the schools for the period 2001-2002. As an illustration of the need for such intervention by STEP at these schools, the average SAT score was 1051, 884, and 868 and the passing percentages on all AP exams were 43%, 7%, and 22% respectively [1, 2]. It should be stressed here that the average SAT score for the under-represented minority students at the first school listed (888) is in line with the other two schools whose

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populations consist mostly of under-represented minorities. These statistics tell a sad truth, but at the same time the numbers also ask weakly, almost reluctantly, “Who will help?” In answer to this call, four African-American women, each with her own motivation, said boldly, “I will.” These women saw the faces of the students behind the numbers and determined to be instrumental in rewriting their statistical story by serving as STEP fellows.

As part of the STEP program, the graduate students introduced primarily minority high school students to multimedia presentations, chartered and mentored extracurricular clubs, enhanced and implemented science labs, and introduced the use of proper scientific research methods. Through STEP, they were able to experiment with the use of innovative techniques in the classroom, and witnessed the students taking ownership of their own learning. Lab activities were altered to allow for more creativity in developing the experimental procedures and expected outcomes. These experiences confirmed the graduate students’ desires to bring creativity out of students through teaching, and their love of working with students to help them translate ideas into finished products, from working robots to science fair projects. In addition to increasing their familiarity with effective teaching tools, time spent in the classroom opened graduate students’ eyes to the fact that research is not the only way to stay active in engineering--that not only are engineering researchers needed, but educators are also a needed asset. The experience as a Fellow also gave them an insider’s look at the current state of education--specifically the education of black youth today in America—fostering in them plans to develop a pipeline to acclimate high school students to the rigors of an undergraduate engineering program.

MOTIVATION

The four women involved in the STEP program represent a broad spectrum of the African-American Diaspora. That is to say, their secondary educational experiences range from public school to private school; their socio-economic status ranges from below poverty to upper middle class; they come from either single-parent or two-parent homes; one is a first-generation college graduate; and geographically, one is a New York native, another is from Utah, and the other two are both Southern – one being from Georgia and the other Mississippi. So, what attracted these similar, yet different women to the same program? Each admits that it was because of her particular personal history and her experiences with outreach programs on the secondary and post-secondary level that she was encouraged to make application to the STEP program. They would even venture to say that had it not been for diversity programs geared to enhance the educational experiences of women and under-represented minorities, that they, like many of the students at the targeted STEP schools, may have never been plugged into the engineering pipeline. Thus, these already pioneering graduate students entered the process of becoming a STEP fellow with numerous expectations – both of themselves and of the program. The four women expected to:

- empower under-represented minority students
- serve as positive role models
- improve their classroom teaching skills
- gain insight into the current state of high school education
- understand how students learn
- be trained in pedagogy
- explore their desire to become a teacher
- keep their skills sharp
- have fun

Each expectation was realized by the graduate students based on their personally designed plans for interaction with the partners at the assigned schools and by the summer training provided by the project’s principal investigators

prior to beginning work at the schools. The activities of these Fellows, as well as the challenges of and lessons learned during their tenures, are explored in the following sections.

ACTIVITIES

This section details the various arenas through which the Fellows were able to achieve maximum impact at the assigned schools. The Fellows brought technology into the classroom and served as mentors to the students in both informal and formal capacities. They developed multimedia presentations, designed and administered open-ended science laboratories, and chartered and supervised varying clubs and organizations such as NSBE, Jr. (the Pre-College Initiative sponsored by the student-run National Society of Black Engineers), SECME (formerly known as the Southeast Consortium of Minorities in Engineering), and the Young Ladies Initiative (YLI).

Multimedia

One STEP activity was to instruct at-risk freshmen and sophomores and at-level juniors and seniors in different uses of multimedia. STEP Fellows found that it is often difficult to keep some groups of students on-task and interested in the class content. However, with the aid of multimedia tools, the students became more eager and anticipated the days that would involve special labs.

The students were much more engaged during labs and lectures involving computers, even if it was simply listening to a lecture that used Microsoft PowerPoint. Probably, novelty was not the major contributing factor to their heightened experience since the novelty factor would have worn off after the first few times. The computerized lectures made it much easier to explain relatively complex topics (such as fuel cells). The STEP Fellows learned that it is much easier to show an animation illustrating chemical reactions needed to convert hydrogen into water and energy than to draw or show slides of individual points in the process. However in general, it was found that one should not be locked into running slides and rambling on; rather one should insure that the students are engaged by asking them questions and continuing to use the board for writing impromptu notes.

As part of a conference (POD Network) workshop, STEP Fellows received a PowerPoint presentation modeled after the television game show Jeopardy. Educators can create custom games depending on their curricula. In the classrooms where STEP is working, there is a need to emphasize critical thinking, laboratory skills, and preparation for Georgia's standardized High School Graduation Test in Science. Therefore, Fellows made questions that broke away from the standard quick answers that belonged to any general category. For instance, there were categories that were based on lab experiments and each question within that category required the students to think critically and have knowledge of regular lab procedures. Unlike television's Jeopardy, this interactive game can have multiple questions with pictures and sounds. For instance, it is very easy to have a question that asks what the waveform of a certain sound looks like, where the educator can click on a button, play the sound, and then display several pictures that could be the correct answer. The students were usually separated into groups and played as a team. Modifications to this included alternating through the team so that each student could answer at least one question.

MathWorks' MATLAB includes special features that can be used to create software that can interface with the sound card found in almost all computers. An aspect of this special feature was used to acquire data through the sound card and display it as an oscilloscope on the computer screen and then save the data for later processing. One STEP Fellow designed a project that included using this computer scope to measure the efficiency of windmills that the students built. An interface was created that connected the soundcard to an ordinary cost-effective motor that can be found in many toys for less than a dollar. The students attached their designs to the motor and used a fan as the wind source. The students were able to translate their design to actual working electricity immediately and they were encouraged to work harder to improve their designs.

The teachers working with STEP Fellows have seen the improved results that working with multimedia tools bring to the classroom, and many now incorporate some of the labs. One teacher even purchased a projector to make working with the tools easier. Unfortunately, some projects involved MATLAB, which is not available to all teachers. Hopefully, this can be ameliorated by writing software that can run on any standard computer. Normally,

this task would be quite daunting; however, with the resources that the STEP program brings to the school, it is quite easy to find a graduate, or even undergraduate, student to develop some code.

Science Laboratories

Often when students are introduced to new scientific concepts, they tend to construct a wall. They think “It’s too hard” or “I’m not good at science”, so they develop a mental block before any learning can take place. The STEP Fellows found this to be true at their assigned schools when introducing the concept of the scientific method. It was found that when students were convinced that they already knew the scientific method, they would deconstruct some of these mental barriers and be more receptive to new concepts.

This process was tried with two sets of classes: General Chemistry and Accelerated Chemistry. The concept was the same, but the route taken was different. The teacher of these classes went through the scientific method with the students. For General Chemistry, laboratory activities were given so that the students could figure out the scientific method. The students were required to discuss the lab before they began, addressing questions such as, “What are you doing?” and “What is the purpose of this lab?” The students generally responded with the lab’s stated objective. Then they were asked to predict the outcomes (hypotheses) and defend their predictions. In the beginning, they were hesitant about explaining their reasoning. However, after some gentle prodding by the STEP Fellows, the students began giving thorough explanations for reasoning why “x” would happen if “y” changed. When asked about “z” they were able to reason that “z” does not change. They understood independent and dependent variables! After the experiment, students were responsible for writing up their conclusions, which they shared the next day. When told that they had gone through the scientific method, several of them remarked that the concept was common sense. All of a sudden, remembering the scientific method was no longer difficult. Once they realized the scientific method was the same method they used in class every time they performed an experiment, the mental barrier that was in place was demolished.

The Accelerated Chemistry class had to do science fair projects. Students were responsible for designing their own projects using the scientific method. Once again, those mental blocks to all things related to science went up. So, the indirect approach was implemented. In the one-on-one meetings to discuss their projects, STEP Fellows asked a series of questions: What are you looking for? What do you expect to happen? Which factors will stay constant and which will change? The young scientists were less intimidated by these questions. While they already had a plan for tackling these questions mapped out in their minds, they were unable to recognize the questions as steps of the scientific method. When it was revealed to the students that the methods they utilized to design their projects resembled the scientific method, discussion then ensued with the students comparing their reasoning to that of the scientific method. This was a great way to get students to gain confidence in their scientific abilities.

The classroom instructor was also impressed with the increased enthusiasm and reduced resistance to science concepts. In addition, the students realized that science was not completely foreign to them. This helped the students become more willing to respond in class and think critically, because they began to compare other concepts to things they already knew.

Extracurricular Clubs

A third medium of interaction for the STEP Fellows was as advisors for two science clubs – NSBE, Jr. and SECME. Prior to the Fellows beginning their tenures at the schools, the two organizations were defunct at these schools; thus, the Fellows had to reestablish the clubs’ charters. Students from the science courses (Chemistry, Physics, Physical Science) were solicited for joint membership in the clubs by the Fellows with the incentives of subsidized membership dues, the opportunity to participate in activities that would enhance their view of science, technology, and engineering, and most of all, fun. Through weekly meetings, the students honed their leadership, public speaking, and scientific investigation skills. The students were introduced to such concepts as design for safety, robotics, and biotechnology, through activities such as the LEGO Mindstorms competition, an Egg Drop competition, and site visits to Georgia Tech. These approaches provided a means for the STEP Fellows to harness the energy of these students and direct that energy into constructive and enjoyable activities. Additionally, the Fellows gained experience in relating with students outside of the high school classroom, logistics, budgeting, parental consent, and compliance with school policies. The STEP Fellows’ experiences with the LEGO

Mindstorms competition, the egg drop contest, and campus visits to Georgia Tech are highlighted in the following paragraphs [3].

LEGO Mindstorms Competition

In conjunction with the Mechanical Engineering (ME) department at Georgia Tech, STEP Fellows organized a three-day robotics competition. Teams of NSBE, Jr. and SECME members from the STEP schools participated in the ME administered competition, which required that the students design and build robots using LEGO Mindstorms kits. Demonstrations were given on the possible uses for the computer controlled LEGO kits by undergraduate ME students and the STEP Fellows. The high school students were then encouraged to draw upon their own imagination in the design of robots to complete an assigned task. An example task was to design a robot that would emulate the NASA Martian Rover by collecting items on a faux Martian landscape. After planning and building their designs, the teams would then compete against each other. Future plans are to extend this activity over the entire school year with different levels of participation and different rounds of competition (semi-finals, finals, etc.).

Campus Visits

STEP Fellows further utilized the resources at Georgia Tech by bringing students on supervised campus visits that introduced the NSBE, Jr. and SECME members to the innovative scientific research conducted at the university. All schools in the Atlanta area are invited to such programs as Buzz on Biotechnology, hosted by the Georgia Tech Institute for Bioengineering and Bioscience, but low income, minority schools are often left out due to poor communication with these high schools. Because the Fellows are in place at some of these schools, they provide a crucial link in ensuring that this stream of information reaches teachers and students at the schools. During one such campus visit, the NSBE, Jr. and SECME members took part in Buzz on Biotechnology and participated in biotechnology demonstrations, lab tours, and campus tours. The high school students learned about neuroscience, orthopedics, and were able to examine the latest in prosthetics such as a pacemaker and artificial knee.

Egg Drop Contest

During one NSBE, Jr./SECME meeting, the student members competed against each other in an egg drop contest. The students were challenged by the STEP Fellows to design and build a contraption that would contain an uncooked egg. The only stipulation on the design was that the contraption should prevent the egg from breaking upon dropping the container (with the egg) from a three-story elevation. The students were noticeably excited about the competition and went to work immediately to design and build their contraptions, using such provided tools as Styrofoam cups, Popsicle sticks, tape, glue, cotton, and paper clips. After 45 minutes, the contraptions were ready to test, and the students, as well as the Fellows, were eager to see which designs would meet the requirements. Of the six individuals who participated in the competition, only one student's contraption survived the three-story fall. This brought waves of excitement from that student and the other members. In the end, the students were helping each other to troubleshoot the failed designs and were making recommendations that they hypothesized would lead to a more positive outcome. Overall, the students were decidedly pleased with their accomplishments and had a lot of fun.

Mentoring

Another means by which the STEP Fellows were able to positively impact the target schools was through mentoring. The necessity for such an outreach medium became apparent while the STEP Fellows were at the schools. The STEP Fellows realized that the difficulties and frustrations that they encountered in secondary school were minute when compared to the issues that today's students deal with on a daily basis. They speculated that many students did not excel in school because they were focused on dealing with serious personal issues. There were indicators like attire, language, and behavior between class periods that led STEP Fellows to believe that the poor academic performance of many students was often due to misplaced focus. The STEP Fellows became interested in learning more about the students and imparting to them the importance of correctly placed focus.

This interest led to the implementation a program for young ladies called the Young Ladies Initiative (YLI). YLI was a mentoring club for female students who indicated misplaced focus by academic performance or behavior.

The program consisted of two 8-week sessions, during which five professional women (the mentors) would meet each week with a group of 8-15 teenage girls. The topics discussed during these meetings included: inner and outer beauty, community service, personal relationships, and health. The young ladies were required to record all positive occurrences in their lives over the course of the 8-week session in journals that were provided to them. Additionally, guest speakers were brought in, and the ladies performed an in-school community service project.

The objective of the in-school community service project was to help some of the mentally challenged special education students develop their social skills. The young ladies' teacher suggested that they play the board game Concentration with the students during lunch. The young ladies were pretty receptive to the experience and they all reported having a great time. Not only was this service project fun and convenient, the young ladies were able to serve students in their own school who they otherwise would never encounter – in a class or during breaks.

The YLI session considered the most critical to the personal development of the young ladies was the one that dealt with the impact of personal relationships on academic focus. The students admitted spending hours talking on the phone while leaving homework undone. As a way of challenging the young ladies to think about the implications of such actions, they were encouraged to talk about the women that they hoped to one day become. Resulting from this discussion was an introspective comment by one of the students who wondered why she was in a relationship with a boy considering he could not help her to become her vision of a woman. By the end of the session, the young ladies committed to actively redirect their focus to their academic and career goals and not let personal relationships interfere with their futures.

A shift in the focus of the YLI participants was indicated by the results of the pre- and post surveys completed by the young ladies. The surveys revealed that the goal setting exercises during the sessions caused the young ladies to give more thought to the type of woman they would like to become. The participants also provided comments on their determination to not base their self-image on the opinions of others. Another lesson learned by the young ladies was the importance of evaluating the worth of a relationship, hence determining whether that relationship is one in which they should invest time. Finally, the ladies learned that they should always demand respect in their relationships with others.

STEP Fellow Introspection

While most doctoral degree candidates on the threshold of entering the job market choose to seek positions as tenure track assistant professors at Research I institutions or as research scientists at the highly prestigious government labs, there are also those who do not confine themselves by the standard definition of an engineer with a Ph.D. Instead, these mavericks in the field choose to follow a road less traveled by their peers. That road is in engineering education. Specifically, it is a career focused on the research, development, optimization, and supervision of programs that seek to increase the number of women and under-represented minorities in science, engineering, and technology. Such an unconventional path is one that was charted by the graduate students' participation in the STEP program.

When applying for a STEP fellowship or one similar to it, it is indeed obvious that the applicants are seeking *something*. Generally, they are seeking something that will enhance their engineering experience, as more often than not, teaching is relegated to the status of a required toll on the road to tenure or possibly even the Nobel Prize. Some may have experience teaching, tutoring, or mentoring; some desire to find a creative outlet beyond the laboratory; and some have little to no experience at all. Regardless of what they brought to the table, the STEP program not only allowed the Fellows to gain invaluable experience in the classroom, but the program also empowered them to explore the broader career spectrum that exists for one with a Ph.D. in engineering. As mentioned previously, it is generally assumed that a graduating Ph.D. student has one of three options – assistant professor, research scientist, or post-doctoral student. It is the assertion here that while all three routes can lead to successful careers in engineering, they do not convey a thorough representation of the career possibilities for someone obtaining a Ph.D. in science, engineering, or technology, particularly women and under-represented minorities. This portion of the paper focuses on one alternative career route – engineering education.

The Questions

As STEP fellows, two particular advisories were given – “Be observant.” and “Don’t be afraid to ask the tough questions.” With these words of wisdom and with intensive training, the Fellows were released into the world of the modern-day high school student. And upon stepping into that world, one of the first observations made was that “*students have changed*” and one of the first questions asked was “*How can these students be reached most effectively – now and in the future?*”

It was immediately apparent that many of the high school students contacted by the STEP Fellows had little to no desire to pursue careers in the science, engineering, and technology fields. The few who were interested in such majors, while they were enrolled in courses that would prepare them for the rigors of engineering, they did not have a firm grasp of just how demanding it would be. For this reason, the Fellows began to ask such questions as the one previously posed, but even more specifically, they began to ask such questions of themselves as – “How could *she*, as an individual, positively impact the students?” and “Where did *her* passion lie within the world of engineering?”

One Answer

With continued participation in STEP, some of the Fellows discovered that they possessed a passion for and desire to utilize their engineering training in the educational arena. This decision was due in part to the influence of the exceptional leaders (many holding graduate degrees in engineering) who were involved with diversity programs in which they participated on the undergraduate and graduate level, e.g. programs like STEP. Additionally, the decision was based on the challenging and positive experience that they had as an engineering student, their personal background, and also the obvious critical need for the contribution of women and under-represented minorities in *all* aspects of science, technology, and engineering – research, teaching, and educational programs. While this role is certainly not the standard, however, as ones who had successfully navigated the system, it became their belief that it is critical to the future of the science, technology, and engineering community because it can have a direct impact unlike that of traditional engineering careers on the people who will be making career decisions.

A career as a researcher in engineering education, with the goal of increasing the number of women and under-represented minorities in the pipeline is a valuable contribution to the science, engineering, and technology fields and not a career sacrifice. On the contrary, the training attained as an engineering student will aid in the person’s ability to reach the target students. A diversity program director having a Ph.D. in engineering can potentially have a greater positive impact on those students participating in the program, because he/she has navigated many of the same roads as the student. Furthermore, someone having said credentials with a focused career in engineering education has the potential to influence policy issues, thereby making changes on a national level.

CHALLENGES AND LESSONS LEARNED

During the time spent as STEP Fellows, the Fellows were challenged in many ways, but from their perspective, the lessons learned in the process far outweigh those challenges. This section summarizes the challenges and lessons learned by the Fellows who participated in the previously discussed activities.

Many people put up a mental barrier when they are unfamiliar or uncomfortable with a subject. If the concept is approached in a way that makes people more comfortable, they are more apt to be open to learn. This could be by comparing the concept to things people do every day or by having them use a common sense approach to the problem. The Fellows believe that making concepts come to life is one of the best ways to help people learn subject matter they deem difficult.

The ideas of wisely investing time and properly placing one’s focus seem to be foreign to many of the students encountered in STEP schools. One recommendation is a study skills class for students who show that they obviously need it. Some students had no concept of time management, prioritizing tasks, stress management or other pertinent life skills. It seemed that the students with the greatest issues were the least prepared with the tools

to deal with them. There were great teachers who were aware of these types of disparities but they too were required to prioritize.

CAREER DEVELOPMENT

Although the STEP Fellows' career aspirations do not include teaching at the K-12 level, they gained a deep respect and appreciation for teachers. The Fellows who anticipate jobs in academia are now interested in bringing high school students into their research labs. The STEP experience has shown that high school students add cost-effective, untapped energy, and potential future colleagues to a research environment.

The experience of getting to know at-risk high school students has increased the sensitivity of the STEP Fellows to the life issues that many students have to deal with in addition to schoolwork. It has also reinforced the idea that regardless of the circumstances that students face, the key to success lies in where they choose to place their focus and invest their time. Through the STEP experience, the Fellows learned that in a career as a professor, they can help students in the classroom by giving clear and concise instruction and, on occasion, by lending an ear.

SUMMARY

The Fellows found that their expectations of the STEP experience were exceeded. They received unexpected insight and were able to:

- understand the importance of building and maintaining partnerships with secondary educational instructors,
- gain a new respect for teachers because of the demands on their time and the constraints on their resources,
- receive exposure to the life issues that students have to face without adequate preparation,
- break down walls in teaching scientific concepts to reluctant learners.

The STEP program served as a vehicle to transport knowledge between educational communities of graduate programs and secondary schools. The symbiotic relationships developed in this knowledge transfer have proven beneficial to Georgia Tech, the metro-Atlanta public schools and the Fellows.

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