# AC 2010-2070: TECHNICAL OUTREACH COMMUNITY HELP: AN ENGINEERING OUTREACH-MENTORING PROGRAM FOR MINORITIES

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# Technical Outreach Community Help:
# An Engineering Outreach-Mentoring Program For Minorities


## Abstract

Providing exposure, stimulating enthusiasm, training, promoting the value of engineering, and mentoring minority K-12 students, as a means to increasing STEM participation is the primary goal of the National Society of Black Engineers (NSBE) Technical Outreach Community Help (TORCH) program. The program has taken advantage of its unique opportunity to increase the number of minority students that are exposed to engineering through an outreach and mentorship model using the face of NSBE's collegiate and alumni members. Utilization of formal and informal environments, with African American mentors in engineering provides a unique experience for participants to discover the field and explore the disciplines. The combination of mentors who share ethnic background, similar experiences, and the actual content of the program help to diminish the barrier between minority K-12 students and engineering. This paper will cover the design, content, and assessment of the TORCH program, as well as discuss the program's progress and future.


## Introduction

The National Society of Black Engineers (NSBE) has a mission statement and primary goal to support an increase in black engineers globally and through a student-managed model has maintained a board of directors of college and graduate level engineering students. In 2002, Technical Outreach Community Help, TORCH was formed as an initiative of the board of directors to take the NSBE mission into action by "positively impacting the community" and narrowing the digital divide through service of the organization's membership. Selection of the learning environment is also key; TORCH experiences take place in various settings including after-school and Saturday programs, at NSBE events, and in community centers, churches, college campuses or even a shopping mall.

Recently, a new structure has been developed for the program to enable members to take their engineering experiences, example, and exposure and put it into community action through the TORCH program. Our program development has lead to the development of five program branches for TORCH: Informal engineering and science, STEM community training, technical expertise services, A Walk for Education (AWFE), and traditional community service activities. STEM community training and informal engineering and science are paramount to this paper for several reasons: both promote the overall goals of the program most directly, involve all aspects of NSBE collegiate, alumni, and pre-college membership base, and will directly influence the increase of African Americans exposed to and prepared for college study in engineering and science[1].

## Motivations for TORCH

Much work has been done to promote and motivate interest in engineering for students at the K-12 level with general and target populations. Websites, summer and Saturday programs have been a primary vehicle for universities, organizations, engineering companies and the like to reach students with the message of engineering as an educational option. One of the more notable general engineering outreach initiatives is Engineering Go For It (eGFI) developed by the American Society of Engineering Education[2]. The magazine, website, resources for students and teachers provide a broad view of engineering, and also give a diverse perspective of who engineers are and how to become one.

Diversity in engineering outreach is also an issue that has begun to be tackled, specifically gender diversity. "Engineer Your Life: A Guide to Engineering for High School Girls" a website launched in 2004 funded by the National Science Foundation, Northrop Grumman Foundation, Stephen Bechtel Jr. and the United Engineering Foundation[3] is focused on getting girls interested in engineering. The site provides information for girls, their parents, counselors and working engineers who would like to contribute to the initiative. Similar pages have been created by organizations like Girl Scouts[4] and similar websites for girls in middle school[5].

Some work has been done focused on minority populations, however much of it is not published and nearly as available as the before referenced websites and programs. This clear vacancy is one that the TORCH program seeks to fill in a unique way.

## TORCH philosophy and niche

The primary purpose of the program relies on four key components: engaging content, mentoring, exposure experiences, and academic preparation. These aspects combined will likely increase technical literacy and increase the chances of the student participants to enroll in engineering or science in college. TORCH's niche focuses on access to a large manpower base with NSBE's membership, many of whom are involved in some sort of community service in the name of the organization already. Matching the background of mentors and students is significant, and is often done and successful in programs for females. Eliminating this particular barrier will enable more students to at least look inside the door of engineering. The nature of the national organization provides many geographic opportunities, and the socio-economic differences in those areas that come with it. TORCH is also different as it is a departure from academic based community service for college students. Many students who are consistently involved in engineering outreach do so as part of a departmental requirement or request or as a part of a scholarship as many of the similar programs to be highlighted will show. The final additional feature that tends to be more unique is built in mentoring, personal skill development, and goal alignment, which are part of the curriculum of the TORCH program.

The programmatic characteristics are important as they contribute to the primary research question that will be answered through the program results and its assessment. The difference of research and assessment is recognized throughout the work, and the research teams and assessment teams work parallel to each other to avoid confusion on these differences. Our research question is:

Do informal engineering experiences motivate under-represented students to pursue STEM in the K-12 classroom and as a post-secondary education option with the influence of mentors of similar background?

There are several key hypotheses that guide the research design and methods to be tested.

- Under-represented students are more likely to consider STEM when introduced by those of similar ethnic or socio-economic background
- Informal experiences have a greater likelihood to engage under-represented students in STEM pursuits than traditional classroom experiences
- Participating in outreach projects benefitting other under-represented groups provide the mentor or volunteer greater satisfaction and motivation in their own STEM pursuits
- Engaging in personal development experiences with under-represented STEM students and professionals provide adults and seniors without a similar background a greater motivation to continue their own technical development

**Prior research and outreach**

The research objectives of the TORCH program also rely heavily on four primary categories of prior research: (1) engineering outreach models for females (2) engineering education outreach programs and practices (3) the lack of formal K-12 engineering education and (4) persistence, mentoring and goal alignment. Again, the differences of program assessment and research are duly noted, however much of the literature is assessment in nature. We still refer to these publications as a baseline for developing the program and the research agenda.

**Engineering outreach models for females**

In recent years several organizations, universities, corporate entities, and the National Science Foundation have partnered to develop widespread and successful informal engineering programs for girls in k-12. These programs are generally outside of the classroom and involve several key elements including mentoring from students and technical professionals, campus exposure, corporate visits all supporting highly interactive and engaging curricula. There is also a significant number of websites developed to provide initial exposure, specifically for girls, interested in engineering and science. There are some gaps and weaknesses in the published research, which is limited, however provides an example platform for this research. Another significant portion of the research is based on formal education experiences.

Out of classroom, but classroom-like experiences are done often on Saturdays or at summer camps like Saturday Academies at North Carolina State University. This particular program is for middle school girls and middle and high school science and math teachers who are engaged in engineering exploration activities with industry professionals, faculty and students in science and engineering. The program has multiple levels and covers most of the traditional engineering disciplines. The goal overall is to provide an introduction and motivation for female students to pursue STEM, educate their teachers on what STEM professionals do and provide information to

parents and counselors on how to prepare students for STEM post-secondary study[6]. Many other programs exist, however academic publications of those programs are limited.

**Engineering education outreach programs and practices**

A stronger publication history of general engineering outreach exists, so is drawn upon for this research. Many of the programs that are published are university based, tend to provide more exhibition than research, much of the data is assessment based, and nearly all are short term projects, so longitudinal data essentially does not exist on these programs. The combination of these limitations results in a very general availability of information on the topic. Much of the engineering education outreach that is currently being done focuses on technical services being provided to the community and community based organizations, especially when college students are involved[7]. There is also an established need to increase American enrollment in engineering while diversifying the field[8]. Some of the programs that we draw upon are The Pre-Engineering Instructional and Outreach Programs (PrE-IOP)[9], Adventure Engineering[10], and the Detroit Area Pre-College Engineering Program[11].

**The lack of K-12 engineering education**

Much of the motivation behind engineering outreach programming deals with the clear nonexistence of engineering specific classes in K-12 education. This is discussed in much of the research as well education and engineering education literature. The Commonwealth of Virginia in both the mathematics and science Standards of Learning call for "connections" and state the need for technical literacy, of citizens[12,13]. As technical literacy is still different than engineering education, the grade level requirements for both math and science do not demonstrate connections to other fields and technical literacy is not specifically included in the standards.

**Persistence, mentoring and goal alignment**

Persistence, in engineering especially for minorities is often the result of mentoring and goal alignment, thus for the research purposes of TORCH, persistence literature is referenced.

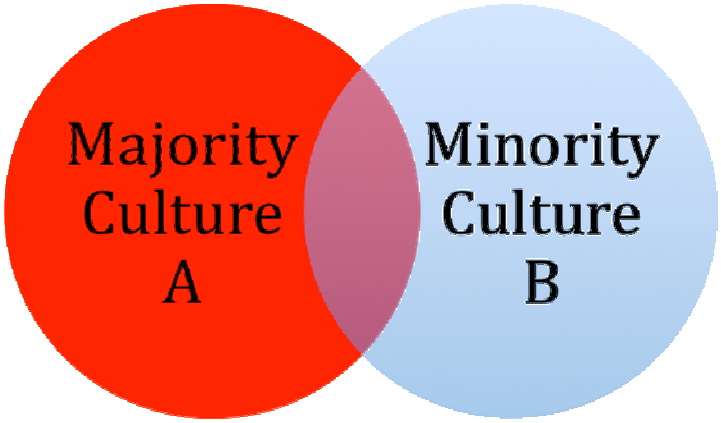
One of the most significant studies on persistence and migration in engineering is Ohland's "Persistence, Engagement, and Migration in Engineering Programs."[14] The purpose of this study was to determine significant factors in the reasons why students choose engineering as a major and as the title suggests, their engagement levels and the influence of all of these on the migration patterns of freshman engineering students. Students who were engaged were more likely to persist. In a similar study, Pierrakos' research goal is to promote engineering enrollment and diversity by uncovering how students identify themselves as engineers and utilize that information to develop more effective recruitment methods for underrepresented students[15]. Their research shows that knowledge of the profession, interest/motivation, preparedness and belonging are significant themes among students who remained in engineering and those who switched majors.

Studies have also been done on college level African American engineering populations. One such paper seeks to answer questions regarding the motivation, self-efficacy and factors

contributing to leaving engineering by African American female students[16]. The group utilizes a survey instrument as the main data source, however additional information is captured from students via interview as well. While very brief, the paper does provide a very basic research project focused specifically on African American females. As there are very few published studies on this group it is added as a resource to this research for the fact that it covers specific groups that will be affected by the NSBE project. Their scope only however includes current college students, and not any information is gathered specifically regarding the K-12 level.

Mentoring has been stressed as a key component of the TORCH project not just for the program sake, but also will have an influence on the research results. The theoretical foundation for this comes strongly from *Theoretical Considerations in the Study of Minority Student Retention in Higher Education* a chapter of Reworking the Student Departure Puzzle [16]. Several social and educational theories as applied to minorities, specifically African Americans and Latinos are discussed within this valuable chapter. The theory of dual socialization supports the need for similar ethnic background of mentors and mentee in the TORCH program. Biculturation can best be described by the figure below.

**Figure 1. Biculturation Diagram**




*Adapted from deAnda 1984*

In the figure for biculturation the experience of cultures of minority students is captured. The red circle represents the majority culture, which in this case values engineering education. The blue circle, which is minority culture, in general, does not value engineering education at the same level of the majority culture does. Mentors who are minorities in engineering demonstrate the middle section of a shared value system of minority culture and engineering. deAnda, the developer of this model "argues that converging the two worlds could allow the individual to function more effectively and less stressfully in both worlds." The theory is applied broadly to education and is completely applicable to engineering, science and math education.

## Methodology

There is limited research on outreach projects influence on black students. We seek to determine effective informal experiences to motivate minority K-12 students to pursue STEM as a post-

secondary education option. The TORCH program will require carefully selected curriculum, both formal and informal, solid quantitative results as well as qualitative results. Longitudinal data on students' performance, goals, and enrollment are crucial data points to be collected and are primarily the quantitative results of the program. Interviews, focus groups and surveys will be the primary qualitative base of the assessment. These assessment results from individual programs will be collected and research to determine significant findings are the primary result of the work.

**Table 1. Research Questions, Data, Methods of Collection and Methods of Analysis for TORCH Program**

| Research Question | Data Required | Methods of Collection | Methods of Data Analysis |
|---|---|---|---|
| What experiences best motivate under-represented students to pursue STEM in the K-12 classroom and as a post-secondary education option? | Student response from activities. Increased grades in K-12 science and math courses. Enrollment in STEM majors in college. Qualitative link to experiences. | Grades, interviews, surveys | Statistical data analysis, interview protocol |
| Do informal engineering experiences motivate K-12 students in their current STEM classroom experiences? | Increased grades in K-12 science and math courses. Self-efficacy increase and positive attitude toward science and math. | Grades, interviews, surveys, observational | Statistical data analysis, interview protocol, survey responses |
| Do informal engineering experiences motivate K-12 students to pursue STEM as a post-secondary option? | Enrollment in STEM majors. Indication of STEM major intent on applications. Application to STEM colleges, scholarships, etc. | Enrollment data, college application data, scholarship awards | Statistical data analysis |
| How does technical community service impact college and graduate level mentors who serve K-12 students? | Interview response, survey data. | Interviews, surveys | Interview protocol, survey responses |

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|---|---|---|---|
| Do SOL based informal experiences increase K-12 classroom performance? | Grades increase. SOL achievement comparative data. Independent course selection. | Grades, SOL scores, data on student course selection | Statistical data analysis, qualitative data information |
| What is the impact of mentors of similar ethnic, socio-economic or other backgrounds have on K-12 students interested in STEM? | Self efficacy increase, interview response, personal goal development. | Surveys, interviews, | Statistical data analysis, interview protocol |

**TORCH status report**

To date, the TORCH curriculum is in final revisions however the program is in operation in select locations with data being collected from those sites. For the intervention experiences that are a part of the informal engineering and science aspect of the program has collected some data to date from student participants, parents, and member facilitators. Early results have some interesting findings regarding students understanding of engineering, math and science performance and interest in attending college in a STEM discipline, yet have not yielded enough statistical data for publication purposes.

STEM community training programs have had several target populations and curricular outcomes. An ACT program conducted in October of 2009 included 80 students and 15 college student mentors. Mathematics, English and science university faculty instructed ACT preparation modules and students took sample ACT pre-tests.

A design competition was completed and follow-up survey at a summer camp program in August 2009. Students reported that they had not participated in many design experiences before and were faced with significant challenges when the mathematics aspects of the challenge were necessary. Students also reported that the support of the college mentors to help them figure out the problems was very valuable and helped them realize that they actually did have the skills to solve the problem, just did not clearly know the process to follow.

Another successful long term program provided computer literacy training to adults over a two month period and the same group provided computer skill training and tutoring to students in grades six through 8 and in a separate group students in grades nine through twelve. Some of the computer programs that have been instructed by the college and professional mentors are Microsoft Office Suite, Adobe Photoshop, and Alice. This particular program is so well utilized by the community that the core group of volunteers increased from ten to well over thirty to provide enough mentors for the interested community members. Additional program sessions have been added to accommodate the demand in the community.

## Future work

The program will be rolled out to NSBE members and chapters for full implementation in the 2010-2011 academic year, while pilot programs are being completed in the spring of 2010. During pilot programs, the instruments will be tested for reliability and begin collecting data for the longitudinal nature of this study. Target locations have been identified for the full implementation including the cities of Detroit, Atlanta, Boston, Chattanooga (TN) and rural areas of Indiana. Funding sources are being solicited to fund the work, as much of the overhead expenses are being absorbed by the organization's regular operating budget, with little funding being provided to the program and its research.

### Bibliography


1. Thomas, L.D., et. Al. "Work in Progress – Informal Engineering Experiences in the African American Community." Frontiers in Education 39, 2009.
2. Engineering Go For It. www.eegfi.org, accessed December 16, 2009.
3. Engineer Your Life. www.engineeryourlife.org, accessed December 16, 2009.
4. Girls Go Tech. www.girlsgotech.org, accessed December 16, 2009.
5. Engineer Girl. www.engineergirl.org, accessed December 16, 2009.
6. Secola, P.M. et. Al. "Assessing the Effectiveness of Saturday Academies in an Engineering Outreach Program." Frontiers in Education Conference. 2001: Reno, NV.
7. Coyle, E.J., L.H. Jamieson, and W.C. Oakes. "Integrating Engineering Education and Community Service: Themes for the Future of Engineering Education" Journal of Engineering Education. January 2006. p.7-11.
8. Chubin, D.E., G.S. May, and E.L. Babco. "Diversifying the Engineering Workforce" Journal of Engineering Education 94(1) p. 73-86.
9. Rockland, R.H., H. Kimmel and J. Bloom. "Engineering the Future: Enhancement of Pre-engineering Programs Through Outreach." International Conference on Engineering Education. 2002: Manchester, UK.
10. Mooney, M.A., and T.A. Laubach. "Adventure Engineering: A Design Centered Inquiry Based Approach to Middle Grade Science and Mathematics Education." Journal of Engineering Education. July 2002. P. 310-318.
11. Ayorinde, E., and R. Gibson. "A Pre-collge Primer Course for Composites Engineering." Journal of Engineering Education, January 1995 p. 1-4.
12. Commonwealth of Virginia Board of Education. *Mathematics Standards of Learning for Virginia Public Schools*. 2001.
13. Commonwealth of Virginia Board of Education. *Science Standards of Learning for Virginia Public Schools.* 2003.
14. Ohland. M.W. et. Al. "Persistence, Engagement, and Migration in Engineering Programs" Journal of Engineering Education . July 2008 p. 259-278.
15. Pierrakos, O. et. Al. "On the Development of a Professional Identity: Engineering Persisters Vs Engineering . (Switchers." Frontiers in Education: 2009. San Antonio, TX.
16. Rendon, L. I., Jalomo, R.E., and Nora, A.. (2000). Theoretical Considerations in the Study of Minority Student Retention in Higher Education. In Braxton, J.M. (Ed.) *Reworking the Student Departure Puzzle.* (127-156). Nashville: Vanderbilt University Press.
17. Frizell. S.S., and F.M. Nave. "Reexamining the Problem of Engineering Persistence for African American Female Students." Frontiers in Education: 2008 Saratoga Springs, NY.