The Science of Fire

Bruk Berhane, M.S.: Center for Minorities in Science and Engineering, University of Maryland, College Park, Maryland

Andre Marshall, Ph.D.: Department of Fire Protection Engineering University of Maryland, College Park, Maryland

The Science of Fire

Bruk Berhane, M.S.: Program Coordinator, Center for Minorities in Science and Engineering, University of Maryland

Andre Marshall, Ph.D.: Associate Professor, Department of Fire Protection Engineering, University of Maryland

Abstract

The Department of Fire Protection Engineering and the Center for Minorities in Science and Engineering at the University of Maryland collaborated to create a program designed to inspire students to consider engineering as a career in general and fire protection engineering in particular. The Fire Protection Engineering Program at the University of Maryland is unique in that it is the only accredited program of its kind in the United States. Twelve students participated, including one female, eight African Americans and one Latino. Students were exposed to fire protection engineering through various laboratory experiments and interactions with professionals in the field. Students learned how fires spread and how they can be prevented, as well as looked at how historical fires could have been prevented. Each student was assigned to maintain a journal to record observations made in the laboratory. The program was staffed by an associate professor of Fire Protection Engineering and four freshman engineering students involved in a service-learning program. Students met for six Saturdays at the University of Maryland for three and one-half hours each day.

1. Introduction

The University of Maryland's A. James Clark School of Engineering is nationally renowned for its cutting-edge research, as well as for its graduate and undergraduate programs. Currently ranked 23rd in the country among all engineering colleges and 9th in the country among public engineering institutions, the School of Engineering at the University of Maryland is considered by many to be extremely prestigious (Clark School of Engineering 2009). The Clark School of Engineering includes five departments that are ranked in the top 20 in their areas, including the Aerospace Engineering Department, which is rated 6th in the nation. The Department of Fire Protection Engineering, also in the School of Engineering, offers the only fully accredited undergraduate program in this discipline in the United States. According to the Clark School of Engineering's Strategic Plan outlined by the Dr. Darryll Pines, Dean of the School of Engineering, the college aims to increase the percentage of freshman underrepresented minority students in engineering to 15% and of freshman women to 25% by the year 2014 (Clark School of Engineering 2010).

Presently, the undergraduate student body in the Clark School of Engineering consists of 10.4% underrepresented minorities (African American, Latino, and Native American) and 19.9% women (Clark School of Engineering 2009). Underrepresented minorities make up 8.7% of graduate students enrolled in the college and women comprise 22.7% of graduate students in the college. Overall, underrepresented minorities comprise 9.8% of the entire college (graduate and undergraduate) student body and women make up 21% of the entire college student body.

African Americans are the largest underrepresented minority group in the college, followed by Latinos.

The Center for Minorities in Science and Engineering (CMSE) was created in 1981 as a unit within the Clark School of Engineering at the University of Maryland. The mission of CMSE is to recruit, retain and graduate increased numbers of underrepresented minority students in engineering at the University of Maryland. To accomplish this mission, CMSE facilitates graduate and college level retention programs, such as the Louis Stokes Alliance for Minority Participation (LSAMP) Program, and a number of pre-college recruitment and outreach initiatives. CMSE's pre-college programs include robotics summer camps for elementary and middle school students, a year-round research mentoring program for high school seniors, and academic and summer experiences to support Gaining Early Awareness and Readiness for Undergraduate Programs (GEAR UP) in Prince George's County, Maryland.

The Science of Fire was facilitated as a joint outreach effort by the Department of Fire Protection Engineering and CMSE. Program objectives were to expose participants to various engineering careers and to inspire them to consider fire protection engineering as a career through real-world experiences. Students benefit from real-world exposure to applications of mathematics and science, but African American and Latino students often receive less of this exposure than do their White counterparts (Prewitt, Eugene & Daily 2009). The program also provided students with an African American role model in the person of an associate professor in the department, who oversaw all activities during the six-week period. The importance of role models in students' lives has also been discussed in literature, particularly in light of the fact that there are fewer African Americans in engineering fields than there are in some other professions (Prewitt et al. 2009; Commission on Professionals in Science and Technology 2005).

The Science of Fire ran for six Saturdays for three and one-half hours in the morning each day on the University of Maryland, College Park campus from October to November of 2008. Parents were responsible for bringing their children to the campus. Twelve students were enrolled in the program, including eight African Americans and one Latino. There were eleven males and one female in the program. The majority of students resided in Prince George's County, Maryland, in which African Americans make up 63.8% of the population and Hispanics/Latinos make up 12.2% of the population. The remaining students resided in Montgomery, Howard, or Anne Arundel County, Maryland. Since this was the first time in which such a program had been facilitated, the primary goal was to recruit twelve students for the program and to expose them to the field of Fire Protection Engineering.

The faculty facilitator is an Associate Professor in Fire Protection Engineering who is an African American male. There were also four undergraduate engineering teaching assistants selected for the program who were Caucasian males. Program participants engaged in laboratory experiments, career exploration activities, journaling, and creating technical reports that the lead instructor shared with parents on a weekly basis. The following sections will discuss the curriculum and schedule in more detail and will explicate the administration of the program, including how the program was funded.

2. Curriculum

The Department of Fire Protection Engineering at the University of Maryland offers a unique program of study in Fire Protection Engineering at the undergraduate and graduate levels. Fire Protection Engineering includes the thermal and fluid sciences, combustion, materials, human behavior, egress modeling, toxicity, and reliability and risk analysis. This field focuses on reducing the burden of fire losses through engineering design, development, and research. Fire Protection Engineers may be involved with the design of fire protection systems; the analysis of fire protection performance in buildings, nuclear power plants, or even aerospace vehicles; or research in areas such as fire propagation, suppression, or detection. Fire Protection Engineering is a multi-disciplinary field that is not fulfilled by any other branch of engineering. Our pedagogical aim is to provide the technical knowledge and skills to either practice or pursue advanced studies in the field. Our curriculum shares a high degree of commonality with the other UM engineering departments in the first two years of study. The Saturday academy described in this paper introduces middle-school students to Science Technology Engineering and Mathematics (STEM) concepts and careers through the exciting field of Fire Protection Engineering.

The Saturday academy consisted of six sessions focusing on different fire themes (e.g. flame structure, fire size, fireballs). Each session incorporated a number of elements to hold students' attention during the three and one-half hour sessions. These elements included a video introducing the fire topic for the day (30 min.), a guest speaker from the profession (30 min), a career activity (30 min.), a snack (30 min.), a laboratory exercise (60 min.), and a journaling activity (30 min.). These elements provided students with a variety of perspectives on fire from hands on lab activities to real-life fire incidents. The laboratory exercise was by far the students' favorite element as evidenced by their extensive journaling and questions during this period.

2.1 Topical Video

Videos were used to introduce students to fire issues in their everyday lives. Video topics including the World Trade Center Fire, the MGM Grand Fire, and the fire on the Columbia Space Shuttle were used in the sessions. Often, the laboratory exercise was focused on a particular aspect of the fire discussed in the topical videos. These videos often generated questions and discussions which were addressed at the end of the video session. The undergraduate student helpers typically led these discussions and addressed these questions. Students were given supporting materials before the session to support discussions. This supporting material was largely obtained from the internet where there is a wealth of information regarding fire disasters.

2.2 Guest Speaker

Guest speakers from the fire community were invited to speak to students. The faculty facilitator was responsible for coordinating the guest speakers. Speakers that were recruited included the facilitator's former students, researchers, collaborators, and other departmental stakeholders. When asked by the facilitator, the guest speakers were excited about the program and eager to volunteer their time, especially given the relatively small 30 minute time commitment. Speakers discussed a variety of topics including fire litigation cases, major fire investigations, and exciting fire research activities. Students were given opportunities to ask topical and career questions of the guest speaker.

2.3 Career Activity

Career activities were led by the undergraduate students from resources made available by CMSE. The career activities focused on getting students to consider STEM careers in general and were not so narrowly focused on Fire Protection Engineering. This provided students with a broader view of career choices, training requirements, and an understanding of how they may relate to their interests. Students would typically review a career and then respond to associated questions about it; the undergraduate teaching assistants distributed worksheets to the students to guide them through this part of the class.

2.4 Snack

Snacks were administered by the undergraduate helpers. Students were allowed to have a break from structured activities. This generally ran for half an hour and was combined and included time for students to walk outside of the classroom. With four undergraduate teaching assistants, it was possible for the students to remain supervised at all times.

2.5 Laboratory Exercise

The laboratory exercises consisted of hands-on activities where the students were actually able to burn materials. Experiments ranged from candle flames to fireballs. Images from the fireball experiments are included as Figure 1. Fireballs occur during accidental releases of flammable vapors and were a key component in the World Trade Center fire just after airplane impact. In these laboratory exercises, students were able to see fires first hand. These experiments always motivated questions from the students and initiated interesting discussions. Students were asked questions about what they saw. For example, in the fireball experiment, students were asked to identify factors that may influence the color and size of the fireball. The faculty facilitator would lead this discussion and provide answers in easy-to-understand language. For some of the labs, simple calculations were performed on a white board to perform some basic analysis on the laboratory data. Funds for laboratory supplies were obtained from the NSF research grant connected to this outreach activity.

Figure 1. Progression of a fireball created with a methane filled balloon.

2.6 Journal Activity

At the end of the session students were encouraged to draw a picture describing something that they learned during the day. Figures are an important part of technical communications. This exercise was included to get the students to think about how they may convey their observations and ideas visually. The students' figures were scanned into an electronic format for use in their session journal sheet.

As a very final exercise the students gathered in a computer lab where each student was able to have her/his own machine. Photographs from the day along with each student's figure were preloaded onto the machines. The students were provided with a one-page journaling template which included dedicated space for photos, a figure, and caption and a brief description of the day's activities. Students were encouraged to take notes throughout the day in their notebooks. The undergraduate teaching assistants were also busy taking photos throughout the day during the activities. The students were asked to use their photos, figures, and their notes at the end of the day to describe something that they learned. At the end of the Saturday academy, students would have six of these visually appealing summary/journaling sheets describing their activities. This exercise was intended to teach students about the importance of scientific reporting based upon their raw data and observations.

3. Administration

CMSE managed the majority of the administrative operations of the Science of Fire. This included recruiting and registering students for the program, generating funds for and purchasing snacks and give-a-ways, and recruiting and selecting students to serve as teaching assistants. The faculty facilitator recruited guest speakers for each week of the program.

3.1. Recruitment

CMSE recruited program participants through e-mail solicitation. The CMSE program coordinator e-mailed parents with students who had participated in prior CMSE outreach programs and also e-mailed teachers at schools in Prince George's, Montgomery, Howard, and Anne Arundel County, Maryland. The e-mail consisted of a short description of the program and an attached brochure with registration instructions. Additionally, the Maryland Mathematics, Engineering and Science Achievement (MESA) Program distributed information on the program to schools enrolled in the Maryland MESA program after receiving a request from the program coordinator.

At least thirty schools and fifty parents were contacted to recruit students to enroll in the Science of Fire. In this and all programs facilitated by CMSE, all students, regardless of race or gender, are eligible for admission and in many cases (as with the Science of Fire) admission is on a first-come, first-served basis. Scholarships are in most cases not advertised as part of the recruitment process. CMSE determines the cost per child based on the estimated cost of facilitating the program.

3.2 Resources

Parents paid a fee of $100 per child to cover give-a-ways and snacks for the program. The undergraduate teaching assistants served as volunteers as a requirement for a service-learning program of which they are part and so no funds were spent on student salaries. Guest speakers were recruited by the faculty facilitator and discussed topics that were consistent with the lesson covered on a given week. Materials and supplies associated with the program were supported by a research grant that the faculty facilitator received through a technical proposal to the National Science Foundation.

Electronic communication was a key component of the program and was entirely facilitated by the faculty facilitator and the teaching assistants. Each week students created slides in Microsoft Power Point that illustrated what they learned. The teaching assistants helped students in this process and then the faculty facilitator e-mailed this information to parents. This provided a means of formative assessment that engaged the instructional staff, parents, as well as the program participants.

3.3 Teaching Assistants

The undergraduates completed this program as part of a service-learning requirement for a program of which they were part; they received no financial compensation for their work. Through correspondence with the instructor of the service-learning class, the program coordinator was able to identify four freshman students who were both interested to work and available on Saturdays to work with the faculty facilitator and program participants. The instructor was able to identify undergraduate students for the Science of Fire who were both

outgoing and able to lead workshops with the children in the program. The teaching assistants came from different engineering departments, including electrical engineering.

All teaching assistants were Caucasian and male, which may be attributed to the fact that racial and gender composition of the Clark School of Engineering is largely Caucasian and male. The four students staffed the program over the entire six-week period, which enabled the program participants to have consistency. This level of consistency may have been an added benefit for the children in the program, allowing them time to form more solid relationships with the teaching assistants. During the time that the program was in session, the undergraduate teaching assistants were always present, allowing them substantial time to work with the students in the program both in completing assignments and affording them ample opportunity to act as role models.

4. Outcomes

The Science of Fire demonstrated that students were able to engage in real world applications of mathematics and science, presumably making connections to how the mathematics and science taught in school is used to solve engineering problems. It also exposed students to a large college campus, a college laboratory, an associate professor in engineering, to undergraduate students, and to professional fire protection engineers. Students also had the opportunity to do scientific reporting using state-of-the-art computing facilities, as well as discuss careers and professional interests with continual feedback from the instructors. Parents benefited by learning what students were experiencing on an ongoing basis and by having an opportunity to evaluate their children's strengths and areas needed for improvement.

The relationship between the administration (CMSE) and faculty facilitator was extremely important to the functionality of this outreach program. Often faculty who are the recipients of technical grants understand the importance of including service components that have broad impact, but it is prohibitive for them to make serious efforts in providing outreach themselves. In these cases, the Principal Investigator often is limited in time and generally does not have the organizational capacity necessary to facilitate these initiatives. It is therefore beneficial for the grant recipients to leverage resources such as CMSE to strengthen their proposals and thereby provide broader impact. This requires little additional work on the part of the faculty and creates a win-win situation for all involved.

5. Conclusions

The Science of Fire program provided a way for the Department of Fire Protection Engineering and the Center for Minorities in Science and Engineering to collaborate in an effort to increase interest in engineering among underrepresented minorities. Resources were leveraged in such a way that instruction and administrative support were delivered seamlessly. Students benefitted from the resources provided by the instructor, guest speakers, and undergraduate teaching assistants. Parents remained informed of the instruction their students received through communication delivered by the faculty facilitator. Although students seemed interested throughout the program in the material, in the future a pre- and post-survey would be useful to measure program effectiveness. When the program is facilitated again, a similar structure/curriculum will be used and the goal will be to recruit approximately twelve students;

however, effort will be made to ensure that pre- and post-assessments are administered to evaluate the overall effectiveness of the Science of Fire.

In order to continue to engage the students in the program, they will be invited to future University of Maryland events as they progress in their academic careers. Specifically, these students can be invited to other outreach and recruitment initiatives facilitated by the Center for Minorities in Science and Engineering while they are in middle school and/or high school. Ultimately, it is the goal of the program to recruit these students to apply to, be admitted to, and enroll in to the Clark School of Engineering after graduating from high school. In this way, more of a longitudinal analysis will be possible.

Bibliography

A. Prewitt, W. Eugene and S. Daily, *Minority Retention and Success in Engineering: Diversifying the Pipeline through the Development of Social Capital,* American Society for Engineering Education, Washington, DC, 2007.

Clark School Facts and Figures, The A. James Clark School of Engineering, University of Maryland, College Park, MD: 2009. (http://www.eng.umd.edu/aboutus/aboutus_facts-figures.html)

Clark School of Engineering, *Strategic Plan,* The A. James Clark School of Engineering, University of Maryland, College Park, MD 2010.

Commission on Professionals in Science and Technology, *Sisyphus Revisited: Participation by Minorities in STEM Occupations, 1994-2004*, STEM Workforce Data Project, Washington, DC, 2005.