COMMUNITY OUTREACH TO INSTILL INTEREST IN SCIENCE AND ENGINEERING

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Abstract *– Benet Laboratories, US Army Armament Research, Development and Engineering Center, Watervliet, NY, is committed to increasing the diversity of future scientists and engineers through extensive community involvement. One of our major efforts has been hosting daylong visits to our Laboratory by female middle and high school students. These visits typically include tours of our facilities, presentations by the technical staff, and hands-on science activities for the students. Benet scientists and engineers are encouraged to informally discuss their careers and related experiences with the students. Feedback from students indicates these casual interactions were the most beneficial aspect of their visit. Another highly successful effort has been our three science workshops conducted for elementary, middle and high school students: Fractals, Polymer Materials and Electrostatics. These workshops have been developed to introduce students to basic scientific principles through demonstrations, hands-on experiments, pen and paper exercises and a variety of computer-based activities. The degree of complexity of these workshops is tailored to the student's age and ability. While we have presented these workshops to a wide range of students, recent target audiences have been students from disadvantaged schools. Feedback from the classroom suggests that our activities are successful in exciting students about science and mathematics, which we believe is an important step in ensuring a diverse population of future scientists and engineers.*

Index terms *– diversity, community outreach, education*

INTRODUCTION

Benet Laboratories, US Army Armament Research, Development and Engineering Center, Watervliet, NY, has long recognized the value of diversity within the scientific and engineering community. A laboratory dedicated to supporting the entire life cycle of large-scale cannon and associated components, Benet is recognized as a world leader in large caliber gun technology. We attribute this reputation to a diverse and talented work force dedicated to supporting the US Army Mission. Benet exploits the benefits of diversity in its researchers by encouraging a team-based approach to solving difficult Army problems. Teams are comprised of a heterogeneous mix of engineers and scientists, with different backgrounds, in an effort to preclude the possibility of unquestioned preferences or prejudices. The productivity of the teams has been exceptional, which can largely be attributed to the variety of hypotheses that are developed in finding the optimal solution. In an effort to ensure this success with its future workforce, Benet is committed to motivating students from all backgrounds to pursue careers in the hard sciences. Many efforts have focused on females and minorities; demographic groups that have been traditionally under-represented in the sciences and engineering.

Benet's commitment to furthering diversity among its future researchers has been demonstrated through a variety of in-house programs, including Cooperative Research and Development Agreements, student co-ops, and visiting faculty programs. Benet Labs also conducts extensive education-related community programs. To date, these activities have included job shadowing, student mentoring programs, lab tours, a pen-pal scientist program, and participation in several career-related programs for students We also participate regularly in many annual programs hosted by local colleges and universities, including Siena College's Expanding Your Horizons™ in Science and Mathematics Conference for 7th to 12th grade women and the State University of New York at Albany's Junior Science and Humanities Symposium. Benet's activities are not limited to the "gifted student". While we have worked with local "Young Scholars" programs, we have also hosted students with special needs.

THE GOAL

Benet's goal is to ensure diversity among its future researchers by motivating students from all backgrounds to pursue careers in the hard sciences.

THE OBJECTIVES

1.) Provide students with an opportunity to meet and interact with scientists, engineers and technical staff.

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2.) Focus efforts on students typically underrepresented in the sciences and engineering.
3.) Conduct interdisciplinary science workshops at schools and relate math/science curriculums to potential career opportunities.

APPROACH

We have responded to requests from several local school districts to provide students with an opportunity to meet and interact with scientists, engineers and technical staff. One of our major efforts has been hosting daylong visits to our Laboratory by female middle and high school students. These visits typically include tours of our facilities, presentations by the technical staff, and hands-on science activities for the students. Benet scientists and engineers are encouraged to discuss their careers and related experiences with the students. An informal session is included during which students interact exclusively with female engineers and scientists. The students are typically concerned with academic preparation, the experience of working in a male-dominated atmosphere, and the challenges of balancing work and family. Feedback from students indicates that these informal interactions were the most beneficial aspect of their visit.

INTERDISCIPLINARY HANDS-ON SCIENCE WORKSHOPS

Another highly successful effort has been our three science workshops conducted for elementary, middle and high school students: Fractals, Polymer Materials and Electrostatics. These workshops have been developed to introduce students to basic scientific principles through demonstrations, hands-on experiments, pen and paper exercises and a variety of computer-based activities. The degree of complexity of these workshops is tailored to the student's age and ability. The workshops are designed to last about 50 minutes and introduce students to new problem solving skills. They also serve to illustrate how the students' mathematics and science curriculum is applied to solve important engineering problems.

In an effort to excite students about careers in the sciences, the workshops are based on our own research interests so that students can appreciate the enthusiasm we have for our work.

Benet is currently employing fractal techniques to better understand the physics of new coating processes for armament systems. The results of this work and others employing fractal concepts [1-15] serve as the basis of our fractals workshop, developed for secondary school students. In this workshop students are first introduced to fractal concepts with a simple paper and pencil exercise to demonstrate the limitations of Euclidean geometry by challenging Mandelbrot's claim [15] concerning the difficulties involved in determining the length of a ragged coastline. They then construct fractal patterns using iterative processes. Students use this technique to draw the Koch and Hilbert curves, which illustrate how one-dimensional curves grow into complex structures that appear to nearly fill two-dimensional space. Computer generated images are used to demonstrate how these techniques can be applied to higher dimensions. Artificial fractal landscapes, Menger sponges, and fractal ferns and trees show students the interesting structures that evolve using linear and random generators. Analytical techniques for determining fractal dimensions are then discussed using examples of engineering applications at Benet. These include fractal analyses of coating structure [1], thermographic images of hazardous breech residue [9], and flicker pulsing techniques used to mask the spectral signature of electronics [2,6] Students then explore the Mandelbrot and Julia sets using educational software [16] to introduce them to the concept of statistical self-similarity. Finally, the students are provided with references and a home exercise from the National Council of Teachers of Mathematics [17] to encourage them to explore fractal concepts on their own.

The polymers workshop introduces students to the molecular structure of materials and how it relates to bulk material properties. It begins with a discussion of the 3 basic types of materials (metals, ceramics, polymers) whose differences are explained in terms of atomic structure using Styrofoam™ models. Students are then presented with a variety of common polymer materials and asked to make observations about their physical properties at room temperature. Students can appreciate the etymology of the word polymer when these properties are explained in terms of molecular chains. The students are asked to predict the behavior of polymers at very low temperatures. Heat is explained in terms of particle vibration and liquid nitrogen is used to demonstrate the concept of glass transition. Students then make polymer materials called "Gluep" and "Obleck" [18]. Gluep is made with white craft glue, Borax™, and water; Obleck is made with cornstarch and water. The interesting viscoelastic properties of Obleck are explained in terms of molecular structure. Students are also provided with the recipes for these materials to encourage them to repeat this activity outside of the classroom. The engineering applications of polymers are then discussed using Benet's Bunker Defeat Munition Launcher as an example. This "Bunker Buster" gained international notoriety from its deployment during the Persian Gulf War.

The electrostatics workshop introduces students to the concept of charge and its conservation. It begins with a discussion of Benjamin Franklin's observation that during any physical process charge can be transferred, but not created or destroyed. The students are introduced to the concepts of positive and negative charges, charge neutrality, polarization, and how an electric charge develops by adding

or removing electrons. They then experiment with balloons to better understand these concepts. They use friction to charge balloons that attract the student's hair or "stick" to the walls of the classroom. They also use charged balloons to pick up shredded paper from a tabletop, and to separate table salt from black pepper. Students then make Rice Krispies™ "dance". The cereal is spread on a tabletop underneath a slightly elevated (1 – 1 ½ inch) sheet of insulating Plexiglas™. The Plexiglas is rubbed vigorously with different materials (e.g. flannel, wool, silk, fur) to transfer electrons to the surface. This static charge polarizes the cereal by repelling the negative charges and creating a charge imbalance across the surface. The cereal pieces begin to stand on end as the induced positive charge one end of the cereal is attracted to the Plexiglas. When the attraction is great enough, the cereal is lifted to the Plexiglas surface where it accumulates electrons until the attractive forces are insufficient to maintain the contact. The cereal then drops to the table and the process repeats until Plexiglas loses its most of its charge.

Since a female scientist and a male engineer conduct these workshops, they allow students to challenge their perceptions of traditional gender stereotypes of these professions. In particular, our polymers workshop is generally presented in grades 3-5, which have been reported to be "a period during which gender-specific attitudes are rapidly forming but are not yet ingrained" [19].

The workshops are simultaneously addressing the subtle problem of female students having less experience with "hands-on" science-related activities than male students. This lack of exposure has been reported to result in a loss of confidence and motivation by female students, which is perpetuated as they make choices about secondary level courses and future college plans [19]. It is our goal to encourage *all* students in our workshops to actively and cooperatively participate, explore, question, and discuss in an effort to cultivate interest and diminish anxiety in science and mathematical activities.

CONCLUSIONS

While it may be impossible to determine if these efforts will be successful in ensuring diversity in our future workforce, feedback from educators, students and parents has been overwhelmingly positive. The letters that Benet has received from both students and teachers clearly indicate these workshops are successful in exciting students about topics in materials science. The teachers have emphasized the significance of the opportunity for students to interact with a working scientist and engineer.

Our laboratory tours and workshops are not actively promoted, but have received a wide audience due to networking among local educators. Unfortunately, the number of requests has far exceeded Benet's capacity to respond. It has been suggested that many organizations support similar education-related workshops to promote student awareness. Our experience in the 30 schools visited over the last 4 years suggests otherwise. With very few exceptions, our visits have been the first for these classrooms. In fact, most teachers have indicated that they never had a scientist or engineer visit their classes before. The material costs associated with the workshops are negligible and we hope our interested colleagues will initiate similar programs at their organizations.

We believe these educational programs will help to ensure a pool of diverse talented future materials scientists and engineers. Further, they support an organizational goal to "Be a good neighbor by developing mutually beneficial relationships with our surrounding communities."

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