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Abstract

It is self enlightened survival for engineering disciplines to become involved in outreach programs. This fact is subliminally recognized in most engineering colleges and engineering dependent industries. In these situations, the issues boil down to "how should it be done?". There are several models available that range from individuals with a common interest in engineering education volunteering their time on Saturday mornings through organized programs sponsored by NSF or NASA. Each of these models can be effective within the boundaries of their mission statements. However, one highly affective and very efficient outreach model is to directly deliver the message to the high school science teacher.

There are important characteristics that must be met if the engineering outreach program is to successfully impact the performance of a science educator. First, it cannot be focused on just the physics teacher. Second, it has to include a healthy dose of engineering science concepts and must include instructors across engineering disciplines. Third, it has to have a hands-on element that can be easily transported to all high school laboratories and translated into all science courses taught. Finally, such an outreach program cannot be a parochial effort, but must be national in scope.

This paper will describe a very successful engineering outreach program that meets these criteria. The Science Educator Workshop sponsored by the American Vacuum Society (AVS) has been working with high school science teachers throughout the country for eight years. This workshop provides a focused educational experience annually to 30 high school biology, chemistry, and physics teachers brought together for two days in an extremely professional environment enhanced by corporate and university support.

Introduction

Outreach means many things to many people and there certainly is a need for each of its many modes. Some traditional modes for high school science courses include providing specific simplified case studies as classroom exercises; providing videos and computer simulations to enhance and expand the student learning experience; and providing project, laboratory activities, and demonstrations to reinforce instructional concepts. In addition, sometimes human resources are added to the recipe when science and engineering professionals volunteer to give guest lectures; to conduct out-of-class accelerated and/or remedial sessions; to organize and facilitate various science-related competitions and contests; and to provide direct individual mentoring to enhance student motivation and success. All of these and many other examples of outreach are extremely valuable and share some common characteristics. They tend to focus on immediate local needs and the energy spent on each is applied directly to the student.

Another important perspective of outreach is not to directly focus attention on the student, but rather on their primary resource, the high school science educator. This strategy provides the additional opportunity to address important fundamental engineering and science issues. There is no doubt, that the

fact that "Johnny cannot add." is a serious impediment to engineering education. This and other student related science issues must be faced, and are being addressed by the outreach modes suggested above. However, the underlying essence of engineering and science as a complex and creative activity also needs to be addressed. The ability to ingest, analyze, model, and then synthesize new information must be infused into the science teacher who, in turn, can then stimulate the students initial curiosity and facilitate their initial grasp of this integrated and layered intellectual activity.

An efficient way to accomplish this infusion task is to create an outreach activity conducted by engineers and scientists that is focused on classroom high school science educators. To be effective, the activity must use and review the basic concepts of familiar material. It must also provide background and activities for using mathematics to define and interpret scientific observations. Furthermore, activity should provide a multi-disciplinary engineering perspective on the science being addressed in the workshop. Naturally, there must be hands-on activities that the teacher can translate, transpose, and/or transport directly into their classroom. Such activities must provide student opportunities to work on open-ended problems using tangible equipment; to practice data acquisition and simple modeling exercises; and to extrapolate results to more abstract but universal situations.

Ultimately, the workshop must facilitate attitude adjustment of the participants in three ways. First, it must make participants realize that science is related to the basic philosophy, information processing, and problem solving techniques of engineering. Second, it must help them understand that this relationship, although complex when executed in a professional environment, is elegantly simple at the conceptual level. Third, it must leave an indelible impression with them that the activities learned have immediate and relevant importance to today's world of high-tech science and engineering.

Science Educator's Workshop

The Science Educator's Workshop sponsored annually by the American Vacuum Society and developed through a cooperative effort with university, industry, and national laboratory professionals accomplishes these objectives. The workshop focuses on different aspects of the natural and physical sciences. It relates to the observations that are possible because of the different pressure environments that can be generated by a vacuum system. However, it also directs the high school science educator's attention to the engineering perspectives of these same phenomena and the impact these engineering perspectives have on our lives.

The workshop's success requires that the science educator come to appreciate two important aspects of the scientific method within a vacuum technology framework. First, there are predictable events that occur when the pressure of an environment is manipulated. Second, there is great deal of satisfaction when a engineering and/or scientific concept is completely understood. The workshop attempts to accomplish this task by focusing the participants on the pressure-related physical phenomena to be understood, and then requesting the participants to explain the observations by a satisfactory theory, successfully describe that theory with a mathematical model, and ultimately characterize the model's performance by repeatable observations.

This two-day workshop begins with a description of a vacuum environment and how it is generated. Common vacuum-related demonstrations familiar to most participants are conducted. These include, the falling feather, variations on a marshmallow expansion, and transmission of sound. By mid-morning, most participants have reached a satisfactory comfort level with their surroundings, and the workshop activities begin to increase in intensity and focus. Participants are introduced to the concept of pumping speed as a tool for characterizing their vacuum system, and asked to measure the system parameters that predict the pressure of their vacuum system as a function of time. This exercise requires

the participant's appreciation of the fundamental and ubiquitous exponential decay model and the various ways to express it.

With this modeling tool firmly in hand, the participants are moved to another popular mathematical statement that deals with direct and indirect proportional relationships. Participants experimentally explore Boyle's Law using an expanding balloon experiment. This classic exercise allows another opportunity for participation in the observation-model-data validation experience. It also provides the opportunity to shift the workshop to an engineering focus via the thermodynamic aspects of PV experiments. Topics and activities in this section include phase equilibrium issues, polytropic processes, the work function associated with the expanding balloon, and the role that work has in the construction and operation of thermodynamic cycles.

Additionally, the workshop has other aspects that compliment its controlled environment focus. For example, the participants are shown how vacuum technology is used in several environmental remediation applications. The role that vacuum plays in high technology products is also explored. Finally, the workshop always includes a visit to a major facility that incorporates various aspects of vacuum technology in their daily operations.

Workshop Logistics

Although the AVS workshop satisfies the academic goals of a good outreach experience, it is by no means the only criteria that must be met. For a workshop to go beyond the normal outreach modes conducted at a local or statewide basis, it must accept global criteria that assure its impact can be felt at the national level. Intellectually, the subject covered in the workshop meets one of these goals. Its intended focus of making science educators aware of the critical importance of high school science and applied mathematics education as the gateway to a professional engineering education satisfies another national criteria. Additional criteria include: a workshop platform that can reach key science educators across the entire country. Finally, the workshop requires both a significant financial and resource commitment that will assure its continuity from year to year as well as guarantee that these educators will have the opportunity to interact equally with working scientists and engineers from industry and academia in a professional environment.

The AVS Workshop meets and exceeds these requirements. The society has established an accredited, in-service workshop with a teacher selection procedure that invites state-recognized high school educators to attend the workshop. Local chapters provide the financial support for travel, accommodations, and, when necessary, for substitute teachers. They also identify a society member to mentor the participant before, during and after the meeting, to establish a long term, local relationship. In addition, state and district science coordinators are invited. The workshop itself is conducted in conjunction with the AVS annual international meeting. Workshop participants not only receive full admission to this five-day meeting, but also are given a grant for the purchase of a small, fully functional vacuum system. The society also arranges events that provide the teachers with ample opportunity to interact with the engineering and science professionals that attend the meeting.

Summary

The paper provides an overview of an outreach activity that is focused on high school science educators as an important component in the development of a nationally-needed engineering resource. The AVS recognized this critical need and is investing membership and financial resources to support this endeavor. The paper indicates the type of workshop that has been developed, the underlying philosophy of the workshop, and the nature and extent of the financial commitment needed to assure its success.

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