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Cooperative Pre-College Educational Programs at the Continuous Electron Beam Accelerator Facility (CEBAF)*

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ABSTRACT

The Continuous Electron Beam Accelerator Facility (CEBAF), under construction in Newport News, Virginia, is a particle accelerator laboratory for nuclear physics research funded by the U.S. Department of Energy. CEBAF's research and supporting technologies offer a rich environment for capturing the interest of and augmenting the experiences of pre-college teachers and students. This paper describes some of the pre-college educational programs underway at CEBAF in collaboration with schools, colleges, and business partners. The BEAMS program -- Becoming Enthusiastic About Math and Science -- is highlighted. BEAMS brings entire classes of fifth and sixth grade students with their teachers into CEBAF for a full school week of special science and math activities. A pilot program involving seven inner-city classes was conducted in spring 1991. The 1991/1992 program is well underway with fifty classes scheduled to visit CEBAF.

INTRODUCTION

The Continuous Electron Beam Accelerator Facility (CEBAF) is an accelerator laboratory for basic nuclear physics research under construction since 1987 in Newport News, Virginia. The site plan for this laboratory is shown in Figure 1. CEBAF has been identified by the nuclear science community in its long-range plan as the nation's highest-priority project for nuclear physics. The Southeastern Universities Research Association (SURA), a nonprofit research consortium of 41 universities in 13 southeastern states and the District of Columbia, is building and managing CEBAF for the U.S. Department of Energy (DOE).

At CEBAF, a superconducting accelerator will provide a beam of electrons at up to 4 GeV (billion electron volts) energy and 200 microamperes current for use in nuclear physics research. The high-quality, continuous-wave beam will be split three ways for simultaneous use in three experiment buildings. In these buildings, enormous detectors monitor interactions between the beam and the nuclei of target atoms to provide scientists with data to use to gain new knowledge of nuclear structure and behavior. Currently, with construction 70% complete, work underway includes planning experiments, designing detectors, and developing computerized control systems. Another priority is the assembly, test, and installation of the high-tech accelerator components and the commissioning of the accelerator. Low-temperature cryogenics, superconductivity, clean room assembly, and computerized simulations and modeling are part of daily activities at the laboratory.

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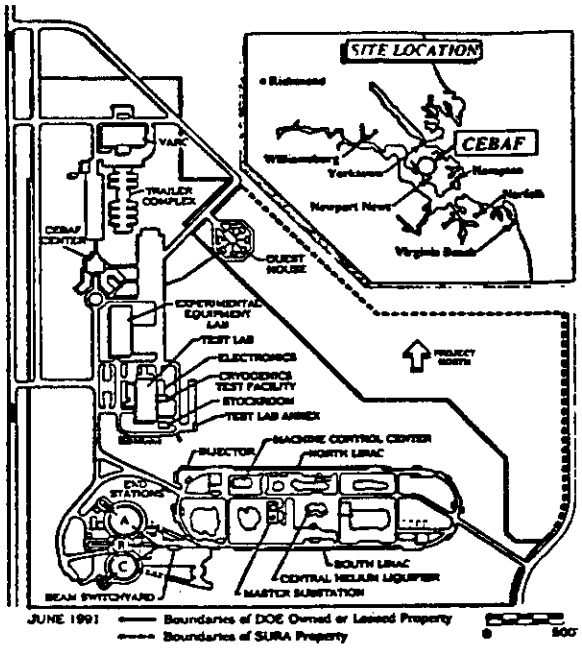

Figure 1: CEBAF site plan showing the laboratory's location in southeastern Virginia.

The expertise of the staff and diversity of activities involving high technology and basic research make CEBAF a rich environment for capturing the interest and augmenting the experiences of pre-college teachers and students. In May 1990, the Secretary of Energy established DOE policy in support of math, science, and engineering education. This policy serves the President's National Education Goals. Thus, the Secretary of Energy directed all DOE facilities to use their resources to support science and math education and to set a highly visible and creative example of educational collaborations and assistance for the private sector. This paper describes some of the efforts in pre-college education underway at CEBAF.

CEBAF'S PRE-COLLEGE EDUCATIONAL PROGRAM

Overview

Like many R&D facilities, CEBAF has had an ad hoc, small-scale, volunteer-centered K-12 outreach effort since the laboratory was established in 1985. In response to the Secretary of Energy's direction, CEBAF moved in 1990 to expand and formalize the educational programs conducted in partnership with local, regional, and state education authorities. Through March 1992, participation in CEBAF's K-12 programs totals about 8200 students and 800 teachers. Formal and informal partnerships are in place with seven school districts, seven colleges and universities, numerous businesses, and nearby NASA Langley Research Center.

The purpose of the K-12 Education Program at CEBAF is to work with local, regional, and state education authorities to:

1. Motivate students, especially those in underrepresented groups, by allowing them to experience the excitement, challenge, and fun of science and math and by exposing them to diverse technical career options.
2. Support teachers by bringing them into the science establishment as partners and participants and providing them access to expertise and equipment.
3. Involve parents by keeping them informed of the special science/math activities their children have at CEBAF.

Student-Oriented Programs

What characterizes many successful scientific and engineering personnel at CEBAF and other laboratories is their enthusiasm about the subject matter and their confidence about building, tackling, or discovering something new. When asked where this interest originated, most recall childhood experiences and encouragement that made math and science real and attractive. Such experiences are rare in the U.S. today, except for children whose parents or other very close adult mentors happen to work in technical jobs.

Given the rich scientific environment at CEBAF and the mandate to support education, we have centered our student-oriented programs around providing for many students the kinds of experiences and encouragement that got us hooked on science, engineering, and math. A special focus is the pre-middle school age group, as these students have reading, writing, and arithmetic skills, are generally inquisitive about their world and about learning, and will shortly make choices about (or be assigned to) math tracks and science electives. Generally, their science and math experiences have been dominated by textbooks and worksheets. Often they have been exposed to math and science anxiety and negative cliches.

CEBAF's educational programs for students, therefore, emphasize participatory, hands-on exploration and discovery and a lot of interaction with volunteer role models from our staff. We require teacher involvement, as the teacher can integrate the CEBAF experience into the student's full academic program.. In addition, we provide opportunities for parent participation so that they, too, can reinforce their children's experiences.

Becoming Enthusiastic About Math and Science (BEAMS). In 1991, CEBAF, in partnership with Newport News Public Schools and funded by the Department of Energy Office of University and Science Education Programs, launched the BEAMS Program. Called BEAMS for " Becoming Enthusiastic About Math and Science," the program brings inner-city fifth and sixth grade classes with their teachers to CEBAF for a specially modified version of their regular academic week. Each school day for five consecutive days, the children are immersed in CEBAF's forefront research environment, where they participate in science and math events and activities. These activities encourage students to ask questions, to make and test predictions, and to realize that there isn't always one correct answer. BEAMS takes place in a CEBAF on-site classroom, outdoors, in the staff cafeteria, and in laboratories, assembly areas, and at the accelerator. In short, the class is integrated into CEBAF's normal activities for the entire week.

About 50 role-model volunteers drawn from our staff of physicists, engineers, designers, computer programmers, and technicians conduct the activities with the students. The role models have no special qualifications other than an interest and willingness to infect youngsters with the contagious enthusiasm they feel for science, math, and their jobs. Each person spends a few minutes introducing himself or herself and describes how and why he or she got interested in and trained for the job he or she has at CEBAF. We have two to four staff volunteers plus the classroom teacher involved in each activity, making the ratio between students and knowledgeable adults range from 8:1 to 5:1. Typically two or three special science or math activities occur each day. This scheduling leaves time for the teacher to continue with regular academic work in spelling, reading, and social studies.

Prior to the class visit the teachers attend a BEAMS orientation and workshop. This training introduces them to key CEBAF staff their class will meet, familiarizes them with the special math and science activities, shows them how to conduct the activities as a team member with the CEBAF technical staff, resolves any concerns they might have, and gives them an opportunity to provide special input for the week their class will spend at CEBAF.

CEBAF sends a " Class Mentor" to visit the class prior to and after its week at CEBAF. The mentor talks to the class about CEBAF and his/her job and background. Questions and orientation or follow-up discussions occur. The class mentor typically participates in one or more of the class' activities during its BEAMS week. The mentor visits extend and reinforce the BEAMS week and help integrate it into the school year.

The 1991 BEAMS pilot program involved 175 students (over 60% minority) and seven teachers from two schools in Newport News. The 1991/92 program expanded to 50 classes (1250 students and 50 teachers) from four school districts. Hampton Public Schools, Williamsburg/James City County Public Schools, and York County Public Schools have been added to the partnership. Two classes with their teachers are on site simultaneously. This arrangement provides peer support for the teachers and allows them to continue the team teaching arrangements in effect at their home school. BEAMS at CEBAF is currently limited to two classes per week by the availability of conference rooms suitable for use as classrooms. With dedicated classrooms integrated into a CEBAF building, we envision expanding BEAMS to have four classes (100 students) on site each week.

One goal of BEAMS is to convey to the students and teacher the fun of science. A broader goal is to determine whether this type of in-depth experience and integration of the classroom with a real workplace has a significant motivational impact. Does it influence the student's interest in science and math academically or for a career? Does it affect a student's overall motivation for and performance in school?

To answer these questions, a multi-year evaluation effort involving BEAMS students and control students has been initiated. To measure the outcomes of interest, we must monitor the attitudes, performance, and choices of participating students from their BEAMS experience through middle school, high school, and past high school to the start of their careers. Our evaluation program relies on the school district partner to identify control students who did not participate in BEAMS, to administer and evaluate pre- and post-visit attitudinal surveys, and to provide us with yearly data on participants and controls. The types of data required are readily available to the school district and include: standardized test scores, math and science course choices through middle and high school, grade point average, and graduation status. We are in the process of establishing data bases and working out the details of the long-range evaluation program.

Initial feedback for the 1991 and 1991/1992 programs include student, teacher, and parent reactions and for the 1991 program, the results of an attitudinal survey administered to the students two weeks before and four weeks after their BEAMS week. The school district's Supervisor for Research/Program Evaluation concluded from the 1991 surveys that " it is clear from reports by the teachers and survey

results from the students that BEAMS made a powerful impression and was beneficial to all concerned."[1] Students' attitudes toward math and science and their perceptions of themselves in relation to math and science interest and career options increased significantly between the pre- and post-survey. Qualitative written student evaluations indicated that they were eager to spend more time in the program each day and that they wished the experience would continue beyond the week. They valued the respect and individual attention they received from CEBAF staff. The attitudinal surveys for the 1991/1992 program will be measured against control groups (450 students from 18 schools) and will be analyzed during summer 1992.

From the teacher surveys, we learned that 80% of the teachers were apprehensive initially about the program due to the difference from a traditional school setting, concern about the academic preparation of their students, and concern about discipline problems. Of those initially apprehensive, 80% reported, much to their relief, that the students' academic level and preparation was fine and that discipline problems were minimal due to constant activity and high student interest. All of the teachers believed the activities and content were appropriate for the students with 95% judging the age group to be appropriate. The teachers also remarked that the program was an excellent horizon-expanding experience that the students will remember for a long time.

Feedback from parents was obtained in person at a participatory and informative "Open House" held one night each BEAMS week and by using an evaluation form sent home from school. Parent participation was disappointing (but we are told much better than the school district expected), with fewer than one-third of families represented at the "Open House," and only a small percentage of the evaluation forms returned. However, all parents responding to the survey would recommend BEAMS to other parents, and 66% reported that during the BEAMS visit their child spoke about school activities significantly more than usual.

To measure BEAMS program impacts on key long-range outcomes -- such as high school graduation rate, academic performance, and enrollment in math/science electives -- requires long-term follow-up, large sample size and comparison to control groups. For 1% statistical significance we need to have over 10,000 students in the data base. Therefore, expanding CEBAF's capacity to host classes and recruiting other organizations to provide similar experiences is essential to determine on a reasonable time scale whether the BEAMS experience makes a significant difference. With dedicated facilities CEBAF could accommodate 2500 students per year in 100 classes.

If BEAMS is successful in motivating students to greater interest and improved performance in math, science, and school, then it would be beneficial to provide similar opportunities for all children. Already the Department of Education of the Commonwealth of Virginia has approached us about helping other school districts and businesses launch similar programs. Nationally, 1500 sites with facilities similar to CEBAF could afford all U.S. students at the BEAMS grade level a BEAMS experience.

Implementation of a BEAMS-Type Program. Figure 2 shows CEBAF's planned phased development and implementation of BEAMS, indicating the primary focus of each phase.

1. K. P. Divine, "Analysis of BEAMS Survey Results," August 19, 1991.

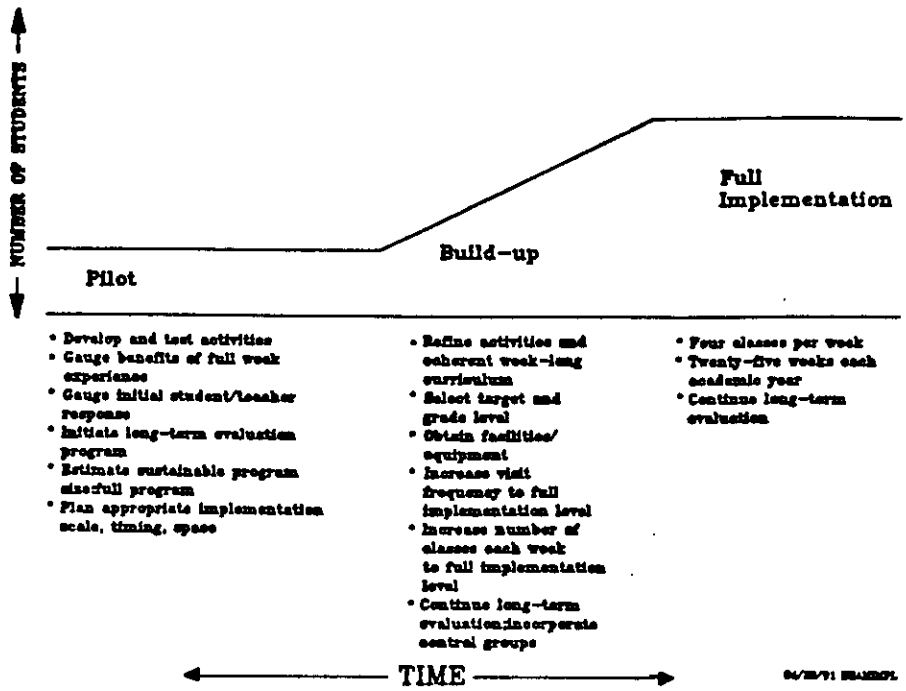

Figure 2: Three-phase implementation of the BEAMS Program.

For organizations and school districts interested in launching a BEAMS type program, we offer the following brief guidance. The first step is to find an interested and committed partner school district or business/laboratory and pay close attention to each's strengths, limitations, boundary conditions, and safety/liability issues. Then develop and implement the program:

- Identify and agree on each partner's responsibilities and program logistics. For example, the participating school districts supply transportation, and lunch, take care of parent permission, provide data for long-term evaluation, and release time for the participating teachers so that they can attend the orientation workshop.
- Develop or find and adopt enough grade-appropriate hands-on activities to interest, inspire, and challenge the students for five school days. At CEBAF we focus less on learning facts and "content" and more on exercising science and math "process" skills, such as questioning, observation, data-taking, and prediction. It is useful to have activities relevant to the main science/math field(s) of the business or laboratory.
- Recruit enthusiastic staff volunteers to conduct the activities and work as role models with the students. Encourage role models to invent and improve activities. Have the role models test activities before using them.
- With teacher input, create a generic schedule for the week that schedules the special science/math activities and leaves time for normal school work.
- Plan and hold a teacher orientation. The first teacher participants are justifiably nervous about the content and quality of the experience and about student preparation and behavior.
- Start slowly: only one class at a time, with a few weeks to recover and modify the schedule or activities before the next class arrives. Build up gradually to maximum capacity.
- Have fun.

Other Partnership Student Outreach Programs. ATOMS (Adventures in Technology = Options in Math and Science) is a regional career-awareness program organized by the local community college to motivate seventh-graders at all local middle schools by giving them contact with a variety of technical workers and their jobs. In collaboration with other area high-technology business, CEBAF participates in ATOMS by sending teams of technician role models to the schools, where they conduct hands-on activities and discuss their jobs and how they got there. Women and minorities are well represented on ATOMS teams.

The CEBAF Science Series offers monthly interactive evening seminars presented by area scientists and engineers who are gifted at making science not only informative but fun. The seminars are aimed at sixth through twelfth graders who attend on a voluntary basis. The topics covered in the series go beyond those found in the middle or high school science curriculum, covering for example superconductivity, local geology, high-precision surveying, and nuclear physics.

On request, CEBAF sends volunteers, speakers and role models to local and regional Career Days and schools, gives special CEBAF awards at major local science fairs, and provides judges. At the three largest local science fairs, the CEBAF high school award is the offer of a summer job working with our physicists or engineers.

CEBAF employs 100 students each summer, provides mentorships for high-achieving high school students, and serves as a field-trip site for children's science camps and academies sponsored by seven different regional colleges and universities, including two historically black colleges/universities.

Teacher-Oriented Programs

CEBAF's objectives for supporting science and mathematics instruction are to bring science and math teachers into the science establishment as full partners and contributors, to strengthen teachers' scientific and technical backgrounds, to increase their curricular and pedagogical resources, and to heighten their technical confidence and prestige.

The BEAMS program has important benefits for the participating elementary school teachers that we hope will influence their approach to math and science instruction in the immediate and following years. By participating in BEAMS, the teachers become familiar with successful, simple hands-on activities in both math and science. In addition, they experience, usually for the first time, a real scientific/technical environment that brings relevance and applications to the math and science subject matter they are called upon to teach to many classes of young students.

To give math/science specialist teachers in middle and high school experience with the many technical jobs utilizing these disciplines, CEBAF offers summer fellowships, administered through the DOE- and NSF-sponsored programs of TRAC (Teacher Research Associates) and STRIVE (Science Teachers Research Involvement for Vital Education). These eight-week fellowships allow teachers to work at the forefront of science and technology. Each teacher spends 75% of his/her time on a research project with a CEBAF mentor and 25% on development of classroom applications. Additionally, a seminar series is given which provides an introduction

to a broad range of CEBAF-related topics. Graduate credit is available to the fellows through a local college. In 1991, ten teachers were involved, and fourteen will participate in 1992. The program is envisioned eventually to involve up to 15 teachers per year.

CEBAF participates in a variety of professional educational courses and in-service activities for teachers, both on and off site, run by local colleges and universities. Some 700 science and math teachers were involved this year. Access to CEBAF staff expertise and certain equipment is available to area teachers at all levels, and some 100 calls -- ranging from information requests to field-trip requests -- were fielded this year.

SUMMARY

The BEAMS program and CEBAF's other cooperative educational programs for students and teachers show promise for benefiting pre-college science and math education. As our programs have developed and more people have become aware of them, the demand has increased. Since scientific research is our primary mission, our role in pre-college education is to serve as a resource for the education establishment. With CEBAF's talented and enthusiastic scientific and technical staff and the rich scientific environment, we can provide motivational and informative learning opportunities for students and teachers. By developing and evaluating creative educational programs, we test models for how laboratories and businesses can help strengthen pre-college math and science in the U.S.

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