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*New Mexico Supercomputing Challenge
1993 Evaluation Report*

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BSM93006L-21

Members of the 1993 first place team from Las Cruces High School met President Bill Clinton during his visit to Los Alamos National Laboratory and presented Challenge T-shirts to the Clinton family.

New Mexico Supercomputing Challenge 1993 Evaluation Report

by

Mary Trainor, Pat Eker, David Kratzer, Marilyn Foster, and Margaret Anderson

ABSTRACT

This report provides the evaluation of the third year (1993) of the New Mexico High School Supercomputing Challenge. It includes data to determine whether we met the program objectives, measures participation, and compares progress from the first to the third years. This year's report is a more complete assessment than last year's, providing both formative and summative evaluation data. Data indicates that the 1993 Challenge significantly changed many students' career plans and attitudes toward science, provided professional development for teachers, and caused some changes in computer offerings in several participating schools.

1. INTRODUCTION

This evaluation report is a second assessment of the New Mexico High School Supercomputing Challenge, which completed its third year in April 1993. New Mexico Technet; Los Alamos National Laboratory (LANL); Phillips Laboratory (PL); Sandia National Laboratories (SNL); the University of New Mexico; New Mexico School of Mining and Technology; New Mexico State University; Digital Equipment Corporation; Cray Research, Incorporated; and others collaborated to sponsor the Challenge.

The Challenge is an academic-year-long program for teams of one to five high school students and their sponsoring teachers. The program is open to **all** New Mexico high school students.

Challenge observers have asked, "Why should high school students use supercomputers?" This report answers that question in qualitative and quantitative assessments. This year's evaluation is the most comprehensive to be performed thus far. Many new insights regarding technology in the schools and in the lives of students and teachers were obtained.

1.1 Program Goals

The main goals of the Challenge are *to foster creativity in devising computational solutions to*

scientific problems and to make a positive difference in students' lives, motivating them to prepare for the workforce of the future. The Challenge State Committee developed objectives to meet these goals.

1.2 Program Objectives

We evaluated the 1993 Challenge to determine whether the program met the Challenge State Committee's objectives discussed below.

Objectives That Address Students and Teachers

Provide access to high-performance computers so that teams can conduct complex scientific inquiry, experimentation, and simulation;

Increase high school students' interest in science-related disciplines and promote careers in science and engineering by instilling enthusiasm in students, their families, and their communities;

Develop students' confidence to perform complex problem solving through their participation in an academically challenging competition;

Institute electronic networking among all schools to reduce the isolation of students and teachers in remote locations;

Provide an educational experience that is otherwise unavailable to students and teachers in their regular curriculum; and

Evaluate the effects of a high-performance computer competition on students, teachers, and curriculums.

Objectives That Address the Program

Design a science and math program that can be replicated in other parts of the United States.

2. PROGRAM DESIGN

2.1 Program Activities

The Challenge provides events and services to support students, teachers, and coaches throughout the year. The program spans October to April and includes the following activities.

CALL FOR PARTICIPATION: Each high school math/science teacher and administrator receives information about the Challenge and a registration packet early in the school year.

TEAM FORMATION: Students form a team, either as part of a class or as an extracurricular activity. Each team must have a teacher as its sponsor.

KICKOFF CONFERENCE: The Challenge experience begins with a two-day, multitrack conference in October at Glorieta Conference Center. The Conference presents multiple opportunities for students to learn about the Challenge process, computer networks, supercomputers, software development methods, and programming. Two hands-on computer laboratory sessions give students and teachers an opportunity to work in both a structured and unstructured setting.

COACHING: We recruit volunteer scientists and engineers from the national laboratories, industry, and academia to advise teams on both the science and the computing aspects of their

projects. Former Challenge participants who are now enrolled in college also coach.

SCHOOL VISITS: A Challenge staff member visits each team at school during November or December to answer questions and ensure that all necessary hardware and network connections are in place.

CONSULTING: LANL, New Mexico Technet, SNL, and PL provide on-line and phone consulting.

NETWORK SUPPORT: New Mexico Technet supplies either a local or 800 number for students and teachers to use for accessing an electronic mail network and reaching the supercomputers at participating laboratories.

REGIONAL WORKSHOPS: Student teams and teachers attend one of five one-day regional workshops in January or February to address project/technical questions. As part of their instruction, teams also compete to answer basic computing questions.

INTERIM REPORTS: Students who plan to enter the Challenge competition submit a written interim report in January. Judges then review the reports.

JUDGING: A panel of 9 -- 12 judge-scientists from throughout the state studies the final report, selects finalists, reviews projects, listens to finalist team presentations, and selects the winners. Students are provided with the following rating system and criteria by the judges.

Scientific Content	30 points
Effectiveness of Approach	30 points
Creativity	20 points
Originality	10 points
Clarity	<u>10 points</u>
Possible Total	100 points

AWARDS DAY: Challenge sponsors supply numerous major and minor awards. In April, the Challenge year concludes with two days of presentations about current scientific and industrial applications and the Awards Ceremony held in Los Alamos.

2.2 Competitive and Noncompetitive Design

In the competitive category, student teams can select and define a scientific problem, write a program to solve the problem, run the program on a supercomputer, and write a summary report to present the project results. Most teams write and edit the code on a microcomputer and then upload the program to debug, generate graphics, and obtain output on the supercomputer.

Even teams that elect not to enter the competition learn much about computers and computer applications. They learn to design software, to use electronic mail, to work as a team, and to work with scientists.

2.3 Changes in Program Design

In this third year, we made the following changes in the Challenge program.

TARGETING THE 70%: The educational component targeted both the 70% of the students who have little or no computing background and are in the Challenge more to learn than to compete, and the 30% who are competitive. Specifically, courses for both categories were offered at the Kickoff Conference.

EMPHASIZING COMPUTATIONAL SCIENCE: The educational curriculum stressed computational science over computer science, which involved teaching more about software engineering and problem solving than programming.

GIVING MORE AWARDS: Every participant should be rewarded. Therefore, each person received a minor award to recognize that he or she had learned much and demonstrated that learning in his or her performance. At the Challenge Awards Day, winning teams received trophies, scholarships, and computer equipment. Additionally, poster contest winners and outstanding Regional Workshop participants won awards also. Challenge sponsors provided the awards, and New Mexico Technet gave a T-shirt and memento to every participant.

PROVIDING BETTER COACHING: We provided additional coaching support through a new electronic mail service that allowed a scientist in a particular field to answer specific questions on-line.

ENSURING MORE PERSONAL ATTENTION:

We supported teams and teachers by providing more individual attention. This is especially critical during the early months of the Challenge, when basic learning occurs and when hardware and connectivity problems arise.

Challenge staff members also visited each team during the year to note special needs and resolve problems as resources permitted.

Scientists from laboratories, universities, and industries volunteered to coach the teams, with the laboratories and New Mexico Technet providing consulting.

3. EVALUATION DESIGN

Our evaluation was designed to determine the benefits of the Challenge and the extent to which the Challenge program achieved its objectives. The evaluation design targeted

Direct affective domain measures to determine participant perceptions of the Challenge impact.

Indirect cognitive domain measures to determine the learning cultivated by the Challenge experience,

Formative evaluation data to use in planning Challenge improvements, and

Summative evaluation data to determine the impact of the Challenge experience on students, teachers, and schools.

We used varied sources and tools for gathering data. Most summative data came from 225 follow-up surveys mailed to 1991 Challenge participants in order to research the Challenge's long-term impact on any career plans and/or scientific perceptions.

Other measurement tools are listed below according to activities that provided the data.

Kickoff Conference

- Student and teacher background questionnaires
- Student and teacher formative evaluation questions about the conference

Computer Usage

- Monthly monitoring of LANL's computing resources (Computer usage at NMSU and SNL are not reported here. With New Mexico Technet providing connectivity, LANL

provided the bulk of the supercomputer resources in 1993.)

School Visits

- Checklist for Challenge staff to complete

Regional Workshop

- Registration form
- Student questionnaire about current progress and problem areas

Awards Day

- Student postevent questionnaire
- Student and teacher critiques

4. RESULTS

4.1 Follow-Up Survey

The 1991 Challenge participants were sent surveys by mail before the 1992 holiday season to reach college students during their vacations. Fiftieth Anniversary LANL buttons and brochures about the history of computing were included with the surveys as incentives to complete the short survey.

Out of the 225 follow-up surveys, we received 59 replies, which is an excellent rate of return (26%)

for a long-term, follow-up survey. Figure 1 summarizes the results. Most of the respondents were college freshmen or sophomores (85%), but 15% were still in high school. Most of the college students were majoring in either engineering (44%) or one of the sciences (41%). *All (100%) respondents stated that they recommend the Challenge for all high school students.*

4.2 General Participation

The 1993 Challenge evaluation results show a positive impact on students, teachers, and schools.

4.2.1 Comparison with 1992. Challenge participation increased in 1993, but the rate of increase is less than in 1992 (Fig. 2 and Table 1). Primarily juniors (31%) and seniors (38%) participated, and both freshmen and sophomores made up the remainder. Also, seventy-eight students (18%) chose to participate for a second or third time. Interviews revealed that returning students either spearheaded new teams or participated in the same team but went further in solving the previous year's problem.

Fig. 1. The follow-up survey shows that the Challenge positively influenced student attitudes.

Fig. 2. The Challenge participation increases each year.

Table 1. Challenge Participation.

	1991	1992	1993
Students	235	419	532
Teams	65	112	141
Schools	40	51	61
Teachers	55	91	116

4.2.2 Female and Ethnic Minority Participation. In 1993, female participation totaled 34%, and participation by ethnic minorities was 66% (Table 2). This body of data, collected from registration forms that were fully completed, provides a breakdown of student participants both by gender and by ethnicity. The Challenge ethnicity data correspond to the demographics of the state. Ethnic minorities comprise 59% of New Mexico's population and 56% of the Challenge participants (Fig. 3).

Table 2. 1993 Student Participation Sorted by Ethnicity and Gender

Ethnicity	Gender		Total	
	Female	Male	Frequency	%
Anglo	42	101	143	44
African Am.	2	2	4	1
Hispanic	54	86	140	43
Native Am.	7	15	22	7
Oriental	3	6	9	3
Other	1	6	7	2
	109	216	325	100
	(34%)	(66%)

Fig. 3. In the 1993 Challenge, ethnic minorities exceeded ethnic majorities.

4.2.3 Computer Usage. Computer usage statistics for 1993 show that usage increased disproportionately to the increase in the number of student participants (Fig. 4). In 1991, students used the Cray CPU for 85 hours, in 1992 for 300 hours, and in 1993 for 740 hours. Second-year students, peer teaching, and teachers' added experience created this expanded usage.

In addition to comparing past usage data, this year we collected more detailed statistics to analyze monthly and individual usage patterns. Data in Table 3 reveal that most students logged onto the supercomputers in October (primarily at the Kickoff Workshop) and decreased logons in the following months. The variety of projects, stages of research, and students' interests account for the average decline. In addition, students wrote programs on microcomputers and used supercomputers only to execute the final programs. Thus, the execution stages occurred at different

Fig. 4. Cray CPU usage increased from 1991 to 1993.

times. Also, most teams did not plan to enter the competition but wanted to begin a project to learn about problem solving with computers.

4.3 Challenge Student Profile

At the Kickoff Conference we gave students an Evaluation Booklet in which we asked questions about their backgrounds and interests. The sample size obtained in this way was very large (439). The answers furnished not only a baseline with which to compare attitude changes during the Challenge year but also a profile of a typical Challenge student. The profile changed some of our assumptions and also gave us information about computer availability and experience.

The Kickoff evaluation data show that most 1993 participants

- had prior experience on more than one computer system;
- had some background in BASIC programming;
- did not have a computer at home;
- were new to the Challenge this year;
- signed up for the Challenge to increase their knowledge (not for the awards);
- expected to learn more about programming, using supercomputers, and solving problems with computers through the Challenge;

- were already interested in careers in either the sciences or engineering; and
- planned to go to a 4-year college.

The Kickoff student profile data is especially interesting. The profile indicates an improvement in the hardware skill level and in the amount of computer technology in New Mexico school curriculums. Note, also, that the Challenge population is large and representative of the state and its wide range of school sizes. Interviews pointed out, however, that a wide range existed in the amount of support, the type of hardware, and the connectivity available at the schools. Having no phone lines available to dedicate to the Challenge created a significant barrier for many schools.

4.4 Challenge Teacher Profile

At the Kickoff Conference, we collected (for the first time) background information about the Challenge teacher population and their schools. The response rate was very high, with 89 of the 116 teachers responding. The 1993 Challenge teacher profile is as follows:

- Fifty-two percent were new to the Challenge. However, many worked in schools that participated previously. A total of 75% of all teachers taught in former Challenge schools.
- *High Schools (17%) have implemented improvements in computer courses and hardware as a result of the Challenge.*
- All but one Challenge teacher was computer literate, and 69% had computers at home.
- Other teachers, students, or the principals encouraged about half of the participating teachers to join the Challenge. The remainder participated after reading about the Challenge.

One teacher said this about the value of the Challenge experience:

"From the onset of the Challenge, students and teachers are assisted in setting their programs, becoming familiar with equipment, and establishing ties with others utilizing the Los Alamos supercomputers. Friendships are developed and the competition begins. For teachers, the opportunity to develop

professionally is unbelievable. If teachers have not been involved with the Challenge yet, START NOW!"

4.5 Kickoff Conference Evaluation

Participants in the Kickoff Conference completed a formative evaluation. The response rate (89% of 116 teachers and 83% of 532 students) provided a representative sample population.

Students (89%) and teachers (100%) rated the Kickoff Conference as valuable. Both teachers (99%) and students (84%) rated the computer hands-on sessions as the most valuable part of the conference, and students suggested adding more of those sessions as an improvement for next year. (We doubled the number of sessions this year.)

In addition to receiving hands-on computer experience, this year's participants had a choice of sessions to attend. Students (86%) and teachers (97%) rated highly the opportunity to select their own sessions.

Most students also said they felt more confident and excited about the Challenge after the Kickoff (72%) and more knowledgeable about the rules and procedures of the Challenge (77%). Because they worked in schools and homes sometimes remotely located, students needed to know how to get assistance when problems arose. Most students (77%) said that after the Kickoff they knew where to go for help.

Another key to the Challenge success was the team's relationship with the technical coach. Forty-four percent of the students were able to talk with their coach early in the year at the Kickoff Conference.

The Kickoff Conference evaluation also asked about students' and teachers' experience with the Challenge. Most students (76%) and many teachers (52%) were new to the Challenge this year. (A few of the repeating teachers did not attend the Kickoff Conference.)

We used the Glorieta Conference Center for the Kickoff for the first time this year. Most students (72%) and teachers (94%) rated the facility as good. Teachers (79%) and students (47%) said the food was also adequate.

4.6 School Visits

In November and December, one or two representatives of the Challenge State Committee visited each team. The visit required setting up appointments, coordinating visits within one

geographical area for the same time frame, obtaining feedback from students and teachers, and then responding to that feedback. School visits occurred for the first time this year and replaced the first set of regional workshops held in the past two years.

The individual school visits were a great success. Early in the Challenge year, the visits exposed local problems that could be obstacles to team abilities to meet their objectives. These obstacles were aggressively pursued after diagnosis during on-site visits. Obstacles included

- the lack of an assigned coach,
- an inability to contact the coach,
- an inability to connect to Technet (usually the lack of a phone line),
- an inoperable personal computer,
- the lack of the correct compiler on the personal computer,
- the lack of adequate computing information to accomplish the project,
- the lack of knowledge about Challenge resources, and
- a project that was too ambitious for the time available.

Although costly for the Challenge staff that performed them, the visits proved to be vital to getting teams underway earlier than in past years. Because of limited resources, however, the staff could not remove every obstacle. Some of those obstacles will continue to exist because the Challenge resources cannot provide solutions (e.g., phone lines).

4.7 Regional Workshops

We held regional workshops in five different locations in the state during January and February. Teachers and coaches attended with their student teams. These workshops were one-day sessions located at universities or community colleges. We designed the workshops to help teams progress, regardless of their accomplishments up to that point. We tailored content and format to student needs at that point and conducted competitive sessions with teams being asked to answer commonly asked computing questions. Teams received points for correct answers. We identified the team receiving the most points as a "Regional Hot Shot" and gave prizes. Furthermore, a breakout time allowed each team to meet with an expert to discuss a topic of the team's choice.

The workshop registration and evaluation forms revealed much about progress and needs (Table 3). Note that after 3 months in the Challenge, most teams were still defining the problem and doing research or beginning to program.

Table 3. Team Status in January–February.

	% of teams
Teamwork, brainstorming	19
Define problem, research	25
Define problem, programming	31
Program refined and debugging	15
Other	9

On the workshop registration form, students also indicated the technical areas in which they wanted help (Table 4). Graphics and programming languages created the highest levels of interest. Students had progressed far enough in their projects to realize the importance of these skills in achieving their objectives. However, workshops do not include instruction in programming languages. Instead, we provided tutoring and consulting and loaned instructional videotapes to schools as needed.

Table 4. Students' Requests for Help. (Students could choose all that applied.)

Programming languages	68%
Graphics	63
Writing Challenge report	37
File transfers	31
UNIX/UNICOS	29
Preparing poster	26
Judging	23

4.8 Awards Day

The Awards Day activities included two days of judging, tours, and an awards ceremony. The judging took place on the first day. Teams arrived early in Los Alamos to begin 30-minute presentations to the judges. Also the media interviewed and filmed each finalist team. All

teams, including the nonfinalists, enjoyed tours and attended the awards ceremony.

The tours this year gave students not only a view of the Cray supercomputers and the Thinking Machines (CM-2 and CM-5) but also a snapshot of computational science at work at LANL. Scientists demonstrated research applications ranging from materials science to biology and environmental science.

At Awards Day, participants were asked to complete a questionnaire so that we could collect affective postevent information. Figure 5 depicts students' learning expectations at the Kickoff Conference and their realized learning by the culmination at Awards Day. Note that students learned more than they expected about supercomputers and problem solving but less than they expected about programming. This was an

Fig. 5. Students rated their expected learning and their realized learning.

expected and favorable outcome because many students initially equate programming with computational science. Therefore, in the educational components of the Challenge, we stressed problem-solving methods and presented programming as a tool.

Figure 6 presents further data showing that almost all participants rated the Challenge to be a valuable experience and one that improved both their attitude and knowledge about science/engineering and math.

The Awards Day evaluation provided additional data that indicated positive feedback about the

Challenge's effect on the choice of a career and/or college major. We asked students about their career expectations at both the Kickoff Workshop and the Awards Day and found that the Supercomputing Challenge influenced 67% of the students in their career-related choices (Fig. 7). Many students selected more specific areas of science, while others moved from nonscience to science (Table 5). Only 30% did not change career expectations between October and April. We had incomplete data on 24%. The remaining 46% changed laterally from one area of science to another.

Fig. 6. Students and teachers rate the values of the Challenge.

Fig. 7. Students agreed the Challenge would influence career choice/major in college.

Table 5. Examples of Student Changes in Career Plans from the Beginning to the End of the 1993 Challenge Year.

From	To
English Health Engineering Business/Accounting Undecided	Computer Science
Computer Science Art Health	Engineering
Computer Science	Health Biology/Chemistry Engineering Earth Sciences
Social Sciences	Physical Sciences
Health	Earth Sciences
Art	Psychology

We also collected significant qualitative information about the diversity of the tours. For the first time, many students saw the careers available in science, saw scientists at work, and observed examples of computational science projects underway.

4.9 Finalists

Twelve teams were chosen on the basis of their interim reports. In April these teams made presentations to judges who selected and ranked the six top finalists.

The large number of minority and female top finalists is noteworthy. *On the six top finalist teams, 77% of the team members were female and 83% were minorities*, a quite different composition than that of the overall Challenge population. However, judges did not record participant gender and ethnicity; they asked each team the same questions and determined top finalist teams through an objective multivoting process.

Therefore, it is clear that the Challenge competition provides an attractive opportunity for ethnic minority and female students to excel. Finalist students disclosed in interviews that many thrived in the creative, self-paced, coached team

learning environment, where they had much responsibility and tailored help.

5. PROJECT COMPLETIONS

Seventy-three teams chose to compete and submitted interim reports. The competition was completed by 30% of all Challenge teams that submitted interim reports.

What happened to the rest of the teams that did not enter the competition? Interviews revealed that this year many teams began a project they plan to submit for judging next year. These teams saw their first year of participation as a time to learn the basics of programming, networking, and computing on the supercomputers and anticipate competing the second year. Other teams saw the Challenge as a valuable learning experience and were not interested in competing. Six Challenge teams withdrew because of

- lack of support by a coach and/or teacher,
- lack of time (commitments in sports and other activities were too demanding), and/or
- personal reasons (unexpected events arose in the students' lives, causing them to feel they could no longer participate).

We compiled this list of reasons from verbal or electronic exchanges with the teams.

Table 7 lists the project titles of the 12 finalists. Note the great range not only in subject areas but also in degree of sophistication.

Table 7. Project Titles of 1993 Challenge Finalists

- Computer-Simulated Ecosystem
- Supercomputer Simulation of Brittle Fracture
- A Study of Kinematics Involving a Motion Analysis of Classical Balletic Movements
- Baseball Simulator 1.0
- Creating a Geographical Information System (GIS) and Using It to Locate Lightning Strikes in New Mexico
- A Critique of Methods for Performing Numerical Simulations of the Long-Term Motion of the Solar System
- Balloon Tracking
- Measuring the Ozone Using a High-Altitude Balloon
- Two-Dimensional Placement of Objects
- Predicting the Depletion of the Ozone Layer
- A Six-Hour Simulation of an Unenvironmentally Controlled House
- Brute Force Reality: Simulating Mass and Gravity in Three Dimensions

6. DISCUSSION

This section offers an interpretation of the collected data and integrates direct observations. Exposing students to the prevailing method for solving real-world problems through the Challenge experience changed their lives and ambitions. Participants saw for the first time that they could indeed make a difference in this world and could accomplish more than they thought. As a result of the Challenge, most students now seem to be able to make choices that better prepare them for careers.

The data we collected this year revealed a great deal about the Challenge student and teacher populations. The profiles of both populations revealed an interest in computers and a zeal to know more.

In this third year, we implemented changes to the Challenge program and analyzed the results. A discussion of programmatic changes and our success follows.

TARGETING THE 70%: We modified the Kickoff Conference to include special sessions for the 70% who had little or no computing background as well as for the 30% who were experienced. The data indicates our overwhelming success in this modification of the education component.

EMPHASIZING COMPUTATIONAL SCIENCE: We emphasized computational science both in the Kickoff Conference sessions and in the Awards Day presentations. In the Kickoff, we offered a two-hour session on this subject, and in the Awards Day activities, we gave tours focused on solving scientific problems with computing (as opposed to a focus on the computers and software). Participants rated these sessions very highly.

GIVING MORE AWARDS: At the awards ceremony we gave both major and minor awards. We added sponsors' awards, along with the "Regional Hot Shot" awards, and LANL provided the first Award for Environmental Modeling. This diversification was very well received.

PROVIDING BETTER COACHING: A special electronic mail service that allowed students to consult with subject area experts was initiated midyear and has yet to be fully developed. Some subject area experts were not yet identified. There was a shortage of coaches this year, as the time commitment for volunteers is large and the number of teams has increased. Therefore, we failed to fully implement this change and are planning a more realistic approach for 1994.

During interviews, we collected anecdotal information that suggests the success of a team is partially related to the amount of attention the technical coaches and/or teachers provide. Obtaining technical coaches is difficult, so some teams had no coach. While some coaches spent several hours almost every week with their teams, other coaches were available only by phone or electronic mail when problems arose. Additionally, the teacher population is bimodally split. Teachers are either nontechnical sponsors, filling the role of administrator and encourager to the team, or they are technical sponsors actively involved in the problem-solving aspects of the team's project.

ENSURING MORE PERSONAL ATTENTION:
We successfully addressed this plan in one area of the Challenge. We replaced the first set of regional workshops with individual team visits at the schools by one or more members of the Challenge staff.

7. EVALUATION OF OBJECTIVES

The goals of the Challenge are to foster students' creativity in devising computational solutions to scientific problems and to make a positive difference in students' lives, motivating them to prepare for the workforce of the future. The appendix data, the list of project titles, the responses to the Awards Day questionnaire, and the computer usage statistics indicate that the Challenge met these goals.

OBJECTIVE 1: To provide access to high performance computers so that teams can conduct complex scientific inquiry, experimentation, and simulation.

DISCUSSION: The Challenge met Objective 1 in 1993. All teams used high-performance computers throughout the Challenge as well as in the Kickoff Conference laboratory sessions.

OBJECTIVE 2: To increase interest in science-related disciplines among high school students and promote careers in science and engineering by instilling enthusiasm among students, their families, and their communities.

DISCUSSION: We directly measured and met this objective in 1993. We administered pre-event and postevent questionnaires to discover changes in career interests. Data indicate that students felt the Challenge would indeed have a large impact on their career choices, and many students did change their career interests more toward science by the end of the Challenge. The Follow-up Survey of 1991 participants furnishes the most conclusive data. Two years after participating in the Challenge, the majority of the respondents said the experience did indeed impact their choices of career/college majors.

OBJECTIVE 3: To develop student confidence to perform complex problem solving through their participation in an academically challenging competition.

DISCUSSION: We qualitatively measured and met Objective 3 for many Challenge students as well as for teachers. Informal interviews and observations provided the data. Many students said that as a result of their experience in the Challenge, they knew they could achieve success in a scientific field, thus revealing an increase in confidence.

OBJECTIVE 4: To institute electronic networking among all schools to reduce participants' isolation in rural/remote locations.

DISCUSSION: We unquestionably met Objective 4. Students communicated electronically not only with their coaches but also with other students they met at Challenge workshops and, in at least one case, with scientists studying the research problem internationally. There is still much technical work to be done, however, in terms of providing universal connectivity in the schools.

OBJECTIVE 5: To provide for students and teachers an educational experience that is not available to them in their regular curriculum.

DISCUSSION: We reached Objective 5 in 1993. Teachers clearly pointed out that the Challenge provided an educational experience unavailable to students through their regular curriculums. The Challenge also encouraged schools to provide better support for students by providing computing software, hardware, and courses. Student-led pressure on the schools' administrations gave the impetus for these advances. In fact, one former Challenge student who entered college this year expressed disappointment in the university's computing resources. He expected the university to provide resources similar to the Challenge.

OBJECTIVE 6: To research and evaluate the effects of an academic competition that uses high-performance computers.

DISCUSSION: We met Objective 6. Reporting the effects of the Challenge is this document's purpose. Our evaluation builds upon the last year's data to provide basic assessment information. This year's evaluation was much more extensive and revealing than last year's. Part of the evaluation was collecting supercomputer usage statistics; the usage statistics from the supercomputers at Los Alamos reveal that usage on the machines shot up in 1993. Student supercomputer literacy is increasing each year as the Challenge program matures.

1994 Challenge will focus on planning more cost-effective components and on using our limited resources to the greatest benefit of students, teachers, and schools.

OBJECTIVE 7: To design a science and math program that can be replicated in other parts of the United States.

DISCUSSION: We realized Objective 7 in 1993. We received inquiries from 13 other states including Minnesota, Arizona, Montana, and Florida. By interacting and sharing materials, we allowed others to learn about the Challenge program. We worked to form a nationwide consortium to support high school supercomputing programs.

8. IMPLICATIONS

Our data supports the claim that the Challenge met all seven objectives for 1993 and reached the goals to foster creativity in devising computational solutions to scientific problems and to make a positive difference in students' lives, motivating them to prepare for the workforce of the future. We also successfully executed four of the five strategies for change proposed in the 1992 Challenge evaluation. Our findings clearly indicate that the Challenge program successfully motivated students and teachers to learn to use high-performance computers to solve real-world problems. In addition, as the Appendix shows, the Challenge changed several students' career plans. The Challenge is a program that is better preparing both teachers and students for the future.

Our evaluation also points out improvements we should make in the Challenge program for 1994, and the Challenge State Committee is planning those changes. These improvements include more teacher training. Our ability to implement improvements depends on the funding that Challenge sponsors can provide. Resources are limited, yet the needs are growing. Therefore, the

APPENDIX

Anecdotes and Quotes from Challenge 1993 Student and Teacher Participants

STUDENTS

"I joined the Challenge because I was intrigued at the chance to use some supercomputers. I didn't have any idea at all what supercomputers were, and neither did anyone else in the group. Our first year on the Challenge was spent figuring out E-mail and asking questions like, "What is a modem?" After the awards ceremony that year we decided to try a serious project for the next year. We spent the summer attempting to learn the C language and hand picked our own technical coach, who helped develop our original idea into something feasible. After that we worked hard. More than anything, I truly valued the experience the whole Challenge offered. I didn't realize until late in this year's Challenge how truly privileged I was to be so intimate with the most powerful computers in the world. I also had a bunch of fun. Everyone was so nice, friendly, helpful, and excited. It was well worth the time and frustration." (*female finalist*)

"The Challenge sparked an interest in me in a more scientifically oriented career, whereas I hadn't previously considered it seriously. I learned a lot about computers; before I knew very little more than how to turn a computer on and use WordPerfect. Being with each other as a group forced us to learn how to work together. Initially I thought this was just a competition for computer nerds and the kickoff would be like a "Geeks R Us" convention, but I met a lot of great people who have a lot going for them. Everyone at the Challenge has been warm and friendly and supportive." (*junior finalist*)

"My mom told me that I could never be an engineer and someone else told me that it would be too difficult. Then we won and my mom couldn't say that engineers never earned anything and it was an unworthy job for anyone. I can now say that it may be hard, but I stand a chance. While it was confusing at first, I got used to it and really learned a lot." (*female first place winner, minority*)

"I feel this is an excellent opportunity to learn more about computers. I have seen from others how being part of the Challenge can help you in furthering your education. I am interested in solving problems in science using computers and I hope to continue and further my education in a field involving both." (*sophomore participant*)

"The Challenge is a program that provides excellent hands-on experience for any high school student with an interest in computers. I want to earn as much experience with computers as I can. I am aware of the time and dedication required, and am giving all." (*female minority participant*)

"I am interested in the Challenge because I am interested in continuing the great status and recognition that my community gained as a result of winning the Challenge last year. I am also deeply interested in computers and all the great wonders they are capable of and I enjoy designing and researching projects." (*sophomore, minority finalist*)

"I like the Challenge because I want to compete against other schools. This makes me want to work harder to prove to other schools and people that our school isn't as bad as they say it is. I also am getting experience working with other people as a team and with computers. My goal in life is to be a computer scientist." (*junior, minority finalist*)

Two individual scholarship winners told us

They were both one of several children and had little hope or no hope of getting to go to college. Now they would get to go! (One of the winners was working while finishing her senior year to help with the family expenses.)

TEACHERS

"The students involved have learned a great deal about the supercomputer. The teachers are becoming more involved in computer technology as a result of their exposure as sponsors. The benefits to the school are significant now and will continue to be in the future. We are anxious to expand on this technology in making our school a positive role model in dealing with computers."

"My team made me very proud in how well they interacted with their coach. At first they found him intimidating, but gradually they gained more confidence and assurance and developed a wonderful intellectual and emotional relationship with their coach. In some ways it was a relationship of equality which I believe is an important lesson for students to learn."

"This was our first year, so it was a totally 'different world' of computing for our students. *Awe inspiring!*"

"This experience is invaluable to me and to my students."

"I hope that this Challenge continues. It's a fantastic experience for students!"

"I was impressed with organization of conferences and Awards Day activities. Things were done **on time** and well-planned. KUDOS!"

"I am a big believer in the Challenge - Keep up the good work!"

"Keep the program going, it's great!"

One Teacher's Story

"Last year was our first year to participate in the Challenge. Mark was invited to join our team. At that time, he had an acceptable knowledge of computers and some limited experience with BASIC. He was introverted and had problems interacting with the other stronger personalities on the team.

"As a member of our Supercomputer Challenge team, Mark was given an account on the University of New Mexico computers. Though we were also given a terminal and modem here at the school, Mark chose to use the University machines to avoid intimidation from the other team members. He frequently used the University computers from 3:30 or 4:00 a.m. until the time for school to begin. He became so fascinated with the wonderful world of supercomputing that he began to absorb any and all knowledge he could find about supercomputers.

"Supercomputing became his passion. He taught himself C and UNIX. He studied everything available to him and worked hard at learning all he could about supercomputers.

"Our team didn't 'go anywhere' that first year in the Challenge, but Mark grew in so many ways as a result of his personal experiences. This year he is the leader of our team and he is in every way 'the leader.' His

whole personality has changed as a result. He even ran for a school office this year and won!!! The Challenge, in Mark's case, has taken a very shy, quiet, uninvolved individual and turned him into a confident, self-assured, involved member of our student body. He even has a paying job for writing programs for a local computer firm.

"Sandia Prep owes a lot to the Supercomputing Challenge and we are very thankful for the incredible opportunities afforded us by this program.

"As the sponsor, the inspiration I have received from watching Mark's personal, educational, social, and business growth will sustain me to continue the Supercomputing Challenge at our school, if the opportunity continues. Personally, there are no words to express my appreciation for this unique experience created by the Supercomputing Challenge."

ANECDOTES

One of the finalist teams selected a research problem related to lightning. They chose that topic because a friend of theirs from their school was struck by lightning and killed last summer while playing baseball. They wanted to better understand how lightning worked, and help avoid these kinds of accidents in the future.

Another team chose a project on the parking configuration (painted lines) in their high school football field lot. They had observed a real problem with cars leaving after the games, if an emergency occurred, as the parking was disorderly and inefficient. They presented their project to the School Board at the conclusion of the Challenge Awards Day, and won support from the School Board for the parking lot redesign.

Several teachers told us about

The school board or principal getting them better computer or communications equipment for their classroom because they saw what the students were learning in the Challenge.

The shy student who "came out of his/her shell" as a member of a Challenge team.

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