

CONF-9505221- -1

## Adventures in Supercomputing: An Innovative Program

Barbara G. Summers  
Office of Science Education

H. Richard Hicks  
Director, Office of Computing and Network Mangement

C. Edward Oliver  
Director, Computing, Robotics, and Education  
Oak Ridge National Laboratory\*  
P. O. Box 2008  
Oak Ridge, TN 37831-6486

To be presented at the Dual-Use technologies & Applications Conference  
Utica, NY, May 22-25, 1995; to be published in the Proceedings.

### DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

\*Managed by Martin Marietta Energy Systems, Inc., under contract DE-AC05-84OR21400 with  
the U. S. Department of Energy

MASTER

## **DISCLAIMER**

**Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.**

\* Managed by Martin Marietta Energy Systems, Inc., under contract DE-AC05-84OR21400 with the U.S. Department of Energy.

## Adventures in Supercomputing: An Innovative Program

### *Abstract*

Within the realm of education, seldom does an innovative program become available with the potential to change an educator's teaching methodology and serve as a spur to systemic reform. The Adventures in Supercomputing (AiS) program, sponsored by the Department of Energy, is such a program.

## I. INTRODUCTION

Adventures in Supercomputing is a program for high school and middle school teachers. It has helped to change the teaching paradigm of many of the teachers involved in the program from a teacher-centered classroom to a student-centered classroom. "A student-centered classroom offers better opportunities for development of internal motivation, planning skills, goal setting and perseverance than does the traditional teacher-directed mode"[1].

Not only is the process of teaching changed, but evidences of systemic reform are beginning to surface. After describing the program, we will discuss the teaching strategies being used and the evidences of systemic change in many of the AiS schools in Tennessee.

## II. PROGRAM DESCRIPTION

### *A. The Genesis*

Adventures in Supercomputing was funded in 1992 as part of the U.S. Department of Energy's (DOE) High-Performance Computing and Communications Program. The program presently involves 69 high schools and 6 middle schools in five states: Alabama, sponsored by the University of Alabama at Huntsville; Colorado, sponsored by Colorado State University; Iowa, sponsored by Ames Laboratory; New Mexico, sponsored by Sandia National Laboratories, and Tennessee, sponsored by Oak Ridge National Laboratory. Within these five states, over 160 teachers and more than 3,000 students are involved in the AiS program.

### *B. Goal*

*The primary goal of AiS is to capture and cultivate the interest of minority, female and disadvantaged students in science, mathematics and computing.* To accomplish this goal, the computer literacy and scientific knowledge of the teachers of these students are improved through education, training, and curriculum materials.

### *C. Summer Institute*

A faculty team consisting of at least two teachers from each of the participating schools attends an intensive Summer Institute for two weeks. During the Institute, the teachers are prepared to guide students in programming solutions to scientific problems. Teachers receive curriculum materials for presenting introductory concepts in high-performance computing. They also receive software applications with demonstrated success in the content areas, along with examples on the use of high-level tools in modeling scientific problems. The Institute provides hands-on experience in several areas: FORTRAN and parallel programming techniques, UNIX system, Spyglass

Transform (visualization software), Macintosh familiarization, ClarisWorks (an integrated software package), and Internet usage.

The teachers begin the Institute by unpacking Macintosh computers and connecting them to a local area network with Internet access. After they learn some Macintosh basics, they are ready to begin working with the AiS curriculum.

Using skills learned during the Institute, the teacher teams complete mini-projects and present oral reports to fellow Institute members. Within the two weeks, the teachers acquire the skills necessary to begin a computational science course at their school.

The teachers understand the importance of the interconnection of computer networks in "a global research and development communication and information infrastructure" as they correspond through E-mail [2]. E-mail and Internet access allow them to collaborate with persons from around the world as they do research and carry out communication on the Internet.

Another essential element of the Institute is the development of curriculum materials specific to meet the needs of each school. After the teachers decide on a course outline that will fit best into their school situation, they prepare a time line for student project development. This time line will enable them to keep the students on target as they begin to work on their projects.

With the curriculum materials provided by AiS and the course outline developed by the teaching team, the teachers are well prepared to guide their students in a year-long computational science project.

On two weekends during the school year following the Institute, Midcourse Workshops are held. These gatherings are intended to further enhance the communication among teachers within the state. During the workshops, teachers are given time to share successes and make suggestions. By sharing with each other both successes and failures, the overall AiS program is strengthened.

#### *D. Resources Provided*

The AiS students and teachers have access to a multiprocessor nCUBE high-performance parallel processor computing system located at each of the three DOE laboratories involved in the program. The nCUBEs are attached to a frontend machine, either sun workstation or a silicon graphic machine, which provides the user environment and accounts for AiS students and teachers. Program participants access this system through 56-kilobit-per-second Internet connections provided for each school to carry out their computational programming and electronic mail.

DOE lends each school four Macintosh computers and an HP inkjet color printer. Each Macintosh is provided with the necessary software to help students complete computational science projects. This software includes visualization software and Internet exploration tools, such as Mosaic and TurboGopher.

Traditionally, even those schools fortunate enough to have technology resources donated usually have obsolete technology in the form of cast-off equipment. The AiS program provides hardware, software, and network access that is as modern as that found in most universities and research centers.

#### *E. Experiments*

Although the AiS program itself is an experiment that is being closely monitored, we have conducted some experiments within AiS by introducing variations on the basic program in some schools. One school has been provided with a UNIX workstation and four X Terminals, to

compare this environment to the Macintosh environment. Several schools have been loaned PowerBooks to provide both additional computers in the classroom and the capability for teachers and students to work from home.

#### *F. Grade Level*

Initially, the program has been available to high schools. It has been observed that often the 9th and 10th graders have been the best AiS students. In the 1994-95 school year, appropriately modified AiS materials were introduced into five middle schools, one in each AiS state. The intent is to expand AiS through the addition of middle schools that are feeders to current AiS high schools.

### III. TEACHING STRATEGIES

#### *A. Awakenings*

When many of the schools applied for the AiS program, they viewed participation in the program as a means to obtain computers for the classroom. Little did they realize the full impact of the AiS program.

#### *B. Training Begins*

Training for the AiS program begins during the Summer Institute. Teachers are exposed to FORTRAN, UNIX, visualization software and various Internet access tools. During this intense two-week training, teachers quickly learn the value of the advanced technology and realize the impact it will have on their students. "If introduced on a large scale, experts say, cutting edge technology would improve public education's bottom line significantly" [3].

During the Summer Institute, teachers find themselves getting excited about learning! They push themselves to learn how to write FORTRAN programs to produce and analyze data. They renew research skills and learn to use the Internet to find information for projects. They no longer rely only on the library collection, but also on the Internet connection. As the teachers work as teams on mini-projects, they are reminded of the value of cooperative learning. They are not in competition with team members; they are collaborating with them.

#### *C. New Technology, Renewed Enthusiasm*

While using these technological tools, it becomes apparent to the teacher that these tools would also foster the "student's abilities, revolutionize the way they work and think and give them new access to the world" [4]. The computer would become a tool to do research, solve mathematical problems, simulate and model problems and help students produce a finished product.

It became evident that students would respond in the same enthusiastic way in which the teachers responded. It was clear that the traditional teacher-directed classroom would not be suitable for the AiS course in computational science. Teachers would no longer be the dispensers of knowledge and the imposers of tasks--the sages on the stage; instead they would become the facilitators of learning and the mentors--the guides by the side.

#### *D. Curriculum*

Today supercomputers are powerful enough to simulate scientific experiments and to perform mathematical modeling. Computational Science is about using computers to analyze scientific and engineering problems using high-performance computers in innovative ways, and it complements

experimental and theoretical science. Computational techniques can be practical and useful when the experiments would be too expensive or unsafe, when the experimental results would be difficult to analyze, or when the experiment would be too large or too small, too slow or too fast. The scientific world is relying increasingly on computational scientists to construct models or simulate experiments. The AiS curriculum brings computational science to the classroom in the context of high school supercomputing science or mathematics classes. Because the curriculum is project-driven, the students learn the importance of computational science as they begin work on projects.

As students develop projects collaboratively, their teachers share the many skills they acquired during the Summer Institute. The knowledge of FORTRAN enables the students to incorporate formulas into a program and execute it using different value for the variables. After producing data, the students analyze and represent the data. To do this, they must understand and be able to manipulate the visualization software. Students produce a final report and usually do an in-class presentation for their classmates.

True integration of curricula is achieved as students use math, science, and English skills to help them complete their projects. After the students understand the procedure for developing a project, they do research on various topics of interest to determine an area in which to concentrate. The student team members must narrow the usually broad topic into something more focused. Teachers and students seek out mentors to work with the students on their projects. The curriculum is enhanced as many educators and professional scientists and researchers become involved with the students. As the different project teams share their work with the class, students acquire knowledge in biological sciences, physical sciences, earth/space sciences, and applied mathematics. This new methodology varies considerable from the average science class that concentrates on one discipline. Student's awareness of all areas of science is increased. This new approach allows students, especially girls, who have a delayed interest in science, to be motivated and encouraged to become involved in more science courses [5].

One of the most important skills the students must learn is the management of information. Students need to interpret and analyze data in order to understand them. Their ability to organize and relate information demands an integration of math, science, computing and English. For the first time, students may see the relationship between these disciplines. Until now, most of these courses have been isolated packets of knowledge requiring synchronized learning. The need for language skills is demonstrated as the student communicates with the project mentor and also as the student shares the project, both in written and oral presentation.

The AiS curriculum requires each student to participate in a project. It is strongly suggested that the students work as teams and work with a mentor on this project. In late spring, these projects are displayed in a state-wide Exposition. The top projects from each state compete in a national Exposition during the summer in Washington D.C. Last year's national winner was a talented sophomore team of female students from Murfreesboro, Tennessee. The title of their project was *Atomic Radii: Speculate or Calculate*.

### *E. New Methods*

It is important to integrate computer use into the AiS computational science curriculum and not be guilty of teaching only computer techniques or *computer science*. The AiS teachers quickly learned that the *computer* is not the primary objective. "The primary objective is to learn ideas from math, science, language, art, social studies, or some other content area" [6]. Teachers came to the realization that the computers were tools to aid in the teaching of science.

Instead of the traditional lecture followed by questions, teachers learned to allow students to explore areas of interest. Students learned to examine the Internet and became familiar with

accessing information on the *World Wide Web (WWW)*. They were able to post questions to bulletin boards and sometimes receive answers within hours. Students became more self-confident as they searched for answers and information. No longer did they depend on teachers to answer every question. Teachers discerned that they were guilty of "Mickey Mousing the lives of students by denying them control, the very thing we should be teaching them so they can find the meaning of life and learn to survive in the real world" [7]. Teachers realized that students had been passive in their learning. Now the students demanded to be active learners. Students were tired of being acquiescent and were ready to be self-directed as they worked on the computational science projects.

#### IV. SYSTEMIC IMPACT

##### A. Assessment

When examining the results of the AiS program, it is clear that the goal of the project is being met. The 1993-1994 assessment conducted by the Center for Children and Technology established that a substantial number of AiS students demonstrated mastery of the computational areas of inquiry. The assessment further states that "there was no evidence of a gap in achievement based either on student sex or race suggesting that the AiS approach to learning is effectively overcoming sex- and race-based performance gaps that remain evident in numerous indicators of math and science performance" [8].

##### B. Systemic Impact

Even more encouraging than the assessment of the program are the far-reaching changes that are occurring in many of the AiS schools. Within these schools, the stages of systemic reform [9] are evident. First, there has been an *awareness* for the need for change. Within these schools, enough students, teachers, and administrative leaders have become involved to have the critical mass necessary to effect change. Next, there has been an *exploration* of new ideas and methods---the seeds necessary to begin systemic reform. During the *transition* phase, the AiS students and teachers have been consistent and persistent in using the new approaches to learning. *A new infrastructure* is emerging where there is a change in the way the teachers are teaching and the students are learning. Neither students or teachers are willing to return to the old way of doing business. They have realized that when a school continues to do the same things in the same way the results will be the same as they have always been with no real growth.

These schools are willing to be on the cutting edge of technology and change. They are willing to maximize the opportunities for their students. They are willing to be change agents. These schools are "innovative schools who are increasingly reaching beyond the walls of their building to welcome parental and community involvement, share resources, and find help enhancing what is available to students on a daily basis" [10].

#### V. CONCLUSION

It has been well established in the AiS program that the technology provided for the schools is not the answer for all the problems that face education today. However, the technology is a valuable *enabler* for these schools. One of the greatest services that technology can render to education lies in communication and curriculum. As the students and teachers become users of this technology there is a change from their being pragmatic to visionary. They are willing to experience the *world* made available to them. These students and teachers are no longer confined by a set of traditional limits. As they access the world via E-mail and the *WWW*, students and teachers are in a school without walls. They are able to transcend the limitations of time and space and travel without leaving the traditional classroom. Even beyond their classroom, they are reaching out to the community and neighboring schools and inviting them to join them.

## VI. REFERENCES

- [1] Smith, Katy, "Becoming the 'Guide on the Side,'" *Educational Leadership*, Oct.93: pp 35-37.
- [2] Maslen, Geoffrey, ""Society Oversees the Global Growth on the Internet," *The Chronicle of Higher Education*, Jun.94: pp A20-A21.
- [3] Toch, Thomas, "The Perfect School," *U. S. News and World Report*, Jan.11.93: pp 46-61.
- [4] Peck, Kyle and Dorricott, Denise, "Why Use Technology?" *Educational Leadership*, Apr.94: pp 11-14.
- [5] Tobias, Shelia, "Keep Culture From Keeping Girls out of Science," *Education Digest*, Sept.94: pp 19-21.
- [6] Muir, Mike, "Putting Computer Projects at the Heart of the Curriculum," *Educational Leadership*, Apr.94: pp 30-32.
- [7] Dixon, R. G., "Future School And How to Get There From Here," *Phi Delta Kappan*, Jan.94: pp 360-366.
- [8] Honey, Margaret and McMillan, Katie, "Adventures in Supercomputing 1993-94 Assessment," Center for Children and Technology/Education Development Center: New York, 1994.
- [9] Anderson, Beverly L., "The Stages of Systemic Change," *Educational Leadership*, Sept.93: pp 14-17.
- [10] Orwig, Ann H., "The Hone/School/Community Connection," *Technology and Learning*, Nov/Dec.94: pp 12-16.