

*Title:* **Distributed Computing Network for Science and Math Education in Rural New Mexico**

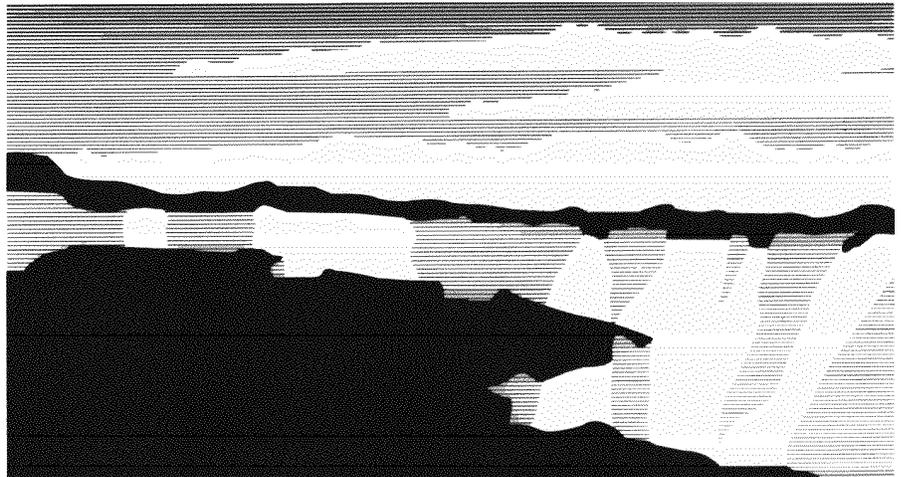
*Author(s):* Andrea P. T. Palounek, Connie L. Witt, M. Carolyn Briles, Jeff Dulaney\*, Norman Georgina\*\*

\* Estancia Middle School, Estancia, New Mexico

\*\* Kirtland Middle School, Kirtland

*Submitted to:*

**Los Alamos**  
NATIONAL LABORATORY



Los Alamos National Laboratory, an affirmative action/equal opportunity employer, is operated by the University of California for the U.S. Department of Energy under contract W-7405-ENG-36. By acceptance of this article, the publisher recognizes that the U.S. Government retains a nonexclusive, royalty-free license to publish or reproduce the published form of this contribution, or to allow others to do so, for U.S. Government purposes. The Los Alamos National Laboratory requests that the publisher identify this article as work performed under the auspices of the U.S. Department of Energy. Los Alamos National Laboratory strongly supports academic freedom and a researcher's right to publish; therefore, the Laboratory as an institution does not endorse the viewpoint of a publication or guarantee its technical correctness.

# Distributed Computing Network for Science and Math Education in Rural New Mexico

Andrea P. T. Palounek (aptp@lanl.gov)  
P-25, Subatomic Physics Group, Los Alamos National Laboratory  
Los Alamos, New Mexico, 87545 USA

Connie L. Witt (cwitt@lanl.gov)  
HR/SEO, Science Education and Outreach Group, Los Alamos National Laboratory  
Los Alamos, New Mexico, 87545 USA

M. Carolyn Briles (cbriles@lanl.gov)  
P-22, Hydrodynamic and X-Ray Physics Group, Los Alamos National Laboratory  
Los Alamos, New Mexico, 87545 USA

Jeff Dulaney (jeff.dulaney@geonetbbs.lanl.gov)  
Estancia Middle School, Estancia, New Mexico, 87035 USA

Norman Georgina (norm.georgina@geonetbbs.lanl.gov)  
Kirtland Middle School, Kirtland, New Mexico, 87417 USA

**Abstract:** This paper describes the TOPS (Teacher Opportunities to Promote Science) and TOPS Mentor programs, which focus on telecommunications and science, math, and technology content. The backbone of these programs is GeoNet, an electronic bulletin board system set up and maintained at Los Alamos National Laboratory. The TOPS experience exposes teachers to science and math in the context of a real problem of genuine scientific interest, increases their knowledge of science and math, enhances their teaching skills, provides activities for their students, and increases student and teacher abilities to communicate with other teachers and scientists. Their students, in turn, learn to approach scientific problems with enthusiasm and confidence. They perceive the beauty and joy of scientific endeavor and develop self-assurance, persistence, and enthusiasm.

## Introduction

The Teacher Opportunities to Promote Science (TOPS) program promotes excellence in the teaching of middle school science and math; interests the students of participating teachers in science, mathematics, advanced technology, and advanced communication; and creates new avenues for teachers and their students to learn and retain new math and science skills, use telecommunications, develop and build scientific equipment, and collaborate with other classes throughout the state. The TOPS program is sponsored by Los Alamos National Laboratory (LANL) and Sandia National Laboratories, and enrolls 50 middle school teachers from New Mexico for three years. Two cohorts of teachers have completed the program; the third cohort is nearing the end of the program and we are beginning to recruit a fourth. The intensive, multi-year TOPS Mentor Program, sponsored by Los Alamos National Laboratory, includes fifteen master middle school teachers from all areas of New Mexico who have already completed the TOPS program. The experienced teachers who participated in the Ring of Light project act as mentors and advisors to the new TOPS teachers.

This allows for the free exchange of ideas, relieves the feelings of isolation that many experience, and improves expertise on both sides. Both programs enlist teachers and their students to gather information about the weather and other environmental data, to use those data to study the dynamics of storms, and to contribute the data and results to others studying atmospheric statics and dynamics. Having students participate in experiments of genuine scientific interest creates a motivation to learn science and the underlying mathematics, and to become more proficient in the use of technology and telecommunications. Students and their teachers gather weather data and other environmental data; propose, design, execute, and analyze their own experiments; and design and build their own detectors as needed.

The backbone of these and other possible projects is the capability for instant communication provided by GeoNet, a bulletin board system (BBS) set up and maintained by LANL. GeoNet connects geographically remote schools with each other and with Laboratory scientists, allowing the free exchange of ideas, techniques, and solutions, regardless of how geographically isolated a school may be. Because many of our schools have limited access to resources, GeoNet is relatively low-tech. This enables every participating school district, school, teacher, and student to take advantage of GeoNet for telecommunications. Different levels of technology are available to accommodate those few schools that have direct internet access and are able to participate on a more technologically advanced level. We have recently upgraded GeoNet to provide limited line access to the internet and to global E-mail.

It is crucial for teachers to be knowledgeable and experienced enough to be capable of fostering their students' interest in science and math. Both TOPS projects provide equipment, computer network support, training, and other assistance, and develop a discovery-based, intercurricular physical science and mathematics program. Through this support, teachers are given broader experience in science and technology, which they can then share with their students. The projects use a modular, hands-on approach to learning. Because students usually decide whether to continue studying math and science during middle school, but need support and encouragement in high school, the program includes grades 6–12, with a strong emphasis on the middle grades.

The TOPS teachers and Mentors have arranged themselves into regional groups that meet frequently and provide mutual support. Academic year and summer workshops for the teachers and for highly motivated students provide instruction, training, and assistance with the materials, activities, and information necessary for targeted experiments.

## **Ring of Light and Storm Tracking**

The TOPS programs build and expand on the experience of the highly successful Ring of Light Project. Ring of Light was established around the May 10, 1994, annular solar eclipse. During an eclipse, the moon's shadow travels at supersonic speeds through the atmosphere and creates substantial localized temperature variations. Theoretical work [Chimonas and Hines, 1970], [Chimonas and Hines, 1971] has shown that a bow or shock wave should be associated with the supersonic passage of the shadow spot. Ring of Light measured, for the first time, surface barometric pressure variations, wind speed and direction, temperature, and insolation over a large distributed array of sensors in and around the path of annularity.

We recruited nearly 50 middle school teachers and their classes throughout New Mexico to operate weather stations and log data during and around the time of the eclipse. Most science classes used a connection to the GeoNet BBS at Los Alamos to enter data, analyze their findings, and exchange information. After the eclipse, teachers who were also in the TOPS program began preliminary data reduction and analysis. Those preliminary searches indicate that we may have indeed detected the predicted bow wave.

The students and teachers found that participating in a real experiment (that had genuine scientific interest) to be one of the most exciting aspects of Ring of Light. We wanted to maintain that excitement. We discovered that the modeling of ground friction is a major problem in predicting weather. Because meteorologists now rely heavily on satellite data for weather monitoring and prediction, there are few ground-based sources of data available to modellers. Data from those sources are typically averaged over 15 minutes, so any fine structure in the measured values is not detectable. Difficulties in properly modeling the travel of air masses over different kinds of terrain further exacerbate the problems we encounter from the dearth of ground-based data sources. New Mexico, with its wide variety of topography and vegetative cover, including mountains, plains, canyons, mesas, forest, and desert, is ideally situated as a laboratory for storm tracking.

Through the TOPS programs, teachers and their students learn how to gather valid data, and develop techniques to deal with and analyze those data. Field techniques require familiarity with the equipment, how it works, and how to fix simple problems. Analysis requires many skills, including classifying, comparing, estimating, planning, developing ideas, testing hypotheses, making models, exploring, and discovering. Teachers and their students learn how to use computers and networks as tools in all those activities. They explore how to find and understand patterns, proportional relationships, and generalization. They have been (and continue to be) exposed to the limits of measurement. Computer networks already make significant amounts of data freely available to the public about environmental factors such as rainfall, insolation, temperature, barometric pressure, and so on. Participants in this program are able to contribute their own data to local, state, and national databases, and to understand how their location fits into the national picture. Participants in our programs learn methods of communication, including the making and use of plots and figures, graphs, tables, models, and charts. Teachers and their students use GeoNet to exchange information between schools, and to provide information to other teachers, students, and parents in a compact, coherent, and understandable way.

## **GeoNet**

Participating teachers and their students share data and communications through GeoNet, a BBS designed and administered at LANL. We used a commercial information management tool, TBBS 2.3 by eSoft, Inc., to create and compile the GeoNet software. The program maintains a system of menus which teachers can navigate to transfer data, read informative files, post public messages, send private mail on the local system and out to the internet, explore internet sites and converse in real-time chat sessions.

GeoNet is a dedicated program that runs on an Intel 486 machine on top of the DOS operating system and uses 12 MB of RAM to give teachers a quick response. While the system itself must run on a fairly powerful computer, teachers can connect to it with simple machines, such as a Mac Plus or an Intel 8088. The minimum requirements are a phone line, a modem, and a basic computer running telecommunications software. Those turn the remote computer into a terminal for GeoNet.

Participants access GeoNet either by dialing up via serial communications protocols and a phone line, or by telnetting to the system using IP (the internet protocol) and a line connected to the internet. Teachers can send internet mail and access any file on the system regardless of their connection method and protocol. Those who dial up to GeoNet can send and receive internet mail, and those who telnet to GeoNet via the internet can send and receive mail local to the bulletin board. In addition, teachers who dial up to GeoNet using serial communications can telnet out of the system to internet sites using IP.

To orchestrate and synchronize these very different communications protocols (serial and IP), two additional computers are necessary. The first is another Intel-based 486 machine, called the IPAD (Internet Protocol Adapter), which literally becomes a protocol interpreter for all three machines in the system. It is available commercially from eSoft, Inc. The second is a Novell network fileserver which stores files that can be accessed by the DOS machine running GeoNet and by the IPAD. The network server introduces another communication protocol, the Novell protocol IPX. The coordination among these three computers is instantaneous and seamless. GeoNet users always see the same menu system and follow the same procedures for sending mail and viewing files regardless of their connection method and protocol.

Following the path of internet mail and a data file illustrates the roles of the three computers that comprise the GeoNet system. A teacher dials up to GeoNet and enters a private message with an internet mail address. The DOS machine sends that message to the network fileserver. The IPAD regularly checks for new mail on the fileserver and, when it finds a message, sends the mail to the internet. Similarly, a teacher may dial up to GeoNet and need a data file that has been transferred to the system through the IPAD by a teacher using the internet. The data file is stored on the network fileserver. When the teacher downloads the data, the GeoNet DOS machine retrieves the file from the fileserver and transmits it over the modem. The receiving teacher is unaware of the location and origin of the file but receives it successfully.

## **Instructional Component**

The Science Education and Outreach groups at Los Alamos and Sandia National Laboratories conduct the TOPS programs. The TOPS programs are conduits between the Laboratories and classrooms. They bring the unique resources of a national laboratory: teams of world-class research personnel; complex research projects; and state-of-the-art facilities and technologies, into the classroom to help meet the instructional needs of science, math, and technology teachers and their students as identified in [AAAS 1993] and by local and regional needs assessments. Specialists in science education designed and continue to improve the programs to provide a conceptual bridge between the classroom and the science at the Laboratories. Education specialists work with scientists to identify those salient pieces of science content and the research process that are key to student learning and understanding. Scientists and education specialists collaborate to design and implement an instructional model based on national standards and accepted best practices and on exciting, current scientific research.

Teachers are immersed in Laboratory science through site visits and field trips, and by working directly with scientists on research projects. Laboratory-sponsored experiments provide an immersion experience for the yearly TOPS Summer Institute and follow the Pacific Northwest Laboratory (PNL) immersion model based on the four-step instructional model developed and described by [Loucks-Horsley et al. 1990]. The emphasis is on using scientific tools, methods, and processes.

The programs provide participants with experience in curriculum development, designing assessment consistent with inquiry based learning, and integrating technology and a computer network support system into their curricula. We present several exemplary instructional models to the teachers. These include: the constructivist model [Yager 1991]; Russell Wright's "Event Based Science" curriculum (developed through a grant from the National Science Foundation); Microcosmos [Zook 1992]; and the "Interlearn," the integrative learning model by Laurence Martel of the National Academy of Integrative Learning, Inc. Teachers integrate these models into curricular units of their own design that they then implement in their own classrooms.

Participating teachers develop hands-on, investigative activities using weather data and other environmental data. Those activities confront their students with the problems and challenges of collecting and dealing with data, and with the problems and challenges of our global environment. Classes and individuals are encouraged to develop, propose, and execute their own investigations using the collective data, and to disseminate their discoveries. For example, classes have proposed and begun insolation studies, discussed energy alternatives, and studied passive solar techniques. Others have characterized our commercially available Davis Weather Monitor II™ stations and LANL-designed insolation devices at a meteorological station at Sandia National Laboratories, or used filters to study the insolation detector frequency response. Teachers, students, scientists, and engineers collaborate on these and other studies. Classes also participate in several experiments initiated by Laboratory and other scientists such as the characterization of weather patterns in New Mexico and tracking storms as they travel across the state. When appropriate, Laboratory scientists help participants develop, design, and build new detectors, and incorporate those new data into studies. For example, Laboratory scientists have developed and designed a simple lightning sensor, with a sensitive radius of about 100 kilometers. This sensor is simple to build; teachers and their classes are beginning to assemble these detectors and use them to characterize some lightning patterns during New Mexico's spring/summer thunderstorm season.

Integration of science and math curricula is another goal of the program. We encourage teams of teachers to participate in the program, either at a single school or in a given district. Preferably a team has at least a math and a science teacher. Even when only one teacher in a given school participates, we have had success in enlisting the aid of other teachers at that school in modifying curricula, incorporating the weather and environmental experiments into classes, and encouraging students to participate. Teachers have arranged themselves into geographically close regional groups that meet in addition to the regular meetings and workshops, to help foster communication and cooperation. Laboratory scientists and education specialists attend those meetings as well. We have found that the math/science integration also promotes coordination and incorporation between other areas. For example, traditional Native American responses to the May 10 eclipse increased cultural awareness: we found there were cultural concerns in a science event and were able to explore those. The total immersion in one particular topic encouraged by these programs thus expands into other areas of study.

## **Evaluation**

Formative and summative evaluation are an integral part of the TOPS programs. TOPS has piloted several evaluation tools for the National Center for the Improvement of Science Education, including a template for the evaluation of national teacher enhancement programs and a teacher impact survey. TOPS, in partnership with a cognitive psychologist at the University of New Mexico, has completed a study on the use of concept mapping to assess the structural knowledge of middle school science students. We are currently researching the impact of the TOPS programs on students. We conduct implementation and process evaluation for each planned activity such as a workshop. The majority of the questions focus on what teacher participants have learned and whether they are making progress in transferring their new knowledge to their classrooms.

## **Conclusions**

A program that promotes excellence in the teaching of math and science while increasing enthusiasm and confidence in the learning of math and science can be a reality. The successes of the TOPS and TOPS Mentor programs are a testament to this. We find three elements are vital to such a program: incorporating a real experiment of genuine scientific interest to establish a base of

curiosity and purpose; a multi-year program with support from education specialists, scientists, and engineers to provide a sound instructional model and a scientific base of information; and ongoing communication and support between the teachers, students, education specialists, and scientists to sustain enthusiasm and growth.

## References

[AAAS 1993] American Association for the Advancement of Science (1993). *Benchmarks for Science Literacy*. London: Oxford University Press.

[Chimonas and Hines, 1970] Chimonas, G., & Hines, C. O. (1970). Atmospheric Gravity Waves Induced by a Solar Eclipse. *Journal of Geophysical Research, Space Physics* 75, 875.

[Chimonas and Hines, 1971] Chimonas, G., & Hines, C. O. (1971). Atmospheric Gravity Waves Induced by a Solar Eclipse, 2. *Journal of Geophysical Research, Space Physics* 76, 7003-7006.

[Loucks-Horsley et al. 1990] Loucks-Horsley, S., & Kapitan, R., & Carlson, M. O., & Kuerbis, P. J., & Clark, R. C., & Nelle, G. M., & Sachse, T. P., & Walton, E. (1990). *Elementary School Science for the 90's*. Alexandria, Virginia: The National Center for Improving Science Education.

[Yager 1991] Yager, R. (1991). The constructivist learning model: Towards real reform in science education. *The Science Teacher*, 58, 52-57.

[Zook 1992] Zook, R. (1992). *The Microcosmos Curriculum Guide to Exploring Microbial Space*. Kendall/Hunt.

## Acknowledgments

These experiments would not have been possible without the enthusiastic and energetic response and participation from the teachers and their students. The approximately 15,000 students are too many to name individually; the Ring of Light teachers are: Babs Benge, Clayton Jr. High; Ric Berglund, Ruidoso Middle School; Sandy Bolton, West Las Vegas High School; Trudy Brewington, Cloudcroft Middle School; Glenda Brown, Tohatchi Mid School; Stephen Burrow, Gallup Middle School; Patricia Castillo, Rio Grande Elementary; Alfredo Chacon, Loving Middle School; Danica Coyle, Mesilla Valley Christian School; George Cronin, Mescalero Middle School; Jeff Dulaney, Estancia Middle School; Clint Fisher, Laguna Middle School; Gary Ford, Tucumcari Middle School; Dennis Forsythe, Tse Bit' Ai Middle School; Mercedes Gallegos, Coyote Elementary School; Ray Gallegos, Memorial Middle School; Mamie Garceo, Horace Mann Middle School; Norman Georgina, Kirtland Middle School; Mark Headlee, Armand Hammer United World College; Jill Hernandez, Hagerman Middle School; Josie Jimenez-Boreson, Ortega Middle School; Flo Lenhart, Pueblo School District #60; Bob Longwill, Clayton Junior High; Anna Marie Marquez, Santa Fe High School; Albert Martinez, Belen Middle School; Shirley Maurer, Mesa Alta Junior High; Danny May, Quemado Elementary; Diana May-Diaz, Deming Junior High; Peggy McCracken, Cuba Middle School; Toni McElroy, Cloudcroft Middle School; Mike Medina, Angevine Middle School; Ivette Miranda, Chama Middle School; Vivian Montoya, Holmes Junior High School; Rex Morris, Ramah High School; Jill Olsen, Los Alamos Middle School; Paula Peters, Houston Junior High; Linda Pickett, Chaparral Middle School; Margaret Pino, Memorial Middle School; Dick Powell, Magdalena Middle School; Shirley Prince, Columbian Elementary School; Laurie Robison, Alta Vista Middle School; Mario Sandoval, Union Street School; Katherine Salazar, Coyote Elementary; Cindy Smith, Zuni Middle School; DeLoyce Smith, San Jon School; Nelma Smith, Santa Teresa Middle School; Richard Stanley, Texico Junior High; Glyn Starr, T or C Middle School; Mechelle Taylor, Los Alamos High School; Michael Tenorio, Valley Middle School; Randie Uranga, Enos Garcia Middle School; Leonard Velasquez, Santa Rosa High School; Mary Ann Vigil, Pecos Elementary School; Louise Watkins, Thoreau Middle School.

This work is supported by the Department of Energy, Office of Defense Programs under contract number W-7405-ENG-36.