WORKSHOP REPORT

TECHNOLOGY, SCIENCE, AND EDUCATION: A SEA OF OPPORTUNITIES
NEPTUNE PROJECT

November 17-19, 2000
Sleeping Lady Conference Center, Leavenworth, Washington
Sponsored by Smart Tools Academy

Workshop Conveners
Louis B. Fox, Vice Provost, University of Washington
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John R. Delaney, Chair, NEPTUNE Project

Summary of Report

A workshop was held in November 2000 to explore the potential linkages and collaborations between the NEPTUNE Project and the informal and formal science education communities. Sixty-five attendees heard panel presentations and met in small groups to brainstorm ways in which NEPTUNE's real-time data from a network of undersea laboratories in the northeast Pacific Ocean could be used in educational settings. One of the key concepts to emerge from the workshop was the NEPTUNE Institute, an organization that would incorporate a K–12 school within an active research and technology community. Next steps in developing NEPTUNE's educational and outreach programs include holding two more workshops in early 2001 to develop material needed to prepare funding proposals, and formalizing an Education and Outreach Implementation Team.

The NEPTUNE Project

Background: The earth, ocean, and planetary sciences are on the threshold of major changes driven by rapidly emerging ideas and powerful enabling technologies. Historically, oceanographers have gone to sea in ships to collect data for short periods of time. Missing from this traditional approach has been crucial information on the fourth dimension of natural processes: time. Now, by combining advances in many different technological fields, we have the ability to enter, sense, and interact with the total ocean-earth environment for long periods of time. The NEPTUNE Project can be a key component in capitalizing on these new real-time, *in situ* approaches that will create a suite of new operational paradigms in the earth, ocean, and planetary sciences—that of being continuously and interactively within a selected, dynamic environment. Opportunities exist to couple this scientific-technical revolution with entirely new approaches to educating learners of all ages.

Science and the NEPTUNE Network: NEPTUNE is creating a network of undersea laboratories that will enable unprecedented real-time observations and experiments with changing earth-ocean systems. By laying 3,000 kilometers of fiber-optic/power cable on the seafloor, NEPTUNE will convert the Juan de Fuca tectonic plate and the overlying ocean to a suite of more than 30 extended natural laboratories spaced about 100 kilometers apart. This tectonic plate, one of a dozen or so plates that make up the surface of the earth, is in an ideal location in the northeast Pacific Ocean off the coasts of British Columbia, Washington, and Oregon, and offers a representative spectrum of global earth-ocean processes.

In contrast to traditional modes of expeditionary science, NEPTUNE will operate 24 hours a day, 7 days a week, for at least a quarter century. Plans call for the project to begin operations in 2005. Data from the NEPTUNE network will flow in real time via the Internet to land-based laboratories, classrooms, and living rooms around the world. Scientists, students, decision makers, and the general public will interact with the NEPTUNE network to gain new understanding of earthquakes, tsunamis, fish stock assessment, marine mammal populations, metal and hydrocarbon deposits, and human influences on ocean and climate systems.

Educational Potential: This interactive technology offers powerful educational potential and provides a wide range of new opportunities for learners of all ages to explore and investigate the dynamic processes of earth and marine science. NEPTUNE's capabilities, which include access to a wide variety of sensor packages and robotic vehicles via the Internet, will be significantly more engaging than turning the pages of a textbook. By capitalizing on real-time communication with an entire earth-ocean system, NEPTUNE could be used to develop fundamentally new approaches to scientific inquiry and human creativity.

Project Development: One of NEPTUNE's important early efforts was to identify powerful intellectual and societal reasons for implementing the project and to establish that the entire concept is technically feasible. Our results have been published in the June 2000 NEPTUNE Feasibility Study, which was undertaken with support from the National Oceanographic Partnership Program and the four NEPTUNE Phase 1 partners: Woods Hole Oceanographic Institution, Jet Propulsion Laboratory (Caltech), Pacific Marine Environmental Laboratory (NOAA), and the University of Washington. Scientists and engineers from these and many other institutions generously contributed their time and effort to this study. The full study is posted on the NEPTUNE web site at *www.neptune.washington.edu*.

Phase 2, Development, is now well under way and we have added two new partners: the Monterey Bay Aquarium Research Institute and Canada's Institute for Pacific Ocean Science and Technology. Phase 2, involving all activities prior to cable laying, will include two basic efforts: 1) infrastructure design and testing to ensure success in cabling, seafloor instrument interfaces, and shore stations, and to provide the interface via the Internet to scientists and the public, and 2) identification and development of a broad user base within the scientific and educational communities, including specific scientific experiments and public involvement.

Education and Outreach Workshop: As part of the Phase 2 effort, a workshop entitled ***Technology, Science, and Education: A Sea of Opportunities*** was held November 17–19, 2000 at the Sleeping Lady Conference Center in Leavenworth, Washington, to explore the potential linkages and collaborations between NEPTUNE and the informal and formal science education communities. Within this context, workshop participants focused on the use of NEPTUNE as an evolutionary testbed using real-time data products in education.

The workshop was hosted and sponsored primarily by the University of Washington's Smart Tools Academy, a unit within the Office of Educational Partnerships directed by Vice Provost Louis B. Fox. The meeting was co-hosted by the Technology Alliance and the NEPTUNE project.

Workshop Structure and Activities

Approximately 65 people attended the meeting. Attendees represented a cross section of professionals in scientific and educational fields: teachers, administrators, scientists, and educators from science centers and aquaria. The goal was to create an environment and mix of participants that would inspire a diversity of discussion and cross-fertilization of ideas.

The meeting began with dinner Friday evening, followed by presentations by John R. Delaney, Chair of the NEPTUNE project, and Véronique Robigou, of the REVEL project. Delaney provided an overview of NEPTUNE, its history, capabilities, and plans, while Robigou discussed REVEL, a project that for six years has trained teachers and then taken them to sea on oceanographic research cruises (*http://www.ocean.washington.edu/outreach/revel/)*. These presentations grounded the participants in their knowledge about NEPTUNE and the possible professional development parallels between REVEL and NEPTUNE. Delaney's charge to workshop participants was to think as creatively as possible, to avoid being held back by perceived or existing barriers, and to project 20–30 years into the future.

Saturday morning and early afternoon were devoted to four panel presentations, described below, followed by small group discussions. These panels were developed and organized by Dana Riley Black, Director of the University of Washington's K–12 Institute in the Office of Educational Partnerships. Riley Black also contributed greatly to the overall structure and organization of the workshop.

• ***Real-time Data and Education*** (Presenters: Bill Steele, Seismology Lab Coordinator, University of Washington; Kathee Terry, Director of Curriculum, Bellevue School District; Tom Charouhas, Integrated Science Teacher, Lake Washington School District; Jacqueline Brown, Director, Technology Outreach and Partnerships, Computing and Communications, University of Washington.)

• ***The Nature of Learning and Science Education Reform*** (Presenters: Dennis Schatz, Associate Director of Education, Pacific Science Center and Washington State LASER; Scott Stowell, Science Coordinator, Spokane Public Schools.)

• ***Quality Professional Development*** (Presenters: Trish Morse, Acting Professor, University of Washington, Zoology; Debra Brice, Science Teacher, Vista, California; Midge Yergen, Science Teacher, West Valley Middle School, Yakima, Washington; Patricia MacGowan, Director, Mathematics, Engineering, Science Achievement [MESA], University of Washington.)

• ***Informal Science Education*** (Presenters: David Taylor, Director of Science and Exhibits, Pacific Science Center; Judith Connor, Director of Information and Technology Dissemination, Monterey Bay Aquarium Research Institute; Marion Rice, Senior Director OPB Interactive, Oregon Public Broadcasting.)

Each presenter spoke for 10 minutes. The goal was not to present a comprehensive overview of each topic, but rather a snapshot that would stimulate the thinking of participants. Sam Eaton of KUOW Radio served as moderator, introducing speakers and asking follow-up questions at the end of each panel.

After each panel, attendees met in small groups of 5–7 people to discuss the essence of the presentations and to brainstorm ideas for applications to NEPTUNE. Group membership had been deliberately structured to be heterogeneous, mixing professions within each group, again to stimulate the highest levels of creativity and thought. Each discussion group entered notes into a networked system of laptop computers.

The goal of the late afternoon session, entitled "Idea Focus," was to reorganize attendees into groups that were homogeneous, e.g., teachers together with other teachers, in order to identify and expand upon one idea that had been generated by the heterogeneous groups. The results of these group sessions were written up and collated into a Power Point presentation. Dinner Saturday evening was

followed by an informal exhibits session with NEPTUNE and ocean-science related videos, posters, and literature.

The half-day session on Sunday was kicked off with a welcome from Louis B. Fox. He described the successes and future plans for Smart Tools Academy and discussed the opportunity to put the State of Washington on the forefront of the national Internet2 effort. A full group discussion was then led by John Delaney to further elicit creative ideas for uses of NEPTUNE and to flesh out one of the ideas, the NEPTUNE Institute, that emerged from the idea focus groups on Saturday afternoon.

All notes from all sessions and discussions have been posted at *http://depts.washington.edu/academy/neptune* by Bryan Chee, Smart Tools Academy Program Manager. The site includes a bulletin board for participants to express ideas and thoughts that have come up since the workshop. Chee and the Smart Tools staff provided computers, projection equipment, technical support, and conference management for this meeting.

The NEPTUNE Institute

The concept behind the NEPTUNE Institute is an integrated, holistic approach to lifelong learning. It will include a K–12 school and will gather teachers, researchers, technologists, engineers, data managers, librarians, informal science educators, the public, and students within a single physical facility. The Cybership NEPTUNE component of the Institute will use electronic communication technology to encapsulate and extend the Institute's capabilities, particularly its educational capabilities. Cybership NEPTUNE will help the Institute reach a broad international and national audience.

The NEPTUNE Institute embodies the following key ideas that emerged from the workshop:

Real-time data: Fundamental to the NEPTUNE Institute are the unique opportunities and excitement generated by the real-time data streams coming in from 30 NEPTUNE nodes on the Juan de Fuca Plate. The NEPTUNE approach creates the opportunity to develop a holistic understanding of an environment the size of a tectonic plate. It also allows students to fully participate in the scientific investigative process, to learn that it is okay to fail, as scientists often do in their search for answers to their questions, and to learn from those failures and develop alternative solutions. Students in classrooms will work with teachers and scientists to develop and execute their own experiments for the NEPTUNE nodes.

A current NASA project provides a good example of the potential for students and teachers to work with real-time data streams. Using computers in their classrooms, students at 25 middle schools and high schools in 13 states are guiding a Deep Space Network radio telescope to scan Jupiter. Their goal is to monitor and record natural radio-wave emissions from the planet. These data will be used to help interpret measurements made by the Cassini spacecraft as it flies by Jupiter in early 2001. One student was quoted as saying that he likes the unpredictability of the real research, compared with textbook learning. "It inspires you to go on and do more in science," he stated in a NASA press release.

Mentoring: This component of the NEPTUNE Institute is intended to occur vertically and laterally at all levels: between engineers and students, scientists and teachers, teachers and technologists, students and scientists. We envision opportunities for teachers to mentor scientists about how to teach kids, for data librarians to mentor teachers in the use of data archives, for an informational corps of knowledgeable teachers, i.e., master teachers, to mentor less experienced teachers, for engineers to incorporate students and teachers into their instrument design work.

Immersion learning environments: We imagine creating naturally evolving 3-D virtual environments of the seafloor and overlying ocean space, fed by high bandwidth real-time data streams from NEPTUNE nodes. These environments will be used to foster the highest quality of interactive learning opportunities. Indeed, an entire classroom could become a virtual environment, which, with NEPTUNE-like capabilities, would become a 4-D experience.

Integrated approach to science, art, and the humanities education: One of the challenges of the world of scientific research is to effectively communicate the excitement and art of scientific discovery to citizens, voters, taxpayers, and students. How do we convey the essence of our enthusiasm without the mind-numbing complexity intrinsic to real science? One solution is to merge the borders of art and science, to incorporate "translators" into the NEPTUNE Institute. Integrating writers, visual artists, musicians, philosophers, and science historians into the Institute will tap a rich source for education at all levels. Artists and writers in residence and art exhibits/installations were just two of the ideas that emerged from the workshop. International partnerships with schools and classrooms around the world would open doors to opportunities for not only scientific but also cultural exchanges and collaborations.

Next Steps

This workshop provided the foundation upon which to build the community of scientists and educators dedicated to making the wisest and best use of NEPTUNE's educational capabilities. From within this group of attendees, we will identify ten people from a cross section of disciplines and invite them to a two-day workshop at the University of Washington in early 2001. This group will review and assess the ideas born of the November 2000 workshop and then identify the concepts most worthy of further development. From this distillation of information, participants will be asked to develop recommendations that NEPTUNE can use to prepare proposals to federal, state, and private funding sources.

NEPTUNE must further explore the realities and possibilities of using the project's high-end data feeds in informal science settings. We will invite a selected set of representatives from aquaria and science centers in the U.S. and other countries for a two-day meeting, also in early 2001, that will focus exclusively on this issue. The goal will be to develop recommendations that can be used to prepare requests for funding. We expect this group to eventually be formalized as a NEPTUNE Consortium.

Following the 2001 workshops, we will form an Education and Outreach Implementation Team of five to seven members, which will function within the NEPTUNE organization on the same level as the two other major NEPTUNE teams: Science Implementation Team and Infrastructure Implementation Team. A NEPTUNE Education and Outreach Coordinator will be hired to oversee this component of the project.

Described briefly below are program development steps that could be taken to make the transition from the present to the time when the NEPTUNE Institute is a reality.

1) NEPTUNE summer camp, perhaps at the Pacific Science Center. A short-term, immersion experience for both teachers and students; would serve as an initial testbed for development of NEPTUNE educational curriculum.

2) Package the NEPTUNE summer camp experience into a Space Camp or Challenger Center type experience that could be distributed nationally and internationally through museums, aquaria, and other learning centers.

3) Create the Institute, incorporating lessons learned and curriculum developed in 1) and 2).

One of the exciting early possibilities for the NEPTUNE Institute is participation in Internet2. Under the leadership of Vice Provost Fox, the University of Washington has the opportunity to sponsor Washington State's K–20 Network as a participant in Internet2. The NEPTUNE Institute would play an active role in developing creative educational projects that would take advantage of the newest networked technological capabilities and to create as yet unimagined forms of cultural interaction.

Participant Comments

Friday evening, immediately after the NEPTUNE overview presentation, participants were asked to write out their spontaneous responses to the question "What ideas or thoughts were prompted by the NEPTUNE Overview presentation?" A sampling of responses is provided below.

"How exciting real-time science would be for my students! To be able to develop a research line/connection that they could follow daily/weekly would provide a connection to science that is obviously missing when you are 'locked into' a classroom."

Kathleen Heidenreich, Educator, Chinook Middle School

"The concept of the elements of DISCOVERY -- selection, idea flow, technology, persistence -- invoked a powerful feeling in me. Instruction along such lines is necessary for students to take risks in future thinking and exploration. It is an important step in helping kids interact and engage in the possibilities of NEPTUNE. Classrooms need to encourage risk in order to understand accomplishment."

Grace Dublin, Teacher, Canyon Creek Elementary School

"The term 'education' is too limiting— we need to redefine what can be created with a program like NEPTUNE."

Patrick Olenick, Vice President for External Affairs,
Vancouver Public Aquarium

"Further revelations within this area of inquiry may provide additional educational opportunities by entraining students whose interests are not, per se, in the oceans, but rather lie in the biomedical, biotechnology, and industrial engineering sectors."

Dan Schwarz, Manager of Marine Operations,
University of Washington, School of Oceanography

"Exploration of complex ecosystems to address environmental concerns is the #1 issue of human security for teenagers today."

Julie Zilber, Co-Director, EXCITE, Simon Fraser University