UNDERSTANDING THE UNIVERSE
Education & Outreach

http://www-ed.fnal.gov/uueo/

Discussion Meeting on Education and Outreach

Developing a National Initiative

Organized by

GriPhyN/iVDGL and QuarkNet Projects

Arlington, VA
April 8, 2004

Coordinators
Paul Avery (University of Florida)
Marjorie G. Bardeen (Fermilab)

Facilitator
Edward Moyer, Jr.

Table of Contents

Understanding the Universe Education and Outreach Discussion Meeting

Held on April 8, 2004 in Arlington, VA

Attendees (see Appendix C for Affiliations)

Paul Avery	William Frascella	Ed Moyer	Harold Stolberg
Keith Baker	Doug Gatchel	Soma Mukerjee	Sheldon Stone
Marge Bardeen	Marvin Goldberg	Lori Perine	Wayne Sukow
Beverly Berger	Tom Greene	Randy Phelps	Alex Szalay
David Bynum	Francis Halzen	Liz Quigg	Kevin Thompson
David Campbell	Sangtae Kim	Jim Reidy	Kathy Turner
Todd Clark	Laird Kramer	Randy Ruchti	David Ucko
Mark Coles	Dana Lehr	Aaron Schuetz	Barry Van Deman
Joseph Dehmer	Michael Marx	Brian Schwartz	Ken White
Lucy Fortson	Stephanie McLean	Robert Semper	Jim Whitmore
Barbara Fossum	Allen Mincer	Orrin Shane	Mike Wilde
Geoffrey Fox			

Meeting Background

Scientific and engineering disciplines today are rapidly expanding the frontiers of human knowledge, combining intellectual insights with new advances in research methods and technologies. However, continued progress challenges research communities to communicate their achievements more effectively to the general public and to develop better strategies for training their students in these quickly evolving research methods and technologies. Emerging information technologies such as Grids could provide these disciplines a powerful infrastructure for developing and deploying new learning strategies and education/outreach tools.

These considerations led to the April 8, 2004 meeting, which brought together education and outreach leaders from a variety of physical science projects to explore the idea of linking efforts within a common framework that we call "Understanding the Universe." UUEO (UU Education and Outreach) member projects are listed in Appendix C and an online list can be found at the UUEO website (http://www-ed.fnal.gov/uueo/).

Meeting Goals

This meeting explored how education/outreach could benefit from the synergistic integration of three research frontiers:

- Physical Science Research
- Computer Science Research and Technology
- Research on the Science of Learning and Teaching

Individuals and teams from the physical science, computer science and education communities came together to discuss the benefits of forming a consortium that could take advantage of connections among education and outreach efforts targeting both formal education (K-16) and informal outreach (museums and other forms of public outreach). Attendees noted that such a broad coalition would be well poised to develop and deploy advanced learning environments that take advantage of advanced information technologies such as web portals, Grid infrastructures, databases and high-speed networks as well as powerful new Grid-based "virtual data " tools.

We believe that Understanding the Universe offers a framework for leveraging the education and outreach efforts of various physical science experiments and Grid computing initiatives supported by the National Science Foundation. This federated approach, in which the education, computer science and physical science communities maintain their separate identities and agendas while working together within a common framework, holds great promise for promoting and supporting collaborative learning. By collaborating and using advanced information technologies, UUEO members can create an environment where scientists, researchers, educators and students can contribute knowledge, skills and resources and continue to expand the store of human knowledge.

A New Vision for Education

The context for this discussion meeting is best set by outlining a new vision for collaborative outreach. The issue driving this vision is the need for horizontal and vertical integration of the educational and scientific systems. This need manifests itself in the isolation of efforts for most institutions within these systems. Research in Science, Technology, Engineering, and Mathematics (STEM) education targets learning environments, course content, curricula, and educational practices. What does this research suggest? How are the findings infused into the practices of both systems? How might teachers, students, and scientists collaborate on meaningful issues? The landscape of learning, both formally and informally, is rapidly changing, and how are these two systems responding? Our passion and expertise motivate our efforts, but our isolation inhibits our potential.

The education and outreach efforts of the various experiments and institutions represented at this meeting symbolize a potential network of learning communities. By employing network tools and techniques, we begin to establish both vertical diversity within our respective systems and horizontal diversity across them. Addressing the capacity of the system to support these efforts must reflect this diversity and include such areas as policy, research, CyberInfrastructure, professional learning, materials, and opportunity. A federated approach to our efforts leverages the knowledge and skill that exist within our embryonic network, moving us beyond happenstance and toward a more purposeful consortium. The idea of an e–Lab represents one possible structure to serve as connective tissue for collaborative outreach. By bringing to bear tools and techniques from the Grid environment to our network of education and outreach efforts, our vision may move closer to reality.

A Pilot Project: High School Cosmic Ray Studies

Student Homepage: quarknet.fnal.gov/grid/
Teacher Homepage: quarknet.fnal.gov/grid/teacher.html

The cosmic ray study is a pilot project to explore the potential of using virtual data grid tools and techniques in high school physics classes. Part of a larger QuarkNet/Grid project, the studies provide a chance for:

- Students to do authentic research—to access, process and publish data, report and share their results as online posters, and have online discussions with one another about their work.
- Student researchers to experience the environment of scientific collaborations.
- Student researchers to make real contributions to a burgeoning scientific field.
- Educational researchers to evaluate the effectiveness of such an endeavor.

Schools with cosmic ray detectors will be uploading data to a "virtual data grid" portal. This portal will enable schools to share their data and enable students to analyze a much bigger body of data when mining for cosmic ray showers. The portal provides schools a mechanism for sharing analysis code while allowing schools that do not have cosmic ray detectors to participate in research by analyzing shared data.

A prototype website provides a place for students to organize their research, access and analyze the cosmic ray data from schools around the country, write a poster to summarize their research, and communicate with other school groups doing similar research.

Two levels will exist for analyzing data: a simple science-based interface and a more advanced virtual data grid interface. We have a prototype web page that will allow students to concentrate on the cosmic ray studies. We also plan an interface that will allow students to interact more deeply using virtual data techniques.

In order to capture the experience and facilitate evaluation of the effectiveness of this approach, Fermilab is developing a password-protected shell that guarantees that students fill out a pre-survey before accessing any data.

QuarkNet/Grid research project is a collaboration between QuarkNet and GriPhyN and supported in part by the National Science Foundation and the U.S. Department of Energy Office of Science.

QuarkNet (http://quarknet.fnal.gov) is an education program for US ATLAS and USCMS, U.S. collaborations working on experiments for the Large Hadron Collider at CERN. Participants also work on as many as nine other high-energy experiments, for example, BaBar, CDF, DØ, FAST and MINOS. A long-term program, QuarkNet brings high school teachers and their students into research groups nationwide. Students learn fundamental physics as they analyze live online data and participate in inquiry-oriented investigations.

The **GriPhyN** Project (http://www.griphyn.org/) is a collaboration of computer scientists and physicists who are developing Grid technologies for international scientific and engineering projects that must collect and analyze distributed, petabyte-scale datasets. GriPhyN research is disseminated through its Virtual Data Toolkit to help scientists develop international and even global Grids. A national Grid called Grid2003 (http://www.ivdgl.org/grid2003/) is based on these tools.

Plenary Session - Common Themes: Goals and Tasks for the Future

We propose to develop a nationwide science education consortium. The intent is to bring together programs in education and outreach in several sub-disciplines at the scientific frontier in physics and other physical science disciplines with frontier initiatives in computer science such as the Grid.

The goal of our consortium will be to offer secondary teachers and students any-time (including real-time) access to experimental and simulated data and analysis tools to explore scientific questions. These can be derived from detectors ranging from large-scale accelerator and non-accelerator physics experiments, ground and space-based astrophysics experiments, fusion research, and from new theoretical and phenomenological models, to arrays of student-built detectors to study cosmic ray air showers in high schools networked worldwide.

e-Lab Pilot Project Possibilities

We will engage in a “grass-roots” effort to pilot and assess our approach. This initial step derives data from scintillation cosmic ray detectors built and operated by high school teachers and students associated with QuarkNet and CROP. Teachers and research physicists provide guidance and scientific background for the activity. Suggestions from the meeting include:

- Complete the cosmic ray pilot.
- Develop standards and templates to support a federated approach. All levels of readiness must be honored.
- Initiate new projects; most experiments are just beginning, but one or two may have a project to consider including simulated or real experimental data.
- Bring scientific reality into the classroom.
- Develop student ownership of learning.
- Document what works and what does not.
- Quantify the impact through valid research.
- Design for change.

Needs Assessments

We will hold workshops from time to time in order to assess the needs of teachers and faculty and build ownership among participants. This process will help us identify appropriate audiences from school children to college students and the general public. Suggestions from the meeting include:

- Gather data from other stakeholders such as teachers, researchers and computer scientists.
- Build ownership in the process and the outcomes.
- Inform the solicitation process through concurrent pilot projects and needs assessment. (Each informs the other.)
- Share needs assessment data to shed light on conditions that exist locally, nationally and globally.
- Determine target audience from traditional to nontraditional.

“Matriculation” Center for e-Labs

We will need an entry portal that will serve at least three goals: to build national awareness and excitement, to provide teacher access and support and to provide developer access and support. While we envision an online portal, we will need a small program staff to provide technical and programmatic support and manage the collbaorative. Suggestions from the meeting include:

- Experiment with prototype matriculation center designs.
- Build a national awareness and excitement is important; how do we create this (content areas such as astronomy can do this to some degree, informal science institutions can help as well); grass-roots excitement also can come from the needs assessment.
- Align to standards either through content or process; projects from any of our experiments can meet these standards.
- Help to provide a source for professional development and materials; question remains how to create conditions for replication of the rich QuarkNet experience.

Sustaining This Consortium: Meetings and web site

We will develop long-term plans and goals and specify actions needed in the short term, to include identifying possible outreach models and creating prototypes. We will work within a framework for federated E/O efforts based on a common, shared infrastructure that takes advantage of opportunities created by new NSF-supported high-energy physics experiments, RSVP (accelerator), ICECUBE (non-accelerator) and Veritas (Astronomy). Suggestions from the meeting include:

- Holding another discussion meeting with greater focus.
- Posting information on the UUEO website (current URL <www-ed.fnal.gov/uueo>).

Appendix A: Summary of Breakout Sessions

Session A: R. Ruchti

- Teacher input is critical to moving this initiative forward; we will have to pay attention to the level of readiness and competency. Some will be users and some may be developers.
- What is the difference between the Grid for research and Grid for education?
- CMS data stream will allow students to be participants in a forefront physics experiment.
- Grid tools and techniques will impact education and outreach efforts; the question is how much can that be shaped by us at these initial stages.
- Creating an integrated system is hard; requires both horizontal and vertical integration.
- How can disciplines other than high–energy physics and astrophysics be brought into consortium?
- Teachers desire scientific reality in the classroom, through data, laboratories, equipment and people.
- How can we build a community of scientists, teachers and students with these ideas?
- Scientists want to be teachers as well.
- Which levels of the educational system can and should be targeted? Nontraditional science students and those reached informally should be included, and indeed may benefit significantly. Community colleges are also an important audience.
- There are other positions necessary to support these experiments; these are viable careers for many of our students.
- Providing workshops for science writers is also a useful service.
- We need to maintain interests of both researchers and teachers through the process.
- We need formal and nonformal entries to engage students (schools, museums, national labs, and Internet).
- Passion is an essential ingredient to this mix; systemic change can happen as a result.
- Vision of the Grid still evolving: network of people, resources, and opportunities.
- We want students to take ownership for learning; exchanging information informally can help foster this sense.
- Children already form virtual communities on their own using readily available technologies. They will likely already be familiar with the tools,
- We will need ways to help teachers who run into things they don't know how to do or understand.
- Who are our target audiences? Broadly defined would strengthen the work; we should pay attention to specific needs of each of these audiences.
- How do we quantify the impact of these efforts? We need valid educational research.
- Incentive for participation may be needed, either in the form of stipends or university credit.

Session B: M. Bardeen

How to work together so teachers can use our education materials and projects

How Will They Find Us?

- Create entry point (see Matriculation Center).
- Link from a new NSF website - too much out there.
  - Ask teachers for input
- Use project ambassadors.

Establish an e-Lab Matriculation Center – real, virtual, web interface.

- Provide an entry point for educators, science centers, developers, and researchers.
- Respond to requests.
  - Brokers - NASA model
  - Integration engineers
- Support change.

New Frontier – Plan How to Get There

Find PI with energy, passion, skills.

Develop prototypes.

- Look at first set.
  - Create templates.
    - Visualization (informal)
- Develop and implement evaluation strategy.
  - Document designs that work and don't work
- Create virtual experiences.
- Develop career modules.
  - Different roles involved in science
  - Place and function
  - Training technicians

- Creative process
- Instructional materials in new ways
- Research and education

- Build capacity.
  - Infrastructure that allows projects to tap resources all are developing
  - Research center – readiness for participation
  - Big projects a good resource
    - Project ambassadors
- Provide training.
  - EPO professional training
    - EPO agents in research centers
- Maintain directories.
- Maintain e-Library.
- Promote project standards with flexibility
  - Commonalities
- Help science centers.

Hold Needs Assessment.
- Begin building ownership.
- Include small and large experiments with different needs.

Build on characteristics of Successful Education Projects.
- Build on unique contributions experiments can make to education.
- Include professional development.
  - Local involvement
  - Ownership (by teachers)
  - Teaching by doing – does it transfer to other projects?
    - Research
    - Are they more flexible?
    - Transfer?
- Build infrastructure (teacher groups).
- Link to standards, zooming in on standards.
- Provide young people research opportunities.
  - Move information around
  - Provide hook
    - Visualization – whiz bang
    - MIT OpenCourseWare
- Involve reasonable, committed, caring people.
- Target HS – college audience. (Provide different levels.)

Sustain the Pace of Change.
- Design for change.
- Work with CS people on this.
- Develop a set of standard tools.
  - Avoid reformatting data
  - Transform data to meet standard input parameters
- Enable the web developers and educators to easily make changes.

Hold needs assessment meeting.
- Establish an organizing committee.
- Invite people to use VDL tools; experiments, educators, formal & informal.
- Emphasize why it is good from them what could they contribute.
- Send results to NSF to aid in preparing solicitations.

Build communities.
- Consider peer-to-peer applications.
- What is the Grid?
  - Virtual data language and data
  - Students forming virtual communities
  - Students to take ownership
  - Role for informal education centers
    - Professional Grid vs. what students do on their own
  - What if the data is visual?
- Include informal education and the public.
  Advanced technological group

Agree on target audiences.
- K-16
- Attracting technicians
  - Lack of teachers here
  - Input from teachers needed
- Quantify success

Create matriculation center.
- Create a prototype hub.
- Consider the long term (five years).
  - What can be done to get this started?
  - Actions both top down and bottom up
- Develop but do not duplicate lots of Infrastructure.
- Use NSF CyberInfrastructure.
  - Better EO in CyberInfrastructure
  - How to influence education with new technology
- Requires people.

Involve informal Institutions as Mediators.
- Serve as hub for content.
- Transfer content.

Directories
- Fathom
- Science in Motion

Hire gamer

$ Where's the money?

Appendix B: Discussion Agenda Meeting

Morning Plenary Session	
Welcome	J. Dehmer (NSF)
New Vision of Education based on new science, new tools, and new research in education	W. Frascella
QuarkNet/GRID Story	M. Bardeen & M. Wilde
Understanding the Universe (SkyServer)	A. Szalay
Museum Connections	B. Van Damen/ R. Semper
Grid 2003 and Outreach	P. Avery
Breakout Sessions (Working Lunch)	
Session A	R. Ruchti
Session B	M. Bardeen
Afternoon Plenary Session	
Reports from breakouts	
Discussion of next steps and action for follow up	
Adjourn	

Appendix C: Meeting Participants and Their Affiliations

First Name	Last Name	Organization	Position
Robert	Aiken	Cisco	Special invitee
Heidi	Alvarez	Florida International U	Associate Director, CIARA/AMPATH
Paul	Avery	U Florida	GriPhyN/iVDGL PI
Keith	Baker	Hampton U	ATLAS/QuarkNet
Marge	Bardeen	Fermilab	Ed. Office Manager/QuarkNet PI
Beverly	Berger	NSF	MPS/PHY Program Director
Henry	Blount	NSF	MPS/OMA Head
David	Bynum	Stony Brook U	Director, LIGASE
Manuela	Campanelli	U Texas Brownsville	iVDGL/GriPhyN Outreach
David	Campbell	NSF	EHR Program Officer
Todd	Clark	DOE Office of Science	Contractor, Workforce Development
Mark	Coles	NSF	BFA/OAD Deputy Director
Deborah	Crawford	NSF	CISE/OAD Deputy Asst. Director
Joseph	Dehmer	NSF	MPS/PHY Div. Director
Peter	Faletra	DOE Office of Science	Asst. Dir. For Workforce Dev.
Lucy	Fortson	U Chicago/Adler Planetarium	VERITAS
Barbara	Fossum	NSF	CISE/SCI Assoc. Program Dir.
Geoffrey	Fox	Indiana U	iVDGL review
William	Frascella	NSF	EHR/ESIE Div. Dir.
Eileen	Friel	NSF	MPS/AST Program Director
Doug	Gatchel	NSF	CISE/SCI Program Director
Marvin	Goldberg	NSF	MPS/PHY Program Director
Dave	Goodwin	DOE Office of Science	HEP Scientist
Roy	Gould	Harvard–Smithsonian Ctr. For Astrophysics	Science Education Dept.
Tom	Greene	MIT	iVDGL
Francis	Halzen	U Wisconsin–Madison	ICECUBE PI
Mike	Haney	NSF	EHR/ESIE Program Director
Paul	Horwitz	The Concord Consortium	Senior Scientist
Chris	Impey	U Arizona	Distinguished Teaching Scholar
Judy	Jackson	Fermilab	Office of Public Affairs
Kerri-Ann	Jones	NSF	SBE/INT Director
Sangtae	Kim	NSF	CISE/SCI Div. Director
Laird	Kramer	Florida International U	CMS/CHEPREO
Richard	Kron	U Chicago/Fermilab	Director, Sloan Dogotal Sky Survey
Dana	Lehr	NSF	MPS/AST Asst. Prog. Director
Michael	Marx	Brookhaven	RSVP/KOPIO

Steve	McGuire	Southern U	LIGO Outreach Center
Stephanie	McLean	NCSA	NSCA Program Director
Allen	Mincer	NYU	RSVP/MECO
William	Molzon	UC IRVINE	RSVP/MECO
Ed	Moyer	Fermilab	Consultant
Soma	Mukerjee	UT Brownsville	iVDGL Outreach
Lori	Perine	NSF	SBE/INT Consultant
Randy	Phelps	NSF	MPS/AST Program Director
Steve	Pompea	NOAO	Manager Sci. Ed. & Astronomer
Liz	Quigg	Fermilab	Computing Specialist
Fred	Raab	LIGO	Director, Hanford Observatory
Jim	Reidy	DOE Science	HEP Program Officer
Elisabeth	Roberts	M. J. Young and Associates	Consultant
Randy	Ruchti	U Notre Dame	CMS/QuarkNet PI
Aaron	Schuetz	DOE Office of Science	Einstein Fellow
Brian	Schwartz	CUNY	Newmedia Lab
Robert	Semper	Exploratorium	Exec. Assoc. Director
Orrin	Shane	NSF	EHR/ESIE Program Officer
Mildred	Smalley	Southern U	LIGO Outreach Center
Larry	Smarr	U San Diego	Director, Cal Inst for Telecom & IT
Robert	Sparks	The Prairie School	Teacher
Harold	Stolberg	NSF	SBE/INT Program Coordinator
Sheldon	Stone	Syracuse U	BTEV Spokesperson
Mark	SubbaRao	U Chicago/Adler Planetarium	SDSS, VERITAS
Wayne	Sukow	NSF	EHR/ESIE Section Head
Curt	Suplee	NSF	OD/OLPA Director
Alex	Szalay	Johns Hopkins U	SDSS, NVO
Kevin	Thompson	NSF	CISE/SCI Program Director
Robert	Tinker	The Concord Consortium	President
Kathy	Turner	DOE Office of Science	HEP Program Officer
Michael	Turner	NSF	AD for MPS
David	Ucko	NSF	EHR/ESIE Program Director
Barry	Van Deman	NSF	EHR/ESIE Head
Ken	White	Brookhaven	Director, Of Ed. Programs
Jim	Whitmore	NSF	MPS/PHY Program Director
Mike	Wilde	U Chicago/Argonne	GriPhyN coordinator
Mike	Zucker	LIGO	Director, Livingston Observatory