FINAL VERSION:
DATE: September 8, 2006
REVIEW STATUS: revision after review

Education and Outreach at DUSEL

Susan Pfiffner
Contributors:* Elizabeth Arscott, Marjorie Bardeen, Willi Chinowsky,
Sharmila Kamat, and Bill Miller

1 Introduction

People's curiosity will be sparked by the very notion of conducting a vast range and scope of scientific research deep underground in a mine-like environment. The fields of study include physics, microbial ecology, molecular biology, geology, mining engineering, chemistry, hydrology, to name a few of the different disciplines that will be highlights at DUSEL. The unsolved scientific mysteries will feed their fascination with and eagerness to learn more about natural phenomena. DUSEL presents an exceptional opportunity to provide a unified program that integrates education and outreach (E&O) with multidisciplinary research. This project has a great potential to educate and mentor the next generation of professional scientists and teachers and to expand the much-needed diversity in the workforce. The S-1 E&O committee surveyed the scientists, engineers, educators and students participating in the S-1 DUSEL workshops[1]. Many participants noted an increased understanding of other disciplines, enormous potential of other sciences contributions at DUSEL, and a possibility for developing research partnerships as gains of the workshop. About half of the DUSEL users indicated their involvement in various E&O activities. The DUSEL E&O staff will continue to enhance an established practice of research community participation in E&O efforts.

The following text is one of a number of detailed technical reports supporting the general arguments for DUSEL presented in *Deep Science*. We discuss here the facilities and personnel needed to support an ambitious education and outreach program at the DUSEL campus. The recommendations herein are the result of DUSEL workshops held from 2004-2005 in Berkeley, CA, Blacksburg, VA, Boulder, CO, and Minneapolis, MN. Its goals are to: (1) promote science literacy, (2) recruit, engage, and encourage students toward scientific careers, (3) foster interdisciplinary investigations through integrated programs in education and research, and (4) strengthen international collaborations that enhance the exchange of ideas, technology, and learning. To achieve these goals, the DUSEL campus will require designated above- and below-ground infrastructure and personnel that is based on E&O programming and projected audience expectations. E&O at DUSEL will contribute uniquely to the national effort to address the identified critical need to enhance, expand, and strengthen science, technology, engineering, and mathematics (STEM) education. The national need is well documented. NSF's National Science Board[2], in its report *Science and Engineering Indicators 2006* notes "S&E jobs play a growing role in the U.S. economy, but U.S. S&E degree production lagged growth in S&E occupations." The report also remarks that "Foreign students earned one-third of U.S. S&E doctorates and 55% of engineering doctorates (in the 1990s), whereas doctorates earned by U.S. white males dropped sharply." The National Academies' Committee on Science, Engineering and Public Policy[3] in its report *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Future* states "In a world where advanced knowledge is widespread and low-cost labor is readily available, U.S. advantages in the marketplace and in science and technology have begun to erode. A comprehensive and coordinated federal effort is urgently needed to bolster U.S. competitiveness and pre-eminence in these areas."

* Working Group members and contributors to the report, and their affiliation, are listed at the end of the document.

E&O activities and campus facilities should be incorporated into any DUSEL design from the start. Infrastructure and coordinated efforts are fundamental for the development of innovative formal, informal, and outreach programs. A campus that will accommodate visitor *and* education programs must be appropriate for groups such as community officials and legislators; visiting scientists (professors, postdocs, graduate and undergraduate students) and staff scientists; site staff (technicians and students), vendors and miners; K-12 students and teachers; and the general public. For example, the DUSEL campus would be a place where seminars or week long "Camps" could be offered at all levels of education.

Table 1 gives an idea of potential audiences and suggests what each group may want to know, what they can do, what challenges they present, and particular strategies to achieve the broad E&O goals.

Table 1. DUSEL E&O Audiences

AUDIENCES	MESSAGES/ACTIVITIES	PARTICULAR CONSIDERATIONS STRATEGIES
VIPs Decision makers Opinion makers Lab VIPs	**What we want them to know:** Understand the importance of DUSEL science and research at a basic level How this laboratory, based in the US, and its research projects advance science, have education and economic benefits, and provide a worldwide interaction **What they can do:** Key for funding, and legislation	**Considerations:** Always in a hurry **Strategies:** Public website Quick one-page informational handouts and/or hands-on displays to take to Congress, etc Site tours including underground
Scientists Scientists from other facilities Scientists and engineers from other fields Professors and students	**What we want them to know:** Be aware of current and future research and opportunities for academic, research and educational mentorship Learn how they can be involved and/or collaborate **What they can do:** Bring new, collaborative research, education, and development opportunities	**Considerations:** Limited by funding, time to operate experiment or project, and access to areas of study or equipment **Strategies:** Protected website for data exchange Site tours including underground Research and/or educational programming particularly during the summer
School Groups Elementary and secondary students Preservice and inservice teachers Other educators	**What we want them to know:** Understand and appreciate science and research at a basic level Advance that level of understanding with their students and colleagues Be enthusiastic about science and engineering **What they can do:** Hold research internships	**Considerations:** Limited by the level at which they can understand and participate in the science Can come in large groups **Strategies:** Education website Grade-specific curriculum and professional development material

	Develop and test educational materials for formal, informal or outreach activities Disseminate materials and serve as ambassadors for the laboratory	On-site and/or remote access to educational exhibits, student investigations, web-based interactive communication Coordinated programs with regional colleges
General Public Local residents Tourists	**What we want them to know:** Understand and appreciate science and research at a basic level **What they can do:** Disseminate materials and serve as ambassadors for the laboratory	**Considerations:** Learn what their money is buying May come in large groups **Strategies:** Public website Tours and Q&A sessions Informational handouts Visitor center with hand-on activities or interactive displays and take-away materials

Which strategies are adopted or emphasized depends on the characteristics of the DUSEL environs. An urban location, for example, will require different schemes than will a more rural location. Local and regional minority populations' will need programs tailored to their needs.

2 Infrastructure

Integrated education and outreach programs will require facilities above and below ground, a position in DUSEL management, and dedicated staff. At the lab's "front door," a visitors and education center can be located in a separate building or as part of an "administrative" building. A good model is the visitors' center for a national park. Should the center be located at a distance from the mine, having a small bus would be a good idea to take the visitors to and from the laboratory.

Underground space must be available for staff, tour groups and for some research activities. While E&O programs need dedicated space, they also rely on access to general laboratory facilities. Table 2 below gives a general idea of E&O space requirements; both dedicated and in shared facilities above and below ground. All DUSEL campus facilities should provide access for people with disabilities: visually, hearing, or mobility-impaired. Occupancy and the area required will be determined by activities proposed at individual sites.

Table 2. DUSEL Education and Outreach Building-Requirements

Infrastructure Element	Above Ground	Below Ground
Dedicated Space		
Lobby/Gathering Area w. public facilities	X	X
Theater	X	
Exhibit Facilities	X	X
Classrooms	X	X
Wet Lab	X	X
Clean Labs	X	

Computer Lab	X	X
Offices	X	X
Shared Facilities		
Auditorium	X	
Conference Rooms	X	X
Housing	X	
People-tracking	X	X
Computing Services	X	X
Machine Shop, Electrical Shop	X	
Ultra pure water	X	
Storage	X	X
Loading dock	X	X
Parking	X	

2.1 Dedicated Space

Lobby/Gathering Area: The visitors and education center will have a pleasant lobby with a reception desk and small store, amenities such as bathrooms and coat racks, etc. and sufficient space to gather a tour group or group of students. On average groups of 20 – 50 might be expected. Middle school students often come in groups of 120 – 160.

Theater: A small theater area for around 25 people can serve as a place to show short introductory videos and project educational media materials. (For large groups, E&O will need access to the lab auditorium.)

Exhibit Facilities: The visitors and education center exhibit floor needs sufficient space for a visitor to gain an understanding of DUSEL science and technology without going underground. This area should be a flexible space where traffic flow, lighting, access to power and CCTV, etc. can be controlled and changed. Underground, places to display posters, artifacts, etc. should be incorporated into the tour route along with places to view working areas.

Classrooms: Up to three flexible classrooms with tables and chairs that can be arranged for more formal lectures, small discussion groups or hands-on activities will meet the needs of audiences ranging from young students to adults. Properly designed and outfitted, one classroom could serve as a library, study area and meeting room.

Wet Labs: One on the surface and one underground will be used for regular lab work, for example making a chemical stock solution. These labs will be used by students, faculty and teachers involved in research experiences, and by students and teachers in other education programs. For example, the below ground wet lab might contain a fume hood, laminar flow hood and anaerobic glove bag. The wet lab may serve as a sampling assembly area.

Clean Labs: These labs, to be used by students, faculty and teachers involved in research experiences, will need to be sized and designed specifically for the science activity they serve, for instance assembling a physics detector or extracting DNA.

Computer Lab: E&O programs will need a dedicated computer lab and servers for a web site and data sets. Participants in research experiences will need access to computers and network systems used by

researchers. Issues of security may require special consideration for some of these systems to be available to "outsiders." A set of at least 30 laptops for summer programs will assure that all students have adequate computer access. E&O will also need a visual media set-up with a variety of media—CCTV, DVD, VHS, remote sensors and cameras etc.—both above and underground.

2.2 Shared Facilities

E&O will need access to such shared campus facilities as an auditorium, conference rooms, and housing. Activities will rely on the lab people-tracking system and computing services as well as ultra pure water in the surface labs. Shop facilities and technical staff will be needed to construct and maintain exhibits. It is also essential that the E&O program have dedicated space in a shared campus facility for storage, both underground and on the surface.

2.3 Dedicated Personnel

E&O representation on the DUSEL's Project Advisory Committee will be necessary to support the laboratory as a multidisciplinary research and education facility and to provide evaluation and assessment of its E&O programs.

Director of Education and Outreach who will administer all of the E&O programs; will report directly to the DUSEL director. The E&O director will need a strong background in both science and education and experience as an effective administrator to manage the scale of the program and work with people from DUSEL, funding agencies, schools, local agencies and other organizations. Someone who is a visionary will be able to guide the program into fruitful directions, and someone who is knowledgeable about successful E&O programs will learn from and apply the best of these programs to the DUSEL program.

Administrative assistant will facilitate the day-to-day tasks of the E&O director and assist program coordinators.

K-12 coordinator will manage the design, development, and implementation of K-12 education programs.

Research experiences coordinator will manage the design, development, and implementation of programs for teachers, undergraduate, graduate students, postdocs, and visiting scientists.

Tour coordinator will manage programs for the general public. With the assistance of research scientists, this person will be responsible for training docents and will need to rely on lab staff to keep exhibits up and running and to provide new research results and projects.

Web developer will create and maintain the E&O web site and work with researchers to provide accurate and timely information on events and science.

2.4 Group Size

Estimates of group size are important to determine the space requirements for dedicated areas as well as in the shared facilities. The ratio of docents to visitors could range from 1:10 to 1:20 depending on who has underground access and what areas the underground access are available to the different audiences. Based on the experience at Fermilab, a middle school group can be up to 160 students. High school, college, and general public groups tend to be much smaller, say from 20 to 40-50. Younger children often

come as a class of 25-30. Two to five research experience programs for undergraduates or for teachers might be running concurrently. Generally, these research programs have 10 mentors, 10 students or teachers and some additional support staff. Thus, it would be entirely possible to have 100 visitors at DUSEL participating in summer programs.

3 Implementation

The NeSS02 report[4] stressed that one of the core missions of a Deep Underground Science and Engineering Laboratory should be to develop and support a venue for accessible activities through which educators, students, and the public can experience and, in some cases, participate in working science research facilities in ways that further their knowledge about, understanding of, and positive attitudes toward science and technology, and that the needs of this program should be addressed at the design stage of the facility. Based on individual site designs, existing infrastructure or facility resources available on- and off-site, it should be anticipated that many educational and public outreach activities will occur before construction begins and will continue once the facilities are constructed and the underground laboratories are in operation. Numerous educational opportunities and activities for DUSEL have been suggested and described in previous studies and reports, such as the NUSL 2001[5], NeSS 2002[4], and EarthLab[6]. The ongoing educational outreach programs, such as Quarknet[7] and EarthScope[8], provide additional ideas.

Evaluation and assessment of science research and E&O projects as defined in NSF guidelines will provide valuable guidance as programs are implemented. This evaluation may be formative or summative. Formative evaluations assess initial and ongoing activities, while summative evaluations assess the impact of a fully implemented project. NSF has provided a handbook on project evaluation for STEM education[9].

4 Conclusion

Both the final report of the International Workshop on Neutrinos and Subterranean Science [NeSS 2002] and the EarthLab Plan [2003] emphasize the unique opportunity a deep underground laboratory presents for developing and fostering a venue for accessible resources in which educators, students, and the public can experience active working-science facilities in ways that advance their knowledge and understanding of science and technology, and change their attitudes toward learning. From the start of the project, coordinated, funded education and outreach infrastructure and efforts are fundamental for the development of integrated programs.

DUSEL will create an exemplary 21st century multidisciplinary teaching, learning, and sharing community for officials, legislators, scientists, students, teachers, and the public. Programs will include formal and informal education for K-12 and junior-college students, and professional development for their teachers. In-reach and exchange activities for undergraduate and graduate students and scientists actively participating in the research will enhance multidisciplinary science and cultural exposure. DUSEL will build educational partnerships with universities, minority-serving institutions, schools, industries, local populations, and other local and national organizations. Increasing diversity in science and education and improving public outreach are critical goals for DUSEL. The possible location of the DUSEL campus(es) in less-developed parts of the country and/or close to Native American communities will enhance the impact of the E&O programs. Outreach to the public will integrate research and education through the use and development of digital media (website, virtual tours, operations and experimentations), visitor center

or museum, on- or near campus housing, and telecommunications to expand remote science education and joint science experiments. Both surface facilities and supervised underground access are essential, and flexibility must be key in DUSEL design and operations to allow for E&O growth and future adjustments as DUSEL develops in decades to come.

Contributors and Working Group Members

Susan Pfiffner (WG Leader), University of Tennessee
Willi Chinowsky (WG co-Leader), University of California at Berkeley and LBNL
Elizabeth Arscott, U. C. Berkeley
Marjorie Bardeen, Fermilab
Sharmila Kamat, Columbia University
Bill Miller, Soudan Underground Laboratory, MN

References

1. DUSEL S-1 Participant Survey Results. 2006. See Appendices for the DUSEL S-1 technical report.

2. National Science Board. 2006. *Science and Engineering Indicators 2006.* Two volumes. Arlington, VA, National Science Foundation (volume 1, NSB 06-01; volume 2, NSB 06-1A).

3. National Academies Committee on Science, Engineering, and Public Policy. 2006. *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future.* Washington, D.C. National Academies Press.

4. NeSS02 Final Report, *Report on Neutrino and Subterranean Science Workshop, September 19–21, 2002,* Washington D.C. www.physics.umd.edu/events/spevents/NeSS02/

5. National Underground Science Laboratory 2001. White papers on Education and Outreach: (1) Educational and Research Opportunities for Young Scientists at the National Underground Science Laboratory, (2) National Underground Science Laboratory Tourism and Visitor Center, (3) K-12 Educational at the National Underground Science Laboratory, and (4) Undergraduate Outreach. http://nucth.physicis.wisc.edu/conferences/white/Homestake.html

6. McPherson, B.J., and the EarthLab Steering Committee, 2003, *EarthLab: A Subterranean Laboratory and Observatory to Study Microbial Life, Fluid Flow, and Rock Deformation,* Geosciences Professional Services, Inc., 60 pp.

7. QuarkNet: quarknet.fnal.gov

8. EarthScope, 2002. *EarthScope An Unprecedented Opportunity for Education and Outreach In the Earth Sciences. Education & Outreach Program Plan.* Geosciences Professional Services. Inc. http://www.earthscope.org/links_pubs/doc2002.php

9. National Science Foundation. 2002. *"The 2002 User-Friendly Handbook for Project Evaluation".* Directorate for Education and Human Resources. Division of Research, Evaluation and Communication, Arlington, VA, National Science Foundation (NSF 02-057).