Content Development Report

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Prepared for: Black Hills State University and the Sanford Center for Science Education

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Introduction

This report summarizes initial content development for the Sanford Center for Science Education (SCSE). The report is intended as a preliminary look at potential topics, audiences and delivery vehicles for the SCSE. The material presented in the following sections is based on the input of local, regional and national experts in science, education and public outreach, including staff from David Heil & Associates, Inc. (DHA), the firm contracted to facilitate content development for the SCSE. Most of the input for this report was gathered during a three-day intensive workshop held in Denver, Colorado January 19-21, 2010.

Following a brief description of the SCSE, the report first outlines potential early organizing themes and core content areas. Next the report describes potential audiences, the key messages that may be appropriate for each audience sector and how learning outcomes might be later defined for specific audiences. The next section identifies content delivery vehicles that show the greatest potential for the SCSE and the audiences the center intends to serve. Finally, the report provides recommendations for next steps in content research, development and evaluation.

BRIEF DESCRIPTION OF THE SANFORD CENTER FOR SCIENCE EDUCATION

The SCSE will be the educational and outreach arm of the Deep Underground Science and Engineering Laboratory (DUSEL), now in the planning phase and scheduled for design and construction through 2015. The Homestake Mine at Lead, South Dakota, currently owned by the South Dakota Science and Technology Authority (SDSTA), has been selected as the potential site for the DUSEL and is planned to be the deepest underground research site in the world.

Throughout this early development phase, the SCSE planning team is linked closely to the rest of the DUSEL design effort, the Sanford Underground Laboratory at Homestake, and Black Hills State University (BHSU). The Sanford Laboratory is already in the process of installing a broad range of experiments at several levels of the Homestake mine from the surface to 4850 feet underground to conduct both important science and engineering research and initial feasibility of the DUSEL project. Black Hills State University is playing a lead role in planning the new science education center, in addition to involvement in both science research and implementation of early science education programs.

The breadth of envisioned research offers rich content for exploration for the SCSE, including areas of physics, astrophysics, biology, geosciences and engineering. An educational and outreach facility has the potential to provide innovative and memorable experiences for the public, students, educators and the scientific research community. Currently the mission of SCSE is to "share the excitement and promise of deep underground science and engineering at Homestake with learners of all ages worldwide." Programming will be designed to draw on the unique expertise of DUSEL researchers, the rich cultural history of the Black Hills, and the geology and ecology of the region. At the time that this initial content development effort was initiated, the following top priorities had been identified for the SCSE:

1. Feature unique science and engineering taking place at DUSEL for teachers, K-12 and undergraduate students, and learners of all ages.
2. Embrace and reflect cultural and historical heritage of the northern Black Hills, with special attention to American Indian audiences.
3. Provide highly memorable and educational experiences, including an underground experience, both physically and virtually.

In addition to an interactive science center at the DUSEL site, the on-site experience is planned to include a signature underground experience for visitors. Based on assumptions provided for this study in November 2009, the facility itself is planned to be approximately 35,000 to 45,000 sq ft, with up to 14,000 sq ft of exhibit space. The facility has also been envisioned to include a Commons shared with DUSEL (not included in the science center square footage), which would house a shared space for visitors and scientists, a cafeteria, and a 300-seat auditorium. The SCSE may include an underground experience for school groups and the general public at a depth of 300 feet (not currently included in the DUSEL scope) and an underground experience for selected audiences at a depth of 4850 feet. Beyond the onsite visitor experiences described above, initial plans for the SCSE call for public programming that will incorporate a broad range of educational approaches, including K-12 teacher professional development, research experiences, camps and classes, and public outreach to local, national and international audiences. This breadth of potential audiences and content delivery vehicles is indicative of the fact that, from its initial inception, the SCSE has been viewed as more than just an interactive science center. As a Center for Science Education, the SCSE will occupy a unique position in the education field – a hybrid, if you will, between a traditional informal learning resource such as a visitor center, science center or museum, and a more formal learning resource for students, educators and scientists with characteristics similar to a university, research institute, or regional professional development service district. When reading the following sections of this report, the reader should keep in mind this broader agenda for the SCSE, and the impact it will have on further content planning, development and delivery.

LOCAL & REGIONAL CONTEXT

The local and regional context for the SCSE will have important implications for the design of both the facilities and programs for the center. The SCSE will be situated in the town of Lead, South Dakota, a short drive from Deadwood, South Dakota, and will reside within the context of the Black Hills, Badlands, and Lakes tourist region of the state. The following sections outline important considerations related to population demographics, the local and regional educational system, and attractions and tourism for this region.

Population Demographics. The estimated 2008 population for Lead was 2,892, and the adjacent town of Deadwood, which is less than five miles away, had an estimated population of 1,283 (with an estimated 900 year-round residents). Both towns are located within Lawrence County, which had an estimated population of 23,524 in 2008 (US Census Bureau, 2008).

The populations of both towns are predominantly white/non-Hispanic (96%, compared to 67% for the US) with a low percentage of households with individuals under 18 years (35% for Lead and 23% for Deadwood, compared to 36% for the US). The percentage of individuals with a Bachelor's degree or higher is 15% for Lead and 18% for Deadwood, compared to 24% for the US (US Census Bureau, 2000). Within Lawrence County, the population is also predominantly white (96%), with 30% of households including individuals under 18 years and 24% of individuals with a Bachelor's degree (US Census Bureau, 2000).

Educational System. There are 13 public school districts within 50 miles of Lead and 11 districts that are greater than 50 miles but less than 100 miles from Lead. In closest proximity to the location of the SCSE are the Lead/Deadwood school district, which serves 840 students in 4 schools; the Spearfish school district, which serves 1,974 students in 4 schools; and the Meade school district, which serves 2,548 students in 13 schools (National Center for Education Statistics [NCES], 2007-2008). For the Lead/Deadwood school district, the dropout rate is 7.1%, and 48.3% of students are eligible for the Free/Reduced Lunch program (NCES, 2007-2008).

Attractions & Tourism. The Homestake Visitor's Center in Lead reported over 40,000 visitors for 2009, and Deadwood is estimated to receive more than 1.5 million visitors annually. Deadwood was designated as a national historic landmark in 1961, and legalization of gambling in Deadwood in 1989 resulted in revitalization and increased development in the city. In addition to the historical and gaming industry attractions in the Lead-Deadwood area, the area includes outdoor attractions: the Mystic Miner and Terry Peak Ski resorts are nearby; and the proposed site of the SCSE is within walking distance of the George S. Mickelson Trail. Also of note is the proximity to the town of Sturgis, which brings an estimated 400,000 visitors to the area in August for the annual Sturgis Motorcycle Rally.

Situated in the Black Hills, Badlands, and Lakes region of South Dakota, Lead is within about 48 miles of the State's biggest tourist attraction, Mount Rushmore, which reported 2,416,870 visitors for 2008 (National Park Service [NPS], 2008). Other major tourist attractions in the area include the Crazy Horse Memorial, Badlands National Park, Wind Cave National Park, Devils Tower National Monument (WY), and Jewel Cave National Monument. The closest national airport is 45 miles from Lead, in Rapid City – the second largest city in South Dakota with a population of 63,997.

SOUTH DAKOTA CONTEXT

In addition to considering factors related to the local and regional context, it is important to take a broader look at the South Dakota context in which the SCSE will reside. The following sections outline important considerations related to population demographics, attractions and tourism, the educational system, and significant scientific research initiatives at the state-level.

Population Demographics. South Dakota has a closely matched urban and rural population split with an urban population of 391,427 and a rural population of 363,417 as reported in the 2000 Census. The state showed a 6.5% increase in population from 2000 for a 2008 estimated total of 804,194. In 2007, the per capita personal income was $33,934 with an unemployment rate of 3% in that same year. The largest cities are Sioux Falls (151,505), Rapid City (63,997), and Aberdeen (24,410) as reported in 2008 (US Census Bureau, 2009).

American Indians make up approximately 8% of the population, and represent the largest minority ethnic group in the state. Major American Indian groups include the Dakota, Lakota, and Nakota people – collectively, the Sioux (South Dakota Governor's Office of Economic Development, 2009).

Attractions & Tourism. Tourism is the second largest industry in the State of South Dakota. Popular visitor destinations include Mount Rushmore National Monument, Crazy Horse Memorial, Badlands National Park, Black Hills National Forest, the Sturgis Motorcycle Rally, Historic Deadwood, the Lewis & Clark Trail, Fort Sisseton Historical Park, and the Laura Ingalls Wilder Homestead (South Dakota Governor's Office of Economic Development, 2009).

Educational System. Approximately 90% of the population of South Dakota has a high school degree, ranking South Dakota 14th in the nation (2006). In comparison to other states in the nation, South Dakota ranks eighth for Math SAT scores; ranks third for Reading SAT scores; ranks sixteenth for ACT scores; and ranks first for students per instructional computer and students per high-speed Internet-connected computer (South Dakota Governor's Office of Economic Development, 2009). For the National Assessment of Educational Progress (NAEP) results, 41% of eighth-graders scored at or above the proficient level in science for South Dakota, compared to 27% for the United States (NAEP, 2005), and 42% scored at or above the proficient level in math, compared to 34% for the US (NAEP, 2009). The state has four major technical institutes, six public universities, eleven private colleges and universities, and three tribal colleges.

Scientific Research Initiatives. According to the South Dakota Governor's Office of Economic Development, becoming a leader in research and technology development is an important goal for the state. Since 2003 the State of South Dakota has allocated over $163 million to these efforts, and between 2004 and 2006, the State legislature established six Research Centers of Excellence on the campuses of the state's public universities. These include: Infectious Disease Research & Vaccinology; Accelerated Applications at the Nanoscale; Light-Activated Materials; Signal Transduction; Bioprocessing Research & Development; and Drought Tolerance Biotechnology. The major research centers include Avera Research Institute, EROS Data Center, Sanford Lab, Sanford Research, and Sun Grant Initiative. More recently an additional center, the Center for Ultra-Low Background Experiments at DUSEL (CUBED), has been established.

South Dakota is designated as an Experimental Program to Stimulate Competitive Research (EPSCoR) state by the National Science Foundation, NASA and other agencies. In 1980, the EPSCoR program was established to assist states in establishing a self-sustaining academic research enterprise with the competitive capability to contribute to the states' economic viability and development. Current goals for South Dakota EPSCoR include: 1) increasing South Dakota's science and technology research capacity; 2) providing educational opportunities for K-12, undergraduate and graduate students; and 3) promoting science-based economic development for the state. The other EPSCoR states in the region include Montana, Nebraska, North Dakota, and Wyoming. South Dakota also has an active Space Grant Consortium supporting mostly undergraduate and some K-12 education across the state.

NATIONAL & INTERNATIONAL CONTEXT

Both the international network of underground laboratories and the broader context of national and international science centers, visitor centers and museums have important implications for the development of the SCSE. There are currently 19 major underground laboratories internationally, providing various degrees of educational outreach related to their scientific agendas. Given their range of experience with educational programming, this group of institutions will be an important network of potential partners and resources for the SCSE.

With its public education agenda, the SCSE will also operate within a broader context of institutions that provide on-site and off-site public programming. Of particular relevance to the SCSE's mission to connect the public to cutting-edge research being conducted by DUSEL scientists, are other research institutions that provide public education programs and services, such as the Department of Energy Laboratories and NASA facilities across the country.

To better understand the landscape of relevant public programming activities for the SCSE, and the audiences potentially served by the SCSE, readers of this report are referred to the complementary report prepared by DHA titled *Market Assessment and Analysis* submitted to the SCSE Education Governing Board on February 4, 2010. This report provides preliminary attendance projections, as well as more detailed comparisons of local, regional, national, and international benchmark institutions.

CONTENT DEVELOPMENT PROCESS TO-DATE

DHA's approach to content development for the SCSE's program and institutional design is both deliberate and inclusive, reflecting the team's roots in science, education and community/stakeholder engagement. To optimize success, such planning requires management of both topical content and the people who creatively work with that content. The process is best accomplished iteratively, evolving over

time as new information is revealed, new planning milestones are set, and additional time and resources are available for further content research, development and evaluation. For this initial phase of SCSE content development DHA has focused on those elements essential to informing NSF reviews scheduled for the Spring and Fall of 2010 and for laying the foundation for more extensive research and development when additional time and resources are available.

DHA team members first met with key BHSU and SCSE/DUSEL personnel to identify an initial team of local and national experts and advisors to contribute to the accelerated timeline for preliminary content development between November 2009 and February 2010, and, potentially, in an on-going capacity later. This select team of individuals, with expertise in science, education and public outreach, were convened in January 2010 for an initial three-day intensive content development workshop to explore the fertile content landscape for the SCSE. The agenda included a brief overview of national and international trends in science, technology, engineering and mathematics (STEM) education; facilitated sessions to identify and prioritize potential SCSE topical themes and core content areas, target audiences, and eventual delivery vehicles for SCSE content; discussions of leading models for content development for both formal and informal education and outreach delivery; and finally suggested next steps for further content research and development. Table 1 lists the participants in this initial content development workshop along with abbreviated references to their credentials and areas of expertise in the field. See Appendix A for more detailed workshop participant biographical sketches.

Table 1: Initial Content Development Workshop Participants

Name	Title/Affiliation	Expertise
Jacquelyn Bolman, Ph.D.	Director, Indian Natural Resource Science & Engineering Program, Humboldt State University	Environmental Science, Educational Administration, STEM Education, Native Community Collaboration & Mentoring
Rodger Bybee, Ph.D.	Executive Director Emeritus, Biological Sciences Curriculum Studies (BSCS); Chair, Science Forum and Science Expert Group, PISA	Biology & Earth Sciences, National Standards, Curriculum Development, Professional Development, National and International Trends in STEM Education
Arthur Eisenkraft, Ph.D.	Director, Center for Science and Mathematics in Context (COSMIC), University of MA; Past President, National Science Teachers Association	Physics, Curriculum Development, Distance Learning, Reaching Under-Represented Audiences
Elizabeth Freer	Project Manager, Oppenheim Lewis, Inc.	Museum Development/Planning, Non-Profit Management, Project Management
David Heil	President, David Heil & Associates, Inc. (DHA); Project Lead, SCSE Content Development	General Science, Science Education, Exhibits & Visitor Experience, Science Center Development, Program & Curriculum Development, Public Outreach, Multi-Media
Mia Jackson	Associate, DHA	Elementary Education, Exhibit & Visitor Experiences, Program & Curriculum Development, Native Community Collaborations, Public Outreach
Stephen Krebsbach, Ph.D.	Associate Professor, Computer Science, Dakota State University; PI for vDUSEL	Computer Science, Virtual Outreach & Education

Scott Lewis	President, Oppenheim Lewis, Inc.	Mechanical Engineering, Facility Construction/Expansion, Cost Estimating & Planning, DUSEL Research Agenda
James Lochner, Ph.D.	Education/Outreach Lead, High Energy Astrophysics Science Archive Research Center (HEASARC), NASA	Physics, Astronomy, Public Outreach
Kasey McCracken	Associate, DHA; Project Lead, SCSE Market Assessment & Analysis	Exhibit & Program Evaluation, Market Research
Peggy Norris, Ph.D.	Deputy Director, Education & Outreach, Sanford Underground Laboratory at Homestake	Nuclear Physics, Research, Public Outreach & Education
Harold Pratt	President, Educational Consultants, Inc.; Past President, National Science Teachers Association	Physical Science, Curriculum Development, Professional Development, Science Standards
Ben Sayler, Ph.D.	Director, Education & Outreach, DUSEL/ Sanford Underground Laboratory at Homestake	Earth & Environmental Science, Teacher Preparation & Professional Development, South Dakota STEM Standards, Curriculum and Instruction
Lauren Seyda	Project Coordinator, DHA	Geography, Program & Curriculum Development, Program & Strategic Planning
Charles Trautmann, Ph.D.	Executive Director, Sciencenter, Ithaca, NY; Adjunct Associate Professor in the School of Civil & Environmental Engineering, Cornell University	Physics, Earth Sciences, Engineering, Exhibit & Program Development, Sustainability, Science Center Development & Management
Susan Van Gundy	Director, Education and Outreach, National Science Digital Library	Earth Sciences, Informal Education/Outreach, STEM Education, Distance Learning, Teacher Education, Research/Education Resources
Chris Wallace	Associate, DHA	Science Center Development & Administration, Exhibit & Visitor Experiences, Community Collaborations, Communications
Gerry Wheeler, Ph.D.	Executive Director Emeritus, National Science Teachers Association, Washington, DC	Physics, Teacher Education and Professional Development, Distance Learning, Strategic Alliances

At the three-day workshop, initial attention was given to the specific content arenas already identified for DUSEL such as particle physics, cosmology/astrophysics, nuclear physics, deep underground geology, biology and engineering. From that starting point, the workshop participants considered additional education and outreach topics and organizing themes that clearly complement the DUSEL research agenda but potentially could lend themselves to a broader long-term impact on student, educator and public audiences. These included such themes as The Nature of Science and Engineering, and the Culture of a Dynamic Scientific Research Community.

In addition to the outcomes from the three-day workshop summarized in this report, DHA also reviewed notes from earlier SCSE content development discussions, lessons learned from early SCSE/DUSEL education and outreach efforts, and the *Market Assessment and Analysis* report mentioned earlier. The DHA team also conducted a preliminary review of South Dakota's Science Content Standards (2005), the National Science Education Standards (1996), and documents describing emerging interests in 21st

Century Workforce Skills (2010) in order to provide an early correlation of potential SCSE content ideas, especially for K-12 student audiences and educators.

Future SCSE content research and development will benefit greatly from additional stakeholder engagement; clarity in the SCSE vision, mission and core values; targeted market research and comprehensive business planning. At this phase, readers of this report should consider the material that follows to be a very early look at potential content, audiences, and delivery vehicles for SCSE education and outreach associated with DUSEL. More detailed content research, development and evaluation should follow at a later time.

Organizing Themes & Core Content Areas

Prior to attending the three-day workshop in January 2010, the invited team of experts in science, education and public outreach were sent a copy of *Deep Science* (2006), a report commissioned by the National Science Foundation (NSF) to document the scientific potential of deep underground science and engineering. This report outlines the exciting research possibilities of a future Deep Underground Science and Engineering Laboratory (DUSEL). The research agenda proposed, and the major science and engineering topics associated with that agenda, provide compelling content for the SCSE and therefore served as a foundation for the group's initial discussions about content development for the SCSE.

DUSEL RESEARCH AGENDA

As pointed out in *Deep Science, "*underground experiments are critical to addressing some of the most compelling problems of modern science and engineering." Underground research environments will also provide a platform for transforming traditional content boundaries, seeking synergy across multiple science and engineering disciplines. The benefits to society are many, and yet these benefits, in order to be understood and acted upon, will need to be illuminated clearly to the public through education and outreach efforts. The authors of the *Deep Science* report outlined four main content areas, each with a complementary roster of key questions driving the research in each area. Table 2 below summarizes these core content areas and the lead questions that define their relevance to deep underground exploration and discovery.

Table 2: DUSEL Research from *Deep Science*

Organizing Theme	Key Questions Driving Research
Underground Universe	What is the universe made of? What is dark matter? What are neutrinos telling us? What happened to the antimatter? Are protons unstable? How did the universe evolve?
Dark Life	How do biology and geology interact to shape the world underground? How does subsurface microbial life evolve in isolation? Did life on earth originate between the surface? Is there life underground as we don't know it?

Organizing Theme	Key Questions Driving Research
The Restless Earth	What are the interactions between the various processes controlling the subsurface environment? Are underground resources of drinking water safe and secure? Can we reliably predict and control earthquakes? Can we make the Earth "transparent" and observe underground processes in action?
Ground Truth	What are the mechanical properties of rock? What lies between the boreholes? How does rock respond to human activity? How does water flow deep underground? How can technology lead to a safer underground?

MAJOR CONTENT THEMES FOR THE SCSE

Following a review of the major research themes associated with DUSEL, the team of content development experts gathered in Denver drew up their own list of compelling themes suitable for the SCSE's education and outreach mission. Table 3 below lists the major content themes identified by this group as showing the greatest potential for education and public outreach content. The items were first brainstormed and then prioritized by asking each participant in the workshop to select their top five themes in rank order from 1-5, with the number one ranked item showing the greatest potential as a content theme for the SCSE.

Table 3: Major SCSE Content Themes

Ranking	Theme
1	Search for the Unknown
1	The Nature of Science
2	Origins of the Universe, Matter, and Energy
3	The Culture of a Scientific Community
4	Science and Engineering Relevant to Humans
5	Adaptation, Biological Evolution, Living in Extreme Environments
6	Earth Dynamics
6	The Nature of Engineering
7	Scale
8	Technology
9	Systems

One significant insight from this exercise is that the resulting top five compelling themes reflect a mix of DUSEL research agenda items (i.e., Search for the Unknown, Origins of the Universe, Living and Evolving in Extreme Environments) and themes that are more broadly focused on the nature and processes of science and engineering and how a scientific community goes about its business of exploration and discovery (i.e., The Nature of Science and Engineering, The Culture of a Scientific Community). This reflects a strong opinion on the part of this particular team of individuals that helping

students, educators and the general public better understand the nature of scientific work will go a long way to increasing their appreciation and on-going interest in that work. Because of its close relationship with a world-class research institution, the SCSE has tremendous potential to be a translator of not only fascinating scientific phenomena and engineering endeavors but also the nature of the scientific process and how the community of scientists and engineers engages in these processes. As will be seen later in this report, these additional, more general themes correspond well with increasing global interest in STEM-related educational goals and the development of workforce skills for the 21st Century. The diversified list above also corresponds well with outcomes from an earlier SCSE planning exercise summarized in the report *Education and Outreach at DUSEL* (Pfiffner et al., 2006). In the Pfiffner report the authors listed the following as SCSE audience outcomes for students, educators and the general public: "Understand and appreciate science and research at a basic level; understand the importance of DUSEL science and research at a basic level and how this laboratory, based in the U.S., and its research projects advance science, have educational and economic benefits, and provide a worldwide interaction."

After further discussion, workshop participants recognized Scale, Technology, and Systems as being cross-thematic in nature, and therefore felt that they should be considered differently from the other top six themes which were more content-oriented. Interestingly, these same three topics are often listed as cross-cutting themes in state science standards documents suggesting that, for K-12 student and educator audiences at least, there may be effective ways to incorporate them into other content areas.

SCSE POTENTIAL CORE CONTENT AREAS

The major content themes, rank ordered in the previous section, were generated following an exercise in which participants in the January 2010 workshop were asked to list topics based on the research categories outlined in *Deep Science*. This section provides the summaries for each core content area. The lists below are, by no means, to be viewed as comprehensive or complete. They are a reflection of expert opinion on what topics might be most intriguing to visitors, students and educators who come in contact with the SCSE, either on-site or via electronic experiences remotely. For the purposes of this report, little discussion or explanation will be provided. This is work for later in the content development process, when these and other content topics are vetted for their relevance to the overall DUSEL science and engineering research agenda, particular audience groups, and the education and outreach goals of the SCSE.

Tables 4-10 below summarize these discussions, with topics arranged in rank order. Ranking was determined by a more simple exercise after each list was generated of having the participants place a star next to the one topic from each of the brainstormed lists that showed the greatest potential for SCSE education and outreach. Items that were not starred by one or more of the participants are simply ranked equally below the grey shading in each of the charts. In addition to Physics and Astrophysics, Biology, Geosciences, and Engineering, the group identified Chemistry topics of interest as well as topics associated with the Black Hills and a number of "other" topics that did not fit specifically into one of the *Deep Science* categories.

Physics. The content areas of Physics and Astrophysics are clearly a primary driving force behind the DUSEL research agenda, and therefore a significant contributor to the SCSE content arena as well. With the remarkable shielding possible in a deep underground cavity, the minute particles of matter that are the focus of modern physics can be detected. Neutrinos, dark matter, and antimatter are all targeted particles for study at DUSEL. From the legacy of Nobel Laureate Ray Davis's original experiments at Homestake Mine to detect cosmic neutrinos, experiments in physics will be a major focus of the research, education and outreach of the SCSE.

Table 4: Core Content Area: Physics

Ranking	Potential Physics Topics
1	Universe structure, composition and evolution (7)
2	Dark matter/energy (4)
3	Neutrinos, other particles (2)
4	Cosmic rays (1)
4	Particle/matter change over time (1)
4	Astrophysics (1)
	Proton decay
	Matter/anti-matter
	Fixing the standard model
	Gravity
	Origin of elements
	Detectors

Life Science. In the 1970s National Geographic introduced the world to life in deep ocean environments through astonishing film footage capturing images of giant tube worms thriving in deep sea thermal vents along the Pacific trench. In the 1980s we discovered that life also exists deep underground, in the absence of the earth's surface atmosphere, light, or the kind of temperatures that we assumed were required of all life "on" earth. Dark life thrives in the extremes of deep underground environments, and while these microorganisms may not be large in size, their impact on earth materials and deep environments may be equally astonishing as the tubeworm colonies of the deep ocean. Geomicrobiology merges the fields of geology, geophysics, hydrology, geochemistry, biochemistry and microbiology to study *how* life in these extreme environments first appeared, adapted and evolved over time. The list below recognizes the most fascinating element of deep life may just be the *how* of their survival. Life in extreme environments and the evolution/adaptation of that life are truly compelling topics for SCSE exploration. Also, the human element to the equation – how can engineering help humans *also* survive and work in these deep underground environments?

Table 5: Core Content Area: Life Sciences

Ranking	Potential Life Science Topics
1	Life in extreme environments (6)
2	Evolution/adaptation (4)
3	Human physiology extremes, health and safety issues (2)
4	Bioremediation
	Water
	Diversity
	Bio-prospecting
	Radiation biology
	Astrobiology
	Biochemistry
	Bio-geo-chemistry

Ranking	Potential Life Science Topics
	Taxonomy
	Psychology of "cavers"

Geosciences. The earth is, by casual visual observations, a very solid mass. And yet, through the actions of geomorphology, heat, water, and those tiny, deep life microorganisms, that solid mass is recognizable as a much more dynamic material. While the processes of earth change may be slow, the evidence of their impact is recorded in the striations of deep earth layers and dissolved materials found deep underground. The list below recognizes that water, of all the materials involved, may be one of the best places to focus SCSE education and outreach interpretation. First, there is the continual pumping of the mine itself. Second, children and adults are familiar with some of the dynamics of water on the earth's surface. So there is relevance and familiarity to start. But earthquakes, mountain building and the formation of gold and other rare minerals will also be likely popular content topics to explore with SCSE visitors.

Table 6: Core Content Area: Geosciences

Ranking	Potential Geoscience Topics
1	Hydrology/aquifers (3)
1	Origins of Earth's magnetic field (3)
2	Earthquakes (2)
2	Geophysics, solid/fluid interaction (2)
3	Gold, rocks and minerals (1)
3	Deformation mechanics (1)
	3D study of earth
	Temperature
	Stability
	Geoneutrinos
	Where does heat come from?
	Planetary science
	Carbon sequestration
	Formation of Black Hills, geomorphology
	Materials science
	Radioactivity (natural)

Engineering. Engineering is not yet common in school standards and curricula, but with the increasing interest in STEM education and 21st Century Skills, the field of engineering will continue to be an emerging focus of K-12 education and an intrigue to the public who live in increasingly engineered environments. Perhaps the most fascinating engineering story associated with DUSEL will be the construction of DUSEL itself. The repurposing of one of the deepest mines in the world to serve science research, the civil and mechanical engineering necessary to accomplish that feat, and the elements of engineered safety and environmental management that allow humans to live and work in deep underground environments are all compelling topics for public audiences.

Table 7: Core Content Area: Engineering

Ranking	Potential Engineering Topics
1	Cavern construction (4)
2	Civil engineering at depth (3)
	Use of deep underground spaces, tunnels
	Safety by design
	Movement of water/materials
	Clean rooms/contaminate control
	Drilling technologies
	Air quality/ventilation
	Environmental
	Safety/evacuation
	Waste management
	Experimental design
	Comparisons between Earth and space exploration and arctic (designing modules)
	Rock mechanics
	Specimen management
	New technologies
	Adaption of existing technologies
	Design and building specifications
	Structural dynamics and maintenance
	IT management
	HVAC (heating, cooling, etc.)

Chemistry. While Chemistry was not singled out as a specific area of research focus in *Deep Science,* it is a topic area that is familiar with the general public and school audiences the world over. For this reason, the expert participants chose to create a separate list of potential chemistry topics for the SCSE. As in the geosciences, water and mineral chemistry will be key, but the chemistry of small particle existence and detection, and environmental chemistry also show potential for public audiences.

Table 8: Core Content Area: Chemistry

Ranking	Potential Chemistry Topics
1	Drinking water (1)
1	Detector chemistry (1)
	Water chemistry
	Mineral extraction
	Mineralization
	Origin of elements
	Environmental chemistry and human impacts, mining legacy
	Cryogenic/hazard materials

The Black Hills. From the very beginning, thoughts about a world class Center for Science Education at DUSEL included discussions about focusing on Black Hills natural and cultural history. The area is rich in science, culture and storytelling, attracting millions of visitors annually. In order to accomplish this successfully, the SCSE will need to reach out broadly to the resident populations of the Black Hills, including the American Indian community, to craft culturally rich, scientifically sound, and transformative messages that merge pride with knowledge, wisdom with discovery, and sense of place with transformation and change. As with the nature of science and the unique opportunities that abound with the deep underground science of DUSEL, this topic area will also be a major draw if done creatively and effectively. No other interpretive center in the region can approach these topics in the same way that the SCSE can. Through strong partnerships with the American Indian community, Tribal Colleges, interpretive staff at other Black Hills area attractions and local practitioners of science and education, the SCSE will be able to craft a robust and memorable addition to the Black Hills experience and story.

Table 9: Core Content Area: Black Hills

Ranking	Potential Black Hills Topics
1	Cultural history, conflicts, perspectives (5)
2	Indigenous science, native ways of knowing (3)
2	Health/environment (3)
3	Formation (2)
4	Storytelling (1)
	Ecology
	Impact of mine
	Legal ownership
	Reclamation
	Geography
	Large tourist attraction, Mount Rushmore
	"Island on the prairie"
	Ethics: old, new
	"We are all related" origin of where we came from
	Spirituality in science
	Communicating the findings, communication vehicles
	Community context

Other Potential Content Topics. After generating topical lists in each of the areas above, there were still a number of topics that experts participating in the January 2010 workshop felt were worth further investigation and possible development. These are listed below. Many of these can be encompassed in two of the major themes - Nature of Science and the Culture of a Community of Science. Yet, topics like scale, measurement, imaging, and extreme values also are of interest and value to the education agenda. Whether each of these topics eventually emerges as a major content emphasis or not is not important at this phase. What is important, to paraphrase two-time Nobel Laureate Linus Pauling, is to have as many good ideas as possible at the beginning of the process in order to end up with a few really great ideas at the end.

Table 10: Core Content Area: Other

Other Potential Topics
Sense of scale
Probability
Why do this type of work?
Scientific processes
Evolution of science knowledge
Extreme values
Unique environments
Measurement, imaging
Modeling vs. actual
What is evidence?
Geography, constellations, Lakota ethno-astronomy
Cultural context
Creative solution finding
Unique/original use of space
Shift from mine to lab
Interactions among science communities
Community connections
Economics, need for resources in this region
Me and my place in all of this

Potential SCSE Audiences

For the purposes of early content development for the SCSE, there were four key audience sectors considered as strong potential audiences for SCSE education and outreach programming. While there will be a certain amount of SCSE content that can be developed at a general level to serve all potential audiences, each of these audience sectors will benefit from some level of differentiated content development and delivery based on industry norms and the specific interests, needs and expectations identified through more targeted market research. In the sections below, each of the four main audience sectors is briefly described and delineated by subsectors, along with an initial listing of possible content appropriate to this audience group as identified by the participants in the initial Content Development workshop.

SCIENTISTS AND ENGINEERS

Scientists make up an important audience group for the SCSE. First, there will be a growing community of scientists directly associated with the DUSEL installation and research agenda. These scientists will be seeking advance knowledge and understanding of DUSEL research topics and projects and the teams of scientists and engineers conducting that research. Once on site they will seek intellectual enrichment and content interpretation suitable for fostering dialogue and sharing among the DUSEL research community

in what will become, over time, a very stimulating and dynamic environment. Eventually the SCSE and the communities of Lead, Deadwood, Sturgis and Spearfish, should look to other research rich communities such as Woods Hole, MA; Friday Harbor, WA; and Cold Spring Harbor, NY to get a sense of the power of such a close knit community deeply engaged and dependent on science. The citizens of such a community, both permanent and temporary, will have high expectations for what their residence and engagement entails. Lead, in particular, will be transformed by the DUSEL installation, and the SCSE should be a partner in both the civic sense and an educational/enrichment sense with Lead to help host and engage the scientific community in the culture of DUSEL at Homestake. These same scientists will also be developing funding proposals to support their DUSEL research, and the SCSE should be in position to serve as their strategic partner for broader public impact and outreach. This will mean working closely with scientist teams in advance of their arrival at DUSEL to design appropriate education and outreach strategies for communicating their research and findings to student, educator and general public audiences, directly through on-site SCSE offerings or more locally to their home institutions and communities through SCSE outreach. Once funded, the SCSE can take the lead on helping guide the research team's contributions to that outreach and ensuring that the educational messages and materials are appropriate for the intended audiences and designed, evaluated, and implemented in such a way as to ensure efficacy and fidelity in the field.

In addition, scientists not directly associated with the DUSEL campus or research experiments will be seeking perspective and insight to the research at a level that is commensurate with their particular expertise and interest. While there will be numerous traditional venues for sharing DUSEL research findings within the larger scientific community, such as publications and conference presentations, it is important to recognize the potential for the SCSE to provide more dynamic content development and delivery on behalf of the scientific community as a whole. These dynamic offerings may range from hosting content specific symposia and conferences to staging more casual "science cafes" which are becoming increasingly popular across the globe as a way for the general public to meet and engage with scientists on a more personal level, or through electronic postings and research summaries written in a more general, non-specialist language for cross-disciplinary education an orientation.

Finally, the SCSE will be looking for ways to engage the scientific community in helping the public better understand and appreciate the work they do in affiliation with DUSEL and their colleagues around the globe. This may mean offering trainings for scientists and graduate students on how to effectively communicate their science to school and public audiences, or recruiting scientists and graduate students to help SCSE staff develop and deliver educational content to students, educators or public audiences.

Potential Science and Engineer Audience Subcategories

I. DUSEL Science and Engineering Teams – Local, National, International
    a. Principal Investigators
    b. Team Scientists/Engineers
    c. Graduate Students
    d. Undergraduate Students
    e. Technical Support Personnel
II. Non-DUSEL or Future DUSEL Scientists and Engineers – Local, National, International
    a. Academic Scientists and Engineers
    b. Corporate Scientists and Engineers
    c. Government Scientists and Engineers
    d. Graduate Students
    e. Undergraduate Students
III. Retired Scientists and Engineers – Local, Regional

EDUCATORS

As a Center for Science Education, the educator community will be a key audience for the SCSE. While K-12 educators will likely make up the largest subgroup in this category, the SCSE and DUSEL will have a unique opportunity to provide STEM-appropriate content and rich professional development experiences for educators from Career and Technical Institutes, Community Colleges, Tribal Colleges, and the informal arena, who work outside formal school settings. In each of these cases, differentiated content development and delivery may be necessary to meet the specific needs and expectations of these professionals. Offerings may include on-going coursework, summer institutes, regional professional development workshops or presentations, and distance learning. In some cases, the SCSE may want to establish local and regional learning communities as an effective way to impact large percentages of the professional educator community in South Dakota through on-going, sustainable professional development that will not only enrich the education field, but will ultimately increase the impact the SCSE has on student populations that these educators serve.

While DUSEL science and engineering will lend itself to many content applications for this audience sector, it may be that the SCSE reaches beyond just DUSEL science content to address broader objectives in STEM education, teacher knowledge, attitudes, skills, practices and performance. In order to be an effective provider in this arena, the SCSE will likely want to partner with public and private education institutions and systems across the region and the nation. Professional associations such as the National Science Teachers Association (NSTA), the American Association of Physics Teachers (AAPT), and the Association of Science and Technology Centers (ASTC) are all probable candidates for strategic alliances and collaboration. In addition, there are a number of colleges and universities that have invested considerable resources in building robust infrastructure for electronic content delivery and distance learning, some of them within the region that the SCSE will serve the most, including North and South Dakota, Wyoming and Montana. Partnering with these educational entities will greatly expand the SCSE's reach to formal and informal educator communities in South Dakota, the nation, and across the globe.

Potential Educator Audience Subcategories

I. K-12 Classroom Educators
   a. Pre-School
   b. Elementary
   c. Middle School
   d. Secondary/High School including Career and Technical Educators
II. College and University Science, Engineering and Education Faculty
   a. Community/Junior College Faculty
   b. Technical Institute Faculty
   c. Tribal College Faculty
   d. University Faculty
III. Informal Educators
   a. Museum Staff
   b. Youth Serving Organizations
IV. Teacher Education Faculty – Local, National, International
   a. Pre-service Faculty
   b. In-service and Graduate Faculty
V. Educational Researchers – Local, National, International
   a. University Faculty
   b. Graduate Students

VI. Other Educator Audience Sectors
    a. Curriculum and Educational Materials Developers
    b. Educator Professional Development Providers

STUDENTS

Students will be a prime audience sector for the SCSE. It is through outreach and education to this audience sector that the SCSE, and DUSEL, will help inspire and cultivate the next generation of scientists and engineers. These future scientists and engineers, through innovation and exploration, will help meet 21st century workforce needs and, in doing so, will also help fuel the economies of South Dakota, the nation and the world.

This is also the primary vehicle for sustainably increasing broader citizen appreciation and understanding of science and engineering over time. Each successive generation that is better informed, more deeply inspired, and more authentically engaged with science and engineering will prove to be better able to analyze, understand and act on issues of national and international importance, including, but clearly not limited to, supporting future investments in science and engineering pursuits.

Reaching out to K-12 students in South Dakota has special meaning and importance for the SCSE. Public and private investment in securing the DUSEL installation in South Dakota has included education as a top priority from the beginning, with the clear intent that the SCSE be a transformative force in education in the state and the nation. This suggests that considerable attention be given to SCSE content development and delivery targeted at students, with a particular focus on American Indian students and students previously underserved in science and engineering.

Potential Student Audience Subcategories

I. K-12 Public and Private School Students
    a. Pre-school
    b. Elementary
    c. Middle School
    d. Secondary/High School
II. Community College, Career & Technical School Students
III. University Students
    a. Science and Engineering Students
    b. Non-Science and Engineering Students
    c. Education Students
IV. School Age Youth Served in Non-School Environments
    a. Homeschooled Students
    b. Students Engaged Through Museums
    c. Students Engaged Through After School Programs
    d. Students Engaged Through Youth Serving Organizations

GENERAL PUBLIC

Based on the *Market Assessment and Analysis* report discussed earlier, this will likely be the largest audience segment for the SCSE. This is primarily due to the impact of local resident and tourist traffic through the SCSE on-site facility and the power of the Internet as a vehicle for increasingly large-scale public outreach. As the education and outreach arm of DUSEL, the SCSE has a wonderful opportunity to leverage the unique added attraction that DUSEL will bring to the region amidst an already well-

established tourist industry associated with other Black Hills attractions. More importantly, the SCSE has an opportunity to introduce thousands of adults, families and seniors to compelling science and engineering through memorable on-site and off-site experiences, including a possible underground experience for select audiences.

While large audience through-put is often the focus when tourist audiences are an enterprise target, in the case of the SCSE, it is more likely that the quality of experience and the uniqueness of offerings will be the hallmarks that distinguish the SCSE from other attractions in the region, as well as other science education entities worldwide. Basically, there is nothing like the potential SCSE/DUSEL enterprise anywhere in the world. So, for this audience segment, scarcity and richly authentic experiences will be the motivator for attendance and/or virtual engagement.

The content developed and delivered for public audiences will range from the science and engineering themes already mentioned above, to more targeted messages for business and civic leaders, political stakeholders, and the media. Collectively, the content and experiences developed for this audience sector may have the greatest overall impact on the region due to the large numbers of potential audience members served, and the broad geographical domain from which these audiences originate and return after their experience in the Black Hills of South Dakota. Through local, regional, national and international media outlets and partnerships with other museums and science centers, the potential reach is truly global in nature and scale.

Potential Public Audience Subcategories

I. Local & Regional Audiences
    a. Resident Adults Without Children
    b. Resident Families with School Age Children
    c. Resident Seniors
    d. Resident Business and Civic Leaders
    e. Media Outlets Serving Local and Regional Audiences
II. Tourist Related Audiences
    a. Adults Without Children
    b. Families with School Age Children
    c. Seniors
III. Tourist Related Business & Industry
    a. Travel Agents
    b. Tour Operators
    c. Hospitality Industry Representatives
    d. Regional Museum and Attraction Personnel
    e. National and International Science Center and Museum Personnel
IV. Other Public Audience Sectors
    a. National and International Media Outlets
    b. Internet Content Developers/ Resource Librarians

PRELIMINARY STRATEGIES FOR REACHING PREVIOUSLY UNDERSERVED AUDIENCES

In order to meet its goals as a transformative educational center of excellence, the SCSE will need to successfully and sustainably serve audiences previously underserved in science and engineering. This will especially be important for rural South Dakota students and families and American Indian students and families throughout the region. While SCSE leadership and staff have existing relationships with

regional American Indian communities through prior projects and contacts, these relationships can, and will need to be, stronger, deeper, and more broadly inclusive in nature.

At the request of the workshop facilitator, one of the workshop participants, Dr. Jacquelyn Bolman, Director of the Indian Natural Resource Science and Engineering Program (INSERP) at Humboldt State University, shared with the group a range of initial considerations that should set the stage for further relationship building and collaborative content development for the SCSE. Dr. Bolman is a native of South Dakota, a member of the Lakota Tribe, and was previously Director of the Scientific Knowledge for Indian Leadership and Learning (SKILL) program at the South Dakota School of Mines. It is imperative that the SCSE expand their efforts in building relationships with American Indian communities in South Dakota, and actively engage leadership from these communities in future planning and development for the SCSE. While the team at DHA has experience facilitating this type of engagement, it is DHA's recommendation that individuals like Dr. Bolman continue to assist in this effort. Proper introductions and meaningful engagement are critical, as are respect and the abilities to listen and process the messages heard. It will be important to work with the DUSEL Cultural Committee, as well as a handful of additional advisors and leaders in the American Indian community to expand early efforts and make considerable progress on involving and honoring native cultures in the development of content and delivery strategies for rural and American Indian populations in the region. Listed below are several strategies identified by Dr. Bolman for guidance at this early stage of planning and development.

- Engagement of elders, leaders and role models within the community is essential for building relationships and trust as partners. This must be deliberate and on-going.
- Resources for learning outside of school, such as computers and printed books, are limited in these communities.
- American Indian families will not likely have the same level of discretionary income to spend on enrichment education as other residents of the area.
- Art and music are important vehicles for expression in this culture.
- Rural and American Indian students will need access to STEM tools if they are to learn STEM skills and abilities.
- Use existing community events to begin introducing the community to SCSE and DUSEL.
- Serving these students and families in their own community is an important first step to more extensive engagement at a location outside of the community.
- Convening Tribal College faculty, K-12 Educators, and Tribal leaders would be a way to nurture consensus and collaboration.
- Incorporating Native ways of knowing, Lakota language, and stories into delivery vehicles will be critical for translating science and engineering to these audiences.
- Recognize and honor the work that American Indian communities are already doing in support of science and engineering education.
- Recruit professional associations like the Society for Advancing Hispanics/Chicanos and Native Americans in Science (SACNAS) and the American Indian Science and Engineering Society (AISES) to assist with national and international outreach to American Indian and other indigenous cultures around the globe.

Key Messages and Potential Learning Outcomes

Participants in the January 2010 Content Development Workshop were asked to consider preliminary key messages for each of the major audience segments outlined above. This exercise was conducted in small groups of 3-4 experts each, with a range of approaches and deliberations. Participants pointed out that it was difficult to elaborate on key messages without first being clear on the overall vision, mission and guiding principles of the SCSE. Those experts with experience in institutional development and

management impressed upon the group the importance of having a clear mission statement that should serve to guide decisions about key messages and intended outcomes. For instance, attendees pointed out that the current mission statement of the SCSE "to share the excitement and promise of deep underground science and engineering at Homestake with learners of all ages worldwide," emphasizes public *appreciation,* when in fact it may be more beneficial to focus the efforts of the SCSE on public *understanding.* Getting better clarification on these types of issues will be a necessary step prior to further development of key messages and learning outcomes for the SCSE.

In this section, preliminary key messages for each audience sector are briefly summarized from the small group discussions at the January 2010 Content Development Workshop. Following these message outlines, the report provides a brief discussion of how learning outcomes might be developed for the SCSE, using a variety of research-based models of practice in both the formal and informal education communities, with a few examples to illustrate their application.

KEY MESSAGES BY AUDIENCE SECTOR

Scientists and Engineers. Key messages for scientists will most likely focus on understanding the basic and applied science and engineering associated with the DUSEL research agenda. In addition, key messages relative to education and outreach (i.e., how to be an effective educator) will also be relevant to this audience sector. Participants in the January 2010 Content Development Workshop identified the following as a partial list of key potential messages for this audience sector:

- DUSEL is uniquely designed and built to facilitate research and experiments dependent on deep underground installations and monitoring.
- Research teams at DUSEL draw from interdisciplinary and multidisciplinary perspectives to plan and implement their research.
- There is a community of scientists and engineers who interact in and around DUSEL and there is a resulting culture and context for their engagement and interaction.
- Translating and communicating science and engineering research and content effectively to student, educator and public audiences can be valuable on multiple fronts.
- The SCSE is uniquely positioned to assist DUSEL scientists and engineers in reaching out to public audiences and can partner with them in accomplishing broader public impact initiatives.
- DUSEL research teams, and the broader community of all scientists and engineers can, by example, help the public better appreciate and understand the nature of science and engineering.

Educators. Many of the messages for the educator community will parallel messages associated with the students they serve. Ultimately, these will be tied to local, state and national standards and the course content they are facilitating for their students. But, there will also be messaging specifically targeted at the education practitioner, especially when conveying dimensions of science and engineering relevant to their own content knowledge, instructional skills and abilities as science and engineering educators. Workshop participants identified the following as a preliminary list of key messages for educators:

- DUSEL is uniquely designed and built to facilitate research and experiments dependent on deep underground installations and monitoring.
- Research teams at DUSEL draw from interdisciplinary and multidisciplinary perspectives to plan and implement their research.
- There is a community of scientists and engineers who interact in and around DUSEL and there is a resulting culture and context for their engagement and interaction.
- DUSEL research teams, and the broader community of all scientists and engineers can, by example, help the public better appreciate and understand the nature of science and engineering.

- The DUSEL research agenda and the major content themes translated by the SCSE are relevant to student learning, addressing state and national standards and educator preparation for facilitating that learning.
- The SCSE, by example, is a model for quality teaching and learning.
- SCSE professional development offerings for educators incorporate both research based content and pedagogy integrated to strengthen content knowledge, best practices, continuous improvement and student learning.

Students. As mentioned earlier, effectively reaching student audiences is a primary goal of the SCSE. Developing key messages and clearly articulated student learning outcomes requires careful research, planning and evaluation. Aligning these messages and learning outcomes to local, state and national standards as well as international benchmarks adds a dimension of fidelity and efficacy often not required of content delivered to other audience sectors. For this reason, it is imperative that the SCSE, as a transformative Center for Science Education and a model for excellence in the field, invest additional resources and attention to the development of key messages and learner outcomes for students. This will be especially important if the SCSE develops its own curricular and teaching materials for classroom implementation.

In general, workshop participants felt that understanding the processes of science and the nature of science and engineering are more important outcomes for students than straight content knowledge. Age appropriateness will also be an important guide for developing key messages and learning outcomes for students and there is a body of research available to help guide decisions about what content to deliver when. Progressively sequencing experiences is one way to encourage on-going engagement and learning throughout the K-12 school years. This is something that works well for school group experiences as well as programs for individuals such as summer camps and classes. Finally, having authentic experiences with science and engineering seemed to resonate the most with the experts gathered for this initial Content Development Workshop, recognizing that this is something that is often hard to accomplish in the classroom and leverages effectively the unique resources and infrastructure available through the SCSE and DUSEL. This may include a better understanding of a "day in the life" of a DUSEL scientist or graduate student; understanding what it takes to conduct research deep underground; or what the environment deep underground is like. In addition, student audiences (as well as teachers and parents) will benefit from STEM career awareness, perhaps best presented through compelling profiles of DUSEL scientists and engineers and the pathways they have taken to end up at DUSEL designing and conducting ground breaking research. Below is a list of some of the potential key messages workshop participants identified for students:

- DUSEL is uniquely designed and built to facilitate research and experiments dependent on deep underground installations and monitoring.
- Research teams at DUSEL draw from interdisciplinary and multidisciplinary perspectives to plan and implement their research.
- There is a community of scientists and engineers who interact in and around DUSEL and there is a resulting culture and context for their engagement and interaction.
- Science and engineering are human endeavors characterized by processes of inquiry and problem solving.
- Scientists and engineers use specialized tools and techniques to conduct their research and collect and analyze their data.
- There are pathways of learning that are accessible and lead to successful careers in science and engineering.

Public. SCSE messages for public audiences should focus primarily on the public's understanding and appreciation of science and engineering, in particular, the science and engineering taking place at DUSEL. That said, the SCSE has a unique opportunity to expose public audiences to a level of engagement with science and engineering that will raise their understanding of more than just science and engineering content. The nature of science and engineering, and the value of investing in basic and applied research in these fields will also be a key message for this audience. Besides messages that attract tourists and resident public audiences to the SCSE, the public's interaction with the SCSE, either on-site or remotely via the Internet, should build a greater appreciation and understanding of the role that DUSEL and the SCSE play in the region as an educational resource as well as an economic driver and a transformative force in science and engineering and in STEM education. Below is an itemized list of some of these key public messages.

- DUSEL's unique design to facilitate deep underground research
- Community and culture of engagement and interaction
- Science and engineering as human endeavors of inquiry and problem solving
- Appreciation and understanding of the nature of science and engineering
- Investments in science and engineering are relevant and benefit individuals and society
- DUSEL and SCSE are valuable resources, popular attractions and economic drivers for local communities and the region
- South Dakota is a leader in science and engineering and in STEM education

PRELIMINARY ALIGNMENT OF SCSE CONTENT WITH STATE AND NATIONAL SCIENCE EDUCATION STANDARDS

As mentioned above, alignment with state and national science education standards is increasingly important if learning experiences are intended for K-12 school age youth. This alignment is most important when an experience is specially designed for school groups to engage in as part of their instructional program. In other words, if a teacher is going to commit to bringing their students to the SCSE, or engage in SCSE content via an on-line interaction or outreach program at their school, then it is important to demonstrate to that teacher that the experience will help them, and their students, satisfy one or more of the standards required at their particular grade level. While alignment is not as critical for learning experiences outside of the regular school day, such as after school programs and summer enrichment experiences, it is increasingly expected that any program offered for school age youth in some way help them learn the content contained in these standards. In order to illustrate the potential alignment of SCSE content with both state and national standards, DHA conducted an initial alignment exercise using the South Dakota Science Standards, the National Science Education Standards, and the most popular version of what are being referred to as 21st Century Workforce Skills. In all three cases, SCSE emerging content addresses one or more of the standards in a particular content area. Perhaps more importantly, because of the nature of DUSEL's integrated approach to science and engineering, the SCSE is uniquely positioned to be one of the few educational enterprises in the nation that is focused more broadly on STEM as opposed to just science. In addition, being physically adjacent to a world-class research operation allows the SCSE to offer school and public audiences a first hand experience with real world STEM integration, along with critical exposure to what 21st Century Skills look like in action. These unique attributes of the SCSE could result in increased funding opportunities and innovative partnerships down the road. As an early exercise in potential alignment this section simply demonstrates that SCSE and DUSEL science and engineering content can and will likely align strongly to state and national standards. That said, it will be important to revisit these standards, and any new or revised standards that are adopted locally or nationally in the next few years, as a part of the more comprehensive content development process.

Table 11: South Dakota Science Standards Relevant to SCSE Emerging Content, Gr. K-12

Core Concept	Subcategory
Nature of Science	Processes of science Nature and origin of scientific knowledge
Physical Science	Interactions of energy and matter Properties and changes of property in objects and materials Transfer of energy
Life Science	Structure and function in living systems Reproduction and heredity Regulation and behavior Populations and ecosystems Diversity and adaptation of organisms
Earth/Space Science	Processes and interactions of the universe, solar system and Earth Structures and processes of Earth systems Principles, composition and structure of the universe
Science, Technology, Environment and Society	Science and technology in society Populations, resources, and environments Personal and public health Invention and innovation

Table 12: National Science Education Standards Relevant to SCSE Emerging Content, Gr. 5-12

Core Concept	Subcategory
Unifying Concepts and Processes	Systems, order, and organization Evidence, models, and explanation Change, constancy, and measurement Evolution and equilibrium Form and function
Science as Inquiry	Abilities necessary to do scientific inquiry Understandings about scientific inquiry
Physical Science	Structure, properties and changes of properties in matter Transfer of energy Structure of atoms
Life Science	Structure and function in living systems Reproduction and heredity Regulation and behavior Populations and ecosystems

Core Concept	Subcategory
	Diversity and adaptations of organisms Matter, energy, and organization in living systems
Earth and Space Science	Structure of the earth system Earth's history Earth in the solar system Energy in the earth's system Geochemical cycles Origin and evolution of the earth system Origin and evolution of the universe
Science and Technology	Abilities of technological design Understandings about science and technology
Science in Personal and Social Perspectives	Personal and community health Populations, resources, and environments Natural hazards Science and technology in society, including in local, national, and global challenges
History and Nature of Science	Science as a human endeavor Nature of science and scientific knowledge History of science

Table 13: 21st Century Skills

Core Concept	Components
Adaptability	Ability and willingness to cope with uncertain, new, and rapidly changing conditions on the job Handling work stress Adapting to different personalities, communication styles, and cultures Physical adaptability to various indoor or outdoor work environments
Complex Communication/ Social Skills	Select key pieces of a complex idea to express in words, sounds, and images, in order to build shared understanding Social perceptiveness Persuasion and negotiation Instructing Service orientation
Non-routine Problem Solving	Narrow the information to reach a diagnosis of the problem Ability to reflect on whether a problem-solving strategy is working and switch to another strategy if the current strategy is not working Creativity to generate new and innovative solutions

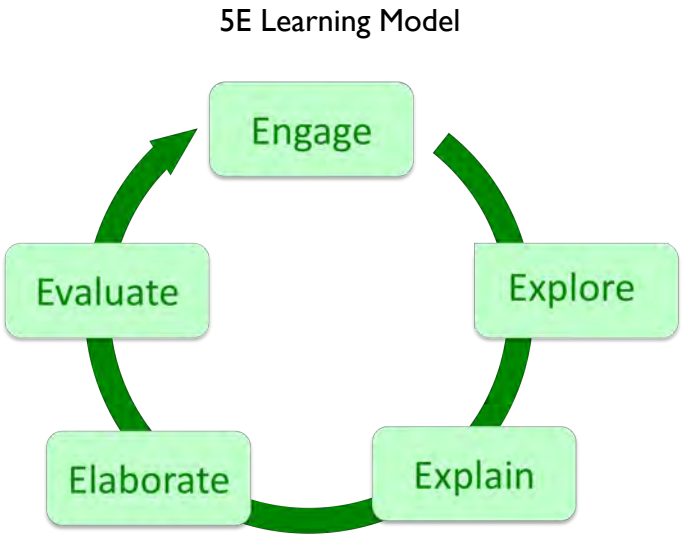
Core Concept	Components
	Integrating seemingly unrelated information Recognize patterns not noticed by novices Knowledge of how the information is linked conceptually
Self-Management/ Self-Development	Ability to work remotely, in virtual teams Ability to work autonomously Self-motivation Self-monitoring Willingness and ability to acquire new information related to work Willingness and ability to acquire new skills related to work
Systems Thinking	Systems analysis Systems decision making

DEVELOPING LEARNING OUTCOMES FOR SCSE TARGET AUDIENCES

Developing specific learning outcomes for the target audiences to be served by the SCSE is an exercise best done later in the planning process. Once more targeted market research has identified audience interests, needs and expectations, and additional stakeholders have contributed to further stages of content development and prioritization, then it will be time to invest time and resources in more specific learning objectives, intended outcomes and strategies for teaching, learning and evaluation. It is important to acknowledge that learning outcomes can be developed following a variety of well established protocols, some of which resonate in both formal and informal educational environments and others that are more commonly used in one or the other setting. At the initial Content Development Workshop held in January 2010, DHA shared a few different models for instructional design and invited two of the national experts to present models that they have authored themselves or successfully used in their work.

The first model, presented by Harold Pratt, was developed by Grant Wiggins and Jay McTighe and is called Backward Design. This approach has become popular in formal education settings where assessments and testing are more prevalent. The basic idea of Backward Design is that rather than beginning the design of a learning experience with the content that you want to convey, then design the lesson or delivery vehicle for that content, an alternative approach is to begin by identifying the desired learning outcome or result, then work backwards to determine acceptable evidence and measures of successful learning, and finally plan the actual lesson or learning experience that will deliver that outcome. Clearly, this approach complements the attention being given today to assessments and testing in K-12 school settings, and it is one of the methods used when designing curricula for implementation in a formal classroom environment.

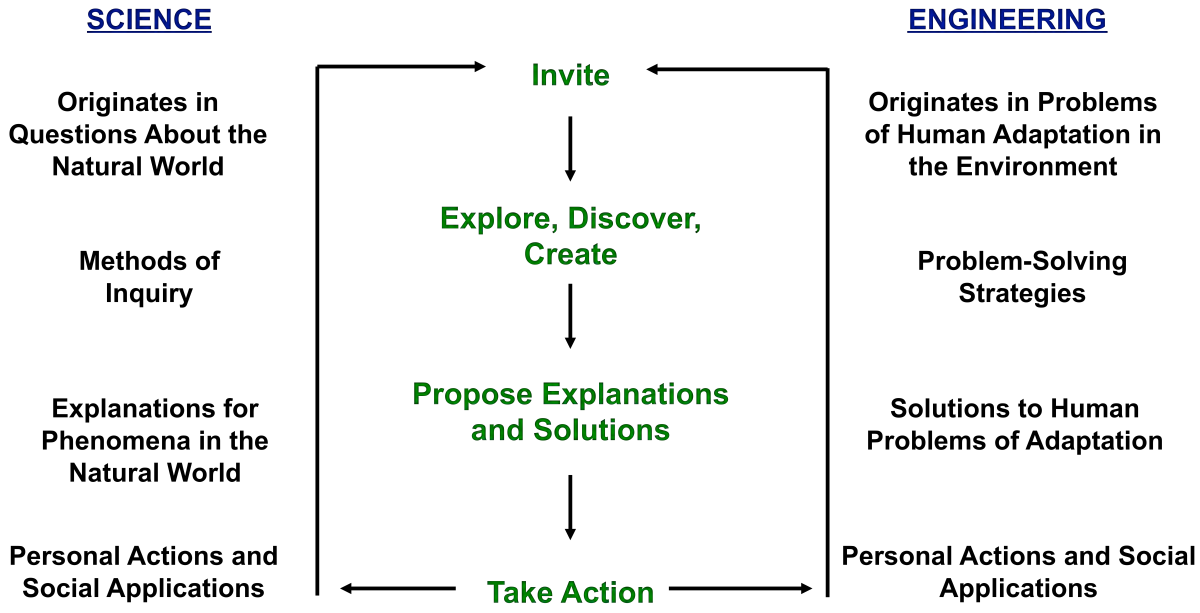
Following a standardized teaching and learning model is another method used to organize and deliver content to students. Rodger Bybee, another expert participant in the workshop, shared a model he created for development of a number of innovative NSF funded curriculum products for K-12 teaching and learning. This model, referred to as the 5E model is illustrated below. In this model, teachers are encouraged to design lessons that first ENGAGE a student to EXPLORE a concept or topic in order to be able to EXPLAIN their observations or understandings. After this middle stage, students are then directed to ELABORATE on their inquiry and finally EVALUATE their learning using an established protocol for assessment. This model has been well received by the education community and is widely adopted and referenced in formal curriculum development and teacher professional development arenas.



Bybee, R. (1997). *Achieving scientific literacy*. Portsmouth, NH: Heinemann.

Finally, David Heil, President of DHA and the author of this report, shared an alternative teaching and learning model that he co-developed with Rodger Bybee and others, originally for a series of publications for the U.S. Department of Education that has been used successfully for both formal and informal teaching and learning design. This model, referred to as the Invitational Learning Model provides two relevant guidelines for SCSE content development. First, it distinguishes Science as originating in questions about the natural world and Engineering (or Technology) as originating in problems of human adaptation in that natural world. This distinction may be helpful to the SCSE content development process where *both* science and engineering content is involved. Second, the learning cycle on the interior of the illustration begins with an INVITATION, something that is easily designed into visitor experiences, exhibits, demonstrations, as well as curricular products. Once a learner has accepted the invitation they are ready to EXPLORE, DISCOVER and CREATE. Again, this step works well for self-guided experiences where materials or resources are made available but little instructional supervision is necessary to facilitate the learning. Next, the learner is ready to EXPLAIN their findings. This may be based on personal observations, experiences, data collection, documented evidence, or emerging understanding of the content explored earlier. Finally, to acknowledge that not all learning ends with a test, the last step in this invitational learning model it to TAKE ACTION with what has been learned. As the outside columns imply, this may result in asking a new question or identifying a new problem stimulating continual learning and refreshing of one's understandings. From this explanation one can see how this invitational learning model can easily be adapted to accommodate content development and delivery for both formal and informal learning experiences.

Invitational Learning Model



Adapted From: Science and Technology for the Elementary Years: Frameworks for Curriculum and Instruction, National Center for Improving Science Education, 1989

In addition to the content design schemes shared above, Mr. Heil also presented to the group definitions of inquiry from the National Research Council's National Science Education Standards (1996) and a definition for Experiential Learning from the work of Pine and Gilmore at Harvard (1999) who have studied the attraction industry and what they call our experience driven economy. All of these models, both theoretical and practical, can help inform and guide future content development for the SCSE.

Scientific Inquiry

"...refers to the diverse ways in which scientists study the natural world and propose explanations based on the evidence derived from their work."

"Inquiry also refers to the activities of students in which they develop knowledge and understanding of scientific ideas, as well as an understanding of how scientists study the natural world."

National Science Education Standards

Experiential Learning

Experiences are memorable events revealed over time that engage individuals in inherently personal ways.

Pine & Gilmore (1999). The Experience Economy, Harvard University Press.

As a way of illustration, brief examples of three potential learning outcomes relevant to DUSEL and the SCSE's education and outreach mission are provided below using a modified Backward Design approach. Each of these examples is drawn from one of the emerging organizing themes for the SCSE and addresses at least one South Dakota or National Science Education Standard. In each of these examples, further development would be necessary to create more comprehensive teaching strategies for content delivery that results in rich visitor learning.

Example #1: Adaptation, Evolution, Living in Extreme Environments

Intended Outcome: *Learners will understand that scientists use evidence to form explanations about scientific phenomena.*

Acceptable Evidence: *Learners select a suitable explanation from a list of possible explanations, based on evidence they have personally collected and interpreted.*

Learning Experience: *Learners observe a variety of organisms living in deep underground environments and determine which adaptations help them survive in that environment.*

Example #2: Origins of the Universe, Matter and Energy

Intended Outcome: *Learners will understand that scientists use models to explain the nature and structure of matter in the universe.*

Acceptable Evidence: *Learners identify acceptable evidence for dark matter, using online data from the Hubble Space Telescope and other sources.*

Learning experience: *Learners explore online simulations and articles using data from the Hubble Space Telescope that explain the observational evidence and possible explanations for dark matter.*

Example #3: Nature of Engineering. Living in Extreme Environments

Intended Outcome: *Learners will understand that Engineers design solutions to problems of human adaptation in natural, but extreme environments.*

Acceptable Evidence: *Learners identify three pieces of safety equipment that scientists must wear or carry with them when they work in DUSEL's underground laboratory environment and the particular protection these items provide humans in that setting.*

Learning Experience: *Learners put on specialized clothing and equipment required to enter the underground laboratory facilities of DUSEL. To better understand the importance of each piece of clothing and equipment, learners will undergo a modified safety training designed to simulate the actual safety training that DUSEL scientists and engineers must complete prior to being allowed to enter the deep underground laboratory environment.*

Potential Content Delivery Vehicles

DHA is keenly aware that the SCSE/DUSEL project will lend itself to a broad range of scientific content and content delivery vehicles. While interactive exhibits installed on-site at the SCSE facility in Lead, SD will be a primary mechanism for translating and interpreting the complex science agenda undertaken at DUSEL, content development will also need to explore non-exhibit based delivery. Innovative programming including camps, classes, institutes for educators and symposia for scientists, resident undergraduate research projects, multimedia and web-based vehicles designed to reach audiences locally, nationally, and internationally should also be explored.

It is anticipated that a deliberate balance of on-site content delivery and innovative visitor experiences associated with the unique installations and infrastructure at DUSEL and a robust roster of off-site outreach and education services will be an important dimension to the long-term sustainability and relevance of the SCSE. It is also important to note that the informal science field itself can benefit from the SCSE's unique assets, innovative programming and affiliations. Impact on the informal science education field and the large audiences they serve around the world may result from the SCSE touring their own exhibits, developing high quality outreach programs delivered through partner organizations,

and professional development for museum and science center professionals offered in South Dakota and elsewhere in the world.

For this report, DHA again used the experts gathered for the January 2010 Content Development Workshop to generate lists of potential content delivery vehicles for the SCSE. When one assembles a group of experienced and enthusiastic educators and museum developers to dream, the ideas are often endless. In fact, it is a well documented pattern in education across the board that organizations with a public service and education mission often have a difficult time focusing, prioritizing resources, and doing only what they do best. Inevitably, educators want to serve *all audiences,* and to do so with *as many creative vehicles* as possible in order to maximize their impact. What we have learned in the planning field is that these professionals need more help winnowing their options down than they do generating options in the first place.

As said earlier, at this stage of the planning process it is valuable to have a wide range of possibilities to research further, test with target markets, build business models around and then return to the task of actually developing the specific content for delivery to specific audiences using deliberate and specific delivery vehicles.

In discussions with the expert group gathered in January 2010, there was strong consensus around a few key content delivery vehicles and visitor experiences. First, the group felt it will be highly valuable to offer on-site visitors to the SCSE *three* different underground experiences, as what they considered to be the hallmark of the SCSE/DUSEL enterprise. For those not interested or willing to actually go underground there should be one or more rich virtual experiences and simulations. These might include dressing up in the safety gear required of actual DUSEL scientific teams that work underground; operating remotely a piece of apparatus actually installed deep underground; or, engaging in a simulated "mission" or team experience where an experiment must be designed, installed and run in an environment that is built to look and feel like the real deal underground.

The next level of underground experience is what the group referred to as *Underground Lite,* to designate a possible walk-in entry and escorted access to the 300L (300 feet below the surface). Limited infrastructure was suggested here, acknowledging the added expense it may bring to the project, but simply having a chance to experience some degree of underground surroundings, conduct a simple experiment, use a monitoring or detecting device has value. The idea here is that this level of experience would be available to fewer in number than the exhibit/simulation/virtual experience, but still provide a significant number of individuals, including possible school groups, with a chance to experience first hand an underground environment.

The third, and most sophisticated version of a deep underground visitor experience would be organized small group access to the 4850L. This experience would be offered to only a select number of individuals and groups, and everyone would have to commit the time and resources necessary to properly train for the experience. Possible audiences for this type of high-end immersive experience include high school and undergraduate students who have completed a semester long unit of study on deep underground science and are ready to actually conduct an experiment at depth, analyze data, and share their results with others; highly select public audiences or families who show a particular affinity to the opportunity and a willingness to plan ahead for the experience; educators in institutes; and graduate and undergraduate students from universities across the nation and the world.

There was also strong consensus that investments in virtual experiences (Virtual DUSEL) be significant enough to create a dynamic and robust suite of experiences, again including but not limited to simulations, remote control of devices, virtual tours of underground facilities and experimental devices, and mechanisms to dialogue/share user experiences with others. This will require cutting edge

programming and graphics, as well as top flight production and design. There are a number of colleges and universities in the region that have invested considerable resources in building robust infrastructure for electronic content delivery and distance learning, including North and South Dakota, Wyoming and Montana. Partnering with these educational entities will greatly expand the SCSE's reach to formal and informal educator communities in the region as well as nationally and internationally. It will also strengthen the SCSE's reputation as a Center for Science Education and a valuable resource for teaching and learning beyond what a typical science center might provide.

With that as an overview, the charts that appear below are rank-ordered summaries of the experts' initial deliberations around potential/possible content delivery vehicles for the SCSE. Further work will be necessary to more deeply research, describe, evaluate and prototype a number of these options. In some cases, the listed items reflect delivery vehicles already being piloted by SCSE and Sanford Lab personnel. These include special on-site Neutrino Day celebrations, teacher workshops, and high school enrichment camps and classes. But, in general, the lists provide readers of this report with a very broad starting point for later consideration.

UNIQUE ON-SITE VISITOR EXPERIENCES

On-site visitor experiences are expected to be part of a host of experiential offerings at the SCSE facilities on the DUSEL campus in Lead, South Dakota. While the ranking provides an initial level of prioritization, more work will need to be done to focus further development and planning.

Table 14: On-Site Visitor Experiences

Ranking	On-Site Visitor Experience
1	Underground visitor experience
2	Interactive exhibits
3	Teacher institutes (pre-service and in-service)
4	Simulated team experimental mission
4	Interpretive theater
5	Access to authentic science
5	Individualized character experience (real or dramatized)
5	Interpreting the DUSEL Laboratory as an exhibit itself
5	Camps, classes for children and families
6	Self-directed dashboard for free choice learning
6	Interaction with docents (students, community volunteers, retired scientists, engineers, and educators, etc.
7	Visitor contributes to actual data collection and analysis
8	Live cams at strategic locations throughout DUSEL
8	Take home
9	Immersive digital interactive
9	Internships for teachers, undergraduates, scientists and informal educators
9	Using art to communicate content
10	Outdoor exhibitry
10	Visual outlooks at strategic locations across DUSEL campus
10	Outdoor trails/interpretive walk

Ranking	On-Site Visitor Experience
11	Cell phone/audio guide of DUSEL campus and/or SCSE exhibits
11	Scientist profiles
11	Object theater
11	Surface guided tours
12	Citizen Science activities
12	Remote operation of underground devices
13	Underground experience only at the 300L; larger number of visitors
13	Visitors role-playing as neutrinos/detectors
13	Video productions
13	Broadcast production, newsroom
13	Access to real DUSEL data
13	Live interaction with DUSEL experiment and scientists
13	Being able to wear underground gear/clothing
13	Elements that reflect the processes of experimentation
13	Interactive digital experience
13	Capture SCSE/DUSEL design, construction story
13	Print materials for schools, universities and home
13	Real time data visualization
13	Living/eco roof
13	Live demonstrations
13	Huge cloud chamber
13	Immersive virtual experience
13	Lectures
13	Symposia
13	Clubs for kids
13	Arrival experience that sets the stage
13	Simulation of underground experience

LOCAL/REGIONAL OFF-SITE PROGRAMS, PRODUCTS AND SERVICES

It is anticipated that the SCSE will also offer a roster of educational outreach programs, products and services to resident populations in the region. Already, there exists a high level of interest on the part of regional museums and science centers, as well as schools, to partner with the SCSE and DUSEL to broaden the reach of these offerings to audiences who make their way to other regional resource facilities.

Table 15: Local Off-Site Visitor Experiences

Ranking	Local Off-Site Visitor Experience
1	Deep partnerships with schools
2	Traveling programs
3	Traveling exhibits hosted by SCSE and/or toured to other sites by SCSE
4	Specialized professional development for K-12 educators, university faculty, scientists
5	Citizen science
5	Exhibits at other regional sites
6	Students designing underground experiments
6	Family events
7	Traveling mini lab van
7	Curriculum materials for K-12 classrooms, university programs
7	Camps/classes for kids
8	Geo-cache on DUSEL campus
8	Science cafes, pub nights in local communities
9	Partnerships with other regional attractions
10	Kiosk at high traffic sites in Black Hills
11	Competition programs for K-12 and/or undergraduate or graduate students
11	Conference sessions
12	Lectures in region – Speaker's Bureau
12	Distributed signage in region
12	Science fairs in South Dakota

NATIONAL/INTERNATIONAL PROGRAMS, PRODUCTS AND SERVICES

Since the DUSEL and the SCSE will draw international attention and laboratory participation, it will be important for the SCSE to also offer educational outreach to audiences outside of the immediate local and regional territory. Clearly, internet based and virtual experiences will help meet this need, but the SCSE should also explore and pursue collaborative arrangements with other organizations and institutions around the globe to deliver innovative outreach services to audiences unable to visit the SCSE in Lead, or hoping to do so in the future. These may include touring exhibits featuring DUSEL science (especially to communities where DUSEL research teams are based); citizen science projects where individuals and groups contribute real time data collection and observation; technology driven engagements with multiple people such as podcasts or webinars; and finally an on-going and deliberate presence at national and international meetings and conferences where the DUSEL/SCSE story can be shared as both an exemplar model for education and outreach and as a deep underground science and engineering resource for the world.

Table 16: Further Off-Site Visitor Experiences

Ranking	Further Off-Site Visitor Experience
1	Independent stand alone virtual experience
2	Dynamic online engagement - push/pull of visitor
3	Traveling exhibits that tour to other science centers and communities
3	Citizen science - national and international engagement
4	Podcasts
5	Presence at national events
6	Presence at other national labs
6	Webinars
7	Links to scientists' hometowns, schools
8	Passport program for underground laboratories
9	Collaborating with Sister labs
10	Student competitions, partner with existing competitions

Recommendations for Next Steps

This report summarizes a broad-spectrum process of expert input and initial prioritization of preliminary content development for the SCSE. Major content themes and potential core content topics in alignment with the emerging DUSEL research agenda as well as local and national science education standards have been identified and prioritized. Potential SCSE audiences have been identified, described, and expanded to subcategory levels to facilitate future target market research and analysis. These audience categories correspond with those identified and explored in more detail in the *Market Assessment and Analysis* report submitted earlier by the DHA team. The report also explores potential key messages for each audience category and demonstrates a range of possible approaches to developing specific learning outcomes for each audience and experience. And finally, the report provides a healthy list of potential content delivery vehicles for the SCSE to further research, develop, prototype and evaluate as part of a more comprehensive process of content development over the next few years.

On the last day of the initial Content Development Workshop in January 2010, expert participants participated in a spirited discussion about next steps in the process. Since some of these individuals have decades of experience in content development and executive level management, it was not surprising that their suggestions ranged beyond the domain of just content development to include what they considered to be more immediate needs in overall SCSE institutional planning and stakeholder engagement. Some of these experts have started museums and Centers for Science Education themselves, and know that laying out the right roadmap, with the right players at the table, at the beginning of a complex planning process is an essential ingredient to both short term and long term success of that project as one journeys down that road. Overall the group was excited and invigorated by the possibilities of the SCSE, and yet cautioned that getting too far out in front of some of what they considered to be early, foundation-building steps could be detrimental to the project over time. Bulleted below is a summary of some of this expert group's suggestions.

- Clarify a unified vision, mission and set of core values for the SCSE before further planning is undertaken
- Engage a broad group of key stakeholders in this unified envisioning process to cultivate strong relationships, ownership and support for the SCSE enterprise going forward

- Clarify the relationships and governing structure between SCSE and DUSEL
- Clarify key stakeholder/investor expectations for the SCSE
- Conduct a comprehensive asset inventory and analysis to know what the SCSE will have in the way of resources
- Conduct front-end research on audience and stakeholder interests, needs and expectations
- Complete a comprehensive, strategic business planning process – engaging key stakeholders in this effort as well
- Identify, obtain agreement among key staff and stakeholders, and communicate to others what SCSE success will look like and how it will be achieved

PRELIMINARY RECOMMENDATIONS

Recommendation 1: Engage Key Stakeholders and Experts in Developing a Unified Vision and Mission for the SCSE Before Proceeding with Further Content Development Work

As the team of experts pointed out above, there are a number of significant and essential planning steps that should be taken now to ensure long term SCSE success as an exemplary Center for Science Education. It is important to note, these immediate next steps do not include further content development. The development team at DHA concurs for a number of reasons. First, the steps outlined above represent a well-established, and broadly practiced process in the field for the creation and validation of a new pubic service enterprise. Second, with limited resources available for planning at this stage, it is imperative that the SCSE dedicate what funds it has to create a unifying vision and mission for the organization and engage a broad spectrum of key stakeholders in that envisioning process. Finally, this exercise will go a long way toward defining for the world who the SCSE is, what it intends to accomplish, and how it will go about that endeavor. In other words, the outcomes from this work will help focus and streamline future content development and evaluation.

Recommendation 2: Conduct Targeted Market Research

Again, drawing from the expert opinions of the workshop participant group, DHA recommends that the SCSE initiate more targeted market research at this phase of the process. Again, this should be done immediately, and ahead of further content development for two key reasons. First, it is important that the SCSE understands and values target market interests, needs and expectations early on in the content planning process. This will ensure that the eventual products from that planning process are designed to address those interests and needs and meet those expectations. Second, for some key market sectors there are only certain windows of opportunity to engage them in providing meaningful input. For school age youth, educators and university personnel, the ideal window is now. Over the next 2-3 months surveys and focus groups should be conducted with these audience sectors before the 2010 academic year comes to a close. Following research on the school market sector, local and regional resident populations; business, civic and government leaders; and tourist sectors should be researched fully. Again, there is a rather tight window of time from the late spring through mid-summer to capture this data and use it effectively to test early assumptions and ideas generated in the initial Content Development Workshop, inform further facility and content planning and prepare for reporting more specifically on SCSE/DUSEL education and outreach strategies to the NSF in the fall of 2010 and the National Science Board in early 2011.

Recommendation 3: Comprehensive Business Planning

As a third acknowledgement of the input from the expert panel at the initial Content Development Workshop in January 2010, SCSE comprehensive business planning should also be completed prior to investing additional time and resources in more extensive content development for the SCSE. As a part of

this comprehensive business planning process, SCSE content, and delivery vehicles for that content, will be more deeply analyzed relative to market insights, cost/benefit, and the SCSE's capacity to undertake full development and delivery. After this level of analysis and planning then the SCSE will be positioned to efficiently and effectively return to content development and evaluation.

Recommendation 4: Develop Criteria for On-Going Content Selection and Prioritization

Another exercise that DHA facilitated at the end of the Content Development Workshop in January 2010 was to ask workshop participants to think about appropriate criteria for future content identification, selection, and prioritization. Bulleted below are a few highlights from this discussion. DHA recommends that this set of criteria be further refined and approved prior to revisiting the extensive lists of potential content areas as well as delivery vehicle options. As a tool to drive informed decision and efficient use of future resources, this set of criteria will help the SCSE and any future consultants and advisors secured by the SCSE to invest wisely and appropriately on future content development and delivery.

- Is the science and engineering accurate and evidence based?
- Is the educational pedagogy research based, and does it represent best practices?
- Is there a documented interest, need or expectation met by this content?
- Does the content contribute to the SCSE actualizing their vision, mission and business model?
- Does the content meet SCSE cost/benefit standards?
- Does the content effectively reach the target market segment and optimize the intended impact?
- Does the content contribute meaningfully to a coherent DUSEL/SCSE content story?
- Does the content reflect or contribute to a strategic alliance or partnership relationship within the community?
- Is the content and content delivery vehicle easily updated to stay current and fresh?
- Is the content developmentally and culturally appropriate for the target audience?
- Can the content and delivery vehicle be scaled for larger dissemination and impact?

Recommendation 5: Leverage Initial Content Experts, and Expand Stakeholder Pool for SCSE Institutional Planning and Future Content Development

The group of content experts and advisors selected to participate in the initial Content Development Workshop in January 2010 are keenly excited and energized by the SCSE project. They are also well informed by their engagement in this initial effort. DHA plans to tap this group's expertise again for future content development and assistance as well as on some of the institutional planning steps outlined above and in the report *Market Assessment and Analysis,* submitted earlier by DHA. Because the SCSE has a relatively small Board and staff at this point in time, it will be important to tap additional outside expertise to help broaden the experience and input to the planning processes ahead. DHA has relevant experience identifying and facilitating diverse, talented groups of professionals to actively contribute to complex planning processes. From Board experience, to executive leadership experience, to institutional development experience and content development experience, this is a group of aware, informed and committed professionals for the SCSE. They can chair small content development teams, review content proposals and drafts, assist in testing ideas at their own institutions, and provide strategic introductions to additional potential SCSE stakeholders, investors and partners. In addition, it is imperative, as mentioned above, that the SCSE expand the pool of stakeholders engaged in all levels and phases of future planning. This includes civic and business leaders, American Indian elders and leaders, University leaders, Educational leaders, and leadership from the science and engineering communities planning for DUSEL.

Recommendation 6: Proposed Approach for Future Content Evaluation and Validation

Content evaluation should include both front-end evaluation to test ideas for key messages and delivery vehicles with potential audiences, and formative evaluation to provide on-going input from audiences during the development of exhibits; digital media; unique on-site visitor experiences; and educational and outreach programs, products, and services. The evaluation team at DHA is prepared to work with the project development and planning teams throughout each phase of the project to design and conduct an evaluation plan that meets each team's immediate and long-term needs (a utilization-focused evaluation approach). This process is often best facilitated through the development of a logic model or theory of action that visually describes the short-, intermediate-, and long-term outcomes related to the delivery vehicle(s), so that the evaluator and the project team are clear on the goals and objectives related to a given set up of exhibits or programs and have instruments and methodologies that serve as a framework for the evaluation implementation.

Front-End Evaluation. Front-end evaluation provides an opportunity to test early content themes, key messages, and ideas for delivery vehicles. Examples of questions that should be addressed by the front-end evaluation include:

- What types of on-site visitor experiences are most appealing to potential audience groups such as educators, students, local/regional audiences, national and international audiences, and tourists?
- How do the key messages resonate with the potential audience groups?
- What gaps exist in current programs and services for local and regional audiences, and how do the range of proposed programs and services address these gaps?

Formative Evaluation. Formative evaluation provides an opportunity to check-in with potential audiences while content and delivery vehicles are under development, using prototypes or pilot programs and activities. Examples of questions that should be addressed through formative evaluation include:

- Do the experiences support the achievement of the intended learning outcomes?
- What elements of the experience best support learning and what elements are confusing to audiences?
- How do audiences engage in the experiences (e.g., do interactive exhibits support multiple points of entry for diverse audiences)?

Front-end and formative evaluation are best supported through a mixed methods approach that uses qualitative and quantitative data to obtain input from multiple informant groups. It is often useful to gather quantitative data from a large group of respondents (using a survey tool) and then to gather qualitative data from a subset of this group, using focus groups or structured interviews to provide more in-depth exploration of the themes that emerged from the quantitative data collection strategy (a sequential evaluation approach).

Timely reporting will be essential for front-end and formative evaluation to support the development of SCSE content and content delivery vehicles. In some cases it may be most useful to utilize informal feedback reports, presentation slides, or project team debriefings to summarize findings and present recommendations, rather than produce formal reports that require greater production time. During each phase of the planning process it is essential that the evaluation approach ensure that all data collection, analysis, and reporting efforts are tailored to support on-going development of the SCSE enterprise.

DHA has extensive experience in visitor experience, exhibit, and education and outreach program evaluation. Working in concert with planning and development teams, the evaluation staff at DHA will help ensure that the SCSE has the information they need, when they need it, and in a format that suits their needs at each stage of the planning and development process.

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Appendices

APPENDIX A: INITIAL CONTENT DEVELOPMENT WORKSHOP PARTICIPANT BIOGRAPHIES

Jacquelyn Bolman, Ph.D.
Director, Indian Natural Resource Science and Engineering Program (INRSEP)
Humbolt State University

Dr. Bolman grew up on a family ranch in rural South Dakota near the town of Chamberlain. A Lakota Sioux by heritage, her current work incorporates native ways of knowing and understanding the environment with a wide range of scientific disciplines including physical, chemical, and biological interactions. She began her career as a curriculum development and training specialist with the Aberdeen Area Tribal Chairmen's Health Board, which worked to improve services for Indian people living in South Dakota, North Dakota, Iowa and Nebraska. While her research at this time focused on alcohol-related issues, she continually noticed the connection between a healthy environment and the health of the people living in that environment. This led to advance degree work in environmental science and education. After a long tenure at the South Dakota School of Mines and Technology serving as Director of the Scientific Knowledge for Indian Leadership and Learning (SKILL) program as well as Director of Multicultural Affairs and Special Projects Manager for the NASA South Dakota Space Grant program, Dr. Bolman moved to her current position in California. The INRSEP Program supports North American indigenous students pursuing higher education degrees in Science, Technology, Engineering and Mathematics (STEM), providing academic and cultural counseling and mentoring to help students integrate the working knowledge of Indian communities with Western Science and ensure a culturally strong Native scientific workforce. Dr. Bolman earned undergraduate degrees in Psychology and Allied Health Sciences and a Masters Degree in Educational Psychology and Counseling from the University of South Dakota before returning to the University to complete a Ph.D. in Environmental Science and Educational Administration.

Rodger Bybee, Ph.D.
Executive Director, (Emeritus) Biological Sciences Committee Study (BSCS)

Dr. Bybee is one of the nation's leading science education scholars and has been an active leader in the development and implementation of national and state-level science standards. Most recently he served for eight years as Executive Director of the Biological Sciences Curriculum Study (BSCS), a non-profit organization that develops curriculum materials, provides professional development, and conducts research and evaluation for the science education community. Prior to joining BSCS, he was Executive Director of the National Research Council's Center for Science, Mathematics, and Engineering Education (CSMEE), in Washington, DC. Between 1985 and 1995 he was Associate Director of BSCS, and from 1972 to 1985 Dr. Bybee was a Professor of Education at Carleton College in Northfield, Minnesota. Dr. Bybee was a leader in the development of the National Science Education Standards. From 1993-1995, he chaired the content working group of that National Research Council project. At BSCS, he was principal investigator for five National Science Foundation (NSF) programs including elementary, middle school, high school and college-level instructional materials development. His work at BSCS also included serving as a principal investigator for programs to develop curriculum frameworks for teaching about the history and nature of science and technology and curriculum reform based on national standards. Dr. Bybee has served as Chair of the Science Forum for PISA 2006 Science and Chair of the Science Expert Group for that prestigious international entity. Dr. Bybee has written widely, publishing in both education and psychology. He is co-author of a leading textbook titled *Teaching Secondary School Science: Strategies for Developing Scientific Literacy*. His recent books include *Achieving Scientific Literacy: From Purposes to Practices* and *Learning Science and the Science of Learning*. Over the years, he has received numerous awards including the National Science Teachers Association (NSTA) Distinguished

Service to Science Education Award, the American Institute of Biological Science First Annual AIBS Education Award, the Keystone Center Keystone Leadership in Education Award, and the University of Northern Colorado recognized him as the Outstanding Alumni for 2006. In 2007, Dr. Bybee was the first recipient of the Public Understanding of Technology Award presented by the International Technology Education Association (ITEA). And most recently, Dr. Bybee was presented the National Science Teachers Association's (NSTA) most prestigious award, the Robert H. Carleton Award. Dr. Bybee earned B.A. and M.A. degrees from the University of Northern Colorado and a Ph.D. from New York University.

Arthur Eisenkraft, Ph.D.
Distinguished Professor of Science Education and Director,
Center of Science and Math in Context (COSMIC), University of Massachusetts

Arthur began his teaching career in Nepal while serving in the Peace Corps. After 25 years teaching high school Physics, he accepted his current position at the University of Massachusetts. While teaching at the high school level, Dr. Eisenkraft became interested in science competitions, serving as Executive Director of the XXIV International Physics Olympiad; Creator and Director of the NYNEX Awards and the prestigious Toshiba Exploravision Awards, Chair of the Duracell Science Scholarship Competition, and the originator of the Toyota Tapestry Awards. He is also the author of the popular NSF funded physics curriculum, *Active Physics*, and is leading a similar project in chemistry. Dr. Eisenkraft is a fellow of the American Association for the Advancement of Science (AAAS), a past President of the National Science Teachers Association (NSTA), and has been recognized with numerous awards including the American Association of Physics Teachers Distinguished Service Citation and Excellence in Pre-College Teaching Awards as well as a Presidential Award for Excellence in Science Teaching and the 1991 Outstanding Science Teacher of the Year Award in Disney's American Teacher Awards Program. Dr. Eisenkraft earned both B.S. and M.S. degrees from SUNY, and a Ph.D. in Science Education from New York University.

Elizabeth Freer
Project Manager
Oppenheim Lewis, Inc.

Elizabeth Freer currently provides project management for the Deep Underground Science and Engineering Laboratory (DUSEL) and the Sanford Center for Science Education (SCSE) in Lead, South Dakota. She is providing similar services to the San Francisco Botanical Garden. Other recent work includes development of the architectural program for the Miami Science Museum, Content Development and program for the International Museum of Women, and managing relocation of the San Francisco Conservatory of Music. Prior to joining Oppenheim Lewis in 2004, Elizabeth was a Project Coordinator at the Cleveland Museum of Art. She holds a B.A. in Art History from Case Western Reserve University and a Certificate in Non-Profit Management.

David Heil
President
David Heil & Associates, Inc.

David Heil, President of David Heil & Associates, Inc., is well known throughout the country as an innovative science educator, new enterprise developer, lecturer, author and host of the Emmy Award-winning PBS science series, *Newton's Apple*. He was the lead author on the award-winning program *Discover The Wonder*, which for five years running was the #1 selling elementary science curriculum in America. He is also the editor of the popular book *Family Science*, is working on a new publication titled *Family Engineering*, and is frequently invited to speak at conferences and public events on science, technology engineering and mathematics (STEM) education and the rewards of experiential learning. Prior to establishing DHA, David was affiliated with the Oregon Museum of Science & Industry (OMSI)

for 13 years, serving as associate director from 1988–1996. While at OMSI, David initiated and administered many of the museum's nationally recognized education and outreach programs, and also developed hands-on exhibits for national tour. David has also taught science and enrichment programs in grades 7-12, conducted research in plant biochemistry and radiochemistry, and worked for five years with the U.S. Fish and Wildlife Service. A native Oregonian, he is active in numerous scientific and educational organizations nationwide, is the past Director of Informal Science Education for the National Science Teachers Association (NSTA), served on the Board of Directors of the Biological Sciences Curriculum Study (BSCS), the Keystone Center, and currently serves as the Senior Science Advisor for the Council of Chief State School Officers (CCSSO) and on the Board of Directors for the Aspen Science Center. In 2009 David received NSTA's award for Distinguished Service to Science Education. Under contract with Black Hills University, David is leading the DHA team responsible for content development for the Sanford Center for science education and will be the lead facilitator for this initial workshop.

Mia Jackson
Staff Associate
David Heil & Associates, Inc.

Mia Jackson specializes in program and exhibit development, project management, and evaluation with an emphasis on public outreach. At DHA, Mia is managing development of the Family Engineering publication and has also focused on the development of young learner resources such as curriculum kits and exhibit areas. Prior to joining DHA, Mia worked for a range of non-profit organizations including the Greater Seattle Chamber of Commerce, Partners In Public Education, the Alaska Bar Association, and the Alaska Dance Theatre where she taught ballet. In 1995, she began working for the Imaginarium in Anchorage, Alaska. From 1997-2003, she served as Director of Programs and Exhibits at the Imaginarium where she spearheaded significant growth and expansion of their offerings, including the launch of their nationally recognized statewide outreach efforts in science and public health. Trained in Elementary Education, Mia has been active in a variety of local, state and national educational initiatives, including serving as Affiliate Director of the Alaska Space Grant program and Chair of the National Educational Outreach Network (NEON).

Stephen Krebsbach, Ph.D.
Associate Professor
Dakota State University

Dr. Krebsbach has been teaching Computer Science at Dakota State University since 2000, following similar positions at South Dakota State University and North Dakota State University. He has been involved in early planning for the Sanford Center for Science Education (SCSE) and is the Team Leader for Virtual Dusel (vDUSEL) a component of the SCSE's education and outreach agenda. Stephen is a member and past President of South Dakota's Information Technology Discipline Council and has also provided workshops and training for K-12 technology educators and advance placement coordinators across the state. Dr. Krebsbach earned B.S. and M.S. degrees from Moorhead State University and a Ph.D. from North Dakota State University, all in Computer Science.

Scott Lewis
President
Oppenheim Lewis, Inc.

Scott Lewis is President of Oppenheim Lewis, Inc., a full service project management and cost-consulting firm founded in 1984 with a focus on non-profit cultural institutions. Currently, the firm is preparing a Project Development Plan and providing project management and cost estimating for the Deep Underground Science and Engineering Laboratory (DUSEL), and the Sanford Center for Science Education (SCSE) in Lead, South Dakota. They are also providing similar services for an expansion project at the Miami Science Museum in Miami, Florida. Mr. Lewis has been involved in developing

approach and scope for sustainable design and environmentally responsible construction projects such as the Exploratorium of San Francisco, California and the Gulf of Maine Research Institute in Portland, Maine. Scott holds a B.S. in Mechanical Engineering.

James (Jim) Lochner, Ph.D.
Education/Public Outreach Lead and Associate Research Scientist
Universities Space Research Association
NASA/Goddard Space Flight Center

Dr. Lochner leads the education/public outreach efforts for NASA's High Energy Astrophysics Science Archive Research Center (HEASARC), which includes the continuity development of the Imagine the Universe! web site and related educational materials. He develops and frequently presents workshops about high-energy astronomy and NASA educational resources to educators. He is also active in NASA's Education Ecosystem, serving as a consultant to education forums for the Sun-Earth connection and Structure and Evolution of the universe. He previously served as a support research astronomer for the Rossi X-ray Timing Explorer's Guest Observer Facility where he assisted in the development of the RXTE Learning Center. Dr. Lochner earned a B.S. in Astronomy from Villanova University and an M.S. and Ph.D. in Physics from the University of Maryland. Jim joined NASA following a two-year post-doctoral position at Los Alamos National Laboratory in New Mexico.

Kasey McCracken
Staff Associate
David Heil & Associates, Inc.

Kasey McCracken specializes in both internal and external evaluation at DHA. Using both qualitative and quantitative methodologies she plans and conducts baseline, formative, and summative evaluations as well as market research studies for a variety of non-profit entities, corporations, and government agencies, including the National Science Teachers Association, the Washington State Board of Education, and NSF and NIH-funded projects across the U.S. Prior to joining DHA, Kasey was an evaluation analyst for the Austin Independent School District (AISD) where she supported a variety of Department of Education-funded initiatives, including AISD's after-school program. As an independent evaluation consultant, she served a range of clients, including the Virginia Department of Mental Health, Mental Retardation, and Substance Abuse Services; the Partnership for People with Disabilities at Virginia Commonwealth University; and the Portsmouth (VA) Community Services Board. Kasey holds an MPH from the Johns Hopkins School of Public Health and a BA in Biology and Anthropology from the University of Pennsylvania. Under contract with Black Hills State University, Kasey is leading the DHA team conducting an initial market assessment and analysis for the Sanford Center for Science Education.

Margaret (Peggy) Norris, Ph.D.
Deputy Director of Education
Sanford Underground Laboratory at Homestake

Dr. Norris came to South Dakota in 2009 to help develop and deliver a range of early education and outreach programs in conjunction with the Sanford Underground Laboratory, the Deep Underground Science and Engineering Laboratory (DUSEL) and the Sanford Center for Science Education (SCSE). Prior to her arrival in South Dakota, she was affiliated with the Lawrence Berkeley National Laboratory (LBNL), a major DUSEL partner, for twenty three years, first with the Accelerator and Fusion Research Division (1983-1993), and then as a Research Coordinator for the 88-Inch Cyclotron, Nuclear Science Division (1993-2008). A fellow of the American Physical Society (APS), Peggy has been an active leader in the APS's forum on education (serving as Chair from 2006-2009) and the APS Committee on Education (2005-2008). Dr. Norris earned a B.S. from Rice University and an M.A. and Ph.D. from Columbia University in Chemical Physics. She began her career at Berkeley with Postdoctoral

appointments in Nuclear Science at Lawrence Livermore Labs (1981-1983) and Lawrence Berkeley Labs (1983-1985).

Harold Pratt
President
Science Curriculum, Inc.

Harold Pratt is a private consultant working in all areas of science education and recently completed a three-year term as a Disciplinary Literacy Fellow in Science at the Learning Research and Development Center at the University of Pittsburgh, in addition to serving as President of Science Curriculum Inc., the publishers of *Introductory Physical Science* and *Force Motion and Energy*. From 1996-1999, he was the Director of Science Projects in the Center for Science, Mathematics, and Engineering Education at the National Research Council (NRC). He has had extensive administrative and curriculum development experience at the local and national levels and served from 1997-1999 as a Senior Program Officer at the NRC for the National Science Education Standards Project. From 1986 to 1991, he was the Executive Director of Curriculum for the Jefferson County (CO) Public Schools, the largest district in Colorado with an enrollment of over 80,000 students. Prior to that, he served the district as the Science Coordinator for twenty three years. He has co-authored or directed the development of three science textbooks, a book on educational leadership, and published numerous articles and book chapters. He is a Fellow of the American Association for the Advancement of Science, and was selected by the National Science Education Leadership Association (formerly the National Science Supervisors Association) as the first recipient of the Nation's Outstanding Science Supervisor Award. He was president of the National Science Teachers Association (NSTA) from 2001-2002. NSTA honored him with the Distinguished Service to Science Education Award in 1999 and their highest recognition, The Carlton Award in 2005. In December 2005, he received the Susan Loucks-Horsley Award from the National Staff Development Council. Mr. Pratt earned a B.S. in Chemistry from Phillips University and an MAT from Brown University.

Ben Sayler, Ph.D.
Director of Education & Outreach, DUSEL/Sanford Underground Laboratory at Homestake
Professor, Physical Science and Mathematics, Black Hills State University (BHSU)

Dr. Sayler has been actively engaged in development of the Deep Underground Science and Engineering Laboratory (DUSEL) and the Sanford Center for Science Education (SCSE) since 2001. From 1999-2010, he served as Director of the South Dakota Center for the Advancement of Mathematics and Science Education (CAMSE) at BHSU where he attracted regional and national funding for a range of Science, Technology, Engineering and Mathematics (STEM) education initiatives including two EPSCoR Research Infrastructure Improvement Grants (2006-2009; 2009-2014), an NSF-funded local systemic change initiative (1999-2008), and an NSF Math and Science Partnership (2002-2010). In addition to his academic work, Ben serves on the Board of Directors of the Spearfish Foundation For Public Education and as an Advisory Board Member for the Homestake Adams Research and Cultural Center. Dr. Sayler earned B.S. and M.S. degrees in Geology and Geophysics from Yale University, and an M.S. and Ph.D. in Atmospheric Sciences from the University of Washington. Following a postdoctoral fellowship in STEM education, Ben came to BHSU in 1999.

Lauren Seyda
Project Coordinator
David Heil & Associates, Inc.

Lauren Seyda supports a range of projects at DHA primarily focusing on environmental science, curriculum development, organizational business planning and facilitation, and document layout and design. Recent projects include reports and plans for the Washington State Board of Education, the Pacific Science Center in Seattle, WA, and place-based curriculum materials for the National Oceanic and

Atmospheric Administration in Monterey Bay. Lauren previously worked for several governmental agencies, including the Bureau of Land Management in California, Washington State Department of Fish & Wildlife, and the United States Fish & Wildlife Service. Her diverse environmental experience includes geography, botany, horticulture, fish and wildlife biology, geomorphology, environmental education and public outreach. Lauren holds a BA degree in Geography and Environmental Resource Management from Huxley College of the Environment at Western Washington University.

Charles (Charlie) Trautmann, Ph.D.
Executive Director, Sciencenter, Ithaca, NY
Adj. Associate Professor of Civil & Environmental Engineering, Cornell University

Since 1990, Dr. Trautmann has served as Executive Director of the Sciencenter, an educational science museum located in Ithaca, NY. At Sciencenter, he has overall responsibility for the museum's exhibits, programs, fundraising, and management. Dr. Trautmann has directed more than $9 million of sponsored research and has had more than two decades of teaching experience from pre-K through graduate and in-service training of professionals. As a professional geologist and engineer, he has worked with the U.S. Geological Survey (Menlo Park), Geotechnical Engineers Inc. (Boston), and Cornell University (Ithaca). Dr. Trautmann has a long-standing interest in teaching and community service and served as President of the Ithaca Montessori School Board of Directors for two years. He is a regular contributor to conferences and publications on informal science education. In 2007, he traveled to Europe to survey a wide range of informal educational institutions on how they communicate topics of sustainability and global climate change to the public. He has published more than 75 articles and reports, and has consulted on a number of design and construction projects, with more than 50 assignments completed for public utilities, private industry, and the U.S. Government. He is a member of various professional societies including the honorary scientific and engineering societies Sigma Xi and Chi Epsilon. In 1996, he was named Engineer of the Year by the New York State Society of Professional Engineers for his work in developing the Sciencenter and his service to education. Dr. Trautmann is a registered professional engineer and certified professional geologist. He is past-president of the Ithaca Section of the American Society of Civil Engineers, serves on the Board of Directors of Tompkins County Area Development, and is past president of the New York State Science and Technology Museum Consortium, representing 3.5 million visitors annually. Dr. Trautmann earned a B.A. in Physics/Geology from Amherst College, M.S. degrees in Engineering Geology and Geotechnical Engineering from Stanford University, and a Ph.D. in Civil Engineering from Cornell University.

Susan Van Gundy
Director of Education and Outreach
National Science Digital Library

Susan Van Gundy is the Director of Education and Outreach for the National Science Digital Library, a federally-funded online collection of resources, tools, and services that support science, technology, engineering, and mathematics (STEM) education and research at all levels. Susan works with leading educational organizations focused on STEM education as well as with the universities, museums, federal agencies, and professional societies that constitute NSDL's network of more than 200 resource providers. She leads the NSDL Teacher Professional Development Program, delivering presentations and workshops online and around the country. Van Gundy has been involved in designing and delivering programs for students, educators, and the general public for more than fifteen years. Before joining NSDL, she directed two of the largest hands-on science outreach programs in the country as the former Outreach Programs Manager for the Denver Museum of Nature and Science, and the Director of Outreach Education and Science Classes for the Oregon Museum of Science and Industry. Susan's professional activities emphasize bridging the scientific and education communities, and using innovative technologies to enhance teaching and learning. Susan's scientific background includes research experiences in geology,

archaeology, and marine biology. Susan holds a B.S. in Geology from Oberlin College and an M.S. in Geosciences from Pennsylvania State University.

Chris Wallace
Staff Associate
David Heil & Associates, Inc.

Chris Wallace has an extensive background in nonprofit management, marketing and communication, which she brings to her work at DHA in facilitation, business planning and project coordination. Prior to joining the DHA team, Chris worked with founders to launch a new science museum, ScienceWorks Hands-On Museum in Ashland, Oregon, and then served as its first executive director for five years. In that capacity she developed a strong community-based organization with a national reputation among small science centers. As a result of her focus to bring stronger environmental and natural history programs to the museum, Chris served on the Advisory Board for the Southern Oregon University Masters in Environmental Education Program and was nominated as Chair of the Regional Environmental Education Leaders (REEL), a collaborative working group which she co-founded. Prior to her work in Ashland, she served as marketing director for the Pittsburgh Center for the Arts and as marketing associate for the Pittsburgh Zoo and Aquarium. Chris has worked as a consultant for a variety of nonprofit organizations, providing support in management, marketing and fund development. She holds an MA in Speech Communication from Miami University in Oxford, Ohio and a BA from the University of Denver. She has taught university courses in public speaking, group dynamics and intercultural communication.

Dr. Gerry Wheeler
Executive Director (Emeritus)
National Science Teachers Association (NSTA)

Dr. Wheeler served as the Executive Director of the National Science Teachers Association (NSTA), the world's largest professional organization representing science educators of all grade levels, from 1995-2008. During his tenure at NSTA, Dr. Wheeler was the driving force behind SciLinks®, a collaborative project with major publishers that links science textbooks to teacher-approved websites, and Building a Presence for Science, a program that works to connect science education contacts in each school building nationwide and provide them with teaching resources and professional development opportunities. Dr. Wheeler has played a key role in the development of mass media projects that showcase science for students, including creation of *3-2-1 Contact* for the Children's Television Workshop, served on advisory boards for the *Voyage of the Mimi* and the PBS children's series *CRO*, and created and hosted *Sidewalk Science*, a television show for young people on CBS-affiliate WCAU-TV in Philadelphia. Prior to joining NSTA, Dr. Wheeler was Director of the Science/ Math Resource Center and Professor of Physics at Montana State University. While at MSU, Dr. Wheeler co-directed the National Teachers Enhancement Network, an NSF-funded distance learning project offering science and math courses nationwide. After leaving Montana, he headed the Public Understanding of Science and Technology Division at the American Association for the Advancement of Science (AAAS), and has served as President of the American Association of Physics Teachers (AAPT). His awards and accomplishments: include: outstanding teaching awards from Temple University, University of Hartford, Montana State University, and the AAPT Milliken Award. He is a fellow of the W.K. Kellogg Foundation and the AAAS, and has served on advisory boards and committees for American Institute of Physics (AIP) and National Assessment of Educational Progress (NAEP). Gerry is the author or co-author of numerous books, research and education articles, and reviews. Dr. Wheeler earned a B.S. in Science Education from Boston University, an M.S. in Physics from State University of New York at Stony Brook, and a Ph.D. in Experimental Nuclear Physics from the State University of NY Stony Brook.

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