

The Sanford Science Education Center: Addressing Key Design Challenges in Sharing Complex Science with Diverse Audiences

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INTRODUCTION

In facilities throughout the United States and abroad, communities of scientists share infrastructure, instrumentation and equipment to conduct scientific research. In these large facilities -- laboratories, accelerators, telescope arrays, and research vessels -- scientists are researching key questions that have the potential to make a significant impact on a broad segment of a scientific or engineering discipline.¹ In most of these large facilities, there is also an effort being made to share -- through education, outreach and other public communications activities -- the science research being explored at these labs and to contribute within the science education arena. These education and outreach activities are important for increasing the public understanding of science, technology, engineering and mathematics. These activities can also be complex and difficult undertakings, involving the need to serve diverse audiences and communicate abstract science. Just as the facilities themselves are intended to be infrastructure for science, the education and outreach activities associated with these facilities are regional infrastructure for science education.

One such scientific facility is the Sanford Underground Research Facility.² At Sanford Lab, in the small historic mining town of Lead, in the heart of the Black Hills of South Dakota, hoists built in the 1930s for the Homestake gold mine now carry scientists and equipment thousands of feet underground, where cutting-edge science experiments are taking place. Since 2007, supported by a variety of funders including the Department of Energy, the South Dakota State Legislature, a substantial donation from T. Denny Sanford, the National Science Foundation, and many others, Sanford Lab utilizes some of the most sensitive detectors in long-term experiments to answer questions about the foundational particles that make up the universe.

For the past five years, the education and outreach effort of Sanford Lab has been supported by a grant from the National Science Foundation to plan, develop, prototype and prioritize the suite of educational activities of the lab. Now known as the Sanford Science Education Center (SSEC), education and outreach activities that showcase the science, engineering and technology of Sanford Lab are offered in partnership with the

¹ For more on large facilities funded by the National Science Foundation, see <http://nsf.gov/bfa/lfo/index.jsp>. For more on Department of Energy funded laboratories, see <http://science.energy.gov/laboratories/>.

² For more on Sanford Lab, see <http://www.sanfordlab.org/>.

Sanford Lab Homestake Visitor Center and Black Hills State University. Education and outreach work happens in classrooms at the Lab, in a visitor center near the Lab at the mine's old open cut that also focuses on local history and mining, at Black Hills State University, and in outreach activities in schools and communities throughout the state and region.

Building a regional infrastructure for science and science education is no small task. While the design challenges the Sanford Science Education Center have faced are unique to this specific context, there is value for those engaged in the work of communicating cutting-edge science to the public to consider them in relation to their own context. Inverness Research has been the evaluator of the SSEC planning grant and has studied similar efforts in Louisiana as evaluators of the Laser Interferometer Gravitational-Wave Observatory Science Education Center (LIGO SEC).

We at Inverness Research have prepared this case study to share the design challenges the SSEC has faced (and where appropriate, drawing on other examples as well), and the lessons learned from trying to meet these design challenges³. The audiences for this case study are those in the broader field of education, outreach and public communication of science; and federal agencies who fund these efforts, such as the National Science Foundation and the Department of Energy.

DESIGN CHALLENGES

The Sanford Science Education Center works in a specific and unique context, but the design challenges it has faced as it has worked to create arrangements for connecting the science research and education outreach enterprise are not unlike those faced by others engaged in similar work. These challenges include the following:

- being in a remote location,
- explaining abstract science that can not be seen or touched,
- reaching and serving a diversity and range of audiences, and
- structuring workable interfaces among many stakeholder organizations.

In addition to these shared challenges, the SSEC has also faced particular challenges related to the funding of the overall science facility. In this section of the case study, we examine these key design challenges.

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Being in a remote location

Sanford Lab, and the research being conducted there, are remote in several ways. The Lab itself is in a small community in rural South Dakota. In addition, the science being conducted at Sanford Lab -- which covers “everything from physics and chemistry (dark matter, neutrino oscillation and neutrinoless double-beta decay) to geology and biology (seismic observation, rock strain sensing, astrobiology)”⁴ -- is conducted thousands of feet underground so the experiments can be shielded from cosmic radiation. The public cannot go “see” the science research in action. LIGO SEC, which is located in a remote, sparsely populated location, has faced a similar design challenge. The design challenge is how to bring the science research to the general public.

Explaining abstract science

The research being conducted at Sanford Lab is often difficult to model and explain. The science is abstract, theoretical and complex, including deep underground physics, biology, and geology experiments. There are underlying science and engineering concepts and practices that are integral to both the science research and the general operations of the facility that are more accessible to diverse audiences. Determining what to convey to what audiences in what ways, and at what level of detail and comprehension, is no small undertaking. Which concepts and practices are most appropriate for which audiences? How are they best taught? How do they tell the story of Sanford Lab?

Reaching and serving a diversity and range of audiences

The SSEC effort has to design its education and outreach programming for diverse audiences that span distance as well as generations. Key audiences for education and outreach activities include K-12 teachers and their students; college students interested in entering the science, technology, engineering and mathematics fields; and the broader public. Broader public audiences for the SSEC’s education and outreach activities include toddlers on up to retired people.

In addition, in South Dakota, the Native American population is a critical audience and their historical relationship with the Black Hills makes this a particularly interesting and challenging population to reach and serve well. Traditionally, the Black Hills of South Dakota belonged to Native Americans, until gold was found and treaties were broken. Thus, the outreach to Native American tribes has been a sensitive and critical design challenge not only for the SSEC, but for the larger Sanford Lab itself.

Thus, a key design challenge for the SSEC is this: what are the best mechanisms and venues by which the education and outreach effort can reach each of these different audiences? How are decisions made about who to serve and why?

⁴ See <http://www.sanfordlab.org/science>.

Structuring workable interfaces among partner and stakeholder organizations

The SSEC operates in partnership between Black Hills State University, Sanford Underground Research Facility and the Sanford Lab Homestake Visitor Center. The SSEC also operates within a complex array of agencies that provide input and oversight. These include Sanford Lab (itself a complex partnership of academic institutions, other national laboratories, university faculty, and experiments), Denny Sanford -- a local philanthropist who has donated millions of dollars, and the state of South Dakota -- including the education department, legislature, and the South Dakota Science and Technology Authority. Each of these partners, agencies and organizations are key stakeholders in both the Sanford Lab and SSEC. In light of the complex partnerships and agencies that partner in and oversee the work, a critical design challenge is how to structure the roles, responsibilities, interfaces and oversight in ways that allow for maximum efficiency and best use of everyone's expertise. The dynamics of these different agencies working together are a complex context in which the SSEC education and outreach effort operates. And while LIGO SEC has different types of partners (mostly institutions of higher education), they have also faced the challenge of structuring the interaction and arrangements for the mutual benefit of all.

Dealing with funding uncertainties

The Sanford Underground Research Facility was originally funded through NSF; then NSF decided the Sanford Lab was more appropriate to be funded through the Department of Energy. More permanent and ongoing large-facilities funding from the Department of Energy remains somewhat uncertain. Having to plan for education and outreach efforts for a lab that might not have permanent funding has been difficult. Thus far, the funding for individual experiments taking place at Sanford Lab has been good, but at times, the education and outreach effort has been asked to move funds originally earmarked for education and outreach to the Lab funding. This makes sense in that without the Lab, there can be no connected education and outreach effort, but the uncertainty surrounding long-term funding for both the Lab and education and outreach effort makes it difficult to do long-term planning.

LESSONS LEARNED

In this section of the report, we share the major lessons learned from the SSEC's efforts to address the design challenges. These include:

- building from unique strengths and assets,
- developing models and mechanisms for making the science accessible to a wide range of audiences, and
- providing activities in three facilities.

Building from unique strengths and assets

The Sanford Science Education Center has many unique strengths and assets that not only can serve to draw audiences into the more complex science, but also make it possible to offer science education in ways that others cannot. The setting of the Lab in an old gold mine -- high in the Black Hills, in territory once held by Native Americans, rich in history of settlement and discovery -- is a unique asset that has the potential of providing multiple avenues or hooks for the public into the science. The region draws tourists, who come to see Mount Rushmore and Crazy Horse, and who are drawn to the old west location and historic buildings in Lead. Local residents are proud of the gold mine and its continuing legacy for science research in the community. In addition, the technology required to turn an old mine into a facility for leading-edge scientific research is a compelling story in and of itself. Finally, the nature of the science research itself, and why the experiments need to be done underground, are unique and interesting.

SSEC has developed many different types of education and outreach activities over the past five years -- from field trips focused on water treatment, to curriculum units that address how scientists "see" the unseen, to public lectures and events that showcase the work and people of the Lab, to opportunities for college students to have in-depth experiences at Sanford Lab. All of these activities have in common that they build on the unique strengths of the site and Lab, and from the strengths and capacities of the staff.

Developing models and mechanisms for making science accessible to a wide range of audiences

Throughout its work, the education and outreach team has drawn on several mechanisms to make the abstract science accessible to a range of audiences. These mechanisms include explanation; use of models and analogies; use of more accessible science concepts related to experiments underground as a hook to help audiences understand more abstract concepts; a focus on the technology and engineering at work in the Lab that audiences can see and experience; and a focus on the nature of science and what it's like to be a scientist. The education and outreach team has also focused on the importance of layers of explanation and accuracy -- identifying for which audiences the explanations need to be in more depth (i.e. with technical details and highly accurate), versus explanations that are less complicated for others. Importantly, they have not shied away from introducing complex ideas to their audiences.

In terms of making the location and the underground science research more accessible, starting early on in their education and outreach efforts and continuing today, the SSEC has had success in videoconferencing with scientists underground as a mechanism for allowing visitors to access locations they are not allowed to visit in person. This also serves the function of extending the reach of the SSEC to a wider audience statewide and beyond.

For example, in the spring of 2015, SSEC developed six K-12 curriculum units -- two for elementary, two for middle school, and two for high school. The units, designed to be replacement units, involve multiple lessons that focus on interesting and foundational science and engineering concepts related to the work at the Sanford Underground Research Facility. The units include introducing key vocabulary and concepts important to the work at the Lab, such as neutrinos, even in the elementary lessons. Some units also include opportunities near the end of the units to videoconference with scientists at Sanford Lab. The units also strike a nice balance of covering generic science that teachers need to cover, along with science that connects to Sanford Lab.

The SSEC staff have also paid particular attention to building strong connections with Native American communities. Staff members have developed and built on existing relationships with representatives from area tribal colleges, offered science communications programming in partnership with several Native American high schools in the region, and engaged a cultural advisory board to help shape the relationship and program building for this audience. They have been supported in these efforts by the Cultural and Diversity Liaison for the Sanford Underground Research Facility.

Providing activities in three facilities

The original vision for the Sanford Science Education Center was to create and support one facility. In year three of the education and outreach planning grant, a model emerged for education and outreach facilities at three sites, which, together, would meet the broad range of education needs. One facility would remain at the underground Lab site, and would be a conference facility that would serve the need for spaces for field trips and other programs; this facility would also be of use to the Lab itself, and include an underground campus for Black Hills State University. A second facility would be at Black Hills State University in Spearfish, which would renovate a current science building on campus. This facility would focus on improved undergraduate science education experiences, courses tied to the science of the underground Lab, science research, and teacher preparation. A third facility would be a remodeled Homestake Visitor Center at the open cut site in Lead that would focus on providing experiences for the general public. The new Sanford Lab Homestake Visitor Center would focus on the underground lab and science experiments as well as history and mining.

This new model capitalized on the strengths and expertise of each of the partnership organizations, and the diverse audiences the SSEC work is trying to reach.

SUMMARY

Over the course of the past five years, the Sanford Science Education Center has worked hard to build on the unique features of the Lab -- the location, the juxtaposition of cutting-edge science taking place in a historic gold mine, and the complex and exciting nature of the science being studied -- to design and implement an array of programs for a wide range of audiences. In doing so, SSEC staff members have worked

strategically to address the key design challenges we have discussed in this case study, so that the SSEC can be a useful, mutually beneficial interface between the Sanford Underground Research Facility and key audiences.