

Building a Regional Science Education Infrastructure: The Accomplishments of the Sanford Science Education Center

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INTRODUCTION

For the past five years, the education and outreach effort of the Sanford Underground Research Facility has been supported by a grant from the National Science Foundation to plan, develop, prototype and prioritize the suite of educational outreach 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 through partnerships with the 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.

Over the course of the past five years, the education and outreach effort has planned for, developed, implemented, and reflected on a wide array of programming for multiple and diverse audiences. Key audiences for education and outreach activities include the following:

- K-12 teachers and their students,
- college students interested in entering the science, technology, engineering and mathematics fields, and
- the broader public.

Key activities over the years have included the following:

- hosting public events and speakers,
- facilitating field trips for students,
- offering professional development programs for teachers,
- offering a scholars program targeting high-achieving undergraduates and incoming college freshmen,
- developing and implementing programs targeted to Native American communities,
- commissioning a market and business study conducted by David Heil and Associates,
- helping to design and retrofit three spaces -- two at/near the Lab and one at Black Hills State University -- for science education,
- hosting a think-tank conference of outside science education experts who provided a facilitated review of the education and outreach efforts, and

- developing curriculum units and assembly kits about the science and engineering at the Lab.

Throughout all of its work funded through the NSF planning grant, the SSEC staff has explored many different modes of sharing the unique science and engineering of the Sanford Underground Research Facility. Inverness Research has been the external evaluator on the planning grant from the National Science Foundation. In this report¹, we highlight the accomplishments of the SSEC, and the return on the investment of the planning grant funds².

ACCOMPLISHMENTS

Building strong partnerships

The SSEC is a partnership of the Sanford Underground Research Facility, Black Hills State University, and the Sanford Lab Homestake Visitor Center. Each of these organizations and agencies brings strengths and connections to the table. For example, BHSU's Center for the Advancement of Mathematics and Science Education brings expertise in statewide professional development for teachers and facilitating science and math education improvement efforts, while the Visitor Center brings knowledge of the interests of the multitude of tourists to the region and how best to serve them.

Serving key audiences through different types of activities

Through these partnerships, the SSEC's education and outreach work has served a wide range of audiences. Throughout its work, the education and outreach team has drawn on several mechanisms to make the abstract science research being conducted at the Sanford Lab 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.

¹ A companion report summarizes the main design challenges faced by the SSEC, and the lessons learned from those efforts.

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K-12 teachers and students

For K-12 teachers and students, early efforts of the SSEC's education and outreach team were focused on piloting an array of education and outreach programs, both on-site and off-site. The activities included professional development workshops for teachers, field trip programs for students, facilitation of a local SciGirls after-school club for middle school girls, and special event days. The field trip days were particularly helpful in piloting activities and programs that could serve a wide range of ages. Staff learned quickly what topics and types of activities would work best for elementary age, middle school, and high school students.

The education and outreach staff members were also very opportunistic in designing their early activities, trying to conduct their work in such a way that they would be seen as accessible, particularly to area teachers. One way they did this was through having a menu of activities for teachers to choose from and adapting activities to meet teachers' schedules and needs.

In year five of the planning grant, the SSEC team focused on developing curriculum and assembly units as a means to reach larger numbers of K-12 teachers and students throughout South Dakota. All of the early activity development and piloting helped to inform the curriculum development. The SSEC team 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. Elementary units are geared for grades 3-5 and include a unit on magnets and motors and a unit on studying the unseen/indirect evidence. Middle school units include one on matter and the big bang theory and another on waves. High school units include one on underground biology and another on nucleosynthesis. 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 strike a good balance between covering generic science that teachers need to cover and science that connects to Sanford Lab.

Work in 2014-2015 has focused on developing the curriculum units, while the work of 2015-2016 is focused on piloting them, with the plan that five or six science teachers will pilot each unit. The curriculum development process has involved teams of one education and outreach staff person, along with two teachers, developing each of the units, and then cross-grade level teams reviewing the units at several stages of development.

In addition, four assembly units are in development to be implemented in the 2015-2016 school year, including one on light and the LUX experiment, one on careers, and one on a day in the life of an underground scientist, with additional assembly units to be developed in coming years.

The long-term plan is for pilot testing of the developed units in 2015-2016, and development of up to 15 curriculum units in total. Teachers would then receive professional development in the units during a summer institute, as well as materials needed to teach the units, before they implement them in their classrooms. In addition, in the long-term, while education and outreach staff are in schools delivering the assembly units, they can check in and offer support to teachers implementing the curriculum units.

Early-college STEM students

With funding from 3M, and with considerable involvement of Black Hills State, the SSEC team helped to provide over 90 college students who are motivated to study and enter STEM fields with the opportunity to see cutting-edge science research, and to interact with scientists at Sanford Lab, across the US and in Italy through the Davis-Bahcall Scholars program. Small cohorts of these exemplary students -- who were transitioning from high school to college or just finishing their first year of college -- came to the Sanford Lab each summer for an intensive academic experience that included visiting the underground lab, helping with education and outreach efforts, and visiting science and technology facilities, such as FermiLab and Argonne National Laboratory in the US and similar facilities abroad.

Past scholars³ reported that the program was meaningful and valuable to them in a variety of ways, and some say it was the best experience of their lives. All of the Davis-Bahcall Scholars we spoke with view their participation in the program as advantageous to them personally. Being exposed to high-level science, in combination with close interactions with other scholars interested in science, as well as having professors and professional scientists with whom they could engage in rigorous intellectual dialogue, was an important outcome of the program to participants, and helped to launch the Scholars on their STEM careers.

Public audiences

For public audiences, SSEC staff helped to organize public lectures and forums, and participated in science festivals throughout South Dakota. In addition, SSEC provided staff and support for the Lab's annual Neutrino Day science festival. Run by the Sanford Lab's communications department and held annually in July, Neutrino Day brings hundreds of people to Lead to interact with Lab staff, participate in hands-on science activities, tour the hoist room, visit the visitor center, video-conference with scientists who are underground in the Lab, and hear lectures. This event has grown every year, drawing more visitors and providing science education learning opportunities for all ages.

Contributing to the design of three new spaces for science education in the Black Hills

³ A summary of findings from Inverness Research's follow-up interviews with past Davis-Bahcall Scholars was reported in the year five annual report.

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 education and outreach need for spaces for field trips and other programs; this facility would also be of use to the Lab itself, and include an underground research 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.

Hosting a conference of national science education experts

In the fall of 2014, a significant event for the SSEC education and outreach effort was a think-tank conference that brought together a group of experienced outside science education and outreach (E&O) experts to discuss design challenges and areas of strength and opportunity for the Sanford education and outreach effort. These outside experts not only came to understand many of the unique features and key design challenges of the SSEC, and to offer advice and recommendations to the education and outreach effort, but were also able to share lessons learned from their own particular education and outreach efforts. SSEC received feedback and advice at a critical time to help in prioritizing and focusing its education and outreach efforts, while at the same time, the outside experts learned from SSEC and each other.⁴

SUMMARY

The SSEC team has accomplished a great deal over the past five years through the support of the National Science Foundation. The education and outreach effort of the Sanford Underground Research Facility 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. These key activities, along with new science education facilities for professors and students at Black Hills State University and for the general public at the Sanford Lab Homestake Visitor Center, are helping to bring the important science work of the Lab to South

⁴ A summary of findings from this conference was shared in a spring 2015 report.

Dakota and beyond. Through all of their efforts, the SSEC team has navigated many design challenges as they have developed and piloted their education and outreach activities, and gained important knowledge about how to best bring complex, abstract science being studied in a remote location to a wide array of audiences.