



Integrating a K-12 Education and Outreach Initiative into a Sustainability Research Network (Work in Progress)

Dr. Daniel Wilson Knight, University of Colorado, Boulder

Daniel W. Knight is the Program Assessment and Research Associate at Design Center (DC) Colorado in CU's Department of Mechanical Engineering at the College of Engineering and Applied Science. He holds a B.A. in psychology from the Louisiana State University, and an M.S. degree in industrial/organizational psychology and a Ph.D. degree in education, both from the University of Tennessee. Dr. Knight's research interests are in the areas of retention, program evaluation and teamwork practices in engineering education. His current duties include assessment, team development and education research for DC Colorado's hands-on initiatives.

Prof. Michael Hannigan

Michael P. Hannigan is an Associate Professor in CU's Department of Mechanical Engineering. He holds a B.S. in Civil Engineering from Southern Methodist University and a M.S. and Ph.D. in Environmental Engineering Science from Caltech. Dr. Hannigan's research group has been actively engaging in the development and validation of low cost air quality monitoring tools with the goal of developing spatial pollutant measurement datasets that will drive a new wave of understanding of pollutant sources, transport and fate. As this effort has progressed, his group has learned that these tools can also provide a conduit for hands-on learning and is now working on further K-12 and community curriculum development.

Ms. Madeline Polmear, University of Colorado, Boulder

Madeline Polmear is a student research assistant in the Department of Mechanical Engineering, College of Engineering and Applied Science at the University of Colorado, Boulder. She is interested in program assessment and education and outreach efforts surrounding oil and natural gas development. Ms. Polmear is in the fourth year of a concurrent Bachelor's/Master's degree program in environmental engineering.

Dr. Lisa Gardiner, UCAR Center for Science Education

Lisa Gardiner is the K-12 Education Manager at the UCAR Center for Science Education and leads curriculum development and teacher professional development. She holds a B.A. in geology and marine science from Smith College, a Ph.D. in geology from University of Georgia, and an M.F.A. in creative nonfiction writing from Goucher College.

Ms. Katya Anna Hafich, University of Colorado Boulder

Katya Hafich is the Outreach and Education Coordinator for the NSF-funded AirWaterGas Sustainability Research Network, based at CU Boulder. She holds a B.A. in Latin American Studies and a B.S. in Environmental Science from the University of New Mexico, and an M.A. in Geography from CU Boulder. She currently shares a joint appointment with AirWaterGas and the CU Boulder Office for Outreach and Engagement, where she focuses on K12 and community science outreach and education, specifically on climate and energy topics.

Ms. Ashley Monika Collier, University of Colorado, Boulder

Ashley Collier is a graduate research assistant at the University of Colorado, Boulder. She holds a B.S. also from the University of Colorado, Boulder in Environmental Engineering. Her work examines the various applications of low-cost, next-generation air quality monitoring systems. This includes deploying sensors to learn about spatial variability of pollutants, testing the use of sensor arrays to speciate for specific volatile organic compounds, and exploring this technology's usefulness in education/outreach and citizen science.

Integrating a K-12 Education and Outreach Initiative into a Sustainability Research Network (Work in Progress)

Background

The AirWaterGas Sustainability Research Network (SRN) is a research, outreach, and education project funded by the National Science Foundation (NSF) that includes nine institutions with a study area that spans the Intermountain West. The goal of the NSF SRN is to find the balance between maximizing the development of natural gas and oil resources – for the benefits of short-term reduction of carbon dioxide emissions from power generation and transportation, national energy independence, and national job growth – and minimizing damage to water and air resources and risks to human health.

Sustainability Research Network development is part of a new program developed by the National Science Foundation to build networks of multidisciplinary teams to address current shortages of reliable information regarding fundamental challenges in sustainability. By providing a science-based framework for studying the environmental, economic, and social trade-offs associated with natural gas resource development and environmental protection, the SRN project aims to provide the basis for evidence-based public discussion and inform public policy.¹

The SRN model incorporates public stakeholders into the research throughout the project for research activities, rather than peripherally for broader impacts goals. Hence, the tasks of education, outreach and outcomes assessment assume a larger role than in some NSF projects and are envisioned to work closely with researchers to foster relationships with stakeholders that benefit both research and broader impacts goals.

Outreach in STEM fields

The National Science Foundation emphasizes education and outreach activities in its science and engineering awards through its required broader impacts section in all submitted research proposals. Funded researchers are required to make a plan for sharing results with public stakeholders.² The goals of this SRN exceed those of the typical broader impacts goals to include the public in decisions and policy resulting from the implications of SRN scientific research. NSF also requires outcomes assessment plans including external evaluators for many of its awards to ensure that education and outreach initiatives proceed with a structured, goal-oriented logic and measurable objectives. Analyzed results are to be used to make program changes in a strategic fashion.

NSF outreach goals exist within a larger field of outreach in STEM fields, particularly in the area of K-12 outreach.³ These K-12 programs go beyond the goals of sharing scientific results with stakeholders to include improving K-12 teaching, attracting youngsters to STEM fields, and

improving standardized test scores.⁴ From the university side, research has found these activities to improve the experiences of the graduate students who frequently apply newly developed curricula and to inspire graduate students to maintain a K-12 connection after they graduate.⁵

SRN Task Teams

The AWG SRN is composed of multiple task teams dedicated to different project goals. The present study is focused on the activities of the SRN Education and Outreach Team (E&O) and the Assessment Team. As part of the SRN, the E&O team aims to improve the public's ability to understand sustainable pathways for energy development. In order to do this, the E&O team integrates network researchers into education and outreach activities by supporting increased communication among network members through online platforms, lunch seminars, workshops, and community partnerships among others. The primary goals of this team are to enhance multi-disciplinary education across network stakeholders, expose minority populations to network education and outreach activities, and incorporate SRN content into graduate education practices. The platforms we aim to discuss in this paper are the K-12 classroom setting, a yearlong teacher professional development program, partnerships with community non-profit organizations, and public events.

Turning to the SRN Assessment team, the goals of this team are to provide outcomes assessment and program evaluation for the SRN E&O team for the purpose of helping this team to meet its own goals, improve its programs and stay integrated with the SRN scientific task teams. To this end, the Assessment Team supports goal setting, translation of goals into measurable criteria, the development and adaptation of assessment tools, data collection and analysis, and reporting of results formatively for the SRN network and summatively for NSF review.

In this work-in-progress paper, the authors wish to present several developing SRN E&O initiatives and describe formative assessment results that highlight the strengths of these initiatives as well suggestions for improvement for the next programming offerings. Initiatives will be described in two school districts, a year-long K-12 teacher workshop, an SRN network open-house, and for community grants related to SRN network related activities. Where available, supporting assessment results will be provided.

School District Outreach

Through the Air Quality Monitoring Pods Project, we are conducting outreach and education activities in two K-12 Colorado school districts, as well as developing a project-based learning curriculum based on our efforts. The first district is part of a rural community on the Western Slope of Colorado; it is primarily agricultural, but there are also several active coal mines and proposed oil and gas development in the region. We are working with 3 high schools in this district (~ 50 students), in classes primarily focused on environmental science. The second school district is suburban and rural and is sustained by agriculture and extensive oil and gas development. In this district, the AWG SRN E&O is working with 2 high schools (~ 50

students). Additional partners in the school district project include a community environmental center and the County Health Dept.

The technical content for this outreach effort is focused around the some of the work of The SRN Air Quality Team. This Team has a research group under the direction of one of the SRN project PI's that works with next-generation, low-cost, air quality monitoring systems – termed Pods. These are used to educate students on air quality and energy development issues, as well as by K-12 students to collect data to answer a research question. In terms of structure, a graduate student works with teachers and students in the classroom on a monthly basis and assists remotely as necessary. The entire administration of the project (including curriculum and students projects) typically spans a school year. The curriculum is comprised of modules which provide students with: (1) an introduction to air quality and air quality measurements, (2) an opportunity to practice air quality data collection, (3) an opportunity to practice air quality data analysis, (4) an introduction to study design, and (5) an introduction to understanding and presenting your data. In addition to the modules, students design and conduct their own research projects and make posters to present their work.

We have taken on a number of assessment activities this year in order to understand how best to improve and use the curriculum. Student surveys on specific modules and the overall project will address whether or not learning objectives are being met. Teacher surveys and questionnaires will assess how beneficial the project is and whether or not teachers are receiving the appropriate amount of support to implement the project. In addition to this data, the project curriculum will be sent to an external review team of teachers and scientists. Finally, questionnaires administered to other stakeholders (community and local government partners) will help us assess whether or not the program is a benefit to the community. Preliminary results from student surveys indicate high school students were more confident in their ability to collect air quality data (4.27/5 point scale).

K-12 Teacher Professional Development Program

Many middle and high school science teachers have a strong desire to incorporate cutting-edge research and new scientific results into their classrooms, especially for difficult to teach and sometimes controversial science topics such as the impacts of oil and gas development and the impact of fossil fuels on climate change. However, teachers also face a number of hurdles when developing new materials for their classrooms, such as: limited experience with research, lack of background knowledge, a shortage of time, difficulty fitting research and new results into their current curricula, and limited opportunities to collaborate with their colleagues. To address these hurdles in the context of the SRN project, we developed a professional development program for K-12 educators that combined online instruction, interaction with SRN scientists and science educators, and time for team-based, teacher-led creation of novel classroom experiences that will bring the findings of a large, multidisciplinary SRN research program to students in grades 6-12.

This teacher professional development program follows a hybrid model, combining online content learning with an in-person workshop and culminates in a month-long residency. The program strives to empower teachers to develop innovative classroom resources with the support of science education mentors, engineers and scientists within the SRN network. Those classroom resources will be disseminated widely to teachers throughout the network. Also unlike many teacher professional development programs, this model is a year-long intensive, striving to build a long-term teacher community while also building teacher understanding of science, engineering, and curriculum development.

A cohort of eight middle and high school science teachers was recruited from areas that are targeted by this SRN. During the fall online course, teachers learned about climate and energy. During the winter online course teachers focused on the environmental impacts of oil and gas development and met graduate student researchers with the SRN project. The spring online course will focus on teaching controversial topics and best practices for curriculum development and will be led by SRN network curriculum design experts. A workshop in the spring will bring teachers and SRN researchers together to discuss ideas for classroom activities that bring the science and engineering of the project to middle and high school learners. During July, teachers will be in residence at an SRN host facility and will work in collaboration with each other with the support of network science educators and researchers to develop classroom materials.

Assessment of the program is being accomplished through surveys of teachers' content understanding and confidence with the material before and after each online course. It will also include interviews of teachers during their July residency period. Preliminary assessment results indicate K-12 teachers were confident in their ability to develop curriculum on AWG topics (4.2/5 point scale) and teach controversial AWG material (4.4/5). They also exhibited a mastery of course content. The primary suggestion for improvement was the inclusion of more of the larger context regarding course content so they could understand the big picture when teaching.

Community Small Grants Project

A third component of the SRN E&O team program is the community small grant projects, which aim to develop partnerships with community groups to address issues related to the technical content of the SRN as it impacts their community. The goal of this program is to integrate SRN research and resources into the work of community groups who have an on-the-ground understanding of community need.

After a competitive review process, six grants of up to five thousand dollars were selected and awarded to groups from across the SRN network. Teachers, schools, non-profits, and tribal groups were allowed to apply. Winning grant proposals were selected for quality of the project, integration of SRN research into their proposal, and partnership potential. Examples of award winners include; (1) a groundwater education program that will incorporate current research on the potential impacts of SRN research on groundwater supply into curriculum and teacher

workshops, (2) an update of a local air quality brochure to include the most recent air quality standards for an area of network focus, and (3) A baseline air quality study with participation by local high schools in the region impacted under the network. To assess project progress, the E&O team will administer quarterly surveys to grant recipients. Part of the assessment will include questions of whether SRN researchers are meeting the needs of community partners for project involvement. Assessment design and data collection are underway with this initiative.

SRN Spring Meet-And-Greet

The SRN E&O team is planning a Meet and Greet event in March 2015 to bring together SRN researchers, teachers participating in SRN E&O efforts, and community partners. The purpose of the event is to foster relationships and collaboration in a format that encourages conversation among stakeholders, in hopes that face-to-face conversations will hatch new ideas and solidify relationships between researchers, teachers, and community groups in the network. The Meet & Greet format will include several five minute long talks given by each SRN research team, teachers, and a summary of community partner projects, followed by a graduate student poster session.

The event will also include a discussion between professional development teacher participants, teachers participating in the school district project, and community partners planning on using SRN curriculum. The discussion will be the first discussion of community users of AWG SRN content which will develop into a community of learners that communicates primarily online with the help of the E&O team. The event will be assessed by surveys of attendees, a count of attendance, and targeted interviews with stakeholders. Assessment tool development is underway.

Future Directions

Moving forward, we hope to synthesize current efforts in K-12 and community groups to create lasting content and curriculum on natural gas resource development, environmental protection and related issues for SRN science education websites. We plan to use resources that were created for and by the teacher professional development workshop for content, and polish several lesson plans created by the teachers in the program. The school district project-based learning curriculum will be reviewed and ready for distribution in Fall 2015, at which point the program may expand to other schools in the network who will be supported by the SRN community learners. Three of the six community grant awardees will also be creating K-12 curriculum as part of their project, which we will integrate into existing curriculum.

A second round of community grants will be announced in Fall 2015, at which point we will have an opportunity to continue to support successful projects and develop partnerships with new organizations. As more SRN research is published, the E&O team will work with teachers and community partners to disseminate research results and create useful resources for K-12 classrooms based on results.

Summary

This work-in-progress paper summarizes the developing education and outreach efforts of a large NSF sponsored SRN project. The goals of the overall SRN project are described along with the two SRN teams under discussion, the Education/Outreach (E&O) and Assessment Teams. These efforts were briefly discussed in the framework of a larger university outreach effort in STEM education.

Four SRN E&O initiatives are described which attempt to bring SRN research to grant stakeholders along with assessment results where available. Preliminary assessment results find stakeholders growing in confidence in their skills at working with SRN technical material primarily through their involvement in hands on learning activities provided by E&O Team members. Future directions for the project are discussed primarily around the development of educational teaching curriculum resulting from E&O initiatives.

Bibliography

1. National Science Foundation. "Sustainability Research Networks Competition (SRN)," 2014. <http://www.nsf.gov/funding>
2. National Science Foundation. "Grant Proposal Guide, December 2014.," http://www.nsf.gov/publications/pub_summ.jsp?ods_key=gpg
3. Jeffers, Andrew T., Angela G. Safferman, and Steven I. Safferman. "Understanding K-12 engineering outreach programs." *Journal of professional issues in engineering education and practice* 130.2 (2004): 95-108.
4. Sullivan, Jacquelyn F., et al. "Beyond the pipeline: building a K-12 engineering outreach program." *Frontiers in Education Conference, 1999. FIE'99. 29th Annual. Vol. 1. IEEE, 1999.*
5. Moskal, Barbara M., et al. "K-12 Outreach: Identifying the Broader Impacts of Four Outreach Projects." *Journal of Engineering Education* 96.3 (2007): 173-189.