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Engaging Diverse Student Populations in Renewable Energy - Undergraduate Research and Building STEM Capacity

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Abstract

Colorado School of Mines (CSM) is a public teaching and research university in Golden, Colorado recognized as a world leader in STEM education. Since its founding in 1874, Mines' robust curriculum in applied and social sciences, economics, and business nurtures an established history in its traditional programs of geology, mining, and petroleum engineering, as well as its rapidly expanding fields in chemical and biological engineering, civil and environmental engineering, electrical engineering and computer science, geophysics, materials science, mechanical engineering, and metallurgical engineering. It has the highest admissions standards of any public university in Colorado and among the highest of any public university in the U.S. Mines graduates have special expertise in the development and stewardship of the Earth's natural resources. It is one of the few institutions in the world having broad expertise in the four critical

areas of resource exploration, extraction, production, and utilization. Mines researchers actively explore strategies to balance resource availability with environmental protection. World renowned, high-impact research efforts match Mines' expertise in earth, energy, and environmental studies, as well as practical areas spearheaded through over two dozen departmental and institutional research centers.

The Mines undergraduate curriculum immerses students in active, hands-on learning experiences that include a first-year engineering practices course to provide an initial team-based design experience. Skills development workshops, summer field sessions, and authentic senior design projects help students evolve from dependent to independent learners within their chosen disciplines. Mines supports its educational mission via its Trefny Innovative Instruction Center, as well as a large cadre of Teaching Faculty who provide leadership in developing and implementing pedagogical strategies based upon education research in their respective fields. For the past seven summers (2009-2015), CSM has hosted an REU that has engaged 137 undergraduate students and 1 high school teacher in renewable energy research. Using a robust application and personal interviews, we judiciously select non-CSM students from underrepresented groups and from institutions where research opportunities are limited. We consistently attract highly qualified, diverse applicants from a broad range of institutions that include historically black colleges and universities, Ivy League schools, liberal arts campuses, Research 1 universities, tribal colleges, two-year colleges, and women's colleges. Students with disabilities and non-traditional backgrounds have actively participated. CSM faculty and scientists from the nearby National Renewable Energy Laboratory (NREL) provide top-notch mentoring and world-class research facilities. All mentors have a record of effective involvement with our participants and create an environment that nurtures a novice researcher as he or she moves from dependence to independence in the research process. Each participant is assigned a primary faculty mentor and near-peer role model. Before the program begins, all three individuals have open discussions to best match a participant's interests and talents to specific project goals. Post-doctoral fellows, graduate students, and undergraduate peers actively contribute to research teams. In addition to their primary research endeavors, participants develop a wider appreciation of the research enterprise through a hands-on laboratory program, professional development sessions, and weekly technical seminars. To foster an appreciation of other STEM areas, students take field trips to alternative energy companies and participate in activities with students from CSM's Advancing Polymer Materials by Integrating Chemistry and Chemical Engineering REU, as well as with students in the nearby National Nanotechnology Infrastructure Network (NNIN) REU at the University of Colorado, Boulder; the Re-Inventing the Nation's Urban Water Infrastructure (ReNUWIt) REU at CSM, New Mexico State University, Stanford, and UC Berkeley; and the Science Undergraduate Laboratory Internship (SULI) REU at NREL. To assess their experience, we have participants complete the Undergraduate Research Student Self-Assessment (URSSA) near the end of the program. With funding in place to support CSM's REU through the 2016 and 2017 summers, Mines has tailored administrative talent in place. The REU continues to strive for gender equity and diversity while recruiting from institutions where research is limited. NREL's commitment is authentic; the lab continuously seeks to develop undergraduate and graduate students' skills, knowledge, and interests in renewable energy with the purpose of creating a pipeline that supports its future research strands and employment needs. Our REU provides CSM graduate students the opportunity to assist in the design and delivery of research projects while

simultaneously mentoring undergraduate students. At the end of the summer, all participants share their results at a poster session with other REUs, while some go on to publish their work in scientific journals or present at scientific conferences. Almost 80% of our participants pursue graduate studies at both the MS and PhD levels, with their REU experience adding significant value to their applications.

To continue building STEM capacity, our next major initiative is to partner with nearby Red Rocks Community College to offer a two-week residential renewable energy research camp for approximately 40 two-year college students that plan to transfer to four-year STEM programs in the fall. Each student will tour a variety of research labs at CSM, NNIN, and NREL that focus on renewable energy. Professional development sessions will address such topics as "Planning Your STEM Studies", "Careers in Renewable Energy", "Integrating Women into Historically Masculine Industries", "Graduate School and Fellowship Opportunities", "How the Research Game is Really Played", "Presenting Scholarly Research", "Ethics and the Responsible Conduct of Research", and "Learning, Teaching, and Working Across the Generations". Technical seminars include "Renewable Energy Research at Colorado School of Mines", "Critical Materials and Energy Research at NREL", "The National Nanotechnology Infrastructure Network", and a series of graduate student research talks. In small-group settings, students will participate in two distinct 4-hour workshops taught by Mines faculty that focus on an analytical process, characterization technique, computer simulation, experimental measurement, or how a specific piece of equipment or instrumentation works. Last but not least, to promote camaraderie, networking experiences, and a robust two-year college student cohort, students will live on-campus in dormitories during their stay. They will also tour the local areas of Golden, Denver, and Boulder while enjoying a number of recreational opportunities.