

## **Experiential Learning and Mentoring to Broaden Participation in Earthquake Science**

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Analysis of STEM degree recipients continues to show that, while some progress has been made in diversifying science, technology, engineering, mathematics (STEM) degrees and careers, geosciences have one of the largest diversity gaps (Dutt, 2020; Bernard and Cooperdock, 2018; Wilson, 2019). This can result in losses of innovation, discovery, and workforce. The Southern California Earthquake Center (SCEC) has demonstrated a commitment to decrease this diversity gap and prepare the next generation of earthquake scientists by providing valuable research opportunities and mentoring.

SCEC has led a number of initiatives to support geoscience educational pathways. Between 2016-2019, SCEC, California State University, San Bernardino (CSUSB) and other partners collaborated in the NSF INCLUDES EarthConnections Alliance to provide opportunities for geoscience students of any background to develop their scientific skills and knowledge while learning to work with communities to address local issues (i.e. earthquake hazards). We developed pathways linking opportunities to learn geoscience with community involvement across grade levels, including curriculum development for high school educators to teach college-level geology courses. A pending NSF GeoPaths proposal, submitted collaboratively by CSUSB and University of California, Riverside, with SCEC as a named partner aims at continuing this work.

SCEC has also demonstrated commitment to develop and provide strong and effective mentorship experiences to the earthquake science community via their Internships Program and Mentoring workshops. Positive mentoring experiences increase recruitment of underrepresented mentees into graduate school and research-related career paths (Junge et al., 2010; Thiry and Laursen, 2011) and graduate students cite positive mentoring experiences as the most important factor in completing a STEM degree (Ashtiani and Feliciano, 2012; Solorzano, 2000). I (McGill) have mentored many undergraduate students via SCEC's SURE internship program. Research mentors play a crucial role in the future interest and success of students in earthquake science. Not only do we provide opportunities and training to students who would otherwise not have opportunities to engage in geoscience research, we also benefit from the contributions students have made to our research and knowledge.

In 2009-2012, SCEC and CSUSB partnered to develop synergies between SCEC's coordination of K-8 outreach activities for a NASA InSight grant, SCEC's Summer Undergraduate Research Experience (SURE) program and CSUSB's NSF-funded project using tectonic geodesy to study deformation rates across the Pacific-North America plate boundary in southern California. Teachers, high school students and undergraduates collected survey-mode GPS observations each summer and used one-dimensional elastic modeling to estimate fault slip rates (McGill et al., 2015). Over the four year grant period, 35 undergraduate students (13 from underrepresented ethnic groups—8 Hispanic, 3 Native American and 2 African American), 25 high school teachers (4 from underrepresented ethnic groups—2 Hispanic, 1 Native American and 1 African American), and 57 high school students (32 from underrepresented groups—29 Hispanic, 2 African American, 1 Native

American) participated in GPS training sessions, GPS data collection campaigns, and workshops on constructing GPS time series and modeling GPS velocities for fault slip rates as well as a one-day field trip to the San Andreas and San Jacinto faults, and to the surface rupture of the 1992 Landers earthquake. SCEC's relationships with community colleges throughout southern California as well as their nationally advertised SURE program increased the ethnic and geographic diversity of the undergraduates who participated in the CSUSB summer research program.

Each year, the participating undergraduates, teachers and some of the high school students presented their research results at the SCEC annual meeting as well as at other professional meetings, as were the lessons learned from our education and outreach efforts (e.g., deGroot et al., 2012). SCEC's Director for Education, Experiential Learning, and Career Advancement, Dr. Robert deGroot, also worked with the participating teachers during the academic year using the Lesson Study approach (Stigler and Hiebert, 1999) to develop, evaluate and improve lessons that enabled them to share their research experiences with their students.

To continue to support geoscience educational pathways, the next earthquake center should continue to forge partnerships with educators and the community to engage students - who would otherwise not be exposed to geosciences or would not have opportunities for geoscience research - in meaningful educational experiences. The center should take advantage of its unique position to bring together earthquake center researchers with interested educators at universities, community colleges, and K-12 schools. The openness of the SCEC annual meeting to including K-12 and community college educators and undergraduate students who have collaborated with SCEC researchers has had a tremendous impact on those participants.

In 2019, SCEC began to provide mentor/mentee workshops with the purpose to improve mentoring relationships, particularly between faculty and students who have been traditionally underrepresented in STEM fields. The series of workshops provide evidence-based, interactive mentor training curricula that engages mentors and mentees in collective problem solving and connects them with resources to optimize their mentoring practices.

According to the NAS Report on *The Science of Effective Mentorship in STEMM* (2019), more diverse and inclusive research centers are more responsive to current and emerging problems because teams comprising individuals with diverse experiences and areas of expertise tend to be more innovative when searching for solutions. More diverse research teams can also result in higher impact research and make better decisions than less diverse teams. To continue to close the diversity gap in geoscience, the next earthquake center should continue to provide access to opportunities, role models, and professional development to underrepresented groups.

The next training center should:

- Continue to provide valuable learning, training, and development opportunities for mentors and mentees
- Have a formalized commitment to diversity, equity and inclusion
- Support evidence-based approaches to mentoring to improve relationships and support multiple mentorship structures

- Continue to provide collaborative research opportunities to students and early career scientists
- Work with Ph.D. programs affiliated with the center to identify and correct ways in which their graduate admissions policies may disadvantage under-represented applicants

## References

- Ashtiani, M., and C. Feliciano. 2012. Mentorship and postsecondary educational attainment of low-income youth. Los Angeles, CA: University of California, Los Angeles.
- Bernard, R.E., Cooperdock, E.H.G. No progress on diversity in 40 years. *Nature Geosci* 11, 292–295 (2018). <https://doi.org/10.1038/s41561-018-0116-6>
- deGroot, R. M., S. McGill, T. Castiglione, H. Corral-Bonner, A. M. Foutz, S. G. Husa, E. Sahl, B. E. Vargas, and S. Wallace. 2012. Teachers using continuous GPS data to learn about earthquakes: Sharing research results in the classroom through lesson study—2012 campaign. *Southern California Earthquake Center Proceedings XXII*:97-98.
- Dutt, K. Race and racism in the geosciences. *Nat. Geosci.* 13, 2–3 (2020). <https://doi.org/10.1038/s41561-019-0519-z>
- Junge, B., C. Quiñones, J. Kakietek, D. Teodorescu, and P. Marsteller. 2010. Promoting undergraduate interest, preparedness, and professional pursuit in the sciences: An outcomes evaluation of the sure program at Emory University. *CBE—Life Sciences Education* 9(2):119–132.
- McGill, S. F., J. C. Spinler, J. D. McGill, R. A. Bennett, M. Floyd, J. E. Fryxell, G. J. Funning. 2015. Kinematic modeling of fault slip rates using new geodetic velocities from a transect across the Pacific-North America plate boundary through the San Bernardino Mountains, California. *Journal of Geophysical Research* 120:772–2793. 10.1002/2014JB011459.
- National Academies of Sciences, Engineering, and Medicine 2019. *The Science of Effective Mentorship in STEMM*. Washington, DC: The National Academies Press. <https://doi.org/10.17226/25568>.
- Solorzano, D. G., and T. J. Yosso. 2000. Toward a critical race theory of Chicana and Chicano education. In *Charting new terrains of Chicana(o)/Latina(o) education*, edited by C. Tejeda, C. Martinez, and Z. Leonardo. Cresskill, NJ: Hampton Press. Pp. 35–65.
- Stigler, J. W., and J. Hiebert. 1999. *The Teaching Gap*. New York: Free Press. 225 pp.
- Thiry, H., and S. Laursen. 2011. The role of student-advisor interactions in apprenticing undergraduate researchers into a scientific community of practice. *Journal of Science Education and Technology* 20(6):771–784.
- Wilson, 2019. 2018 Report on the Status of the Geoscience Workforce. Published by the American Geosciences Institute, 178 pp.