

BOARD # 435: Reflections on a Decade of Engineering Workforce Development for the Engineering Research Center for Bio-mediated and Bio-inspired Geotechnics (CBBG)

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Abstract

The Center for Bio-mediated and Bio-inspired Geotechnics (CBBG) is a National Science Foundation (NSF)-funded, third generation Engineering Research Center (ERC), comprising four partner universities: Arizona State University, Georgia Institute of Technology, New Mexico State University, and University of California, Davis. As the Center approaches its final year of funding, we reflect on a decade of educational programming. The Engineering Workforce Development (EWD) programs are designed to motivate and educate students from diverse backgrounds, inspiring a new generation of engineers interested in pursuing graduate degrees and careers in biogeotechnical engineering.

Over the past ten years, the Center has actively recruited students, teachers, and professionals from underrepresented populations to participate in CBBG EWD programs. The EWD has developed and honed a collection of programs and activities that prepare graduates and the professional workforce with the skills required for proficiency in the field: communication, engineering success, career connections, technical expertise, multicultural skills, and mentorship. Students participate in outreach by conducting lab tours and demonstrating their research at events. Activities of the EWD have produced expert-reviewed biogeotechnical curricula (webinars, modules, courses, etc.) for pre-college, undergraduate, graduate, and practitioner levels. The EWD has fostered industry engagement with CBBG students through research, internships, career connections, design challenges and more. Rigorous assessment and evaluation are seamlessly integrated into all aspects of the education and outreach programs, enabling systematic, ongoing improvement of activities and materials.

Plans for sustainability of the CBBG EWD partnerships and programs beyond the Center's graduation into the Consortium of Bio-mediated and Bio-inspired Geotechnics include disseminating research through the International Conference on Bio-Mediated and Bio-inspired Geotechnics (ICBBG), sharing existing curricula through short courses and certificate programs, and continuing as the leader in biogeotechnical engineering.

Introduction

The CBBG EWD program goals include: 1) Aiding students to become proficient in desired skill sets with six core areas: communication, engineering success, career connections, mentorship, technical expertise, and inclusion and diversity, 2) Developing future professionals and scientists in biogeotechnical engineering who are innovative and creative leaders, 3) Demonstrating diversity, awareness, knowledge, and positive attitudes toward increasing opportunities and careers in STEM and biogeotechnics for underrepresented groups, 4) Ensuring equal partnerships with teaching and mentoring for learning, engagement, and motivation in biogeotechnics, and 5) Developing efficient and effective approaches to create and deliver biogeotechnical content.

To facilitate achieving these goals, CBBG has established partnerships with a variety of educational entities, including K-12 schools, local community colleges, science centers and museums, university education and engineering departments, and a range of industry partners.

Long-term relationships with these organizations have been established and strengthened each year through faculty and student exchanges, CBBG researchers visiting classrooms, non-CBBG faculty and students completing the summer research programs, Center lab visits, and internships with industry partners.

Our EWD programs reach learners at the pre-college, university, and practitioner levels through a variety of activities. By the end of the ninth year, the Center reached 13,701 students and 4,166 teachers through 424 outreach events, including lab tours, museums, science centers, and exchange programs. Over 250 external researchers have participated in research experiences, with an average of 28 participants per year across three programs: Research Experiences for Teachers (RET), Research Experiences for Undergraduates (REU), and Young Scholars Program (YSP) for high school students. Biogeotechnical engineering curriculum and training are offered at various levels, from pre-college to university and professional. More than 10,000 individuals attended over 350 webinars, seminars and workshops. Nine university-level courses are continually improved based on research and student feedback. An innovative cross-institution course titled ‘Connecting Research to the Broader Community’ builds essential workforce skills related to life cycle sustainability assessment, entrepreneurship, leadership, and professional development.

A collection of strategies and approaches implemented at the many partner settings are used to prepare graduates and a professional workforce with the skills needed to be ready to solve global and national engineering problems.

University Education

The EWD university education programs include recruitment and engagement of undergraduate students through outreach activities, courses, webinars, workshops, and cross-institutional collaborations. Professional and career development is fostered through mentorship and industry interactions.

Undergraduate Involvement - The Center employs various recruitment strategies to increase undergraduate student involvement and subsequent enrollment in graduate programs. In addition to participating in ongoing research as an undergraduate, students also participate in outreach by conducting lab tours for visiting K-12 schools, non-ERC undergraduate groups and summer research interns (REUs, RETs, and Young Scholars) and provide demonstrations at large STEM events. Through a combination of this outreach, recruitment efforts, industry partnerships, and supplemental funding (Native American and Veteran Research Experiences), our programs motivate students from all backgrounds to pursue degrees and consider careers in biogeotechnical engineering.

University Curricula - Modules and courses for undergraduate, graduate, and practitioner levels have been developed by the Center. An interactive module for first year engineering students introduces the field of biogeotechnical engineering, CBBG research, and possible career paths. Modules for undergraduate courses focusing on biogeotechnics, geotechnical engineering, bio-inspired concepts have been developed and delivered, with many using a Problem-Based Learning (PBL) format. Graduate courses in Bio-inspired Design, Biogeotechnical Engineering, and Engineering Education have been developed and implemented by CBBG partners. Ongoing opportunities for cross-training in microbiology, geochemistry, and sustainability are pursued whenever possible through interdisciplinary research teams and by faculty integrating these areas into their courses.

A webinar series is scheduled each year to include presentations from various research teams, industry members, education and workforce development, diversity and inclusion, and student leadership. This series is supplemented by recorded lectures (e.g., data archiving, inclusive leadership, intellectual property). To increase interactivity and engagement, knowledge checks have been added to these recorded lectures and must be completed by the students who did not attend the presentation in person.

All developed content materials are reviewed by the Curriculum Committee, which consists of one faculty member and one graduate student from each university partner and chaired by the Education Director. Once materials have been vetted by the committee and updated, they are shared among all partners and more broadly disseminated through various national outlets and the CBBG curricula website.

Cross-Partner Educational Opportunities - CBBG fosters educational opportunities through collaborations across partner institutions, non-CBBG universities, industry, and primarily undergraduate and foreign institutions on publications, outreach, and curricula. Students and faculty collaborate on joint projects, share expertise through virtual meetings, co-author papers, and work in partner labs or Test Pits. CBBG sponsors workshops and symposia that are broadly attended by students, faculty, and researchers from other universities around the world. Students and staff have opportunities to attend external workshops, symposia, and conferences related to biogeotechnics. Papers are co-authored across institutions, cross-training opportunities are offered at multiple academic partners, and collaboration among domestic and foreign CBBG partners are supported.

Mentoring and Career Development - CBBG fosters mentoring relationships between faculty, graduate and undergraduate students, summer intern participants (REU, RET, Young Scholars), and the Industry Advisory Board (IAB). The value of mentoring activities is emphasized with all participants to further enhance mentoring competencies. Mentoring workshops and training offered throughout the year include webinars, Mid-year or Annual Meetings sessions, one-on-one mentor/mentee interactions, and other opportunities as appropriate. Research lead faculty regularly monitors the progress of both mentors and mentees on their team. Feedback is addressed each year to improve the overall mentoring experience.

Each partner university has representatives on the Student Leadership Council (SLC) to create a networking/support system, organize professional development and social activities, and provide input to the educational and career development. The SLC executive committee includes the Center Outreach Coordinator who plans opportunities based on assessments of students' needs and interests, with an increased emphasis on involving industry partners in career development. Achievements, including Center awards, poster awards, selection for limited-appointment programs, and other honors are announced on the CBBG social media sites, weekly BioGeotechNotes emails, and distributed through all partner university communications offices.

Industry Interaction - CBBG industry members engage with students in multiple ways, including teaching courses, serving dissertation committees, co-authoring papers, working on (and supporting) research projects, providing internships, contributing to design challenges, and participating in webinars. Entrepreneurship and innovation training is provided through our webinar series, summer programs, and cross-university course on "Connecting Research to the Broader Community." Several teams have also participated in the NSF I-Corps program training.

Pre-College Education

The CBBG Pre-college Education programs include curriculum development and dissemination, Research Experiences for Teachers (RET) Program for K-14 STEM teachers, Young Scholars Program (YSP) for high-school students, and targeted outreach to K-14 students from underrepresented populations.

Pre-College Curriculum Development - Pre-college curricula are developed across the four CBBG university partners and disseminated through various means. Curricula are created to support CBBG demonstrations for K-12 classrooms, out-of-school-time, and the public. Through the summer RET program, lesson plans are developed by teachers, implemented in their classrooms, and disseminated to partner organizations and programs, once they have been vetted by the Curriculum Committee.

Research Experience for Teachers (RET) Program - The CBBG RET program allows local, STEM-focused K-12 teachers and community college faculty to participate in cutting-edge laboratory research in state-of-the-art testbed facilities. The teachers participate in interactive workshops, for example, engineering and Problem-Based Learning, Universal Design for Learning, engineering standards, remote labs, curriculum design, and educational technology directly related to supporting them as they develop curriculum materials based on project research for use with their own students. Participants collaborate with teachers participating in other RET programs on campus and provide feedback on lessons they have developed.

The education team guides teachers in the development of assessment instruments and as they implement their curriculum project with their own students. After they have implemented the lesson and submitted final versions of their lesson, poster, and implementation report, teachers are paid the final installment of their stipend. All the RETs are invited to present their research poster at the Annual Meeting in the fall.

Teachers report that once they finish the CBBG RET program, their partnership with the Center does not end. Examples of ongoing program impact include participants pursuing publications and conference presentations based on their Center research, sharing CBBG lessons with teachers from Title 1 communities at teacher professional development workshops, and developing Multidisciplinary Course-based Research Experiences (mCUREs) to strengthen the partnership between the university and local community colleges.

Young Scholar Program (YSP) - High-school students are recruited from local schools to participate in the Young Scholars Program at all four CBBG universities. Students from underserved populations at our partner schools are strongly encouraged to apply. Senior investigators identify a research project and graduate student mentors for each scholar. The students work full-time in the CBBG labs for five weeks. The students often participate alongside other summer interns (RETs and/or REUs), with demonstrations, lab tours, safety training, learning about the mentor's research, and hearing from industry leaders about careers in biogeotechnics. The Young Scholars work with their mentors to create a poster, based on their research, to present at the Closing Reception. They are invited to the CBBG Annual Meeting to present their posters, and engage with the RETs, REUs, CBBG researchers, and industry leaders. Each year, students from the Young Scholar Program have been accepted into engineering undergraduate programs at one or more of the CBBG partner universities, where they continue their research with the Center. Several have continued all the way through the educational pathway to earn a PhD with CBBG.

Outreach and Recruitment Strategies - The goals of CBBG outreach activities are to increase participation of talented students in biogeotechnical engineering and provide opportunities to those from groups traditionally underrepresented in the STEM fields. Through long-term partnerships with local schools and communities around each partner institution, we actively engage students and teachers from schools with high percentages of students from populations underrepresented in STEM and low-SES communities. Our pre-college outreach efforts engage the local community of all four partner institutions year-round. For example, ASU's partnerships with on campus centers, such as the Student Accessibility and Inclusive Learning Services and the Center for Gender Equity in Science and Technology help reach a broader audience for our programs. NMSU reaches diverse groups of participants through their partnerships with their STEM Outreach Center and Dona Ana Community College and provides Spanish versions of demos for collaborative use across partners. UCD hosts STEM for Girls to demystify geotechnical research and empower middle school girls for a future in engineering. Georgia Tech's partnership with local schools and industry lead to successful diverse recruitment for our RET, REU, and Young Scholar Programs each year.

Evaluation and Assessment

Rigorous formative and summative assessment and evaluation are seamlessly integrated into all aspects of the university and pre-college education and outreach program to enable systematic, ongoing improvement of activities and materials. This is accomplished through ASU's College Research and Evaluation Services Team (CREST). Data are collected regarding learning, perceptions of skills, outcomes, attitudes regarding STEM and biogeotechnical research and careers, as well as the value of the Center's educational activities and how these can be improved.

Sustainability Plan

The work achieved by the EWD team and collaborations will sustain beyond the graduation of the Center into the Consortium of Bio-Mediated and Bio-inspired Geotechnics. Sustainability plans for the Consortium involve making existing curricula available to students and consortium partners, disseminating research through the International Conference on Bio-Mediated and Bio-inspired Geotechnics (ICBBG), pursuing RET and REU Site funding, designing short courses and graduate certificate programs, and continuing as the leader in biogeotechnical engineering.



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