2026 ASEE ANNUAL CONFERENCE June 21–24, 2026 | Charlotte Convention Center, NC
Host Sponsor UNC Charlotte
ASEE AMERICAN SOCIETY FOR ENGINEERING EDUCATION
Paper ID #52604

NSF REU Black Hills Applied Ceramic Engineering: Programmatic Cohort Building

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Dr. Katrina Donovan received her B.S. degree from South Dakota School of Mines and Technology in 2010. She received her Ph.D. in Materials Science from Oregon State University in 2019, studying the microfluidic investigations of capillary flow and surface phenomena in porous polymeric media for 3D printing. She worked for multiple years at HP, Inc. in the 3D Printing Department. She is currently a Lecturer at South Dakota Mines and Research Scientist at Dragon Materials, LLC, an engineering consulting firm. Her research involve experimental design and technique development for soft materials, complex fluids, and surface phenomena. She a wide range of experience in rheological, thermal, structural, and molecular characterization that she leverage fundamentally for academic purposes as well as industrially for applications. As her three patents can show, designing experiments and creating novel techniques to answer fundamental questions that drive applications and technology forward captivates her interest. She has volunteered countless hours to the community, led multiple STEM Education grants that engage the local K-12 schools of the Pine Ridge Indian Reservation, and has submitted proposals that engage even more tribal communities.

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NSF REU Black Hills Applied Ceramic Engineering:

Programmatic Cohort Building

The Black Hills Applied Ceramic Engineering (BACE) is a ten-week NSF Research Experience program that provided a holistic approach to ceramics and engineering by integrating geology and advanced ceramic materials. This cross-disciplinary program included mentors from five different disciplines and a cohort that was just as diverse. With a BACE program objective to recruit students with varying degrees and academic experiences, the 2025 student cohort included a group of student scientists and engineers ranging from sophomores to seniors. Year 1 of the program began in the summer of 2025. The BACE program had a two-pronged approach to support a common technical language among the students and build community within the cohort. The two programmatic approaches will be discussed in further detail as well as the evaluation of the efficacy of the cohort approach. The assessment utilized a mixed-methods design. The components relevant to this paper include a logic model framework, student attitudinal and feedback pre- and post-surveys, and student focus groups.

The first approach was the development of a one-week technical training. The training ranged from geology to mineral processing to advanced materials with modules including lecture, instrument training, and hands-on laboratory training. The training provided the cohort an opportunity to interact with one another early in the program, while simultaneously building a solid foundation in geology and ceramic materials. Because students came to our program with diverse academic backgrounds, providing technical training allowed for the development of a common scientific and engineering language.

The second approach to cohort building within the program took place throughout the summer and included four field trips that included the Crazy Horse Volksmarch, Black Hills geological field expedition, Badlands geological field expedition, and an industrial field trip.

Program Context and Design

Western South Dakota provides a geologically and culturally rich environment that supports integration of geological sciences with ceramic engineering applications. These regional characteristics enable place-based learning experiences that contribute to cohort cohesion and interdisciplinary understanding. This region of the United States provided the perfect landscape for a synergistic REU site. These cultural and regional experiences contributed to cohort cohesion by providing shared, place-based experiences that extended beyond the laboratory, fostering interpersonal connections and a sense of collective identity within the group.

This work contributes to an integrated cohort-building model that combines early technical onboarding with sustained community development in a cross-disciplinary REU environment. While many REU programs emphasize either technical preparation or cohort cohesion, this work examines how the intentional integration of these components supports the development of a shared technical language and collaborative research engagement among students from diverse disciplinary backgrounds.

BACE Site Mentorship Team Structure

Creation of new materials is the key to future technological development. The BACE team is uniquely qualified with the expertise to utilize the geological resources in our *"backyard"* (Badlands and Black Hills), while simultaneously translating this understanding to new ceramic applications. The BACE REU site was designed to encompass the geological sciences to the mineral processing and characterization building up to advanced materials manufacturing and included multiple research experts spanning over five departments at the university. Consequently, the assembled team of nine BACE researchers comprises cross-cutting interdisciplinary mentoring teams. Research projects have a primary mentor and a co-mentor, providing the students with access to multiple research mentors and provided a two-deep leadership model and has worked successfully in this first year of the REU. This two-deep mentorship structure increased accessibility to mentors, exposed students to multiple disciplinary perspectives, and provided continuity of support across research and professional development activities, contributing to both technical growth and cohort cohesion.

Along with a team of research mentors, there are two invited technical guest lecturers that focus on BACE topics. Two of the guest lecturers, Ms. Jennifer Galindo, archeologist with the Rosebud Sioux Tribe and Dr. Channing Stellato, Vice President of Academic Affairs at Little Priest Tribal College, provided both technical and culturally relevant content. In addition to scientifically technical components of the program, a Technical Communication Coordinator (TCC), Dr. Rodney Rice consulted on the project. He provided over 30 years of technical communication experience to the program and over a decade of experience to the REU program. The BACE program delivers content that has been designed specifically for REU students. The students shared research results, discussed writing practices and procedures, and drafted final technical reports according to a step-by-step protocol. Technical communication activities culminated with a research poster presentation and a final technical report.

Student Professional Development and Cohort Building

The BACE program offers a wide range of activities, see Table 1, with three main focuses of each component *BACE Development*, *Technical Communication*, and *Professional Development*. The activities in Table 1 created numerous opportunities for cohort building and networking.

Table 1. Compilation of professional and cultural development activities for REU BACE students.

Wk	BACE Development	Technical Communication	Professional Development
0	*Mentoring Diverse Students Workshop* provided to the research mentors by the Cultural Center at Mines.		
1	5-day Geology & Ceramic Engineering Course[+]	Pre-Assessment-Writing & Speaking; Writing Intro^	RCR[$] Training & Collaborative Research Ethics (Donovan)
2	Industry Tour (Pete Lien; Pacer)[#]	Writing - Research Reflection^	Literature search tools/training (Library)
3	Lakota Sioux Tribe Pot	Report Writing I^	Research Process (Stellato)
4	Crazy Horse Monument	Report Writing II^	Design of Experiments (Cross)
5	Geology Site Tour[+] (Keenan)	Open Time	Time Management (Kellar)
6	Badlands National Park: (Keenan)	Oral Presentation (Keenan)	Grad School Overview I (Dean of Grad. Ed.)
7	Free Week	Group Writing (Keenan)	Grad School Overview II (Dean of Grad. Ed.)
8	Free Week	Graduate School Resume	Career Planning (Heiberger)
9	Prepare for Research Symposium	Practice Poster Presentation	Innovation and Entrepreneurship (Lambeth)
10	Present at Research Symposium	SD Undergraduate Symposium	What to Expect in Grad School (grad students)

^Topics led by Rice; [$]Responsible Conduct of Research; [#]Letter of Support Provided; [+]Curriculum and program infrastructure provided by NSF IUSE grant (#2120156) [5] and NSF Collaborative Proposal (#1642050) [6]

Collectively, these activities align with the program's logic model by linking structured technical onboarding, communication training, and professional development to intended outcomes of cohort formation, interdisciplinary communication, and research readiness.

As previously mentioned, the *Technical Communication* programming was integrated throughout the summer to support the students' growth for success in scientific dissemination. The program supported *Professional Development,* specifically with programming designed to prepare the REU students for graduate school or for a STEM professional career (e.g. included an industry tour). From the graduate school pathway, the students learned technical skills (information gathering, design of experiments, etc.), and what to expect in graduate school. The program included content revolving around innovation, entrepreneurship, business start-ups, and resume preparation. The students completed lab campus safety training and Collaborative Institutional Training Initiative (CITI Program) for Research, Ethics, Compliance, and Safety Training.

The *BACE Development* component was very customized to support the uniqueness of this program. There were numerous structured activities (5-day workshop, industry tours, geological field studies, etc.) over the course of the summer to reinforce geological and ceramic engineering concepts developed in the research setting and expand their professional and cultural awareness. For example, one cultural activity led by Ms. Jennifer Galindo included a presentation to the REU students on the local Lakota Tribe and their history of the area, with a specific emphasis on the ceramic pottery of the indigenous population from the region. One very successful and cohort building opportunity was the *5-Day Geology and Ceramic Engineering Course,* which was inspired and partially developed by previous work [1]-[4].

The REU site had students spanning multiple disciplines from geosciences to chemistry to civil and chemical engineering, and supported student growth in the field of geology and ceramic

engineering while providing a solid technical foundation and common technical language. The course was led by PIs and senior personnel.

External Assessment Instruments

This paper reports findings from the first year of program implementation, the results should be interpreted as early-stage observations. Ongoing longitudinal assessment will examine outcomes such as continued research engagement, graduate school enrollment, and long-term professional pathway development.The design of the evaluation plan, specifically the survey instruments, is informed by NSF evidenced-based evaluation design methodologies. The external evaluator, Ms. Sharon Chontos, specializes in program and project evaluation services. Chontos is an active member of the American Evaluation Association and is the current evaluator for several NSF and NIH student training programs. The evaluation methods included several models, but the modules relevant to this paper include Logic Model, Student Attitudinal and Feedback Pre-and Post-Surveys, and Student Focus Groups.

The Logic Model, is based on NSF evaluation practices [7]-[9] and outlined below, has been developed to guide the overall evaluation. For the Student Attitudinal and Feedback Pre- and Post-Surveys, all BACE students were surveyed with a pre-test in May and a post-test in August. The pre- and post-summer survey utilized the Undergraduate Research Student Self-Assessment [10] survey that was developed by the University of Colorado – Student Assessment of their Learning Gain [11]. The students participated in a focus group facilitated by the external evaluator during the last week of the program. Data from the focus group validated and enriched the survey data. The questions focused on program strengths and weaknesses and impact on the students' academic career and career choices.

IRB Statement: This study was reviewed by the Institutional Review Board of South Dakota State University and determined to be exempt from further review under Exemption Category 2 as outlined in 45 CFR 46, §104(d). The approved exemption protocol number is IRB-2106010-EXM.

Results: Week 1 Technical Training and external Assessment of the entire summer program

The following data, Fig. 1. represents the quantitative responses from the REU student surveys for the weeklong course. The cohort was composed of eight students, but one student was finishing up finals and arrived after Week 1. The instructors and training module relevance were evaluated.

One hundred percent (100%) of the REU students (7) had the following survey responses: rated the quality of instruction as excellent; rated the instructors as very approachable; rated the pace of the course as just right; and stated the workshop (lecture and labs) gave them a broader understanding of science from geology to mineral processing to ceramic materials. Each of the modules conducted throughout the week were assessed by the students regarding their relevance to the BACE program. The Lab Safety Training was ranked the highest with the SEM, XRD, and XRF training following closely behind.

The high relevance ratings for hands-on instrumentation modules (SEM, XRD, XRF) suggest that experiential components played a critical role in both technical onboarding and early cohort interaction. These activities contributed not only to conceptual understanding but also to peer

engagement and confidence-building during the initial stages of the program. These results directly support the program's objective of establishing a shared technical foundation early in the REU experience, suggesting that the structured onboarding successfully reduced initial knowledge disparities and supported student confidence and engagement.

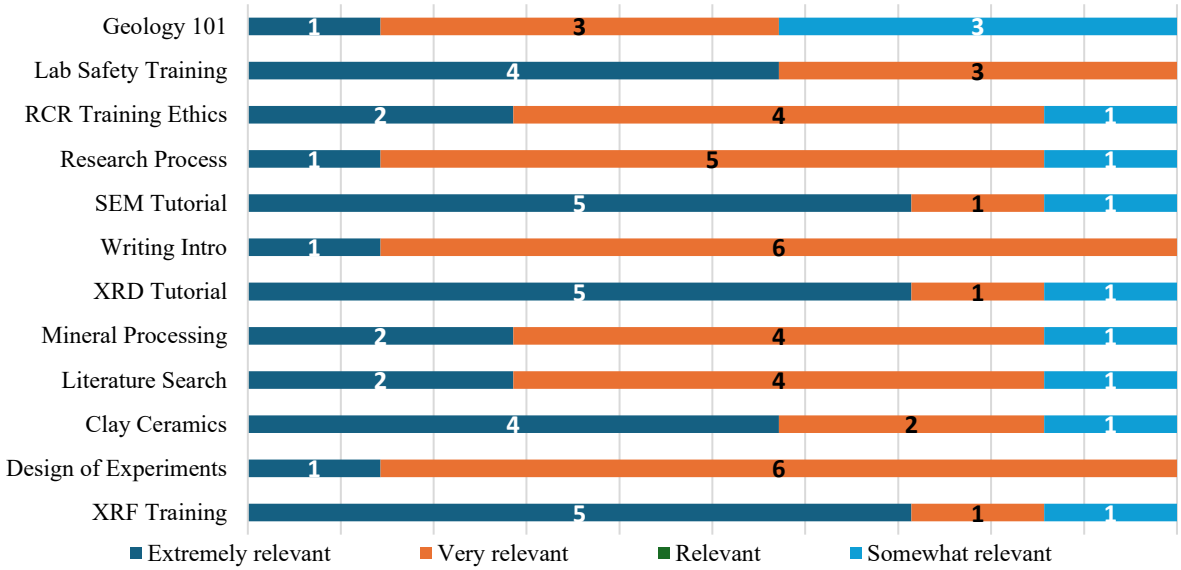

Fig. 1. Distribution of student ratings for workshop module relevance (n = 7), showing strong perceived value of hands-on instrumentation and safety training modules.

In the Post-Summer Student Survey, the students were asked to rate their experience working with their peers and their mentors. One hundred percent (100%) of the REU students (n=8) had stated that they had "good" or "excellent" working relationship with their research mentor and the other BACE students. At the conclusion of the summer 2025 REU, the external evaluator performed a Focus Group. The evaluator asked specifically about the first-week workshop, and students said it allowed them to bond with each other and the PIs, gain baseline background knowledge (especially geology or ceramic engineering), tour the labs, and better understand the campus resources available to them. Networking with peers, professors, and graduate students was consistently cited as a positive part of the experience.

Fig. 2. REU students and mentors after summiting Crazy Horse Monument (top), and a picture of the students on a local hike (bottom).

Qualitative Assessment of the Cohort Building.

Early in the program the students had the entire first week build rapport through the various programmatic opportunities throughout the summer. The first week ended with a cohort building activity where mentors and REU students hiked in a Volksmarch to the top of Crazy Horse Monument, an event that only happens twice a year. One common thread that brought the summer students together is an enjoyment of the outdoors. By the 3rd and 4th week of the program, the students were scheduling their own group outings to explore the area, see Fig. 2.

Citations

[1] K. J. Donovan and J. J. Kellar, “NSF IUSE: Art + engineering: Translating local mineral research to a high school classroom,” in Proc. ASEE Annu. Conf. Expo., 2025.

[2] K. J. Donovan, J. J. Kellar, M. West, S. D. Kellogg, and W. Cross, “Investigating creativity, confidence, and an entrepreneurial mindset through curricular modification and community engagement,” in Proc. ASEE Annu. Conf. Expo., 2023.

[3] K. J. Donovan, J. J. Kellar, M. West, C. Birrenkott, and S. Kellogg, “Investigating the impact of arts on student learning by introducing glass science in the materials engineering curriculum,” in Proc. ASEE Annu. Conf. Expo., 2022.

[4] K. J. Donovan, J. J. Kellar, S. D. Kellogg, “South Dakota Mines Art + Engineering engagement in co-curricular and community-focused events,” in Proc. ASEE Annu. Conf. Expo., 2024.

[5] K. J. Donovan, J. J. Kellar, M. West, C. Birrenkott, S. Kellogg, D. Mitchell, and M. Whitehead, “Investigating the impact of arts on student learning by introducing glass science in the materials engineering curriculum,” in Proc. ASEE Annu. Conf. Expo., Minneapolis, MN, USA, 2022. Available: https://peer.asee.org/42059, accessed Jan. 4, 2026.

[6] S. Keenan, J. Sawyer, and J. Benning, “Collaborative proposal: OLC SDSU SDSMT pre-engineering education collaborative – Phase II,” NSF Award #1642050. Available: https://www.nsf.gov/awardsearch/showAward?AWD_ID=1642050, accessed Jan. 4, 2026.

[7] National Science Foundation, “Foundations evidence-based policymaking act: Evaluation and evidence building - A practical guide for federal program evaluation,” Arlington, VA, USA, 2013.

[8] W. K. Kellogg Foundation, *Logic Model Development Guide*, Battle Creek, MI, USA, 2004.

[9] P. H. Rossi, M. W. Lipsey, and H. E. Freeman, *Evaluation: A Systematic Approach*, 7th ed. Thousand Oaks, CA, USA: Sage, 2004.

[10] T. J. Weston, S. L. Laursen, and A.-B. Hunter, “The undergraduate research student self-assessment (URSSA): Validation for use in program evaluation,” *CBE—Life Sciences Education*, vol. 14, no. 3, art. no. ar33, 2015. doi:10.1187/cbe.14-11-0194.

[11] E. Seymour and A.-B. Hunter, “The student assessment of their learning gains (SALG),” Univ. Colorado Boulder. Available: https://www.salgsite.org, accessed Jan. 4, 2026.