

SPOTLIGHT

Code to Communicate: Empowering Bilingual Connections in Earth Science

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THE BIRTH OF CoCo: A TALE OF INNOVATION AND COLLABORATION

The Earth sciences lack representation of Latine scholars in academia and industry. Latine scholars encounter systematic barriers within academic environments globally, including discrimination and gender biases, lack of guidance due to cultural differences, funding limitations for non-citizens, access burden of visa applications, and language-barriers for non-native English speakers (Valenzuela-Toro and Viglino, 2021; Carrera et al., 2023).

A prominent barrier is the lack of language-inclusive training in programming and science communication (henceforth, SciComm). This missing training increases the knowledge gap between first- and second-language English speakers in Earth sciences. In today's digital age, effectively articulating research to diverse audiences is crucial for marketing, securing funding, and disseminating scientific knowledge through written and spoken outlets. However, the language barrier for many Latine scholars poses significant challenges in learning specialized topics and effectively communicating research findings.

In our community, Latinas in Earth and Planetary Sciences, or GeoLatinas (<https://geolatinas.org/>), we enforce a member-driven structure where members decide on community directions. GeoLatinas fosters a stronger presence of Latinas in Earth and planetary sciences, driving positive change and amplifying diverse voices in academia and industry. In 2021, we established two initiatives, the GeoLatinas Coding Group (GLCG; <https://geolatinas.github.io/>) and the GeoLatinas blog (GLB; <https://geolatinas.org/geolatinasblog/>). The GLB, a multilingual platform in English, Spanish, and Portuguese, provides a valuable opportunity for those interested in science blogging to gain practical experience and explore alternative methods of SciComm. The GLCG has played a pivotal role in providing a welcoming, bilingual, judgment-free environment for individuals at various career stages to learn coding. Recognizing the complementary aspects of these two initiatives, we merged the GeoLatinas Coding Group and the GeoLatinas Blog into Code to Communicate (CoCo), a National Science Foundation funded program.

CoCo FRAMEWORK: DESCRIPTION OF THE PROGRAM

CoCo is a virtual, bilingual program directed at early-career researchers that offers training in Python programming and SciComm. It was created in 2021 by the co-founders of two GeoLatinas initiatives, Angelique Rosa Marín and Mónica Alejandra Gómez Correa of GLB and Isamar M. Cortés and Andrea Balza of GLCG. Our program boasts a team of early-career coaches/scientists from Argentina, Venezuela, Mexico, Puerto Rico, Colombia, and Chile recruited from the extensive GeoLatinas network. Coaches are guided by coding and SciComm coordinators and program directors. CoCo is supported by two Earth science and Python experts, Nicole Gasparini and Mark Piper, and an external evaluator, Julie Libarkin. We draw on a peer and leadership network of 33 Latine scientists worldwide.

CoCo recruits a diverse cohort of Latine participants seeking Python and SciComm bilingual training. Applicants write short essays describing programming and SciComm experiences and how the program supports their academic and career objectives. By targeting students who have challenges due to language barriers, we reach the population who will most benefit from our bilingual program.

CoCo promotes inclusivity by offering free online course materials and engagement in English and Spanish. Our 10-week virtual program offers comprehensive training, with weekly classes focusing on Python libraries for data management, processing, and data visualization. SciComm lectures increase awareness of communication strategies and the importance of producing information accessible to diverse audiences. Teaching goals include: (1) introducing students to Python and its Earth science applications, (2) fostering science blogging and social media as tools for communicating science to non-technical audiences, and (3) promoting collaborative research and network building.

To cultivate teamwork and collaboration, students establish a GitHub account to access our materials (<https://github.com/CodeToCommunicate/CoCoLessons>) and join our Slack workspace. Github facilitates code sharing and seamless interaction among peers and coaches. Coaches teach using the Community Surface Dynamics Modeling System-OpenEarthscape Jupyter Hub, enabling live coding to remove technical barriers. Students can follow the live-lesson and explore Jupyter notebooks independently regardless of computer operating system. Course materials, including class recordings and presentations, are made available. Slack enables connection among students during the program and after. The Code to Communicate website (<https://www.codecommunicate.org/>) and social media accounts, including X (formerly Twitter) (@CodeCommunicate) and Instagram (@codecommunicate), increase program visibility.

CoCo is divided into two five-week sessions containing five hours of weekly experiences. Each week, participants attend one 2-hour coding lesson and a 1.5-hour SciComm class, with an optional extra hour of office hours. The first session introduces widely used Python scientific libraries, such as Numpy, Pandas, and Matplotlib. The second session focuses on libraries developed for specific geoscience subdisciplines. Lessons vary depending on cohort interests. SciComm lessons cover the significance of effective communication, blog writing structure, translation strategies, proposal writing, development of scientific presentations and posters, and audience targeting. Students publish their blogs on the CoCo blog (<https://www.codecommunicate.org/coco-blog>), showcasing their perspectives on topics ranging from volcano monitoring to invasive riverine plants. Students receive constructive feedback from coaches. A total of 28 blog posts have been published, 15 in Spanish and 13 in English.

The program closes with a week-long GeoHackeo, where teams use Python to explore a geoscience question. Teams submit a proposal for their GeoHackeo projects and receive feedback. On the

last day, teams present their findings in English, Spanish, or both. Example team projects include investigating water quality changes using remote-sensing data, temperature effects on vegetation biomass, landslide processes, and plate tectonic movement.

BIENNIAL RESULTS

CoCo received 112 applications in 2022 and 2023 and accepted 34 participants (21 in 2022 and 13 in 2023) from across the United States, Latin America, and Europe, all of whom self-identified as Latine, Hispanic, Latinx, or similar. A mid-term, multiple-mechanism evaluation was conducted after the first season in 2022 to provide guidance for revision in the second season. Completed surveys ($n = 9$) indicated high satisfaction, with participants indicating they felt overwhelmingly more confident in their ability to use Python and were excited about their growing abilities in general and with specific tools. Participants also expressed appreciation for the bilingual nature of CoCo and particularly for the ability to learn in two languages with the freedom to decide which language works best. This sentiment was repeated in subsequent surveys and across both years. Participants provided suggestions such as providing materials before in-person sessions, using one language within training (Spanish or English), providing personalized feedback, and holding participants accountable for engagement. These recommendations were implemented in CoCo 2023.

Participants completed a pre-CoCo survey on perceptions of multiple knowledge domains and an identical survey after the GeoHackeo. Not all participants completed both surveys, so caution is advised in interpreting statistical results. Nonetheless, results indicate that participants experienced increases in both coding knowledge and coding self-efficacy. For coding knowledge, the median post-test ranks were statistically significantly higher than the median pre-test ranks, $Z = 2.74$, $p = 0.006$. Similarly, on coding self-efficacy, $Z = 3.38$, $p < 0.001$.

Finally, the GeoHackeo experience was evaluated using intermittent observation throughout the week and during final presentations as well as a focus group discussion. These observations indicated participants were engaged in their projects through either verbal discussions on camera or active work on shared documents off camera. Both languages were spoken by group members. Groups exhibited a range of activities aligned with the problem-solving required for project completion. For example, groups sought assistance from instructors in troubleshooting code and discussing code output. Groups engaged in self-help by seeking answers to issues via documentation in Github.

After the presentations, a brief focus group discussion probed participant experiences with CoCo. Discussion occurred in English with the option provided to translate into Spanish as needed. Participant responses in the focus group indicated that participants felt they learned coding during the CoCo workshops and were introduced to new SciComm skills. Participants suggested modifications to season two lessons to reduce the difficulty of the material, a suggestion implemented in the 2023 training. Based on this focus group and post-CoCo survey results, participants were happy about the bilingual nature of CoCo, increased their ability to code, and gained new SciComm insights.

EMBRACING LEARNING AND FORGING AHEAD

After year one, it became evident that most students favored using Spanish for all aspects of CoCo. In response, in 2023, we exclusively offered live lessons in Spanish while preserving the bilingual

educational notebooks. The program's length and time commitment were a challenge. The program coincided with the academic semester for most participants. Scheduling the GeoHackeo at the end of the semester led some students to drop out beforehand, leaving some teams with fewer people. We learned the importance of flexible attendance. Recording the live lessons increased accessibility for students with scheduling conflicts.

CoCo offers professional development opportunities to its participants and the team. The core leaders—the first four authors and all junior scholars—had invaluable experiences and established meaningful relationships with peers, students, faculty members, and collaborators.

In their own words:

CoCo is a platform to practice and enhance our teaching, research, project management, and leadership skills, which will undoubtedly benefit our careers in the long run.

Participating in CoCo during the early stages of our careers has given us a unique perspective on the real impact that collaboration and teamwork can have. We have witnessed firsthand the transformative power of working together towards a common goal and the positive change that can result from it.

CoCo provides vital support and resources for second language learners. The virtual format facilitated global participation, enabling students from around the United States and beyond to join. Overall, CoCo has been an enriching experience for everyone involved, empowering us to make a difference and contribute to the growth and development of individuals and communities in the field of Earth science.

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