Eos

A Pandemic Pivot in Earth Science Outreach and Education

For some educators, restrictions imposed by COVID-19 created space for innovation and affirmed the value of online tools and learning environments for increasing access to and engagement with science.

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2 December 2020

Traditional Earth science education often takes students and instructors outside, to places such as San Lorenzo Canyon in New Mexico, as seen here. Amid restrictions resulting from the COVID-19 pandemic, many educational institutions, including the Education and Public Outreach program at the Incorporated Research Institutions for Seismology (IRIS), have stretched the horizons of virtual offerings to support the needs of educators and learners. Credit: Theresa Czech

In classrooms around the world, rapid shifts to fully online learning necessitated by the outbreak of the COVID-19 pandemic **challenged educators and students** from preschool to graduate school. In many cases the hasty switch revealed frailties in educational systems, especially as instructors faced increased workloads and potentially reduced budgets, whereas in other cases, it brought the value of existing strengths to the fore. The inherent flexibility of the **Education and Public Outreach** (EPO) program at the Incorporated Research Institutions for Seismology (IRIS), which operates the National Science Foundation's (NSF) Seismological Facilities for the Advancement of Geoscience, resulted in an experience that differed from those in many educational programs.

Our pandemic pivot began with a rapid assessment of needs within the communities we serve—K–12 teachers and their students, undergraduate students and faculty, graduate students, and early-career scientists—as well as reallocation of staff time and financial resources and reframing how we approach our mission to support seismology education and workforce development. To address these needs, IRIS EPO creatively developed educational solutions, including a free online course for hundreds of undergraduates, increased dissemination of existing resources to support online learning and instruction, livestreaming instruction to learners through social media, and mini-investigations for at-home use. Over several months, these efforts impacted thousands of educators and learners worldwide.

This experience is helping clarify our next steps toward greater involvement in online education, an interest of ours before the pandemic began but not something we were actively pursuing because of resource limitations. However, with resources freed up because of COVID-19 travel restrictions, for example, we were able to take risks and commit to bigger projects more rapidly during the initial COVID response.

Groundwork for Success

In contrast to many educators who saw their workloads increase early in the pandemic as they quickly reworked courses for online delivery, the EPO team's travel and responsibilities were initially reduced because of canceled in-

person workshops, meetings, and summer programs. The resulting staff time and financial resources that became available, along with flexibility from NSF, allowed us to experiment with alternate approaches and pivot quickly to fully engage in online education.

Through direct and indirect stakeholder communication, we identified and prioritized needs, aligned these needs with our team's strengths and experience, and reallocated our resources to design and implement targeted programming. Our pivot was accelerated because our staff had already been operating as a virtual team for over a decade, because preexisting plans to develop online materials were reprioritized and adapted for immediate use, and because plans for beta testing and extensive external reviews of new products prior to release were dropped. In short, our experience and capabilities gave us the means to quickly ramp up content creation to help educators with their changing teaching commitments, support student learning in this new environment, and provide capacity-building and supplemental opportunities for students missing out on experiences like internships.

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Seismology Skill Building Goes Virtual

The pandemic led to the **suspension of many opportunities** for undergraduate students in science, technology, engineering, and mathematics to further develop research skills. Among the canceled programs was the **2020 IRIS Undergraduate Internship Program**, in which about 15 students would have spent the summer conducting seismology-related research alongside research mentors from across the IRIS Consortium. We verified the need to fill the void left by these cancellations through discussions with alumni of the IRIS program, who related one of the most valuable aspects of the internship: learning scientific computing skills in the context of seismology.

EPO staff reflected on this need and identified existing resources that could help build a rapid response. With traditional in-person approaches not possible, we looked for new solutions, preferably involving current partners and repurposed existing materials. A series of introductory, self-paced computing tutorials (accompanied by a downloadable "virtual disk" that provided a uniform computing environment), which were developed by Mike Brudzinski at Miami University of Ohio and already in use as preinternship trainings, offered promise. We decided these tutorials could serve as a foundation for a fully virtual **Seismology Skill Building** Workshop designed to increase students' knowledge and skills in seismology and scientific computing. The workshop would also aim to engage student interest, improve self-efficacy in using seismic data, and advance participants' competitiveness in applying for summer REUs (Research Experiences for Undergraduates), graduate school, or professional positions. The funding available because of canceled staff travel provided the capital to contract Brudzinski to collaborate with EPO staff to develop additional tutorials and implement the skill-building workshop.

> *The Seismology Skill Building Workshop was offered as a fully online, asynchronous learning opportunity with an expected student time investment of 5 to 6 hours per week.*

Our colleagues and peer organizations helped publicize the free, not-for-credit workshop widely through social media. Registration was open to all undergraduates, regardless of major, citizenship, or prior coursework, although at least one semester of college-level math and physics was recommended. We anticipated roughly 100 registrants—and were shocked as interest soared past that, with 773 undergraduates from 60 different countries eventually signing up to participate.

The workshop was offered as a fully online, asynchronous learning opportunity consisting of 7 modules broken into 35 individual interactive learning tutorials [***Sit and Brudzinski***, 2017]. Release of the modules spanned from 1 June to 31 August, with an expected student time investment of 5 to 6 hours per week. Students downloaded a virtual Linux box containing all software needed for the workshop. The tutorials were the backbone of the workshop and consisted of coding assignments framed within a seismological context. One assignment, for example, offered an introduction to the Python programming language as well as libraries (e.g., NumPy, Matplotlib, Pandas, and ObsPy) commonly used for retrieving, processing, and plotting data tables and times series that enable rapid scientific analysis of earthquake catalogs and seismic waveforms.

Scheduled live webinars that were also recorded for asynchronous use presented tips for successful participation in the workshop, lessons on seismological content, and discussions of upcoming assignments. Participants were also subscribed to a Slack workspace to create an active peer learning community.

Over the course of the workshop, EPO staff, workshop instructors, and graduate student assistants learned many lessons, particularly related to managing communications, encouraging student-to-student interactions, and dealing with technical challenges among the global community of participants. For example, many participants, both in the United States and abroad, were working off campus and lacked stable high-speed Internet, creating connectivity problems ranging from mild inconveniences for some to complete barriers to participation for others. With intentional planning beforehand, we believe we can significantly reduce the impact of such problems in future workshops.

Performance statistics and evaluation results suggest the workshop was successful. Of the 773 registrants, 442 completed at least one tutorial and 193 (25% of registrants, or about 44% of those who started the course) completed all 35 tutorials, rates that outperform other courses of similar scale [*Jordan*, **2015**, **2020**]. We are still analyzing evaluation data, but our initial review suggests that nearly all who completed the entire workshop were very satisfied with their experience, described the workshop as a high-quality opportunity, and would recommend the workshop to others.

More Avenues for Online Education

The Seismology Skill Building Workshop was the largest project EPO undertook during the pandemic. But our team also explored a variety of other online education options, some created as self-guided student activities and others intended as teacher-guided activities that students could do at home.

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We produced a series of 11 Facebook Live episodes, called "**Wednesdays with Wendy**," demonstrating hands-on Earth science activities for K–6 students. These sessions were hosted live so students could directly interact with the presenter, and the recordings were later made available on YouTube. EPO also released 10 weekly **Teachable Moment** investigations offering opportunities for teachers and students to explore elements of seismology via guided activity slide sets and links to related materials.

We converted several in-person workshops—including our Anti-Harassment, Science Communication, Networking, and Social Media workshops—for online delivery, drawing more participation than in 2019. We also expanded our participation in online offerings led by other groups, including Skype a Scientist classroom talks, virtual summer camps, and YouTube presentations. Because the cost of exploring these options was minimal, we could try different formats and styles to see what was most useful and effective.

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In addition to creating new products, we pushed out existing IRIS educational products and resources across our social media channels. On Facebook and Twitter, we highlighted lessons and activities that kids could do at home and increased the frequency of our "Teachers Toolbox" posts, which steer teachers toward educational animations and GIFs as well as classroom lessons. Between 1 March and 30 September, we had 14.2 million combined impressions on Facebook and Twitter, 39% more than during the same time frame in 2019. Although some of this rise was due to an increase in followers, some undoubtedly resulted from educators and parents looking for educational material.

This assumption is supported by metrics from our **YouTube channel**, where there was a 42% jump in traffic compared to the same time period in 2019, with the increase occurring when school was in session in 2020 (Figure 1). In addition, much of the traffic to our YouTube channel came from external online learning platforms like CK-12, Blackboard, and

Instructure. Our online pages offering educational materials also showed a significant boost in downloads over 2019, including a 36% increase in downloaded lessons.

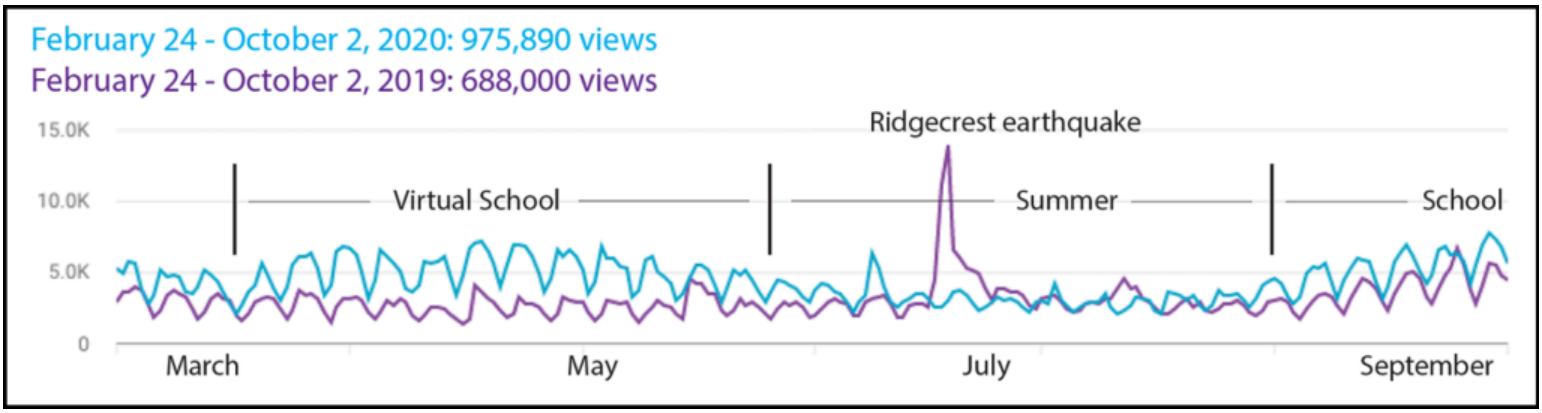

Fig. 1. Traffic, in page views, to the IRIS Earthquake Science YouTube channel between 24 February and 2 October in 2020 (blue) and 2019 (purple).

The COVID crisis has been and continues to be an unprecedented challenge for education. However, the online environments to which so many institutions have adapted this year can improve access to educational products, workshops, and classes by lowering financial and time barriers and allowing greater participation—compared with traditional in-person instruction—by students, academic parents, and others for whom time and travel are limited. Our experience with online workshops and talks showed that participants were engaged, and anecdotal evidence suggests students may be more willing to ask questions via chat than in person.

Benefits like these likely ensure that a wealth of online learning options, vastly expanded compared with prepandemic times, will continue even after the pandemic is over. Online education and the accompanying pedagogy are not new, but changes in education necessitated by the pandemic have highlighted the ongoing potential of online learning and the effectiveness and importance of converting traditional material to the online environment.

Acknowledgments

The authors thank the rest of the IRIS EPO team (Tammy Bravo, Mladen Dordevic, Perle Dorr, Jenda Johnson, and Danielle Sumy) for their efforts in developing and disseminating EPO resources and Mike Brudzinski for his development and implementation of the Seismic Skill Building course. This work is supported by the Seismological Facilities for the Advancement of Geoscience, operated by the IRIS Consortium and funded by NSF, under award EAR-1851048 and earlier NSF awards.

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Citation:

Hubenthal, M.,Bohon, W., and Taber, J. (2020), A pandemic pivot in Earth science outreach and education, *Eos, 101*, https://doi.org/10.1029/2020EO152146. Published on 02 December 2020.