

# Impacts of COVID-19 on the Geoscience Enterprise

How Permanent Will Academic Program and Workforce Changes Be?

Edited by Leila Gonzales and Christopher Keane



American Geosciences Institute



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# Executive Summary

The prolonged duration of the COVID-19 pandemic led to significant and unprecedented structural changes in social, economic, and educational systems worldwide. Frequent surges in virus cases and the emergence of new variants caused waves of disruptions and restarts in educational and business sectors. To adapt, academic institutions and businesses integrated virtual technologies, creating new working and learning models that ensured continuity throughout this volatile period.

In May 2020, AGI initiated a research project to investigate the short- and long-term effects of the pandemic on the geoscience workforce and academic programs. The project's goal was to establish a comparison of pre-pandemic and post-pandemic environments to assess the magnitude and permanence of these changes. Initially planned as a 12-month study, the project eventually expanded into a multi-year investigation that concluded data collection in December 2022. Primary data were collected through a multi-cohort longitudinal survey between May 2020 and December 2022, focusing on five primary cohorts: geoscience employers, non-academic geoscientists, academic faculty, geoscience college and university students, and recent geoscience graduates from 2014 through 2022. Additional insights were gained in 2022 through oral history interviews and a three-part webinar series, gathering best practices from various study cohorts on how they managed pandemic-related impacts.

The study aimed to identify the lasting changes to geoscience programs, departments, employers, and workforce resulting from the pandemic. It explored how research conduct evolved, including identifying new opportunities that emerged from the pandemic, and closely examined skills and knowledge gaps affecting post-2020 geoscience graduates. Strategies employed by employers, academic departments, and graduates to address these gaps were also investigated, along with an examination of career trajectories for recent graduates to assess any variations from pre-pandemic trends.

Furthermore, the project sought to inform future areas of research, including those related to new approaches in digital learning and teaching. By providing insights into the short- and long-term effects of this crisis that necessitated rapid structural workforce changes, the study aimed to assist institutions, employers, and decision-makers in improving response and recovery planning for future crises of a similar nature.

## **KEY FINDINGS**

The pandemic brought about widespread disruptions to the geoscience profession, affecting various aspects of academia, employment, and research. The results of this project highlight the common challenges experienced by the study cohorts, the strategies they employed to navigate those challenges, the new opportunities that arose as a result of the pandemic, and the new ways of working and learning that have emerged in the post-pandemic world.

## **Challenges**

Academic departments faced challenges such as budget cuts, staffing issues, limitations on fieldwork and travel, and declines in student enrollment. The rapid shift from in-person to remote instruction led to significant changes in research methods, mainly towards virtual and computational studies, and caused delays in degree completion due to alterations in project tasks, course availability, and presentation modes.

Geoscience employers struggled with financial and staffing impacts, regulatory constraints, supply chain problems, and limitations on travel and field activities. Hiring new talent proved difficult due to a lack of available skilled people for open positions. In addition, onboarding new employees into virtual working environments presented substantial obstacles, as new hires had difficulty with assimilating into the organization's culture, and training also proved challenging as tasks more easily done in person could not always be replicated in an online setting.

The profession faced obstacles in fieldwork and laboratory activities, impeded by restrictions and increased health protocols. The swift shift to remote work affected families with increased caregiving responsibilities and led to reduced productivity, imbalanced work/life equilibrium, and supply shortages. Challenges with the lack of optimal remote work environments, especially early in the pandemic, were due to the lack of dedicated workspaces, internet connectivity, distractions, and not having the necessary resources and equipment as one would have at the office or on campus. In addition, the loss of in-person communication had a huge impact for many, with online platforms not able to fully replicate in-person hallway discussions.

For academic faculty, the lack of engagement with students in an online setting was a top issue, causing declines in student learning. Furthermore, the rapid shift to online and the push to maintain educational continuity left faculty scrambling to learn new platforms and convert as much as their course content as possible into online platforms. Later in the pandemic, faculty also juggled both online and in-person teaching modalities. This increased workloads and many faculty did not have the time to fully re-design course content for online learning which resulted in frequent comments about the diminished quality of online instruction.

## Strategies

Underpinning many of the successful strategies employed during the pandemic was a can-do attitude. With the restrictions on facility access and travel, projects were re-focused on literature reviews and modeling where possible, and others were redesigned to fit within pandemic-related constraints. Other strategies revolved around being resourceful, which included finding motivation and self-direction to keep projects, work, and research moving forward. Resourcefulness also was found within people's networks and communities, including finding ways to connect, share ideas, and learn new skills.

Integration of technological platforms served as a bridge for communication, collaboration, idea sharing, skill learning, and teamwork on projects. Supportive actions by employers, departments, and faculty were also vital, including providing equipment and financial assistance for the transition to remote work, and allowing flexibility in deadlines and work hours. These measures eased some challenges faced by employees and students, particularly with project delays, supply chain disruptions, and family care responsibilities. Other strategies included upgrading remote workspaces to be more conducive for working and studying, reducing distractions from others, increasing internet speed, acquiring better furniture, and finding/creating dedicated workspaces.

Departments also adjusted promotion and tenure guidelines, with most departments extending the promotion clock, and waiving student and teacher evaluations during the first year of the pandemic. Departments also supported students by adapting degree requirements, such as waiving course requirements, allowing substitutions such as alternate courses or independent study for courses that were cancelled, and giving students who could not complete field courses prior to graduation the ability to take the course once they were offered in-person. Many non-academic employers implemented remote-first work policies to allow employees to choose whether they wanted to work in the office or at home on any given day, thus providing employees with the flexibility to adjust their schedule to maintain productivity.

## Opportunities

During the pandemic, new opportunities for research and collaborations were reported by over a third of survey participants, including collaborations between departments within an organization, as well as collaborations with other organizations. Of those indicating new opportunities, over half indicated that they were pursuing new work and / or research projects.

With the increased familiarity with virtual platforms, people leveraged the ability to connect with others more easily. As a result, some faculty developed collaborations with colleagues around the world to be guest speakers in their courses, and departments did the same for their colloquium series. Researchers connected with others using virtual platforms to develop new projects and collaborate on existing research.

The pandemic provided the opportunity to rethink curriculum and departmental / organizational culture around the topics of diversity, equity, and inclusion. While virtual platforms were able to increase accessibility by providing an alternative to in-person experiences, there were caveats related to internet access. Furthermore, as faculty gained experience with curriculum design and delivery across the different in-person and online modalities, some incorporated virtual resources developed during the pandemic into their curriculum to provide more opportunities for learning for those unable to attend in person.

The pandemic also provided many with opportunities to learn new skills, especially related to modeling and software programming. In part, new skills development was driven by restrictions on facility access and travel which resulted in employees, faculty, students, and researchers pivoting their work to computational research activities.

## Lasting changes

The pandemic has brought about lasting transformations in the geosciences, particularly with the incorporation of virtual technologies into working and learning environments and brought to light the criticality of frequent in-person interactions and the consequences of isolation on social interactions and interpersonal communication. Beyond the challenges it posed, the pandemic also enabled an increase in technical proficiency across the geosciences, opening new opportunities in virtual work and collaboration that many have seized.

Academic departments have embraced virtual instructional methods, using them to enhance student learning or accommodate those who could not attend in-person sessions. This has increased accessibility and content retention for students and allowed faculty to use new skills and instructional modalities learned during the pandemic. Primarily, virtual components are being integrated as supplemental materials or as preparatory or follow-up materials for in-person instruction. Departments have also begun allowing hybrid and virtual options for their students' defense / final capstone project presentations. In addition, some departments are allowing course substitutions in degree plans.

Employers have also adopted virtual technologies, leading to more flexible work conditions, and allowing employees greater leeway in their work location and hours. Concurrently, employees have upgraded their home workspaces to be more conducive for remote work. The increased flexibility has improved morale, as employees can more easily balance personal and work commitments, and the reduction in commute time also helps to increase work-life balance.

In addition, there has been an increase in employers hiring at the doctoral level, whereas pre-pandemic, employers tended to hire primarily at the bachelors and master's level, while doctorates primarily tracked into academic careers. Employers are now also expecting new hires to have proficiency with virtual

platforms for communication and collaboration, database and data visualization skills, and project management.

The pandemic has left a lasting imprint on the geosciences, but also has provided new opportunities for the geosciences in support of society, shaping the future trajectory of the geosciences discipline. Integration of virtual technologies has opened many doors for research advancements, collaborations, and new ways of teaching and learning. The immense challenges posed by the pandemic in terms of the limitations on in-person activities, including lab and field work, has provided the opportunity for geoscientists, employers, and academic departments to think strategically about how to be more efficient in how they work and learn going forward.

## **KEY OBSERVATIONS**

- Resilience prevailed within the geoscience profession despite the immense challenges from the pandemic.
- Successful strategies for adaptation to changes in work and learning were underpinned by a willingness to look for solutions to navigate the challenges faced.
- Supportive actions, such as adjusting project deadlines, assistance with the set-up of remote workspaces, and changes to promotion and tenure guidelines and degree program requirements were key for easing stress and challenges for employees, faculty, and students.
- The pandemic made clear the importance of having a home workspace that was conducive for work and learning, including a dedicated space with proper equipment, furniture, fast internet connection, and one that was free of distractions.
- The prolonged duration of restrictions on in-person activities during the pandemic emphasized the criticality of in-person social interactions.
- Virtual platforms enhanced curricular activities, increased accessibility, and increased content retention as students could review recorded lectures and course materials in addition to their notes.
- Virtual platforms broadened professional networks and increased collaboration among researchers, faculty and employees.
- The pandemic provided many with the opportunity to learn new skills, especially related to computational research, programming, database management, and other related technical skills.
- In addition to integrating virtual components into instructional activities, some academic departments are now allowing more flexibility in the mode of students' final research presentations and providing some flexibility with respect to degree program requirements.
- Employers have shifted to more flexible working environments, allowing for flexibility in hours and work location.
- Employers are increasingly hiring at the doctoral level and are also expecting new hires to be proficient with virtual platforms for communication and collaboration.



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# Introduction

The COVID-19 pandemic had a significant and unprecedented impact on social, economic, and educational systems worldwide, including within the United States. The prolonged duration of the pandemic, coupled with frequent surges in virus cases and the emergence of new variants, resulted in repeated disruptions and restarts in educational and business operations. To cope with this rapidly changing landscape, campuses and businesses adopted flexible working and learning arrangements. Educational systems shifted to online and hybrid teaching methods, while organizations implemented various responses, including temporary closures, layoffs, and work-from-home arrangements. Additionally, different state regulations and supply chain constraints had variety of effects across industries.

In 2020, AGI began this research project to examine the effects of the pandemic on the geoscience workforce and academic programs. The project aimed to capture the changes in workplace and instructional environments in response to the pandemic, as well as to identify which changes would persist beyond the immediate crisis. Initially, it was expected that in-person interactions and a return to normalcy would resume by Spring 2021.

The project began by following five primary cohorts: geoscience employers, geoscience workers (prior to the crisis), academic faculty, geoscience college and university students, and recent geoscience graduates from 2014–2022. These study participants were asked to complete bi-monthly online surveys, providing information on changes in their workplace and instructional environments, employment and enrollment status, geoscience-related activities, and other pandemic-related impacts. Employers, organizational leaders, and academic departments were also surveyed to gather information on the impacts to their work or instructional environments, business operations, and other pandemic-related effects.

Due to the ongoing intensity of the pandemic, including the emergence of multiple waves and variants, the project received a grant supplement to continue monitoring the impacts until March 2022. The expectation was that a transition to post-pandemic conditions would occur by the end of 2021. During this extended period, the project focused on tracking how instructional modes from the pandemic were being incorporated by faculty into teaching and curriculum, and how employers were incorporating pandemic policies related to hiring, adoption of flexible work arrangements. The project also assessed skills and knowledge gaps of students and graduates that resulted from the pandemic's impacts on higher education. Furthermore, the study examined the effects on student academic achievement, career trajectories of new graduates, and strategies implemented by faculty, departments, and employers to address any gaps in skills, knowledge, or achievement.

Unfortunately, by Fall 2021, the nation was still grappling with the surge in infections from the Delta variant, followed by a sharp rise in infections from the Omicron variant starting in December 2021. Although COVID cases and hospitalizations began to decline in early 2022, pandemic-related impacts on higher education and workplaces persisted. Most geoscience academic departments continued to teach in-person but with pandemic-related restrictions, offering hybrid and fully-online instructional methods, and with the expectation that the next academic term would continue with in-person instruction and restrictions. Geoscience employers also experienced ongoing pandemic-related impacts, but there were signs of recovery, such as improved expectations for financial performance and reduced staffing impacts.

However, challenges related to excess workloads and supply shortages persisted. Employers started re-evaluating the incorporation of remote work policies into their long-term strategies and exploring virtual hiring and onboarding of new employees.

With the easing of restrictions and mandates in February 2022, a substantial change in pandemic response became evident. The focus shifted from regulatory measures imposed by the government to choices made by individuals and organizations. As society adopted post-pandemic behaviors, the integration of pandemic-induced changes and lasting impacts on the geoscience workforce and academic programs began to emerge.

The study continued to monitor until December 2022 the integration of pandemic-related changes into work and learning practices in the geosciences. During the final phase of the study, oral history interviews and a webinar series were conducted to gather narratives from individuals and representatives of geoscience employers and academic departments as they reflected on the challenges they faced during the pandemic and the strategies they employed to navigate those challenges. These narratives provided depth and context to the longitudinal survey data and elucidated how pandemic-related methods of teaching, learning, and work had become integrated into day-to-day workflows and operations, and how research methods and opportunities evolved in response to this crisis.

The U.S. response to the COVID-19 pandemic, particularly at the state and local levels, has provided a unique opportunity to understand the short and long-term effects of events that necessitate rapid structural changes in the workforce. The pandemic has left a lasting imprint on the geosciences, but also has provided new opportunities for the geosciences in support of society, shaping the future trajectory of the geosciences discipline. Examining how the geoscience discipline has adapted and evolved during the pandemic provides valuable insights on how to better prepare for similar crises in the future, ensuring greater resilience and adaptability for our country and workforce in the face of such structural disruptions.

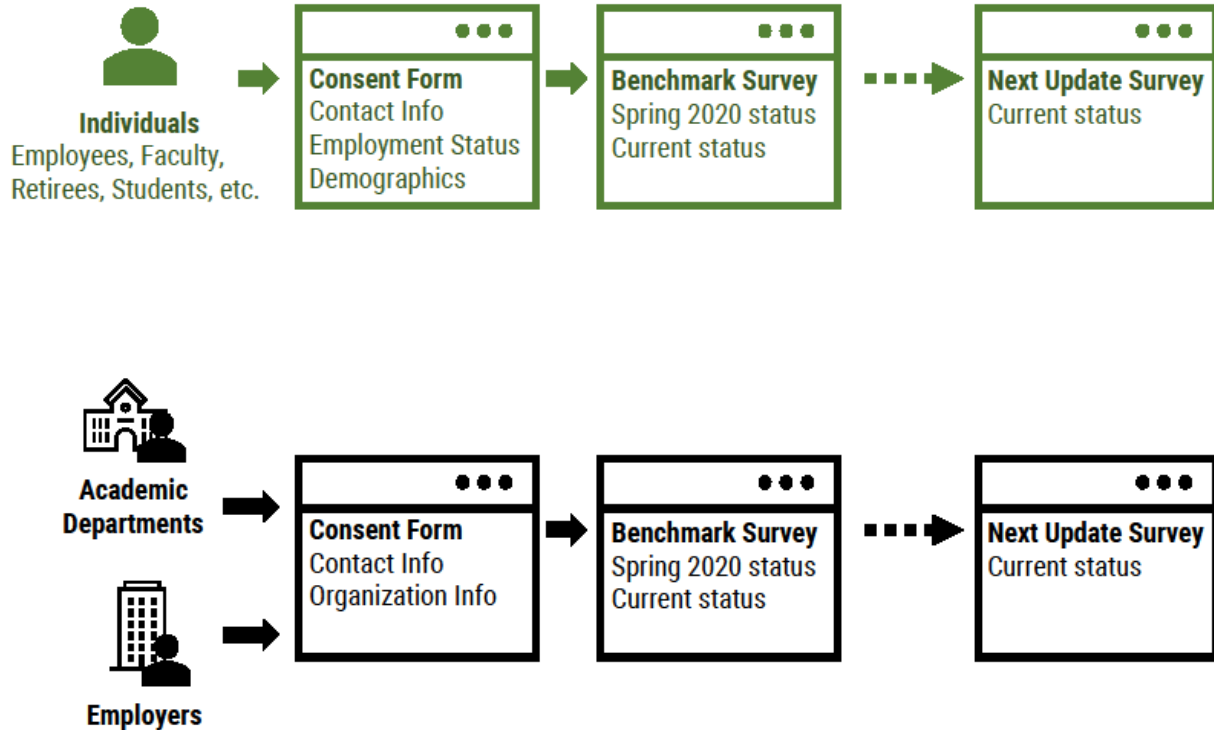
# Methodology

The project expanded from a 12-month study into a multi-year project, spanning 32 months with three distinct phases in each year of the pandemic: 2020, 2021, and 2022. Primary data collection was conducted through a multi-cohort longitudinal survey that ran from May 2020 through December 2022. The survey was designed to be completed within a few minutes and aimed to capture a broad range of pandemic impacts on individuals, academic departments, and geoscience employers. In 2022, during Phase 3, additional depth and context were added to the study through oral history interviews and a three-part webinar series, which gathered best practices on how individuals, academic departments, and geoscience employers navigated pandemic-related impacts.

## MULTI-COHORT LONGITUDINAL SURVEY

The longitudinal survey served as the primary data collection tool for this research study, with participants being accepted into the survey from May 2020 through July 2022. Participants were onboarded into the survey after completing a consent form to verify their age (18 or older), residency in the United States, and their role as leaders of geoscience companies, organizations, or academic departments, or as geoscientists themselves (including students, retirees, and unemployed geoscientists). Geoscientist participants had the opportunity to update their occupational status by selecting one of seven occupational cohorts on each survey: post-secondary faculty, K–12 faculty, geoscience students, non-academic geoscientists, geoscience post-doctoral fellows, geoscience retirees, and unemployed geoscientists.

All study participants followed a similar onboarding process. After completing the initial consent form, participants were invited to provide information about their occupational status in February 2020 on the benchmark survey, and then were added to the list of participants receiving the ongoing update surveys.



#### Survey onboarding flow by major cohort

Due to the rapidly changing conditions relative to the pandemic in 2020 and 2021, Phase I and II of the study involved bi-monthly surveys sent via email to participants to gather feedback on their current occupational status. Starting in 2022, during Phase III, participants received monthly invitations to provide feedback on their occupational status. The surveys were focused on demographic and factual information, without inquiries related to health impacts or prospective views, in order to maintain strict adherence to point-in-time factual measurements of individuals to ensure appropriate exemption from ongoing human subject's review. Organization surveys allowed for the exposition of topics such as changes to curriculum or workflow, but did not collect or retain prospective or attitudinal data.

All identifying information, such as contact and demographic information, was stored in a separate offline database to limit confidentiality breach risk. Study participants were assigned unique tokens that linked them to their survey data. Survey data was aggregated into cohorts (i.e., academic departments, employers, academic faculty, non-academic geoscientists, students, etc.), and where sufficient data existed, further analyzed within sub-groupings.

A standard set of questions was developed and asked on each survey, and once a month additional questions were included to gain deeper insights into how individuals and organizations were adapting to workplace and instructional changes. Whenever possible, similar or identical questions were included across surveys for different cohorts to obtain both individual and organizational perspectives on specific topics.

<b>Data Type</b>	<b>Consent</b>	<b>Benchmark</b>	<b>Next Update</b>
Participant Type	I	I	I
Employment / Enrollment Status	I	I	I
Organizational Affiliation	I A E	I	I
Educational Background	I	I	I
Job-seeking Activities	I	I	I
Retiree Activities	I	I	I
Work / Learning Environment	n.a.	I A E	I A E
Academic Activities	n.a.	I A	I A
Work & Research Activities	n.a.	I A E	I A E
Professional Development	n.a.	I	I
Outlook & Concerns	n.a.	I A E	I A E
Contact Information	I A E	n.a.	n.a.
Demographic Information	I	n.a.	n.a.
Business Operations	n.a.	A E	A E

**Survey question topics by major cohort and survey type (i.e., Consent, Benchmark, Next Update).**

Black I's represents individual cohort surveys, blue A's represent academic department surveys, and dark orange E's represent geoscience employer surveys.

The standard set of questions asked on each survey included the following topics:

#### Academic departments

- Instructional environments (teaching modes for labs, courses, field activities)
- Research activities (research cohorts and modes)
- Department operations (budget cuts, faculty searches, staffing impacts)
- Outlook (institutional status for the next academic term)

#### Geoscience employers

- Business operations (financial performance, productivity)
- Staffing impacts (changes in permanent and temporary staff, travel, and field activities)
- Strategies for addressing COVID-19 impacts
- Work environment options for employees

Individuals (i.e., academic faculty, students, post-doctoral fellows, K–12 faculty, non-academic geoscientist, retired geoscientist, unemployed geoscientists)

- Employment / enrollment status
- Occupational affiliation (non-students only)
- Educational affiliation including school, degree, and fellowship/scholarship information (students only)
- Work or instructional environment (location, mode)
- Instructional modes for courses, labs, and field experiences

- Work and research activities (modes, COVID-19 restrictions, protocols)
- Engagement with co-curricular and professional development activities
- Institutional plans for the next academic term (faculty and students only)
- Degree completion impacts and plans for the next academic term (students only)

## Recruitment and retention strategies

Each phase of the study included new recruitment efforts to onboard additional participants into the survey and other data collection components. During Phase I, invitations to participate in the survey were sent to over 800 U.S. degree-granting and community-college geoscience programs for distribution to their faculty, students, and alumni. Invitations to participate were also sent to AGI's member societies and to AGI's network of over 124,000 geoscience professionals. Project staff also solicited the following 25 organizations to assist in additional efforts to raise awareness of the study through social media, posts to listservs, and newsletters to their membership. These organizations included AGI member society organizations as well as other state and local geoscience organizations.

- Alabama Geological Society
- American Association of Geographers
- American Association of Petroleum Geologists
- American Meteorological Society
- Association for Women Geoscientists
- Association of Earth Science Editors
- American Geophysical Union
- American Institute of Professional Geologists
- Association of American State Geologists
- Central Oregon Geoscience Society
- Earth Science Information Partners
- Geochemical Society
- Geological Society of America
- Geoscience Information Society
- International Medical Geology Association
- National Association of Geoscience Teachers
- National Association of State Boards of Geology
- National Ground Water Association



- New York State Geological Association
- Society of Economic Geologists
- Society of Exploration Geophysicists
- Society of Vertebrate Paleontology
- The Geological Society of Washington
- Utah Geological Association
- Vermont Geological Society

In Phases II and III, additional recruitment was conducted through AGI's network of contacts, outreach partnering organizations, and AGI's member societies. In-person recruitment efforts for the ongoing survey and for the oral history and webinar series components of the study were also made through presentations at the annual meetings of the Geological Society of America and American Geophysical Union.

Because the study spanned over two and a half years of data collection, retention efforts were put in place to help keep survey participants engaged throughout the study. These strategies included monthly emails to study participants that highlighted the latest study results, social media posts, and emails to AGI's network of contacts featuring AGI's Geoscience Currents data briefs that provided the recent analysis of survey data. Survey results were also presented at webinars, research forums, and at the annual meetings of the Geological Society of America and American Geophysical Union to aid in recruitment and retention efforts and to disseminate the information to the wider geoscience community.

## Survey participation

The survey included a total of 97 academic departments, 119 geoscience employers, and 1,648 individuals as participants. Participants were not required to complete every survey, and in fact over the course of the study, participants tended to respond more frequently during periods of increased pandemic activity or significant changes in their lives. As such, participants were flagged as active or inactive depending upon survey completion frequency. Active survey participants were defined as those who completed at least two surveys during the study. There were 84 active participants representing academic departments, 98 active participants representing geoscience employers, and 1,441 active survey participants who were individuals.

To calculate response rates in a way that took into consideration the participants' varying survey completion rates, a chained response rate methodology was used. The number of active participants (those who completed at least two surveys) was divided by the total number of consents for each cohort. The chained response rate was 87% for academic departments and individuals, and 82% for geoscience employers.

## Links to relevant survey data charts

Survey participants by cohort

<https://covid19.americangeosciences.org/data/charts/surveyparticipantsbycohort/>

Chained response rate by cohort

<https://covid19.americangeosciences.org/data/charts/surveychainedresponserate/>

## DEMOGRAPHICS OF GEOSCIENCE ACADEMIC DEPARTMENTS

A total of 97 geoscience academic departments from 4-year and 2-year higher education institutions participated in the study, providing insights about how the pandemic affected departmental operations and instructional environments. Approximately one-third of academic departments were in each major Carnegie Classification category, with 35% in doctoral universities, 31% in master's colleges, and 34% in baccalaureate or associate's colleges. The majority of departments granted bachelor's degrees (82%), while 43% granted master's degrees and 28% granted doctoral degrees. Academic departments were located in 35 states and Puerto Rico, with the largest representation of departments located in New York, California, Texas, and Pennsylvania.

Comparing the representation of academic departments in the study with AGI's Directory of Geoscience Departments revealed similar representation at Hispanic-serving institutions (HSI), lower representation among Asian American and Native American Pacific Islander-serving institutions (AANAPISI), and slightly higher representation among Native American-serving non-tribal institutions (NASNTI). In the study, there was no representation of academic departments from Tribal Colleges and Universities (TCU), Predominantly Black Institutions (PBI), historically Black colleges or universities (HBCU), or Alaska Native-serving institutions or Native Hawaiian-serving institutions (ANNH).

### Links to relevant survey data charts

Academic departments by institutional Carnegie Classification

<https://covid19.americangeosciences.org/data/charts/consentdata-department-bycarnegieclassification/>

Academic departments by degree granting status

<https://covid19.americangeosciences.org/data/charts/consentdata-department-bydegreegrantingstatus/>

Academic departments by state

<https://covid19.americangeosciences.org/data/charts/consentdata-department-bystate/>

Academic departments in minority-serving institutions

<https://covid19.americangeosciences.org/data/charts/consentdata-department-bymysi/>

## DEMOGRAPHICS OF GEOSCIENCE EMPLOYERS

A total of 119 geoscience employers participated in the study, providing insights into how the pandemic affected their business operations, staffing, and hiring between 2020 and 2022. These employers were located in 35 states and Puerto Rico, with the highest concentrations in California, Texas, and Colorado. Most employers (74%) were small employers with 50 or fewer employees, while 26% had over 50 employees.

Geoscience employers represented 11 industry sectors. According to data from the 2021 U.S. Bureau of Labor Statistics Employment Projections dataset, the four primary sectors within which geoscientists work are *professional, scientific, and technical services* (40%), *government agencies* (28%), *mining and oil & gas extraction* (5%), and *educational services* (17%). Geoscience employers participating in the study showed similar representation to federal data in the *professional, scientific, and technical services* and *government agencies* sectors. However, there was an over-representation of employers in the *mining and oil & gas extraction* and the *non-profit organizations* (i.e., *other services, except public administration*) sectors compared to the federal data. Sectors represented by employers in the survey included *professional,*

*scientific, and technical services* (44%), *government agencies* (21%), *non-profit organizations* (i.e., *other services, except public administration*) (14%), *mining and oil & gas extraction* (13%), and *educational services* (3%). Given AGI's promotion of the Geoscience COVID-19 study to its member societies, the high proportion of non-profit organizations relative to federal data participating as employers in the study is not surprising. In addition, the lower representation among the *educational services* sector was because academic departments were included in a separate survey cohort.

## Links to relevant survey data charts

Geoscience employers by state

<https://covid19.americangeosciences.org/data/charts/consentdata-employer-bystate/>

Employer size by number of employees

<https://covid19.americangeosciences.org/data/charts/employer-number-distribution-numberemployees/>

Employment sectors of geoscience employers vs employed geoscientists in the US

<https://covid19.americangeosciences.org/data/charts/consentdata-employer-bysector/>

## DEMOGRAPHICS OF INDIVIDUAL SURVEY PARTICIPANTS

A total of 1,648 individuals participated in the study, providing insights into how the pandemic affected their workplace and instructional environments from 2020 through 2022. At the time they joined the study, participants consisted of non-academic geoscientists (over a third), academic faculty at colleges and universities (just over a quarter), and students (14%). Over the course of the pandemic, there were changes in the occupational types of participants, particularly for graduating students and early-career geoscientists who transitioned into new jobs, enrolled in new degree programs, or experienced periods of unemployment. Unfortunately, participation of post-doctoral fellows was particularly low (2% of the study participants at the time of survey consent) throughout the study, despite targeted attempts at recruitment and retention.

Most geoscientists working in non-academic occupations worked in core geoscience occupations at the time of survey consent (96%), with most working as geoscientists, and 20% working as geoscience managers. Those working in non-core occupations frequently reported using their geoscience knowledge and skills in their job or working within the profession in a non-core capacity. In terms of representation across industry sectors, when compared with the 2021 U.S. Bureau of Labor Statistics Employment Projections dataset, study participants were over-represented in the following sectors: *government agencies*, especially state governments (26% vs 11%) and federal government agencies (13% vs. 7%), *non-profit organizations* (i.e., *other services, except public administration*) (8% vs 2%), *colleges and universities* (12% vs 8%), and *mining and oil & gas extraction* (8% vs. 5%), and *educational services* (3%). Survey participants were under-represented relative to the federal data in the *professional, scientific, technical services* sector (22% vs. 40%), *educational services* (0% vs 9%), and local government agencies (4% vs 10%).

In terms of age distribution, individual survey participants were relatively evenly distributed across age brackets. Gender distribution was nearly equal between male and female participants, with an additional 1% of participants identifying as non-binary. Participants were predominantly non-Hispanic (90%) and White (88%). Hispanic participants accounted for 4% of the total, while 4% belonged to other under-represented racial groups. Study participants were under-represented when compared to the 2019 occupational data from the U.S. Bureau of Labor Statistics for environmental scientists and geoscientists which indicated that 12% of the occupation was of Hispanic heritage and 5% was Black or African-

American. In terms of citizenship, 95% of participants were U.S. citizens while 4% were either permanent residents or non-permanent residents.

## Links to relevant survey data charts

Participants by occupational type at time of survey consent

<https://covid19.americangeosciences.org/data/charts/consentdata-individual-byparticipanttype/>

Occupations of non-academic geoscientists at time of survey consent

<https://covid19.americangeosciences.org/data/charts/consentdata-individual-iwbyoccupation/>

Employment sectors of non-academic geoscientists vs employed geoscientists in the US

<https://covid19.americangeosciences.org/data/charts/consentdata-individual-iwbysector/>

Participants by age at time of survey consent

<https://covid19.americangeosciences.org/data/charts/consentdata-individual-byage/>

Participants by gender

<https://covid19.americangeosciences.org/data/charts/consentdata-individual-bygender/>

Participants by Hispanic heritage

<https://covid19.americangeosciences.org/data/charts/consentdata-individual-byethnicity/>

Participants by race

<https://covid19.americangeosciences.org/data/charts/consentdata-individual-byrace/>

Participants by citizenship status

<https://covid19.americangeosciences.org/data/charts/consentdata-individual-bycitizenship/>

## References

Gonzales, L., Keane, C., 2020. Diversity in the Geosciences, Geoscience Currents, 2020-023, American Geosciences Institute.

<https://www.americangeosciences.org/geoscience-currents/diversity-geosciences>

## ORAL HISTORIES

In 2022, during Phase III of the study, we conducted 40 oral history interviews to capture the firsthand experiences of geoscientists as they navigated the impacts of the pandemic on their work and research activities. Interviewees shared strategies they used to overcome pandemic-related challenges and discussed the new opportunities for work and research that arose as a result of changes brought about by the pandemic. The oral histories included the experiences of geoscience employers, academic departments, academic faculty, recent geoscience graduates, post-doctoral fellows, non-academic geoscientists, and K–12 educators. Oral history contributors were provided the option to publicly release their transcripts to the study's project website (<https://covid19.americangeosciences.org/data/oral-histories/>), and 16 contributors agreed to do so.

Oral histories are invaluable for providing insight into changes within organizations and communities that are often challenging to capture through traditional surveying techniques (Webster, 2016). Oral histories offer unique perspectives into cultural shifts and nuances within organizations and communities that may not be fully expressed through surveys alone due to variances between expression of values versus actual actions (Corritore et al., 2020). The oral histories focused on the interviewees' experiences related to pandemic impacts on their work and research activities, including strategies for overcoming pandemic-

related challenges, and new opportunities for work and research that arose from the pandemic. For employers and departments, there was an additional focus on how they navigated restrictions and revenue setbacks to ensure operational continuity. These focused interviews provided valuable insights into the consistent changes, adaptations, activities, and behaviors of survey participants and their respective organizations.

Candidates for the oral histories were recruited from the existing pool of survey participants as well as from the broader geoscience community. Oral history applicants completed a consent form and initial screening process to ensure that they met the criteria for the oral history interview, namely, residing in the United States, being over 18 years old, and working within the geosciences or representing a geoscience academic department or employer. Oral history interviews were recorded, machine-transcribed and manually checked and corrected for clarity and accuracy. The transcripts were used for qualitative analysis to extract relevant trends in changes to work and research environments over the course of the pandemic. Interviewees who agreed to publicly release their oral history transcript were given the opportunity to review and lightly edit their transcripts for clarity and accuracy for public record.

## Links to relevant survey data charts

Oral history participants by cohort

<https://covid19.americangeosciences.org/data/charts/oralhistoriesparticipantsbycohort/>

## References

Corritore, Matthew, Amir Goldberg, Srivastava, Sameer. 2020. The New Analytics of Culture. Harvard Business Review. <https://hbr.org/2020/01/the-new-analytics-of-culture>.

Webster, Jessica Wagner. 2016. “Filling the Gaps”: Oral Histories and Underdocumented Populations in The American Archivist, 1938–2011. The American Archivist. 79 (2): 254–282. doi: [10.17723/0360-9081-79.2.254](https://doi.org/10.17723/0360-9081-79.2.254)

## WEBINAR SERIES

In Fall 2022, during Phase III of the study, project staff organized and hosted a three-part webinar series that focused on gathering the best practices and adaptations to overcoming pandemic-related impacts across academic and workforce sectors. As the focus of the webinar series was on data collection rather than dissemination, the format of the events was centered on discussion topics which the panelists and attendees reflected upon and shared their experiences. The first webinar focused on insights from recent graduates and postdocs, the second on academic faculty and departments, and the third on geoscience employers. The series included 11 panelists who represented the study’s main cohorts. The series attracted 150 registrants and 43 attendees, primarily from the US higher education sector.

The webinars were recorded and machine-transcribed, and the transcripts were manually checked and corrected for clarity and accuracy. The transcripts were used for qualitative analysis to extract both the challenges faced by individuals, departments, and employers and the strategies they used to overcome and navigate through the pandemic-related obstacles they encountered.

## Links to relevant survey data charts

Webinar series participants by cohort and employment sector

<https://covid19.americangeosciences.org/data/charts/webinarseriesparticipantsbycohort/>

# Challenges: How did the COVID-19 pandemic disrupt the geosciences?

The pandemic caused substantial disruptions across the geoscience profession, affecting operations in academic departments, geoscience employers, academic research, instruction, work activities of geoscientists, and general work and learning environments. Academic departments faced challenges such as budget cuts, staffing impacts, limitations on fieldwork and travel, declines in enrollments and degrees, and student recruitment. The pandemic severely disrupted academic research activities for faculty and students, leading to deferrals, cancellations, and changes in research methodologies. This disruption resulted in a significant shift towards virtual or computational research and literature reviews.

Instruction in academia was heavily impacted as the switch from in-person to entirely remote instruction occurred quickly, followed by subsequent waves of in-person, hybrid, and virtual instruction based on the intensity of pandemic activity. Students' progress towards degree completion was hindered by delays in project tasks, changes in research project design, cancellation or unavailability of required courses, and modifications to the final presentation mode for theses, dissertations, and capstone projects.

Geoscience employers faced challenges ranging from decreased financial performance and staffing impacts to regulatory restrictions and supply chain issues. There were also limitations on travel, field activities, and facility access. Hiring new talent and onboarding new employees into virtual working environments presented substantial obstacles, and employers noted skills and knowledge gaps in hires made during the pandemic era.

Work and research activities in the geoscience profession were affected by impacts on fieldwork and laboratory activities, hindered by facility and travel restrictions as well as increased health and safety protocols. The shift to remote learning and working had further impacts on families with children, as the increase in caregiving and domestic responsibilities affected the productivity of academic faculty and non-academic geoscientists. The rapid changes in response to the pandemic and the continued remote work and learning environments came with their challenges, such as impacts on productivity, lack of in-person interactions, workflow delays, decreased work/life balance, and supply shortages. In addition, most study participants noted pandemic-related concerns focused on workplace safety. For new graduates and students, additional top concerns included job security, employment availability, and financial worries.

## **PANDEMIC IMPACTS ON ACADEMIC DEPARTMENTS**

Between 2020 and 2023, academic department budgets generally stabilized. The number of departments experiencing budget cuts decreased substantially, falling from over half of departments reporting budget decreases in 2020–2021 to less than one-fifth in 2022–2023 academic years. Conversely, departments reporting no change in their budgets increased from one-third to over three-quarters over the same period. Notably, the peak in departments reporting budget increases occurred in 2021–2022 at 13%, before returning to 6% in the 2022–2023 academic year.



"A large part of the university budget that disappeared because the tuition was not coming in has been augmented by federal grants. One of the things that has changed has been an increasing emphasis from the administration on getting grants for everything at every level." —academic faculty

"There was no big change in the core budget. Special money appeared to help us facilitate some of the face-to-face stuff that we still had to do." —academic faculty

"Even though our state budget has shrunk, which reflects our majors going down too, and our general enrollment gradually going down in the last five or six years, it feels like our needs are met because of the generous donors and the CARES money." —academic faculty

## Staffing and travel impacts

Impacts to departmental staffing were most prevalent during Summer 2020, when many departments reduced benefits or salaries, laid off staff, and reduced work hours or furloughed staff. Hiring freezes peaked during Summer 2021, with just under a fifth of departments reporting the impact. By the start of Fall 2021, over half of departments reported no staffing impacts, and by December 2022 staffing impacts were reported only by a small percentage of departments. Hiring activity surged in late spring 2021, peaking at just over 30% of departments reporting actively hiring faculty and staff in May 2022 and decreasing to 15% of departments by December 2022.

The pandemic impacted faculty travel and fieldwork policies from 2020 to 2022. The proportion of departments prohibiting travel decreased from two-thirds to just under a quarter over the period as restrictions eased and vaccines were made available. Notably, governmental prohibitions on travel were limited, and institutional prohibitions declined sharply by Summer 2021, while personal decisions by faculty to not travel or conduct fieldwork continued throughout the rest of the period.

## Recruitment, enrollments, and degrees

Student recruitment strategies were modified by just over half of departments for the Fall 2021 term. Modifications included implementation of virtual events (23%) and innovative methods (32%), such as diversity, equity, and inclusion activities, hybrid classes, smaller class sizes, and earlier admission decisions. Traditional approaches, such as in-person recruiting at conferences and social media usage, were utilized by a small number of departments (3% each).

A decline in geoscience enrollments was reported by most departments during the 2020–2021 academic year relative to the 2019–2020 academic year, rising to two-thirds of departments in 2021–2022. Departments reporting stable enrollments decreased from 40% to 17%, and concurrently in the 2021–2022 academic year, just under a fifth of departments reported an increase in enrollments compared to 2019–2020.

Between the 2020–2021 and 2021–2022 academic years, there was an increase in the percentage of departments reporting lower enrollments for introductory geoscience courses and labs, geoscience major enrollments, and institution-wide enrollments compared to pre-pandemic years. Departments noting lower institution-wide enrollments rose from 46% to 59%, while those reporting lower enrollments for introductory courses and labs increased from 15% to 50% and 19% to 36%, respectively. Departments

reporting lower enrollments in the geoscience major category saw a considerable increase from 15% to 55%. For enrollments during the Summer 2021 term, most departments reported similar enrollments to pre-pandemic summer terms, while just over one-third reported lower enrollments.

"We saw a big drop in enrollment. I want to say enrollment went down over the last couple of years by 10 or 20%, so a significant drop in enrollment. Now we had seen a gradual drop in enrollment over the last decade, but this was like going off a cliff. I feel like at least the numbers for Fall 2022 that we have seen look like things are leveling off." —academic faculty

"We really took an enrollment hit. It was not in Fall of 2020 when we took that enrollment hit. You would think that would be the one where people would be holding off thinking: "Well online learning in Spring of 20 was so hard. I am going to wait till the pandemic's over." No, in the 2020–2021 academic year, our enrollments were close to what they were pre-pandemic, but we saw a big enrollment drop starting in Fall of 2021. We thought we were going to see more people come back because it was more face-to-face, but the enrollments were lower." —academic faculty

"Here's the challenge that COVID did for community colleges is that when COVID hit, our numbers of students declined, and then that affects the number of sections, and then that affects the number of classes you can give to your contract tenured faculty, which means that they were taking the classes from part-timers left and right. So, you had part timers who didn't have a job for up to two years, because those classes were given to fulfill the contract-based loads of faculty members and the overloads of full-time faculty members. So naturally, these people need to find jobs, and they're looking for jobs that are now full time and require them to work the hours that they would have been teaching, or that the salary is significantly better, so they don't need to come back and teach. So now we need to find a new pool of geology instructors coming right out of college. So, it's kind of this major trickle-down effect in terms of staffing and schooling and everything else." —academic department

Regarding degrees, in the 2020–2021 academic year, most departments reported no change in the number of degrees awarded compared to the 2019–2020 academic year. However, in the 2021–2022 academic year, there was a sharp increase from one-quarter to just over one-half of departments noting the decline, as the percentage reporting no change dropped to one-third and those reporting an increase in degree awarded declined.

## Links to relevant survey data charts

Change in departmental budget by academic year

<https://covid19.americangeosciences.org/data/charts/department-academic-budgets/>

Academic departments with faculty on travel or conducting fieldwork

<https://covid19.americangeosciences.org/data/charts/department-facstaff-travel-fieldwork/>



Have pandemic-related institutional policies changed the number of faculty FTEs allowed?

<https://covid19.americangeosciences.org/data/charts/department-fte-changes/>

Departmental staffing impacts

<https://covid19.americangeosciences.org/data/charts/department-staffing-impacts/>

Changes to Fall 2021 student recruiting from previous years

<https://covid19.americangeosciences.org/data/charts/department-student-recruitment-fall2021/>

Trend in geoscience enrollments relative to the 2019–2020 academic year (AY)

<https://covid19.americangeosciences.org/data/charts/enrollment-trend/>

Summer 2021 enrollment compared to pre-pandemic summer terms

<https://covid19.americangeosciences.org/data/charts/department-enrollment-summer2021-trend/>

Enrollments by category compared to pre-pandemic years

<https://covid19.americangeosciences.org/data/charts/enrollment-trend-by-category/>

Comparison of degrees awarded in current academic year to 2019–2020

<https://covid19.americangeosciences.org/data/charts/degrees-current-vs-previous/>

## **PANDEMIC IMPACTS ON ACADEMIC RESEARCH**

The pandemic substantially disrupted research activities for both faculty and students, leading to a wave of deferrals, cancellations, and alterations in research methodologies. Over three-quarters of departments reported deferring research to a later time, and planned research was more frequently cancelled in departments with graduate programs than those with no graduate programs. Furthermore, active research was more frequently cancelled (by about half of departments) for undergraduate research activities.

A widespread adjustment involved transitioning to virtual or computational research. This was particularly noticeable in departments with graduate programs, where the majority of faculty and students implemented this adaptation. In departments without graduate programs, the majority of students — but only about a quarter of faculty - reported making this switch. Approximately a third of departments with graduate programs indicated a shift in research focus towards literature reviews for both faculty and students. This trend was observed in nearly half of the departments without graduate programs, particularly among undergraduate students.

"Summer field class was a month of camping and that was Summer 2021. We were approved to be able to go to the field in-person because it was outside and as long as students were separated, they had to sit in our vehicles as we were driving from different spots like we only have like two or three people, and they had to be separated by a long distance and everybody had to wear masks." —academic faculty

"Both field travel international and local and all the lab stuff that shut down for me. So the lab was 100% shut down since March. And so it was probably November when we were allowed to start going back in, very minimally with like one person a day in the whole facility. And so we have to schedule that between all the researchers who are trying to use the facility and everybody who obviously lost six months worth of lab time and so. Things like really actually slowed down for me a lot. I essentially had enough time to go out into the field to collect a bunch of stuff and start working on it, but not actually get any data yet." —recent graduate

Throughout the pandemic, faculty members divided their time differently across research, teaching, and other responsibilities, depending on their tenure status and gender. Non-tenure-track female faculty spent more time on teaching, committee work, and other academic activities than their male counterparts, who allocated more time to research and writing. For tenure-track faculty, both genders devoted a considerable amount of time to teaching, with women dedicating slightly more time to this activity. Women also spent more time on committee work than men, while men devoted slightly more time to research and writing.

Between April and November 2021, for all faculty types (non-tenure-track, tenured, and tenure-track), the majority of both genders reported no change in the time allocated to academic activities. However, when changes were reported, women generally indicated more changes than men. More women reported increases and decreases in time spent on committee work, other activities, research, and teaching. For writing, both genders reported a slight increase, but more women than men reported a decrease.

## Links to relevant survey data charts

Pandemic impacts on student and faculty research, Spring 2020

<https://covid19.americangeosciences.org/data/charts/departments-research-impacts-spring2020/>

Time spent on academic activities in the 2021 calendar year

<https://covid19.americangeosciences.org/data/charts/faculty-time-by-category-non-tenure-track/>

Time spent on academic activities in the 2021 calendar year

<https://covid19.americangeosciences.org/data/charts/faculty-time-by-category-tenured/>

Time spent on academic activities in the 2021 calendar year

<https://covid19.americangeosciences.org/data/charts/faculty-time-by-category-tenure-track/>

Change in time spent on academic activities between April and November 2021

<https://covid19.americangeosciences.org/data/charts/faculty-time-changeintime-non-tenure-track/>

Change in time spent on academic activities between April and November 2021

<https://covid19.americangeosciences.org/data/charts/faculty-time-changeintime-tenured/>

Change in time spent on academic activities between April and November 2021

<https://covid19.americangeosciences.org/data/charts/faculty-time-changeintime-tenure-track/>

## PANDEMIC IMPACTS ON INSTRUCTION

In the Spring of 2020, academic departments at both 2-year and 4-year educational institutions were forced to alter and cancel field activities due to the COVID-19 pandemic. A substantial majority shifted to online formats, while cancellations were more frequent at 4-year institutions than at 2-year institutions. Approximately a quarter of both 2-year and 4-year institutions postponed activities, giving students the

opportunity to earn credits later. Notably, nearly a quarter of 4-year institutions waived the credit requirement for cancelled activities, a measure not reported by any 2-year institutions. Regarding lab instruction, the vast majority of departments at both 2-year and 4-year institutions switched to virtual or at-home activities. Computational approaches were more prevalent at 4-year institutions than 2-year institutions, while a small percentage of departments terminated lab instruction.

Throughout the academic years of 2020–2021 and 2021–2022, the cancellation rates varied among different types of courses. Cancellations of lecture and lab courses increased, while cancellations of field components and field courses declined. This data suggests a resurgence of field courses during the 2021–2022 academic year, along with a decline in enrollment affecting the availability of lecture courses and lab sections.

## Changes in lecture courses

During the COVID-19 pandemic, academic departments experienced substantial changes in course delivery. Virtual courses, which were reported by about one-fifth of departments in February 2020, increased to nearly all departments by May 2020 due to the shift to remote learning. Virtual courses declined steadily through the pandemic period with sharp declines by Fall 2021 and from the middle to end of 2021. The use of hybrid courses increased over mid-2020, with just over half of departments using this method through most of the 2020–2021 academic year. In-person courses with COVID-19 restrictions were used in tandem with hybrid courses through the 2020–2021 academic year, and increased substantially over mid-2021, becoming the dominant instructional modality for the 2021–2022 academic year as virtual and hybrid methods waned.

As vaccines were rolled out in early 2021, there was a concurrent increase in in-person courses without restrictions to about a fifth of departments incorporating this format. After February 2022, however, the percentage of departments offering in-person courses without restrictions sharply increased from about a fifth of departments to over a half by Spring 2022, and further increased to over 80% by December 2022. Departments also switched from using multiple modes of instruction (i.e., in-person, hybrid, virtual) during the pandemic to primarily in-person only instruction by December 2022.

## Changes in field activities

In June 2020, there was a substantial reliance on virtual modes for field activities across academic departments, but this declined sharply by August 2021 to a tenth of departments using virtual modes. Similarly, hybrid field activities were reported by over a fifth of departments between April and May 2021, before decreasing to around 10% by September 2021. In-person field activities at local sites became the dominant mode of field instruction from mid-2020 onwards. In-person instruction at remote sites steadily increased during 2021 and most of 2022, peaking at near two-thirds of departments reporting this modality in July 2022. Cancellation of field activities was most prevalent during late Spring 2021, and otherwise was generally low throughout the period.

## Changes in lab sections / courses

Through the 2020–2021 academic year, departments primarily used virtual modes for lab sections/courses, with this trend declining sharply after March 2021 to nearly one-fifth of departments by October 2021. Hybrid formats were reported by a third of departments in April 2021, and declined to less than one-fifth of departments reporting this mode by December 2022. The use of at-home activities and computational activities in labs were used throughout the 2020–2021 academic year, with at-home activities reported by about half of departments and computational approaches by about a third of departments during most of the academic year, but these modalities declined steadily over mid-2021. In-

person lab activities with COVID-19 restrictions increased from near one-fifth of departments in June 2020 to over three-quarters using this modality by November 2021, before declining to steadily through 2022 as restrictions eased and in-person lab activities without restrictions steadily increased during that year, becoming the dominant modality by mid-2022.

"We were told to be easy on our students, because although at this time they all had some kind of computer access. When they went home, some of them had no internet connections at home. They had to go somewhere else like a church or school parking lot to tie into the net and take tests. Some of them were only looking at screens on their cell phones, so there you are with a PowerPoint and a picture or chart, and they are seeing a miniature version of it. You had to simplify the tests. Where I used to have a picture for every test question, now I had none because they couldn't load them in time and were timing out on these things. We were told to be easy on the on the students in every way possible. We will all get through this, and we all tried. So, the quality of testing went down; the cheating probably went up. It certainly went up in the next year as students got more used to this online procedure and for the next year we were almost all online." —academic faculty

## Computational skills

In 2020 and 2021, faculty commented on mathematical and computational abilities of their students. The skills most often identified as lacking were mathematical and computational abilities, followed by proficiency in Excel, programming, and analytical and interpretative skills. Improvements were seen over the period, however. In 2021, fewer faculty noted students lacking skills related to analysis and interpretation, math and computational skills, data management, and graphing.

## Satisfaction with online instruction

Given the rapid changes to instruction during the pandemic, faculty and students were invited to share their input on how satisfied they were with different aspects of online instruction. Between December 2020 and January 2022, faculty and student satisfaction with various aspects of online teaching evolved.

Satisfaction with online course content quality improved for faculty, but declined for students, although over half of both cohorts reported at least moderate satisfaction with online course content over the period. Whereas about a third of faculty were satisfied with online assessments, about half of students reported the same. In regard to student-teacher engagement, over half of students reported at least moderate satisfaction with this aspect of instruction, but less than one-fifth of faculty reported the same. Half of faculty reported being satisfied with the online course platforms, while for students that percentage dropped from two-thirds to less than half over the period. Nearly one-fifth of faculty and a third of students reported being at least moderately satisfied with the ability for students to work in groups. In addition, over half of students and faculty reported satisfaction with the availability of courses over the period.

“My professors are due a lot of credit for making it work and transitioning away from that traditional lecture style college course to something that was asynchronous or project based. And I think that there was a direct correlation in my experience between professors who made that switch and the quality of the content. So I like the courses where I could learn at my own pace or do a project and then turn it in and get feedback from the professor. Those courses were great and I learned a lot from them. I got great experience, whereas the ones that were like, alright guys, we're gonna get on Zoom at 7:00 AM and you're gonna listen to me for two hours...I hated those. And that was a really poor experience from a research side. I had to pivot a fair amount because I knew I wanted to go into science.” - graduate student

## Challenges with online instruction

Surveys also asked about challenges with online instruction over the 2020–2022 period. The most substantial challenges were student engagement and a perceived decrease in teaching and learning quality. Problems with technology platforms and increased workloads peaked at just over a fifth of faculty reporting this challenge in April 2021, then decreased to near one-tenth by February 2022. From December 2020 to October 2021, academic faculty consistently found that the workload for preparing, teaching, and grading hybrid and online courses was greater than for in-person teaching. However, these percentages decreased over time with a concurrent increase in the percentage of faculty reporting that the workload was the same for in-person instruction, although this change was more substantial for grading than for preparation of courses or teaching. Similarly, for K–12 faculty, hybrid and online course preparation, teaching, and grading were also viewed as more demanding than in-person teaching. However, there was an increase in the perception that these activities required the same amount of work as in-person tasks over the period.

## Links to relevant survey data charts

Field course changes during Spring 2020

<https://covid19.americangeosciences.org/data/charts/spring2020-instruction-changes-field/>

Lab instruction changes during Spring 2020

<https://covid19.americangeosciences.org/data/charts/spring2020-instruction-changes-lab/>

Course cancellations by type and academic year

<https://covid19.americangeosciences.org/data/charts/deparment-cancelled-courses/>

Lecture course instructional formats

<https://covid19.americangeosciences.org/data/charts/instructional-mode-courses-4yr/>

Lecture course formats by number of instructional modes

<https://covid19.americangeosciences.org/data/charts/instructional-mode-courses-singlevsmultimode-4yr/>

Field activity instructional formats

<https://covid19.americangeosciences.org/data/charts/instructional-mode-field-4yr/>

Field activity formats by number of instructional modes

<https://covid19.americangeosciences.org/data/charts/instructional-mode-field-singlevsmultimode-4yr/>

Lab section / course instructional formats

<https://covid19.americangeosciences.org/data/charts/instructional-mode-lab-4yr/>

Lab section / course formats by number of instructional modes

<https://covid19.americangeosciences.org/data/charts/instructional-mode-labs-singlevsmultimode-4yr/>

Types of math and programming skills students lack

<https://covid19.americangeosciences.org/data/charts/math-compsci-skills-lacktypes/>

Satisfaction with online teaching

<https://covid19.americangeosciences.org/data/charts/online-teach-learn-satisfaction-if/>

Satisfaction with online learning

<https://covid19.americangeosciences.org/data/charts/online-teach-learn-satisfaction-is/>

Workload associated with online teaching

<https://covid19.americangeosciences.org/data/charts/online-teach-workload-rel2ip-if/>

Workload associated with online teaching

<https://covid19.americangeosciences.org/data/charts/online-teach-workload-rel2ip-ik/>

Challenges with teaching courses, labs, and field activities in an online setting

<https://covid19.americangeosciences.org/data/charts/virtual-teaching-drawbacks/>

## **PANDEMIC IMPACTS ON STUDENT PROGRESS**

Enrollment status over 2020 to 2022 showed minor impacts on student progress as the majority of students were enrolled full-time in their degree programs. Enrollment figures decreased during summer as students shifted focus to research related to their studies, as well as towards the completion of coursework for their degrees, culminating in their dissertations, theses, or capstone projects. Part-time enrollment accounted for less than one-tenth of the student population for the majority of this period.

### **Impacts to degree progress**

However, between Spring 2021 and Fall 2022, degree progression for continuing students was substantially impacted by changes in the design of student projects, delays in tasks related to student research projects, cancellations or lack of necessary field experiences, and postponements or delays in graduation. However, these impacts lessened over time, and by Fall 2022, around two-thirds of departments reported no disruptions to student degree progress.

Data reported by students echoes that of departments, and similarly, in the second quarter of 2020, more than half of students faced disruptions to their degree progress, largely due to task delays in projects and deferrals or delays in final defenses. The proportion of students reporting any impact reached its peak in the third quarter of 2021, primarily driven by an increase in project delays, research project design alterations, and final defense postponements. There was also a substantial rise in students deferring graduation or being unable to participate in necessary field experiences or courses. However, by the end of 2022, the proportion of students reporting any impact had reduced to half, with project delays and design changes still being the most frequently reported issues.

From May 2021 to December 2022, there was a considerable improvement in the ability of both continuing and graduating students to take required courses for their degrees. During this time, the courses most

frequently inaccessible were field courses and their components. However, these issues generally declined, as did issues with the availability of other types of courses, such as labs and lecture courses. The most commonly missed topics during this period included field methods, general geology, environmental science, lab methods, and sedimentology.

## Changes in student advising

The frequency of student advising during the pandemic fluctuated somewhat, with half of faculty and students indicating that they maintained similar advising schedules to those before the pandemic throughout this period. A small proportion of faculty and students reported an increase in the frequency of advising compared to pre-pandemic times in October 2020. However, as the pandemic progressed, the proportion of respondents reporting an increased frequency began to diminish in early 2021 but increased over the 2021–2022 academic year to roughly one fifth indicating more frequent meetings.

## Changes to student research presentations

At the onset of the pandemic, there were substantial challenges to student research presentations according to departmental reports. About two-thirds of academic departments experienced cancellations of conferences or sessions typically used for student research presentations. A similar proportion of departments transitioned to virtual platforms for these presentations, while less than ten percent of departments opted for an alternative solution by making presentation slides or results available for review, thereby eliminating the need for in-person or virtual presentations. Only one-tenth of departments reported no impact on student research presentations during this period.

## Links to relevant survey data charts

Pandemic-related impacts related to the degree progress for continuing students

<https://covid19.americangeosciences.org/data/charts/department-degree-progress-impacts-studentprogress/>

What percentage of students were unable to take required courses this academic year?

<https://covid19.americangeosciences.org/data/charts/department-missing-rqmts-pct-students/>

Types of courses continuing students were unable to take

<https://covid19.americangeosciences.org/data/charts/department-missing-rqmts-course-types-continuing-students/>

Types of courses graduating students were unable to take

<https://covid19.americangeosciences.org/data/charts/department-missing-rqmts-course-types-graduating-students/>

Topics covered in courses / sections students were unable to take

<https://covid19.americangeosciences.org/data/charts/department-missing-rqmts-course-topics/>

Impacts to student research presentations between February and May 2020

<https://covid19.americangeosciences.org/data/charts/department-spring2020-presentation-impacts/>

Frequency of student advising meetings relative to February 2020

<https://covid19.americangeosciences.org/data/charts/individual-advising-frequency/>

Pandemic impacts on degree progress

<https://covid19.americangeosciences.org/data/charts/individual-degree-progress/>



Enrollment status of students during the pandemic

<https://covid19.americangeosciences.org/data/charts/individual-enrollment-status/>

## **PANDEMIC IMPACTS ON GEOSCIENCE EMPLOYERS**

In the second quarter of 2020, the majority of geoscience employers experienced disruptions to their operations due to the pandemic. Impacts gradually decreased through 2020 and 2021, although there was a temporary surge in the first quarter of 2021. By the end of 2022, only 40% of businesses reported continued impacts. Initial major issues cited by employers included regulatory restrictions that limited access to facilities, and termination or amendment of contracts that generated revenue, both of which steadily decreased to background levels by the end of 2022. However, disruptions in supply chains and contractor availability were issues noted by 30% to 40% of employers throughout 2020–2022.

### **Financial performance**

At the onset of the pandemic, there was a sharp rise in geoscience employers expecting their financial performance to be lower than the previous year, but these expectations gradually improved until March 2021 and stabilized during the summer months, with fluctuations thereafter through the end of 2022. From the second quarter of 2020 to the fourth quarter of 2022, the majority of geoscience employers reported they were working at full or excess capacity, with the percentage of employers noting that they had more work than capacity, increasing from 30% to 41% over the period, while the percentage of those reporting that they had work levels equal to their capacity declined from near 60% to just over a third.

### **Staffing impacts**

Pandemic-related impacts to business staffing were most substantial in 2020 and early 2021, peaking in the third quarter of 2020 when over a third of employers reported negative staffing impacts, which ranged from benefits or salary reductions, hiring freezes, and layoffs or furloughs. The negative impacts generally decreased as active hiring increased in the second quarter of 2021, with more than half of the employers hiring to expand their workforce or to fill positions left vacant early in the pandemic. Job openings and active hiring surged in the third quarter of 2022, with over half of employers reporting job openings and active hiring.

### **Restrictions on travel and fieldwork**

From June 2020 to March 2022, there was a noticeable shift in the travel and fieldwork status of geoscience staff due to varying pandemic policies and personal decisions. The percentage of employers with staff not traveling or doing fieldwork dropped from over half in June 2020 to one-fifth in March 2022, as restrictions eased and staff resumed travel and fieldwork activities. The influences of personal decisions, institutional policies, and government policies on these changes varied over time, with personal decisions by staff being the most reported reason for not conducting fieldwork or traveling.

In addition, from April 2022 to December 2022, the prevalence of pandemic-related restrictions among geoscience employers declined. Restrictions regarding facility access, staffing, health and safety, meetings, and travel fluctuated throughout the year but generally trended downward. There was a brief spike in restrictions in November, likely due to the anticipated increase in flu and COVID cases during the holiday season.

### **Links to relevant survey data charts**

Pandemic-related impacts to business operations

<https://covid19.americangeosciences.org/data/charts/employer-business-impacts/>



Types of pandemic-related impacts to business operations

<https://covid19.americangeosciences.org/data/charts/employer-business-impact-types/>

Expected financial performance for current calendar year relative to last year

<https://covid19.americangeosciences.org/data/charts/employer-financial-performance-rel2lastyear/>

Expected financial performance for current calendar year relative to pre-pandemic conditions

<https://covid19.americangeosciences.org/data/charts/employer-financial-performance-rel2precovid/>

Level of work relative to capacity

<https://covid19.americangeosciences.org/data/charts/employer-productivity/>

Changes to geoscience employer staffing as a result of the pandemic

<https://covid19.americangeosciences.org/data/charts/employer-staffing-impacts/>

Employers with staff on travel or conducting fieldwork

<https://covid19.americangeosciences.org/data/charts/employer-travel-fieldwork/>

Types of pandemic related restrictions on geoscience employers

<https://covid19.americangeosciences.org/data/charts/employer-workplace-restrictions/>

## **PANDEMIC IMPACTS ON HIRING**

In the third quarter of 2020, the most substantial issue for geoscience employers related to recruiting, hiring, and onboarding new employees was the hiring process, affecting just less than half of employers. This issue gradually declined, affecting only a quarter of businesses by the end of 2022. Recruiting difficulties peaked in the second quarter of 2021, reported by just under a half of employers, and slowly decreased to one-third by the end of 2022. Challenges related to onboarding and training new hires were reported by one-tenth to one-fifth of employers over the period. Overall, employers issues related to recruiting, hiring, and onboarding processes improved over time, with the percentage of employers reporting no challenges increasing from one-fifth in the third quarter of 2020 to over half by the end of 2022.

“Onboarding is proving to be a challenge. Not from a technical proficiency standpoint, but from assimilation into the culture and core values of the organization. Also, some animosity is starting to creep in from those that need to be in the office to do their jobs, vs. those that can work remote 100%. The pandemic has exacerbated some of our pre-existing problems with hiring, onboarding, and training; new hires receive more assistance and direction from mid-level staff of the same latitude than they have access to direction from top-level staff. A lot of the interviewing, hiring, on-boarding, training, etc. of new employees has been changed by the new remote work environment. A lot of these tasks are now done remotely. Recruiting remains an issue, as there seems to be limited number of both experienced and entry-level geoscientists available. Definitely fewer applicants per opening than pre-pandemic.” – geoscience employer

In Spring 2022, over half of employers identified some form of skills or knowledge gap in their new hires, but this percentage declined rapidly to less than a third by Fall 2022. Employers increasingly reported geoscience knowledge gaps, with a quarter of employers noting this in the Fall of 2022. Noted gaps in

productivity and interpersonal skills both improved over this period, while noted gaps in technical skills varied over the period, with just over one fifth of employers noting this in Spring and Fall of 2022. When comparing pandemic-era hires to pre-pandemic hires, most employers reported the two cohorts were similar in terms of their productivity, technical skills, geoscience knowledge, and interpersonal skills. However, the percentage of employers noting that pandemic era hires performed less well in terms of productivity and interpersonal skills increased over the period to 25%, while employers noting declines in technical skills increased to just over 10%.

## Links to relevant survey data charts

Challenges with recruiting, hiring, and onboarding activities

<https://covid19.americangeosciences.org/data/charts/employer-hiring-challenges/>

Skills and knowledge gaps noted by employers in pandemic new hires

<https://covid19.americangeosciences.org/data/charts/new-grad-skills-gap/>

Skills and knowledge of pandemic hires relative to pre-pandemic hires

<https://covid19.americangeosciences.org/data/charts/new-hire-evaluation/>

## PANDEMIC IMPACTS ON EMPLOYMENT STATUS

The employment tenure of study participants demonstrated a clear trend of increasing tenure with more time spent in the workforce. Participants who graduated before 2014 predominantly reported being in their jobs for over 10 years. On the other hand, recent graduates from 2019 to 2022 were mainly in the early stages of their careers and had been in their jobs for less than 1 to 2 years. The trends of employment across sectors varied per cohort. For instance, graduates from 2000 to 2009 saw a shift towards non-academic geoscience employment. In contrast, a balance existed between academic and non-academic geoscience jobs among 2010–2013 and 2014–2018 graduates. Interestingly, the 2019–2022 graduate cohort saw an uptick in academic positions. Those who graduated before 2000 reported a substantial increase in retirements and a decline in academic positions at the end of 2022. For all but the most recent graduating cohort, unemployment rates remained relatively low.

From May 2020 to December 2022, full-time employment was the most prevalent status among participants in the study, with part-time and contract work reported by less than a tenth of participants. Similar patterns were observed across specific cohorts. Academic faculty and non-academic geoscientists mostly reported full-time employment. Furloughs were generally low across all cohorts as well.

Over half of the geoscience retirees continued their involvement in the geoscience profession and/or volunteer activities during the pandemic, with engagement peaking in May 2020. Research, project work, consulting activities, volunteer activities, and participation in geoscience professional activities were the main pursuits among active retirees. Over half of those fully retired stated they had done so before 2020, with just over a fifth entering full retirement in 2021. Among those who reported partial retirement, most had done so before 2020, with the remainder transitioning to partial retirement evenly spread across 2020 to 2022.

From 2020 to 2022, most unemployed geoscientists were actively seeking employment. Job seeking in both geoscience and non-geoscience fields declined over 2020–2022 as job searches became more focused, and a slight increase occurred in those not seeking employment. The professional, scientific, and technical services industry attracted over two-thirds of job seekers between 2020 and 2022, making it the most attractive industry, while interest in mining, oil & gas extraction, and government agencies decreased

over the same period. The primary reasons for seeking employment outside geosciences included a lack of available jobs, reluctance to relocate, and perceived lack of opportunities within the geosciences.

## Links to relevant survey data charts

Length of employment in current job

<https://covid19.americangeosciences.org/data/charts/individual-employment-duration-mostrecentstatus/>

Employment status of survey participants graduating in 2000-2009

<https://covid19.americangeosciences.org/data/charts/individual-ptypechangebycohort-2000-2009/>

Employment status of survey participants graduating in 2010-2013

<https://covid19.americangeosciences.org/data/charts/individual-ptypechangebycohort-2010-2013/>

Employment status of survey participants graduating in 2014-2018

<https://covid19.americangeosciences.org/data/charts/individual-ptypechangebycohort-2014-2018/>

Employment status of survey participants graduating in 2019-2022

<https://covid19.americangeosciences.org/data/charts/individual-ptypechangebycohort-2019-2022/>

Employment status of survey participants graduating before 2000

<https://covid19.americangeosciences.org/data/charts/individual-ptypechangebycohort-pre2000/>

Employment intensity of employed study participants during the pandemic

<https://covid19.americangeosciences.org/data/charts/individual-employment-status-all/>

Employment intensity of employed faculty during the pandemic

<https://covid19.americangeosciences.org/data/charts/individual-employment-status-if/>

Employment intensity of employed K-12 faculty during the pandemic

<https://covid19.americangeosciences.org/data/charts/individual-employment-status-ik/>

Employment intensity of employed post-doctoral fellows during the pandemic

<https://covid19.americangeosciences.org/data/charts/individual-employment-status-ip/>

Employment intensity of employed study participants in non-faculty occupations during the pandemic

<https://covid19.americangeosciences.org/data/charts/individual-employment-status-iw/>

Status of geoscience retirees during the pandemic

<https://covid19.americangeosciences.org/data/charts/individual-retiree-status/>

Types of activities retirees were engaged in during the pandemic

<https://covid19.americangeosciences.org/data/charts/individual-retiree-status-active/>

Year when retirement began for retired study participants

<https://covid19.americangeosciences.org/data/charts/individual-retirement-status/>

Employment sectors sought by unemployed geoscientists

<https://covid19.americangeosciences.org/data/charts/individual-unemployed-industry/>

Reasons for seeking employment outside of the geosciences

<https://covid19.americangeosciences.org/data/charts/individual-unemployed-nongoreason/>

Number of sectors in which unemployed geoscientists are seeking employment

<https://covid19.americangeosciences.org/data/charts/individual-unemployed-seekingnumsectors/>

Status of unemployed geoscientists over the pandemic

<https://covid19.americangeosciences.org/data/charts/individual-unemployed-status/>

## **PANDEMIC IMPACTS ON WORK AND RESEARCH ACTIVITIES**

Pandemic impacts on fieldwork, lab activities, and research activities during Spring 2020 were clearly visible across all study cohorts. Regarding fieldwork, most non-academic geoscientists reported having their projects deferred, whereas cancellations of fieldwork were more common among faculty and students. In addition, just over a fifth of post-doctoral fellows and non-academic geoscientists reported no impact on their fieldwork.

Regarding lab activities, most post-doctoral fellows reported having their research or projects deferred, and nearly half of faculty also reported this impact. Termination of active research was reported by a third of students and just over a quarter of faculty. Just over a fifth of non-academic geoscientists reported no impact on their lab activities.

Regarding research activities, deferrals were most common among academic faculty, non-academic geoscientists, and post-doctoral fellows. Many shifted their research mode to virtual or computational methods or converted to literature review activities, especially post-doctoral fellows. Cancellations of planned research affected nearly 30% of all cohorts, while cancellation of active research was more common among faculty and non-academic geoscientists.

### **Caregiving and domestic responsibilities**

During the pandemic, the impact of caregiving and domestic responsibilities on work hours and productivity among academic faculty and non-academic geoscientists varied between genders and occupational status. In April 2021, more women than men in both groups reported work hour reductions due to childcare and household management, while more men in faculty occupations reported reductions due to eldercare. This difference was also observed in productivity impacts, with more women than men reporting effects due to childcare and household management, and eldercare affecting men more substantially. By December 2021, the distribution had changed slightly. Among academic faculty, men reported greater impacts due to childcare than they did in April 2021. However, women continued to report higher impacts than men due to childcare and household management. Productivity impacts were closer than in April 2021, with men reporting slightly higher productivity impacts than women in terms of childcare, and for eldercare, more men in academic occupations reporting higher productivity impacts than women in academic occupations.

“One of the first kind of personal difficulties I had was having young children at home. We live in a 2-bedroom apartment and so there's not like a whole dedicated office space. And so my kitchen counter became my office. And so the first hurdle was just that logistic of finding the space, the quiet space with young children that, you know, I had a child born during COVID. And then my oldest, she was four at the time, so you can imagine what that looked like. And so, you know, it's kind of adjusting just to the change setting and it's funny, you know, there were days I worked from home before the pandemic. But of course, in those instances, you know, the house was empty, kids were at school, etcetera. Now everyone being home all at once, that was definitely, you know, a good kind of personal challenge.”  
—recent graduate

## Restrictions on work and research

Between June 2020 and December 2022, pandemic-related restrictions such as facility limitations, health and safety measures, and meeting and travel restrictions were observed across different participant groups including academic faculty, K–12 faculty, post-doctoral fellows, students, and non-academic geoscientists. Trends indicated a general decrease in facility restrictions, signaling a gradual reopening of businesses and campuses. Health and safety restrictions also declined gradually after initially remaining high, while meeting and travel restrictions showed a consistent decrease over time. The proportion of participants experiencing no restrictions increased during this period.

In this same period, facility restrictions substantially impacted study participants, with noticeable improvements after Summer 2021. These included access restrictions, staffing reductions, and approval requirements for site access, with over half of participants initially experiencing these challenges. This percentage dropped to less than 10% by mid-2022. Similarly, deferral of field and lab activities also decreased during this period.

From June 2020 to December 2022, meeting and travel restrictions due to the pandemic had substantial but declining impacts on various groups, including academic faculty, K–12 faculty, post-doctoral fellows, students, and non-academic geoscientists. Initially, online or phone meetings were predominant, but travel and meeting restrictions, as well as travel prohibition, self-isolation requirements, and vehicle restrictions, declined substantially by December 2022.

Over the same period, different groups experienced substantial health and safety restrictions due to the COVID-19 pandemic. Across all cohorts, social distancing, face mask usage, and increased health and safety protocols were prevalent. The use of personal protective equipment and health assessments were also reported but decreased over time. COVID testing and vaccination requirements and recommendations became more prominent from October 2021 through March 2022 respectively.

## Supply shortages

Supply shortages also impacted study participants during the pandemic, with most impacts being noted in late 2020 and late 2021. For academic departments, lab supplies were the most critical shortage, especially during December 2021, whereas for employers, personal protective equipment shortages were the most critical, peaking during December 2020, followed by IT supplies throughout the 2020–2022 period. Other groups, such as academic and K–12 faculty, post-doctoral fellows, students, and non-academic geoscientists, also faced varying degrees of supply shortages, with fluctuating reports over the

period. Despite the fluctuations in supply shortages, with most study participants noting no supply shortages by March 2022.

## Links to relevant survey data charts

Pandemic impacts on field activities, Spring 2020

<https://covid19.americangeosciences.org/data/charts/individual-impacts-spring2020-field/>

Pandemic impacts on lab activities, Spring 2020

<https://covid19.americangeosciences.org/data/charts/individual-impacts-spring2020-lab/>

Pandemic impacts on research activities, Spring 2020

<https://covid19.americangeosciences.org/data/charts/individual-impacts-spring2020-research/>

Reduced hours because of caregiving and domestic responsibilities, April 2021

<https://covid19.americangeosciences.org/data/charts/individual-domestic-responsibilities-hours-apr2021/>

Reduced hours because of caregiving and domestic responsibilities, December 2021

<https://covid19.americangeosciences.org/data/charts/individual-domestic-responsibilities-hours-dec2021/>

Productivity impacts from caregiving and domestic responsibilities, April 2021

<https://covid19.americangeosciences.org/data/charts/individual-domestic-responsibilities-impacts-apr2021/>

Productivity impacts from caregiving and domestic responsibilities, December 2021

<https://covid19.americangeosciences.org/data/charts/individual-domestic-responsibilities-impacts-dec2021/>

Facility restrictions to work and research activities during the pandemic

<https://covid19.americangeosciences.org/data/charts/individual-restrictions-facility-all/>

Facility restrictions to work and research activities during the pandemic

<https://covid19.americangeosciences.org/data/charts/individual-restrictions-facility-if/>

Facility restrictions to work and research activities during the pandemic

<https://covid19.americangeosciences.org/data/charts/individual-restrictions-facility-ik/>

Facility restrictions to work and research activities during the pandemic

<https://covid19.americangeosciences.org/data/charts/individual-restrictions-facility-ip/>

Facility restrictions to work and research activities during the pandemic

<https://covid19.americangeosciences.org/data/charts/individual-restrictions-facility-is/>

Facility restrictions to work and research activities during the pandemic

<https://covid19.americangeosciences.org/data/charts/individual-restrictions-facility-iw/>

Health and safety restrictions to work and research activities during the pandemic

<https://covid19.americangeosciences.org/data/charts/individual-restrictions-health-all/>

Health and safety restrictions to work and research activities during the pandemic

<https://covid19.americangeosciences.org/data/charts/individual-restrictions-health-if/>

Health and safety restrictions to work and research activities during the pandemic

<https://covid19.americangeosciences.org/data/charts/individual-restrictions-health-ik/>

Health and safety restrictions to work and research activities during the pandemic

<https://covid19.americangeosciences.org/data/charts/individual-restrictions-health-ip/>

Health and safety restrictions to work and research activities during the pandemic

<https://covid19.americangeosciences.org/data/charts/individual-restrictions-health-is/>

Health and safety restrictions to work and research activities during the pandemic

<https://covid19.americangeosciences.org/data/charts/individual-restrictions-health-iw/>

Meeting and travel restrictions to work and research activities during the pandemic

<https://covid19.americangeosciences.org/data/charts/individual-restrictions-meeting-all/>

Meeting and travel restrictions to work and research activities during the pandemic

<https://covid19.americangeosciences.org/data/charts/individual-restrictions-meeting-if/>

Meeting and travel restrictions to work and research activities during the pandemic

<https://covid19.americangeosciences.org/data/charts/individual-restrictions-meeting-ik/>

Meeting and travel restrictions to work and research activities during the pandemic

<https://covid19.americangeosciences.org/data/charts/individual-restrictions-meeting-ip/>

Meeting and travel restrictions to work and research activities during the pandemic

<https://covid19.americangeosciences.org/data/charts/individual-restrictions-meeting-is/>

Meeting and travel restrictions to work and research activities during the pandemic

<https://covid19.americangeosciences.org/data/charts/individual-restrictions-meeting-iw/>

Pandemic-related restrictions to work and research activities

<https://covid19.americangeosciences.org/data/charts/individual-restrictions-overview-all/>

Pandemic-related restrictions to work and research activities

<https://covid19.americangeosciences.org/data/charts/individual-restrictions-overview-if/>

Pandemic-related restrictions to work and research activities

<https://covid19.americangeosciences.org/data/charts/individual-restrictions-overview-ik/>

Pandemic-related restrictions to work and research activities

<https://covid19.americangeosciences.org/data/charts/individual-restrictions-overview-ip/>

Pandemic-related restrictions to work and research activities

<https://covid19.americangeosciences.org/data/charts/individual-restrictions-overview-is/>

Pandemic-related restrictions to work and research activities

<https://covid19.americangeosciences.org/data/charts/individual-restrictions-overview-iw/>

Supply shortages during the pandemic

<https://covid19.americangeosciences.org/data/charts/supply-shortages-department/>

Supply shortages during the pandemic

<https://covid19.americangeosciences.org/data/charts/supply-shortages-employer/>



Supply shortages during the pandemic

<https://covid19.americangeosciences.org/data/charts/supply-shortages-if/>

Supply shortages during the pandemic

<https://covid19.americangeosciences.org/data/charts/supply-shortages-ik/>

Supply shortages during the pandemic

<https://covid19.americangeosciences.org/data/charts/supply-shortages-ip/>

Supply shortages during the pandemic

<https://covid19.americangeosciences.org/data/charts/supply-shortages-is/>

Supply shortages during the pandemic

<https://covid19.americangeosciences.org/data/charts/supply-shortages-iw/>

## **PANDEMIC IMPACTS ON WORK ENVIRONMENTS**

The analysis of remote work productivity from 2020 to 2022 identified several trends. Overall, study participants reported enhancements in productivity for focus, collaboration, meetings, and research activities over the period. Academic faculty demonstrated a similar trend except for remote work activities related to teaching and the ability to focus, where there were declines reported in the level of productivity over time. Non-academic geoscientists consistently reported high productivity in focus and research, collaboration, and meetings.

From 2020 to 2022, the pandemic brought about various challenges across all work environments. The most frequently reported issue was the lack of in-person interaction, followed by collaboration impacts, less effective communication, and health and safety concerns. Workflow delays were reported more by departments than employers or individuals, as were childcare issues. Having remote work environments that were not optimal for work activities was cited by over half of individuals and employers, and over a third of departments. Impacts on research and work activities were reported by three-quarters of departments, and nearly half of individuals and employers. Decreased work/life balance was mentioned more by departments and individuals than by employers. Decreased productivity was noted by nearly half of departments, and over a quarter of individuals and employers. Increased distractions were reported by over a third of individuals. Impacts to student engagement and learning as well as to teaching and course delivery were noted by about a third of departments and individuals.

From 2020 to 2022, academic departments observed considerable increases in health and safety concerns, lack of in-person interaction, and struggles by staff and faculty with managing childcare. Geoscience employers also noted similar issues, especially a rise in the lack of in-person interaction. Among individual cohorts (i.e., academic faculty, post-doctoral fellows, non-academic geoscientists, students, K–12 faculty) there was a substantial increase in concerns about decreased work/life balance and lack of in-person interaction, followed by increased distractions, childcare management issues, and collaboration impacts.

### **Links to relevant survey data charts**

Productivity with remote work activities

<https://covid19.americangeosciences.org/data/charts/individual-wah-productivity-all/>

Productivity with remote work activities

<https://covid19.americangeosciences.org/data/charts/individual-wah-productivity-if/>



Productivity with remote work activities

<https://covid19.americangeosciences.org/data/charts/individual-wah-productivity-iw/>

Challenges with work environments during the pandemic (2020-2022)

<https://covid19.americangeosciences.org/data/charts/work-format-cons-allyears/>

Faculty and staff challenges with work environments during the pandemic

<https://covid19.americangeosciences.org/data/charts/work-format-cons-dept/>

Employee challenges with work environments during the pandemic

<https://covid19.americangeosciences.org/data/charts/work-format-cons-emp/>

Challenges with work environments during the pandemic

<https://covid19.americangeosciences.org/data/charts/work-format-cons-if/>

Challenges with work environments during the pandemic

<https://covid19.americangeosciences.org/data/charts/work-format-cons-ik/>

Challenges with work environments during the pandemic

<https://covid19.americangeosciences.org/data/charts/work-format-cons-indiv/>

Challenges with work environments during the pandemic

<https://covid19.americangeosciences.org/data/charts/work-format-cons-ip/>

Challenges with work environments during the pandemic

<https://covid19.americangeosciences.org/data/charts/work-format-cons-is/>

Challenges with work environments during the pandemic

<https://covid19.americangeosciences.org/data/charts/work-format-cons-iw/>

## **PANDEMIC IMPACTS ON PROFESSIONAL CREDENTIALLING**

The challenges experienced by academic departments and individuals preparing for geology licensure and professional certifications during the pandemic varied. Only a quarter of academic departments reported that their graduating students intended to take the Fundamentals of Geology exam in the 2021–2022 academic year. While most departments and participants reported no challenges with preparing for licensure and professional certification exams, a small percentage did. The acceptance of field requirements was a problem noted by 15% of departments, and less than 10% of participants noted issues related to the acceptance of lecture or lab requirements. Scheduling was an issue reported by less than one-fifth of departments and participants, as was exam preparation.

Among academic faculty, one quarter held a Professional Geologist license, while nearly one-tenth were Certified Professional Geologists, or held other professional licenses. Non-academic geoscientists had a higher rate of licensure, with over half holding a Professional Geologist license, and about a tenth having Professional Engineer licenses or other geoscience professional licenses.

Regarding intentions to take professional certification or licensing exams, less than 5% of students, and less than a quarter of recent graduates expressed such plans. For those intending to take an exam, state professional geology license exams were commonly cited across cohorts. OSHA safety certification courses were cited by most non-academic geoscientists, while drone licenses were cited by academic faculty. The most common reason for not taking professional licensure or certification exams across most groups was

that the licensure or certification was not required. Other common reasons included being already licensed or certified, lacking enough experience, and the cost of the exams.

## Links to relevant survey data charts

Graduating students intending to take the Fundamentals of Geology exam in the 2021-2022 academic year

<https://covid19.americangeosciences.org/data/charts/licensure-grnrfgplans/>

Challenges with preparing for licensure and professional certifications during the pandemic

<https://covid19.americangeosciences.org/data/charts/licensure-licensurechallenges/>

Reasons for not taking professional licensure / certification exams in 2021

<https://covid19.americangeosciences.org/data/charts/licensure-plansnoreason/>

Plans for professional licensure / certification exams in 2021

<https://covid19.americangeosciences.org/data/charts/licensure-planstype/>

Plans for taking professional certification of licensing exams in 2021

<https://covid19.americangeosciences.org/data/charts/licensure-plansyn/>

Professional credentials by survey cohort

<https://covid19.americangeosciences.org/data/charts/licensure-professionallicenses/>

## PANDEMIC IMPACTS ON LIBRARY USAGE

Library usage and issues related to library resource access in 2020 varied among different study groups. With respect to the types of libraries used, most academic faculty, post-doctoral fellows, students, and unemployed individuals primarily used university or college libraries. Public libraries were mainly utilized by retirees, while K–12 faculty predominantly relied on K–12 libraries. Government libraries were most frequently used by non-academic geoscientists. Notably, a considerable number of individuals across all cohorts did not use any library during this time.

Variations in the use of library resources compared to February 2020 were observed across cohorts and types of resources. Generally, most groups reported a decrease or no change in the usage of customer service resources, Inter-Library Loan resources, journal access, and print materials. Notably, the usage of print materials experienced a substantial decrease across all cohorts. Access issues became prominent in October 2020, with print materials and journal articles presenting the most challenges. Over one-quarter of respondents reported a lack of access to library subscriptions, while about one-quarter reported issues with the Inter-Library Loan system and library closures. In terms of access difficulties, post-doctoral fellows and unemployed individuals faced the most challenges in obtaining certain items, whereas retirees and non-academic geoscientists reported the fewest problems.

## Links to relevant survey data charts

Types of libraries used between September and October 2020

<https://covid19.americangeosciences.org/data/charts/library-access-usage-type/>

Types of library resource access issues experienced by survey participants

<https://covid19.americangeosciences.org/data/charts/library-access-usage-accessissues/>

Have there been items you have not been able to access or obtain through your library?

<https://covid19.americangeosciences.org/data/charts/library-access-usage-accesssyn/>

Usage of library resources relative to February 2020: Customer service (emails, chat, phone)  
<https://covid19.americangeosciences.org/data/charts/library-access-usage-usage-custsvc/>

Usage of library resources relative to February 2020: Inter-Library Loan services  
<https://covid19.americangeosciences.org/data/charts/library-access-usage-usage-ill/>

Usage of library resources relative to February 2020: Journal access  
<https://covid19.americangeosciences.org/data/charts/library-access-usage-usage-journal/>

Usage of library resources relative to February 2020: Print materials  
<https://covid19.americangeosciences.org/data/charts/library-access-usage-usage-print/>

## **PANDEMIC-DRIVEN CONCERNS THROUGHOUT 2020–2022**

From the third quarter of 2020 to the first quarter of 2022, a general decline in pandemic-related concerns was noted among various groups, including recent graduates, academic departments, geoscience employers, and non-academic geoscientists. Key areas of reduced concern involved academic rigor, job security, employment availability, financial obligations, and workplace safety. However, the levels of concern differed and fluctuated over time among academic faculty, K–12 faculty, post-doctoral fellows, retired geoscientists, students, and unemployed geoscientists. For instance, students noted increasing concerns about job security and workplace safety, whereas unemployed geoscientists experienced varying trends, with substantial increases and subsequent decreases in areas such as job security and employment availability. Among these groups, retired geoscientists reported the fewest pandemic-related concerns.

Academic departments noted a general decrease in all pandemic-driven concerns throughout the period, with financial outlook, adapting to new instructional methods, hiring new employees, and workplace safety experiencing substantial declines. Geoscience employers witnessed a substantial decrease in pandemic-driven concerns related to financial outlook, hiring, staffing levels, and workplace safety. However, concerns about supply chain disruptions initially decreased and then resurged by the first quarter of 2022.

Concerns about academic rigor and the availability of educational programs fluctuated among academic and K–12 faculty during the pandemic, but there was a consistent decrease in workplace safety and job security concerns. Additionally, K–12 faculty's financial concerns remained steady, with a sharp rise at the start of 2022.

Geoscience students showed increasing concerns over job security and workplace safety. Pandemic-driven worries about employment availability remained high, and financial concerns surged between the end of 2020 and the start of 2022. Among recent graduates (2014–2018), there was a general decrease in concerns about academic rigor, financial obligations, job security, availability of employment, and workplace safety between the third quarter of 2020 and the first quarter of 2022, with job security and availability of employment witnessing substantial declines. Recent graduates (2019–2022) saw a substantial decrease in pandemic-related concerns, particularly about employment availability and job security, during the same period. Concerns about academic rigor, educational programs, and financial obligations showed minor changes, while concerns about workplace safety remained steady.

Pandemic-driven concerns varied for post-doctoral fellows, with steady financial concerns, decreasing job security concerns, declining employment concerns, but slightly increasing workplace safety concerns. Non-academic geoscientists experienced an overall decrease in concerns across all areas, with a more considerable decline in concerns regarding employment availability, financial obligations, and job security. However, workplace safety remained the most substantial concern throughout the period. Pandemic-

related concerns among unemployed geoscientists varied, with substantial initial increases in concerns related to employment availability, job security, and workplace safety, followed by gradual decreases.

## Links to relevant survey data charts

Recent graduates (2014–2018): Concerns moderately to extremely driven by COVID-19

<https://covid19.americangeosciences.org/data/charts/concerns-covid-cohortallconcerns-2014-2018/>

Recent graduates (2019–2022): Concerns moderately to extremely driven by COVID-19

<https://covid19.americangeosciences.org/data/charts/concerns-covid-cohortallconcerns-2019-2022/>

Academic departments: Concerns moderately to extremely driven by COVID-19

<https://covid19.americangeosciences.org/data/charts/concerns-covid-cohortallconcerns-department/>

Geoscience employers: Concerns moderately to extremely driven by COVID-19

<https://covid19.americangeosciences.org/data/charts/concerns-covid-cohortallconcerns-employer/>

Academic faculty: Concerns moderately to extremely driven by COVID-19

<https://covid19.americangeosciences.org/data/charts/concerns-covid-cohortallconcerns-if/>

K–12 faculty: Concerns moderately to extremely driven by COVID-19

<https://covid19.americangeosciences.org/data/charts/concerns-covid-cohortallconcerns-ik/>

Post-docs: Concerns moderately to extremely driven by COVID-19

<https://covid19.americangeosciences.org/data/charts/concerns-covid-cohortallconcerns-ip/>

Retirees: Concerns moderately to extremely driven by COVID-19

<https://covid19.americangeosciences.org/data/charts/concerns-covid-cohortallconcerns-ir/>

Students: Concerns moderately to extremely driven by COVID-19

<https://covid19.americangeosciences.org/data/charts/concerns-covid-cohortallconcerns-is/>

Unemployed geoscientists: Concerns moderately to extremely driven by COVID-19

<https://covid19.americangeosciences.org/data/charts/concerns-covid-cohortallconcerns-iu/>

Non-academic geoscientists: Concerns moderately to extremely driven by COVID-19

<https://covid19.americangeosciences.org/data/charts/concerns-covid-cohortallconcerns-iw/>

## NON-PANDEMIC RELATED CONCERNS THROUGHOUT 2020–2022

From the fourth quarter of 2021 to the first quarter of 2022, non-pandemic related concerns among various groups demonstrated mixed trends. Concerns related to meeting financial obligations and job security increased among most cohorts. Academic departments and geoscience employers also reported increasing concerns about their financial outlook, hiring new employees, and maintaining staffing levels. However, concerns related to the academic rigor of programs, workplace safety, and employment availability decreased for most cohorts. Concerns related to the availability of educational programs also decreased for recent graduates, academic faculty, post-doctoral fellows, and students.

Academic departments noted a general increase in concerns, specifically in adapting to new instructional methods, financial outlook, hiring, maintaining staffing levels, and student recruitment and retention. Geoscience employers expressed growing concerns about financial outlook, maintaining staffing levels, and hiring, while concerns about business operation regulations and workplace safety diminished.

Students reported a decrease in all major concerns, except for employment availability, which remained their most pressing worry. Among recent graduates (2014–2018), non-pandemic related concerns over the academic rigor of programs and employment availability decreased, while concerns over meeting financial obligations and job security substantially increased. Recent graduates (2019–2022) also reported similar concerns, with minor increases in concerns about academic rigor and employment availability. However, this cohort noted a slight decrease in concerns about the availability of educational programs and workplace safety.

Academic faculty experienced a decrease in concerns about academic rigor and job security, but an increase in concerns about meeting financial obligations and workplace safety. K–12 faculty indicated a decrease in concerns about the academic rigor of programs, but an increase in concerns related to the availability of educational programs, meeting financial obligations, job security, and workplace safety.

Post-doctoral fellows reported a substantial decrease in concerns about academic rigor and the availability of educational programs, but a sharp increase in worries about job security and meeting financial obligations. Non-academic geoscientists noted an increase in concerns about the academic rigor of programs, the availability of educational programs, meeting financial obligations, and job security. However, they reported a decrease in concerns about employment availability. Unemployed geoscientists expressed a decrease in concerns about the academic rigor of programs and workplace safety, but a substantial increase in concerns related to the availability of educational programs, meeting financial obligations, and job security. Geoscience retirees noted slight increases in concerns related to the academic rigor of programs, the availability of educational programs, meeting financial obligations, and job security.

## Links to relevant survey data charts

Recent graduates (2014–18): Concerns driven by factors not related to the COVID-19 pandemic

<https://covid19.americangeosciences.org/data/charts/concerns-noncovid-cohortallconcerns-2014-2018/>

Recent graduates (2019–2022): Concerns driven by factors not related to the COVID-19 pandemic

<https://covid19.americangeosciences.org/data/charts/concerns-noncovid-cohortallconcerns-2019-2022/>

Academic departments: Concerns driven by factors not related to the COVID-19 pandemic

<https://covid19.americangeosciences.org/data/charts/concerns-noncovid-cohortallconcerns-department/>

Geoscience employers: Concerns driven by factors not related to the COVID-19 pandemic

<https://covid19.americangeosciences.org/data/charts/concerns-noncovid-cohortallconcerns-employer/>

Academic faculty: Concerns driven by factors not related to the COVID-19 pandemic

<https://covid19.americangeosciences.org/data/charts/concerns-noncovid-cohortallconcerns-if/>

K–12 faculty: Concerns driven by factors not related to the COVID-19 pandemic

<https://covid19.americangeosciences.org/data/charts/concerns-noncovid-cohortallconcerns-ik/>

Post-docs: Concerns driven by factors not related to the COVID-19 pandemic

<https://covid19.americangeosciences.org/data/charts/concerns-noncovid-cohortallconcerns-ip/>

Challenges: How did the COVID-19 pandemic disrupt the geosciences?

Retirees: Concerns driven by factors not related to the COVID-19 pandemic

<https://covid19.americangeosciences.org/data/charts/concerns-noncovid-cohortallconcerns-ir/>

Students: Concerns driven by factors not related to the COVID-19 pandemic

<https://covid19.americangeosciences.org/data/charts/concerns-noncovid-cohortallconcerns-is/>

Unemployed geoscientists: Concerns driven by factors not related to the COVID-19 pandemic

<https://covid19.americangeosciences.org/data/charts/concerns-noncovid-cohortallconcerns-iu/>

Non-academic geoscientists: Concerns driven by factors not related to the COVID-19 pandemic

<https://covid19.americangeosciences.org/data/charts/concerns-noncovid-cohortallconcerns-iw/>

# Strategies: How did geoscientists adapt and navigate pandemic-related impacts?

Within the geosciences, employers, academic departments, and individuals employed a variety of strategies to adapt to and navigate through the various pandemic-related impacts. Adaptations to instructional methods ranged from shifting the format of courses and learning activities to a combination of in-person and online which also required faculty to re-design their curriculum. Departments also adjusted degree program requirements to adapt to research project delays and in-person activity restrictions.

With the restrictions on facility access and travel, many projects were re-focused on literature reviews and modeling where possible, and others were redesigned to fit within pandemic-related constraints. Other strategies revolved around being resourceful, which included finding motivation and self-direction in the midst of the myriad of challenges to keep projects, schoolwork, work and research moving forward. Technology platforms were used ubiquitously during the pandemic as a bridge for communication and collaboration, providing a way for individuals to check in with each other, share ideas, learn new skills, and work together on projects.

In addition, supportive actions by employers, departments, and faculty helped to ease some of the challenges employees and students were facing. Providing equipment and financial support for employees to make the transition to working from home was helpful, especially in the early days of the pandemic. Adjusting project and research deadlines and allowing for flexibility in work hours, helped to reduce the stress for projects that were in part or completely delayed due to restrictions and supply chain disruptions, and for managing family care and other household responsibilities.

## **ADAPTATIONS TO INSTRUCTIONAL METHODS**

During the pandemic, academic departments and faculty employed various instructional adaptations to maintain teaching and research activities, notwithstanding the challenges brought about by the pandemic. These modifications included incorporating new instructional methods, restructuring courses for online settings, introducing and phasing out courses and degree paths, and implementing health and safety measures during in-person teaching.

### **Four-year academic institutions**

Throughout the pandemic, institutional plans for instructional activity shifted over each academic term. From June 2020 through early 2021, academic departments at four-year institutions reported that their institutions were planning for in-person instruction with pandemic-related restrictions for the next academic term. However, by December 2022, less than a fifth of these departments reported such plans. Pandemic-related restrictions, including altered schedules, class size limitations, face mask mandates, and social distancing measures, were common in 2020 and 2021 but gradually faded or were discontinued by the end of 2022. As in-person instruction resumed in the 2021–2022 academic year, face masks, COVID testing, and vaccination were the principal restrictions, which likewise phased out by the end of 2022. Hybrid courses were reported by one-quarter to a third of departments between Spring 2021 and early 2022, after which they declined to nearly one-fifth for the rest of the period.



## Two-year academic institutions

Academic departments at two-year institutions exhibited a more diverse range of plans for academic instruction when compared to their counterparts at four-year institutions. From June 2020 through March 2022, most institutional plans focused on online courses as the primary instructional modality for the next academic term. This was then replaced by plans for in-person courses with pandemic-related restrictions and hybrid courses, which dominated until early 2022. At this point, plans for in-person courses without restrictions became the prevailing instructional mode. Notably, more than half of the departments reported plans to offer hybrid courses through the end of 2022. Furthermore, plans for online courses saw an upswing during the first half of the 2022–2023 academic year. By December 2022, the most frequently reported plans at two-year institutions were in-person courses without restrictions, hybrid courses, and online courses. During 2020 and 2021, pandemic-related restrictions on in-person instruction, such as altered schedules, class size limitations, and face mask requirements, were prevalent. However, these measures dwindled to minimal percentages or were phased out entirely by 2022. Mirroring the experience of four-year institutions, COVID testing, vaccination recommendations or requirements, face mask mandates, and social distancing reached their peak during the first half of the 2021–2022 academic year, but then sharply declined by Spring 2022.

“We took an extra week of spring break, partly to try and get the servers upgraded to the point we could handle a lot of the online teaching that we knew we were going to have to do for at least a while. Also, to get the faculty on board, and have sort of crash courses on how to use various tools within our online content management system. Fortunately, I had been doing a lot of my grading online, in terms of like keeping track of student records and I had done that for three or four years. I had also put all the class material that was available online prior to the pandemic. I just felt like that was the easiest way for students to stay with it. That helped me a lot because I was already confident in using that system and familiar with it. The thing that I think was not so good was at the end of that first semester we were told not to do many real-time kinds of lecturing or interacting with the students. Again, they were worried about the overload with our servers. I was recording PowerPoints and things, but that did not work for my graduate level class. But those classes were small, and I said: “OK, let’s start meeting online. That way you can ask me questions in real time.” I think towards the end of that semester I also had a help session for teaching an undergraduate class where I would go over some of the homework. I started getting increased student attendance once they realized that that really helped, and they were doing better on exams.” —academic faculty

## K–12 institutions

K–12 institutions saw a faster transition back to in-person teaching than post-secondary institutions. As early as September 2020, more than half of K–12 institutions reported plans for in-person courses with pandemic-related restrictions for the next academic term. This proportion rose to over three-quarters by December 2020, fell during the summer months of 2021, and then climbed again during the 2021–2022 academic year. Throughout the period, the prevalence of plans for online instruction saw fluctuations but generally decreased from over a third of institutions in June 2020 to less than a fifth by August 2021. Plans for hybrid instruction was reported by less than a third of institutions during the same period. In-person instruction without restrictions saw a sharp increase in Spring 2021 and became the primary mode of



teaching during the Summer of 2022. However, this trend declined during the 2021–2022 academic year, only to rebound and become the dominant mode of instruction again by Spring 2022. By December 2022, other instructional modes had significantly reduced or been completely phased out. Pandemic-related restrictions, such as altered schedules, limited class sizes, social distancing, and admitting select cohorts on campus, reached their peak in 2020 or early 2021 and then dwindled to low percentages or were phased out entirely by 2022. During the 2021–2022 academic year, the primary pandemic-related restrictions were the use of face masks, COVID testing, vaccinations, and social distancing. These restrictions saw a sharp decrease by April 2022.

## Course format adaptations

Institutional policies for course formats evolved in response to the pandemic, leading to substantial changes in instructional formats within departments. Academic departments at 4-year institutions experienced a marked shift from predominantly single-mode in-person lecture courses in February 2020 to primarily single-mode virtual courses by May 2020. From June 2020 onwards, a blend of in-person and virtual elements became the norm until in-person instruction resumed as the main instructional mode in the 2021–2022 academic year. Yet, by December 2022, more than a quarter of departments reported utilizing multiple modes of instruction for lecture courses.

## Field instruction adaptations

In June 2020, virtual methods were the predominant mode of field instruction in academic departments. However, by August 2020, in-person activities at local sites overtook virtual instruction. Initially, these in-person activities were undertaken by students alone, but as restrictions gradually eased, these activities included instructors and student groups. From March to August 2021, virtual field activities saw a sharp decline, with fewer than a tenth of departments employing this approach. Between April and May 2021, hybrid field activities were noted by one-fifth to one-third of departments, but this number dropped to nearly one-tenth by September 2021.

By September 2021, over three-quarters of departments reported using in-person field activities at local sites. In-person instruction at remote field sites initially had minimal implementation but saw a gradual increase from 2021 through the Summer of 2022. It peaked in July 2022, with two-thirds of departments employing this mode, before decreasing to just under a third in December 2022.

Field activity cancellations were generally low, peaking in May 2021 when just over a quarter of departments reported either cancellations or non-offerings of field activities. However, after May 2022, no further cancellations were reported.

The number of instructional modalities used varied throughout the pandemic. By December 2022, over a third of departments reported using a mix of instructional modalities for field activities, primarily in-person at either local or remote sites. However, a few departments also incorporated aspects of virtual or hybrid instruction.

“I taught intro geology almost completely online, but with a couple of field trips. One was on campus, and I took people around to see the local building materials and the local history of the school to get them an idea of an introduction to deep geologic time by looking at the buildings and pointing out how the campus had changed over the years. I was pointing out leaves that had left imprints in wet concrete. That kind of thing. I did whatever I could walking around as I figured the ultraviolet would kill most of the virus and we did not have to stand too close together. I still wore a mask. I also had students meet at a couple of other places off campus that were close enough. I had them go to a graveyard and look at weathering and gravestones, and I augmented that with a virtual field trip. It's a large campus, and we have nature trails. We have a few outcrops that are on campus, and chalk, so it was possible to show them some fossils and outcrops and that kind of thing, but the school allowed almost no travel of any kind. We were not going to conventions, and we were certainly not packing students into a 15-person van with poor ventilation to take them anywhere. We haven't changed the curriculum to accommodate COVID very much. Instead, we tried to adapt the courses to the students' needs.” —academic faculty

## Lab section / course adaptations

In June 2020, a majority of departments leveraged various instructional modes to sustain lab sections and courses amid the pandemic. Virtual instruction, frequently combined with at-home activities and computational methodologies, was used extensively throughout 2020. As the 2020–2021 academic year began, in-person instruction with pandemic-related restrictions was often integrated into the instructional mix. Virtual instruction, at-home activities, and computational activities saw a decline throughout the first half of 2021 as in-person instruction with pandemic-related restrictions became the dominant mode for over two-thirds of departments. A sharp increase in in-person instruction without restrictions was noted in early 2022, surpassing in-person instruction with pandemic-related restrictions by Spring 2022. By the end of 2022, less than a fifth of departments reported using any instructional modes other than in-person instruction without restrictions, and slightly over a quarter of departments reported employing a mix of instructional modes for lab sections and courses.

“Group work in breakouts on Zoom saves time moving around, groups get privacy, I can easily screenshot a list of students in each group for attendance, and random assignments get students to meet new people faster. The accessibility was great, including recording and captioning lectures. Virtual labs worked really well when I completely redesigned them to function in that space (not just modified in person) and helped prepare students to use their computers more effectively. Virtual field trips were fantastic for getting more details, accessibility, and by creating my own (with 3D models, thin sections, etc.), I will continue using it, as a way to prepare students for going in the field.” —academic faculty

## Degree program adaptations

In addition to modifying instructional modes, departments also adapted to pandemic conditions by introducing new courses and adapting geoscience degree program requirements, while phasing out

others. During the 2021–2022 academic year, almost a quarter of academic departments launched new courses or degree tracks, while slightly over a tenth of departments phased out existing courses or degree tracks. The new courses covered a variety of subjects such as climate studies, coastal processes, earth systems science, environmental geology, environmental science, field methods, hazards, geology, GIS, oceanography, paleontology, paleolimnology, soil science, and sustainability. New degree programs spanned a range of topics at both undergraduate and graduate levels, including environmental geology, computational geoscience, environmental science, climate change, ocean science, sustainability, geo-intelligence, data analytics, and mineral exploration. Courses that were phased out encompassed electives, courses previously taught by faculty members who had left the department, and those deemed irrelevant to the updated curriculum. Some departments also phased out bachelor's degree programs, citing reasons such as lack of sufficient majors or interest in the programs.

During the pandemic, some departments adjusted degree program requirements to help students meet their program criteria. By November 2021, the majority of academic departments had reported no alterations to degree requirements, but by November 2022, just over half indicated that they had not made any permanent changes to their academic degree programs. Among the departments that did make changes, the most common permanent adjustment, reported by just over a quarter of departments, was offering flexibility in the mode of defense. Other permanent changes encompassed accepting course substitutions, waiving prerequisites, extending the duration of the degree program, integrating new skillsets into the curriculum, and accepting demonstrated competency as a reason to waive courses.

## Adaptations to curricula

During the 2020–2021 academic year, both academic and K–12 faculty made substantial curriculum alterations in response to the pandemic. Within academia, three-quarters of the faculty adjusted their curriculums. The most common alteration was the conversion of course content into an online format, followed by course streamlining and content removal. Other changes involved adding content to courses, modifying the grading format, among other alterations. In 2020 and 2021, faculty also incorporated more math and programming skills into the curriculum for virtual labs and field activities. However, most faculty perceived a lack of these skills among students. In 2020, over three-quarters of faculty observed a deficiency in student math or programming skills. This issue saw slight improvement, but two-thirds of faculty still noted these deficiencies in 2021.

In the K–12 sector, a vast majority of faculty made adjustments to their curriculum, with more than half reducing the amount of content, likely to simplify learning amidst the pandemic. Nearly a third of K–12 faculty adapted to remote learning by converting course content to an online format, while no faculty reported adding content or changing the grading format.

## Links to relevant survey data charts

Courses and/or degree tracks phased in/out during the 2021–2022 academic year

<https://covid19.americangeosciences.org/data/charts/courses-phased-in-out-ay2021-2022/>

Changes made by faculty to curriculum during the 2020–2021 academic year

<https://covid19.americangeosciences.org/data/charts/curriculum-changes-if/>

Changes made by K-12 faculty to curriculum during the 2020–2021 academic year

<https://covid19.americangeosciences.org/data/charts/curriculum-changes-ik/>

Changes made to geoscience academic degree programs

<https://covid19.americangeosciences.org/data/charts/degree-requirement-changes/>

Institutional plans for next academic term related to pandemic restrictions

<https://covid19.americangeosciences.org/data/charts/institution-status-next-term-ipcvdetails-2yr/>

Institutional plans for next academic term related to pandemic restrictions

<https://covid19.americangeosciences.org/data/charts/institution-status-next-term-ipcvdetails-4yr/>

Institutional plans for next academic term related to pandemic restrictions

<https://covid19.americangeosciences.org/data/charts/institution-status-next-term-ipcvdetails-k12/>

Institutional plans for next academic term

<https://covid19.americangeosciences.org/data/charts/institution-status-next-term-overview-2yr/>

Institutional plans for next academic term

<https://covid19.americangeosciences.org/data/charts/institution-status-next-term-overview-4yr/>

Institutional plans for next academic term

<https://covid19.americangeosciences.org/data/charts/institution-status-next-term-overview-k12/>

Lecture course instructional formats

<https://covid19.americangeosciences.org/data/charts/instructional-mode-courses-4yr/>

Lecture course formats by number of instructional modes

<https://covid19.americangeosciences.org/data/charts/instructional-mode-courses-singlelevsmultimode-4yr/>

Field activity instructional formats

<https://covid19.americangeosciences.org/data/charts/instructional-mode-field-4yr/>

Field activity formats by number of instructional modes

<https://covid19.americangeosciences.org/data/charts/instructional-mode-field-singlelevsmultimode-4yr/>

Lab section / course instructional formats

<https://covid19.americangeosciences.org/data/charts/instructional-mode-lab-4yr/>

Lab section / course formats by number of instructional modes

<https://covid19.americangeosciences.org/data/charts/instructional-mode-labs-singlelevsmultimode-4yr/>

Math and programming skills in the curriculum

<https://covid19.americangeosciences.org/data/charts/math-compsci-skills-teachlackyn/>

## **ADAPTATIONS FOR STUDENTS**

From June 2021 to December 2022, the proportion of students postponing their graduation to fulfill degree requirements declined. Although the percentage of academic departments reporting no students delaying graduation varied, the departments reporting that more than 10% of their students were postponing graduation declined from nearly a fifth in June 2021 to none by December 2022.

In addition to extending their degree programs' duration, students also enrolled in courses during the Summer 2021 term, with field and lecture courses being the most common types. Among students who graduated prior to September 2021, field courses were most popular, followed by lecture courses. For continuing students, lecture courses were most popular, followed by field courses. Lab courses or sections

also were of interest, with over a third of departments reporting both continuing and graduating students registering for these courses. In addition, the majority of academic departments did not permit pandemic-era geoscience graduates to take classes post-graduation. Only a small proportion of departments added time slots or sections to accommodate these students.

Even though most departments did not offer any makeup opportunities for students to catch up on their degree programs, several departments provided such opportunities for specific types of classes, including field courses, lecture courses, and lab courses or sections. This demonstrates that despite the majority of departments not offering makeup opportunities, some departments helped students compensate for missed fieldwork and course components due to the pandemic's disruption of their education.

“One thing that we did was we instituted a pass-fail option. If students were worried that they were not going to get above a C on a particular course, they could request that their grade just be recorded as pass or fail. We also extended the withdrawal deadline to the very last day of classes. That way, if students were willing to try it and just gut it out, and they just got to the very end, and they still could not succeed, then they could withdraw, and it would not negatively impact their GPA.” —academic faculty

Despite significant learning disruptions throughout the pandemic, students remained dedicated to their degree programs, with the majority planning to return full-time in the next term to continue their studies. Although about a third of students aimed to graduate by Summer 2021, there was a notable increase to over half of students planning to graduate by Summer 2022. The percentage of students intending to return part-time remained low and generally decreased over time, while the proportion of students considering deferring enrollment, discontinuing studies, or being undecided had two surges, in Fall 2020 and Fall 2021. However, these intentions were no longer reported after May 2022.

Despite the challenges related to the pandemic, most students were able to fulfill their degree program requirements. While completion rates for lecture and lab courses among graduating cohorts were high, field courses posed more difficulties, with completion rates dropping significantly from over three-quarters for the class of 2020 to half for the class of 2022. Substitutions and waivers became increasingly common for field courses and their components, with waivers more common for field courses. Notably, less than a tenth of the students graduating in 2021 were unable to complete the required field components of courses.

## Links to relevant survey data charts

Students delaying graduation in order to complete degree requirements

<https://covid19.americangeosciences.org/data/charts/department-degree-progress-impacts-delaygraduation/>

Types of courses students took during Summer 2021 term

<https://covid19.americangeosciences.org/data/charts/department-enrollment-summer2021-coursetypes/>

Students taking coursework during Summer 2021 term

<https://covid19.americangeosciences.org/data/charts/department-enrollment-summer2021-pctstudents/>

Did your department expand options to allow students to catch up on their degree programs?

<https://covid19.americangeosciences.org/data/charts/department-missing-rqmts-alter-program/>

Were pandemic-era geoscience graduates allowed to take classes after graduation?

<https://covid19.americangeosciences.org/data/charts/department-missing-rqmts-makeup-courses/>

Enrollment intention for next term

<https://covid19.americangeosciences.org/data/charts/individual-enrollment-intention/>

How students navigated degree program course requirements during the pandemic

<https://covid19.americangeosciences.org/data/charts/individual-grnr-rqmt-courses/>

## **ADAPTATIONS TO RESEARCH ACTIVITIES**

Throughout the pandemic, academic departments consistently reported high research engagement among faculty and students. More than 90% of departments with graduate programs and over 80% of departments without such programs reported faculty involvement in research. More than three-quarters of departments with graduate programs also reported faculty participation in a range of research activities including online research, computational research, literature reviews, writing, lab-based and field activities. In contrast, departments without graduate programs reported slightly less engagement in these activities, though over three-quarters still reported faculty involvement in literature review, writing, lab-based research, and online research, and over half indicated faculty engagement in field work and computational research.

Staff involvement in departments with graduate programs increased from less than a fifth to almost two-thirds, while in departments without graduate programs reported relatively low staff engagement in research, which was at or below 10% from June 2020 through June 2021 which then increased to between 20% and 30% for the rest of the period.

### **Undergraduate student research**

Regarding undergraduate student involvement in research, departments with graduate programs reported a substantial increase between June 2020 and August 2020, from just over a third to nearly 90%, which then generally remained at or above this level until March 2022. In comparison, over half of these departments without graduate programs reported undergraduates involved in research in June 2020, with this percentage increasing to over 90% by September 2020, after which fluctuated between 60% and 90% until March 2022. More than half of all departments reported substantial undergraduate student engagement in various modes of research, such as online research, computational research, literature reviews, writing, lab and field activities. Among these, lab activities were the most curtailed in June 2020, and field activities saw the lowest engagement throughout 2020 and the first quarter of 2021.

### **Graduate student research**

Similar to undergraduate students, as of June 2020, field and lab research activities were the most curtailed, with less than half of departments reporting graduate students doing field work and two-thirds reporting lab research. However, by August 2020, over 80% of departments reported graduate students engaged in online research, computational research, literature reviews, writing, and lab and field work.

“The transition from “should I be worried about this” to “you cannot go to the lab” happened very rapidly. In my case it was a benefit to have been in such an early stage of my degree because I talked with my advisor, and we decided to rapidly pivot to doing numerical simulation work in a similar space with the hope that we would then pair that with experimental work. Before things reopened, what happened is for a year and a half of the pandemic where I did not really have access to the lab and whatnot, I worked from home. I was doing the simulation work and I am very thankful that my advisor did numerical simulation. He was able to help me with that. I did not intentionally choose him because I wanted to do numerical simulation, but with his help that meant I could be very flexible. He had access to the tools and let me go to work very quickly. As the pandemic started to progress or regress, our department outlined plans for people to get into labs and work. A lot of that had to be very solo. I had to wait because I was doing some of the experimental work that required the use of other facilities. There was this coordination issue where I would need to make sure I could be in one facility to do the things I needed to do and then be able to go to the other one. Coordinating between the different facilities was a little bit difficult to navigate. There was an added burden of any time I wanted to do lab work I could only go to the lab, and I had to commute. I could not go in, stay in my office, do whatever, eat lunch. I could not do any of that. I had to go in, do my lab work, come back, and that made the barrier to doing the lab work a lot higher, and so it was not until things were back in the office, and we were back full time where I would say got my footing better settled for doing the experimental lab work.” — graduate student

## Links to relevant survey data charts

Active research by cohort

<https://covid19.americangeosciences.org/data/charts/department-research-cohort-4yrwgrad/>

Active research by cohort

<https://covid19.americangeosciences.org/data/charts/department-research-cohort-4yrwograd/>

Research modes used by faculty

<https://covid19.americangeosciences.org/data/charts/department-research-modes-faculty-4yrwgrad/>

Research modes used by faculty

<https://covid19.americangeosciences.org/data/charts/department-research-modes-faculty-4yrwograd/>

Research modes used by graduate students

<https://covid19.americangeosciences.org/data/charts/department-research-modes-graduate-students-4yrwgrad/>

Research modes used by undergraduate students

<https://covid19.americangeosciences.org/data/charts/department-research-modes-undergraduate-students-4yrwgrad/>



Research modes used by undergraduate students

<https://covid19.americangeosciences.org/data/charts/department-research-modes-undergraduate-students-4yrwograd/>

## **USING TECHNOLOGY AS A BRIDGE**

The rapid transition to online work and learning environments during the pandemic led to various study cohorts making extensive use of different communication technology platforms to sustain their work, research, and learning activities. Throughout the pandemic, over two-thirds of all cohorts employed multiple communication and technology platforms for their activities. Zoom emerged as the most commonly used platform, with its usage reported by over three-quarters of the cohorts. Other frequently used platforms included Teams — particularly among non-academic geoscientists — and Canvas and Blackboard, which were predominantly used by academic cohorts. These findings underline the importance of these platforms as tools for communication and collaboration. Despite some variations among cohorts, Zoom and Teams maintained their popularity consistently across different groups.

### **Student research presentations**

The pandemic led to various innovative uses of technology for communication, one of which was its use for senior capstone, thesis, or dissertation final presentations. In March 2021, over 90% of departments reported the use of live online presentations. However, by February 2022, this figure had dropped to just over a third. By this time, in-person presentations had become the primary mode of delivery, with over three-quarters of departments indicating this mode. Over the period, hybrid presentation formats — which combined in-person and online elements — experienced substantial growth. Their usage increased from just over a quarter of departments in March 2021 to two-thirds by February 2022. Pre-recorded presentations accompanied by live discussions were reported by just over a tenth of departments in March 2021, but by February 2022, this format had been phased out.

### **Student recruitment activities**

Throughout the pandemic, communication emerged as a crucial factor, particularly for student recruitment efforts. Nearly three-quarters of departments reported increasing their communication with potential students during this period to assist in recruitment, underlining the value of personal interaction. Over half of these departments hosted virtual recruiting events, and a third ramped up their use of social media. Despite the circumstances, traditional methods like on-campus visits and in-person recruiting at conferences remained popular, being utilized by over half of the departments, particularly as pandemic restrictions began to ease. A small proportion of departments introduced virtual introductory courses as a means of attracting students to their majors. Furthermore, just over a third of departments implemented other recruitment strategies, such as limiting the number of seats in traditional introductory courses, introducing writing and critical thinking courses, enhancing diversity, equity, and inclusion-related outreach activities, and offering more hands-on lab and field opportunities for students.

### **Student advising**

Technology platforms played a crucial role in facilitating student advising throughout the pandemic. In June 2020, over three-quarters of faculty and students reported using online platforms for student advising meetings. This remained the primary meeting format until January 2022, and was still the second most common format by March 2022. The prevalence of phone-based meetings was relatively low throughout this period, as was the percentage of respondents who reported not advising or not having an advisor. Starting in April 2021, the percentage of faculty and students reporting in-person student advising meetings began to steadily increase, with many noting that these meetings were being held with

pandemic-related restrictions. By February 2022, in-person meetings, both with and without restrictions, had become the most frequent format for student advising meetings. One-third of respondents reported no restrictions during these meetings, while just under half noted that meetings were being held with pandemic-related restrictions.

“So as part of the freshman class that I taught, there's a requirement that every first-year student meet with their faculty for a little bit of time, and I did those meetings virtually during the pandemic. Now I've shifted my office hours to being flexible and they can either be virtual or in person, and when I do other things that require me to meet students, I always offer up the virtual option and I think more often than not they take me up on that. So I think that has increased the ability to meet with students one-on-one. Students are more willing to log on for five minutes and meet with me and ask me a question quickly as opposed to walking down to my office and going out of the building and that kind of stuff, even though we're very small campus. I do think that there is a little bit of a barrier that has been removed in that it's much easier to just click a few buttons and meet with someone because I've even taken meetings with students while they're in the library. So I'm assuming that they are working on it and they get stuck and they know it's my office hours and they'll just quickly virtually meet with me and ask a question. So I think that that's something I never would have considered doing pre-pandemic, but once it became a thing, it was a pretty easy change to make.” —academic faculty

## Remote work and learning spaces

The transition to online working and learning environments necessitated a reconfiguration of work and learning spaces. Many people had to create dedicated spaces within their homes to meet their work, research, and learning needs. From November 2020 to March 2022, there was a general increase across all participants in the use of dedicated workspaces for remote work and learning, while the use of shared workspaces declined. Additionally, over half of the respondents reported acquiring additional hardware during this period. The acquisition of extra software applications and supplies was more common towards the end of 2020 and the beginning of 2021 than in early 2022. Additionally, just under a third of respondents noted upgrading their internet connectivity during this time.

Different study cohorts adapted their remote work and learning environments in various ways. Among academic faculty, the use of dedicated workspaces declined from over 80% to just under three-quarters between November 2020 and March 2022. Shared workspace usage was low among faculty, with less than a third reporting its use. Around 60% of faculty reported using additional hardware for most of the period, but this declined to just over half by March 2022. The use of extra software applications and supplies, as well as internet connectivity upgrades, decreased over time.

For geoscience students, the use of dedicated workspaces increased substantially as the use of shared workspaces declined. The acquisition of additional hardware, supplies, and internet upgrades increased over the period. The use of additional software applications was more commonly reported by students towards the end of 2020 and Spring 2021 than in the rest of the period. Post-doctoral fellows most commonly adapted by using dedicated workspaces, followed by acquiring additional hardware. The use of shared workspaces and other adaptations varied throughout the period.

For non-academic geoscientists, the use of dedicated workspaces remained consistently high, while shared workspace usage declined. About half of the respondents reported acquiring additional hardware throughout the period, but the use of additional software applications and supplies slightly declined. Internet upgrades remained steady, with about 30% reporting this adaptation throughout the period.

## Links to relevant survey data charts

Communication technology platforms used by survey participants in 2020

<https://covid19.americangeosciences.org/data/charts/commtech-platforms-2020/>

Presentation mode of senior capstone, thesis, or dissertation

<https://covid19.americangeosciences.org/data/charts/department-presentation-modes/>

Student recruitment strategies used during the COVID-19 pandemic

<https://covid19.americangeosciences.org/data/charts/department-student-recruitment-strategies/>

Format of student advising meetings

<https://covid19.americangeosciences.org/data/charts/individual-advising-mode/>

Remote work and learning adaptations during the pandemic

<https://covid19.americangeosciences.org/data/charts/individual-wah-setup-all/>

Remote work adaptations during the pandemic

<https://covid19.americangeosciences.org/data/charts/individual-wah-setup-if/>

Remote work adaptations during the pandemic

<https://covid19.americangeosciences.org/data/charts/individual-wah-setup-ip/>

Remote learning adaptations during the pandemic

<https://covid19.americangeosciences.org/data/charts/individual-wah-setup-is/>

Remote work adaptations during the pandemic

<https://covid19.americangeosciences.org/data/charts/individual-wah-setup-iw/>

## STRATEGIES FOR OPERATIONAL CONTINUITY

From 2020 to 2022, geoscience employers modified their strategies in response to the pandemic to ensure operational continuity. Remote work flexibility was a primary strategy throughout this period, utilized by 41% of employers in 2020 and decreasing to 31% by 2022. Shortly after the pandemic's onset, the U.S. Department of Homeland Security's Cybersecurity and Infrastructure Security Agency (CISA) published guidelines for industries considered essential for maintaining the nation's critical functions, many of which included primary industries within which geoscientists work. These guidelines enabled workers within essential industries to continue operating during community restrictions that kept non-essential businesses closed or at reduced capacity. In 2020, 43% of employers reported that they were classified in an essential industry.

Other adaptations implemented by employers throughout the pandemic included changes in health protocols, which were reported by a quarter to a third of employers during this period. Increased communication was reported by a tenth of employers during 2020 when responses to the evolving pandemic situation were particularly fluid. Furthermore, just over a tenth of employers reported altering their financial strategy in 2020, and this number declined over the following years. Employers also adopted a range of other strategies, such as changes in workflows, providing more flexibility for employees,

supporting employees' mental health, assisting employees with children at home, renegotiating leases to reduce the physical footprint due to decreased office space usage, and increasing the use of virtual meetings as a substitute for in-person gatherings.

“We did a lot with additional leave options, additional pay options, additional support, trying to be as flexible as we could encouraging supervisors to be as flexible as they could be. So you know, childcare was a huge issue, and instead of having them drop out of the workforce, we gave them 20 hours of free time a pay period right for close to a year. We phased it. I can't remember exactly when it dialed back and so for people especially women who would have dropped out of the workforce. Instead, we just gave them a little bit of breathing room. So we said here's 10 hours a week. It's a significant amount, right? That's 25% of your time and it was not just for women, I'm just saying you know there's the statistics that women drop out of the workforce for childcare more often than men, right? And plenty of parents took it and elder care — actually it was eligible for both. So those sorts of flexibilities, I think, allowed us to retain a lot of employees and allowing people to do what we did this the split parenting shift, right? So work six hours and then take a break and then work two hours after the kids go to bed right? We encouraged that if it worked for you and your family and your supervisor was okay with it and you were still being productive and working all of your hours, absolutely, and I think those things made a difference.” —geoscience employer

## Staffing strategies

Human capital is essential to ensure operational continuity, and during the pandemic, employers' expectations for ongoing staffing for both permanent and contract staff remained strong. In terms of permanent staffing, over half of employers expected no changes in staffing levels throughout the period, while between a quarter and a third anticipated increased staffing. During the third quarter of 2020, a quarter of employers expected a decrease in permanent staffing levels. However, by the end of 2022, employers reported expectations of either no change or increased staffing, with no mention of decreases. Trends in temporary staffing expectations varied. Employers expecting a decrease reached a peak in the second quarter of 2020, with a quarter of employers anticipating a drop. This expectation declined to no mention of decreases by the end of 2022. Throughout the period, about a fifth of employers reported expecting increases in temporary or contract staff, while the majority anticipated no changes in staffing.

## Work and research strategies

In response to the pandemic, individuals pivoted their work and research activities to ensure as much progress as possible despite the challenges. From June 2020 to March 2022, various groups within the geoscience community utilized a range of methods to continue their work and research. For academic faculty, literature review and writing were the most prevalent activities, reported by over three-quarters of faculty. Online research also saw a substantial increase from just over half to nearly three-quarters of faculty. About 40% of faculty noted computational research through 2020, which increased in 2021 to just over half. Lab-based activities and fieldwork were reported by less than a third of faculty during 2020 but steadily increased through Spring 2021, with about half reporting lab research activities and a third reporting field activities.

“When the pandemic hit, field travel, international and local, and all the lab stuff shut down for me. It was not until November that we were allowed to start going back in, very minimally with one person a day in the whole facility. We had to schedule that between all the researchers who are trying to use the facility and everybody who obviously lost six months’ worth of lab time. Things slowed down for me a lot because I had started my project about a year and a couple of months prior to the shutdown. I had enough time to go out into the field, collective bunch of stuff, and start working on it, but not actually get any data yet. It really brought a bunch of my field and data projects to a screeching halt. That is when I had to think about what else to do. There was obviously other stuff for those projects that was background. Oh, let me gather more data and read some more papers. Let me make some maps in GIS, things like that. But it was all kind of cursory. It was not like that helped me move the project along. It was more like I just was waiting. So instead, I tried to push everything into the modeling side of projects that I do and so I changed everything up and focused hard on a lot of the modeling stuff.” —recent graduate

Post-doctoral fellows most frequently cited literature review, writing, and computational research as their main modes of work and research from 2020 through 2022. The use of online research peaked in Summer 2020 with three-quarters of post-doctoral fellows utilizing this method, but this declined to about a third by September 2020, only to gradually increase through 2021 to about three-quarters. Field work was sporadically reported by a small percentage of post-doctoral fellows throughout the period, while lab-based activities increased from just under one-fifth of post-doctoral fellows in June 2020 to just under two-thirds by May 2021 as restrictions eased, and then declined to one-fifth of post-doctoral fellows reporting this mode of research in March 2022.

Most non-academic geoscientists engaged in literature review, writing, and online research throughout the pandemic. Computational research activities remained consistent, involving nearly one-third of non-academic geoscientists from June 2020 through March 2021, after which the percentage noting this mode increased steadily to over half by August 2021. Lab-based activities and field work also saw slight increases over the period, reported by one-fifth and just over 40% of respondents by March 2022.

For K–12 faculty, online research was the primary modality reported, followed by literature review, writing, and lab-based activities. Computational research had low engagement through 2020 but increased to over half of faculty reporting its usage by Fall 2021. Field activities were reported by one-tenth to one-fifth of faculty over most of the period.

## Links to relevant survey data charts

Expectation for ongoing permanent staffing levels

<https://covid19.americangeosciences.org/data/charts/employer-staffing-permanent/>

Expectation for ongoing temporary / contract staffing levels

<https://covid19.americangeosciences.org/data/charts/employer-staffing-temporary/>

Strategies for addressing pandemic impacts

<https://covid19.americangeosciences.org/data/charts/employer-strategies/>

Mode of work and research activities

<https://covid19.americangeosciences.org/data/charts/individual-research-work-modes-if/>

Mode of work and research activities

<https://covid19.americangeosciences.org/data/charts/individual-research-work-modes-ik/>

Mode of work and research activities

<https://covid19.americangeosciences.org/data/charts/individual-research-work-modes-ip/>

Mode of work and research activities

<https://covid19.americangeosciences.org/data/charts/individual-research-work-modes-iw/>

## **FLEXIBLE APPROACHES**

The pandemic ushered in a new era of flexible work arrangements, with remote work becoming the norm. As a result, the geographic distribution of employees relative to their employer's offices evolved over time. In 2022, a clear trend emerged among geoscience employers: more and more employees consolidated in their home states. The percentage of employers reporting that over half of their employees resided in the same state as their company increased from over three-quarters to a full 100% between the second and fourth quarters of 2022. Throughout 2022, only one-third of employers reported that less than half of their workforce was located in neighboring states. Furthermore, the percentage of employers indicating that up to half of their employees resided in further afar declined from slightly over half to just over a third. Less than a fifth of employers reported having employees based in locations outside the US.

The quick shift to remote work at the start of the pandemic opened many opportunities around the possibility of being able to work from anywhere. This flexibility in location allowed employees to rethink their finances and living situations. One of many potential upsides was the ability to move from an area with a higher cost of living one with a lower cost of living, including across the U.S. or overseas. However, the repercussions, especially for smaller employers, of having employees in multiple states and/or international locations included added financial burdens with respect to state and international tax laws and other human resource regulations. Whether or not these repercussions factored into the reinstatement of in-office work policies or resulted in employers hiring only within a commutable distance to the office (i.e., within state or in neighboring states), is unknown, but may factor into this pattern of geographic consolidation of employees over time. Another factor at play may include the lack of in-person work interactions with permanent remote work and the desire of employees to be in the office at least part of the time for social interactions and focused in-person collaborative activities.

## **Work locations of employees**

The nature of workplaces evolved significantly during the pandemic, transitioning from predominantly remote settings to a blend of remote and in-office work. In the third quarter of 2020, three-quarters of employers reported that over half of their employees were working remotely, while a third of employers indicated that over half of their workforce was working part-time in the office. However, by the end of 2022, this landscape had shifted: 30% of employers reported that more than half of their employees were working full-time in the office, 10% reported over half of their workforce was part-time in the office, and 60% indicated over half of their workforce remained remote. The situation of employees working in laboratories, field sites, and at client locations or remote offices also changed over the course of the pandemic. The percentage of employers reporting that over half of their employees worked in labs rose from less than 10% in the third quarter of 2020 to a quarter of employers by the second quarter of 2022, before dropping back to less than 10% by the end of 2022. Between a third and a quarter of employers reported that most of their employees worked at field sites throughout the period. The percentage of employers stating that most of their employees worked at client sites or remote offices remained relatively low throughout the entire period.



## Workplace policies

Throughout the pandemic, employers fluctuated in their office policies in response to the unfolding situation. More than half were reevaluating their policies in August 2021. This trend dipped in the fall, only to rebound in December 2021 and January 2022, coinciding with a surge in COVID-19 cases attributed to the spread of the Omicron variant. From September 2021 to January 2022, over 60% of private sector employers and governmental agencies reported implementing remote-first work policies.

By January 2022, just over 60% of higher education institutions also adopted this approach. Although remote-first work policies remained popular in the private sector throughout 2022, they fell steadily among governmental agencies to 50% by September, before bouncing back to 60% by December. Higher education institutions showed significant variability in their remote-first work policies, peaking at 70% adoption in July 2022 but dropping to just over 40% by the year's end.

From February 2020 to December 2022, remote work policies were offered by over 80% of employers, while in-office work was offered by 60% to 80% of employers throughout the period. In June 2020, half of employers offered field work policies, and this increased to 80% by the end of 2022. Lab work policies increased from 40% of employers in 2020 and 2021 to nearly half of employers during 2022. Shared workspace policies, which were offered by less than one-tenth of employers through 2020 and 2021, increased to between 10% and 30% through the end of 2022. Over the same period, employers shifted towards more flexible work arrangements, with an increase in employers offering both permanent and limited remote and in-office work policies. In addition, by December 2022, 60% of employers offered either only permanent remote work, or both permanent and limited remote work options.

“Coming out of the pandemic we developed a hybrid and remote working policy. While we expect that employees will be in the office as much as possible, we do have a few exceptions for some remote workers. You know, they're not tethered to an office, be that they moved elsewhere or, you know, because they're great employees and we don't want to lose them, or we do have a hybrid program where we expect 60% of the hours to be in the office for that connection because we are collaborative discipline. So, coming out of the pandemic, we saw this as a firm policy.” —  
geoscience employer



“The pandemic made us realize that we can do large pieces of our jobs remotely. So there have been some longer-term changes that I think are going to be net positives for us because the pandemic forced us to rethink the way we go about our business. Our policy is as long as the work is getting done and as long as employees are getting their hours of time completed, we really don't worry too much about the actual timing. We've gone to this flex scheduling model, and the only thing we ask is that employees propose the schedule to us in advance and that for the first month they follow that schedule. And if we find that it's not working, then we modify it after we take some time to see how that schedule works. And if we find that it's working, then let's just keep doing it because it works. The employee is happier. The work is getting done. I found that productivity went up during the pandemic and part of that was because people weren't stuck in traffic for an hour. They were happier. When they got frustrated, they could pet the dog or go stand outside in the backyard, you know, at their house and sit in the recliner for 15 minutes and take their break there and productivity for us went up.” —geoscience employer

The workplace policies offered by academic departments, influenced by the unique demands of academic research and teaching activities, differed from those of geoscience employers during the pandemic. From April 2021 to December 2022, most academic departments provided options for employees to work in-office, remotely, in labs, or at field sites. Except for a drop to 45% in September 2021, between 70% and 80% of departments consistently offered remote work policies throughout the pandemic. Lab and field work policies were also prevalent among departments, while shared workspace policies were less commonly offered.

With the resumption of in-person classes, the proportion of departments offering both permanent and limited remote work policies declined sharply. By September 2021, only a tenth of departments maintained such options. By December 2022, departments were only offering limited remote work policies. Over the same period, an uptick was observed in the number of departments offering a mix of permanent and limited in-office work, with over half offering this approach by December 2022, while the remainder offered only permanent in-office work.

## Re-evaluation of physical office and teaching spaces

In response to the pandemic, academic departments and employers not only adapted their workplace policies but also evaluated the active usage of their office, research, and teaching spaces. In May 2021, the majority of geoscience academic departments reported lower utilization of all spaces, including offices, research, and teaching areas, compared to pre-pandemic levels. By November 2021, however, the majority of these departments reported a return to pre-pandemic usage levels across all types of spaces. Similarly, geoscience employers observed a gradual recovery in office space usage from November 2020 to November 2022. By November 2022, just over half of the employers reported usage levels comparable to those before the pandemic.

## Links to relevant survey data charts

Employee distribution by location

<https://covid19.americangeosciences.org/data/charts/employer-number-distribution-region/>

Employee distribution by work environment

<https://covid19.americangeosciences.org/data/charts/employer-number-distribution-workenvironment-labfieldclrm/>

Employee distribution by work environment

<https://covid19.americangeosciences.org/data/charts/employer-number-distribution-workenvironment-office-wah/>

Active usage of office, research, and teaching spaces relative to before the pandemic

<https://covid19.americangeosciences.org/data/charts/office-space-usage-dept/>

Active usage of office space relative to before the pandemic

<https://covid19.americangeosciences.org/data/charts/office-space-usage-emp/>

Employers offering remote-first work policies

<https://covid19.americangeosciences.org/data/charts/remote-first-policy/>

In-office work policies available to employees

<https://covid19.americangeosciences.org/data/charts/workplace-policies-office-dept/>

In-office work policies available to employees

<https://covid19.americangeosciences.org/data/charts/workplace-policies-office-emp/>

Remote work policies available to employees

<https://covid19.americangeosciences.org/data/charts/workplace-policies-remote-dept/>

Remote work policies available to employees

<https://covid19.americangeosciences.org/data/charts/workplace-policies-remote-emp/>

Workplace policies available to employees

<https://covid19.americangeosciences.org/data/charts/workplace-policies-work-policies-dept/>

Workplace policies available to employees

<https://covid19.americangeosciences.org/data/charts/workplace-policies-work-policies-emp/>

Re-evaluation of office policies due to the current pandemic situation

<https://covid19.americangeosciences.org/data/charts/work-policies-reevaluated/>

## **PROVIDING SUPPORT**

During the pandemic, supportive measures were crucial in maintaining business operations, academic programs, and work and learning at all levels. Financial aid benefited just over a third of employers in 2020, decreasing to just under a fifth by early 2022. Dependence on governmental assistance generally decreased from 29% of employers reporting assistance in the third quarter of 2020 to less than 10% at the start of 2022, with a temporary increase in the second quarter of 2021. Non-governmental financial aid peaked in the third quarter of 2021, with one-fifth of employers acknowledging receipt of this assistance before dropping to less than 10% at the beginning of 2022.

“We basically tried to hold on to everybody and keep paying salaries. We got PPP monies both years. That it was available because we thought there was our production responsibility to the company and our employees to take what was offered. So you know we took advantage of a program that was intended to keep our business viable and healthy and it did. It for sure helped. There's no question about it. I'm not saying we would have gone out of business, but it wasn't clear whether we were gonna go out of business or not. So, the PPP money made it for sure that we were not going to go out of business. And once you have that, it kind of gave you more options because you knew kind of what you were dealing with so. And at the end of the day, if we, you know we had extra PPP money and you know we distributed that that some of that to an employees for sure because you know our thought was that this was also intended as stimulus right so you know we get bonuses to our employees and we also took an opportunity to sort of, you know, tool up our business under the thought that that was in the best interest of the economy as well and our company.” —geoscience employer

## Promotion and tenure guideline changes

In response to the pandemic, over two-thirds of academic departments made changes to their promotion and tenure policies. The most frequently implemented change was extending the promotion clock, which was adopted by just over half of the institutions. Other modifications included the option to exclude Spring 2020 evaluations and to incorporate pandemic impact statements in the tenure review package. Although these changes were accessible to faculty, over three-quarters of faculty study participants did not utilize them. Among the 13% of faculty who did, the most frequently noted options that were utilized included submitting a pandemic teaching impact statement, extending the promotion clock, and excluding Spring 2020 evaluations.

## Hiring and onboarding changes

In response to the widespread adoption of remote work during the pandemic, employers adapted their hiring and onboarding protocols to better accommodate new hires. More than a third of employers modified their training methods for new hires, while just under a third revised their onboarding processes. Changes to hiring and onboarding were primarily focused on converting in-person activities, such as training, onboarding workflows, and interviewing to virtual formats.

## Support for remote workers

Beyond alterations to promotion and tenure policies, over 90% of academic departments provided support for remote employees in 2020 and 2021 primarily through logistical and IT support and training. By 2022, however, only three-quarters of departments reported providing some form of support for remote working employees. Financial support for remote employees fell sharply from a third of departments to less than 5% over the same period. The provision of logistical support and training and IT support also decreased from over 80% of departments offering this type of assistance for remote workers in 2020 to just over half of the departments in 2022. Furthermore, a little over a tenth of departments required remote employees to use their own equipment in 2022.

Support for remote working employees was also provided by employers, although the percentage of employers providing this support declined slightly to three-quarters of employers over the given period. Financial support for remote work activities was reported by less than one-fifth of employers throughout

the pandemic. Mirroring practices in academic departments, slightly more than a tenth of employers in 2022 required remote workers to use their own equipment. However, in contrast to academic departments, employers increased their training and IT support, moving from just over a quarter to nearly half of all employers providing this support, despite a slight decrease in logistical support to just under two-thirds.

“Everybody could take their laptop and monitor home and their mouse and keyboard. We draw the line like we are not going to buy you a desk, and we cannot pay for your Wi-Fi to be upgraded. That is part of your part of the bargain in the remote work agreement. It is optional and it is the same as our teleworker agreement. By signing the telework agreement request as an employee like you are saying I have a good place to work at home that does not have children in it, it is not distracting and like I can focus. That is part of that contract on the other side. As the employer is required to provide a workspace for you where you can do work, if you as the employee want to ask for the privilege of working at home, you must provide some of that. We buy printers and get that kind of stuff too if there is a reason for the employee to be printing stuff.” —geoscience employer

Declines in support for remote working activities were also noted by survey participants between 2020 and 2022, from over three-quarters to just over two-thirds. Just over a tenth of participants reported that employees were required to use their own devices in 2022, while throughout the pandemic, financial support for remote work activities was reported by about one-tenth of participants. Additionally, both logistical and training and IT support diminished to under half over the same timeframe.

For various study cohorts, there was a consistent reduction in support from 2020 to 2022. Among academic faculty, support was noted by over three-quarters of faculty in 2020, and this declined to just over half by 2022. Financial support was available for a tenth of faculty in 2020 but fell to less than 5% by 2022. Both logistical and training and IT support experienced considerable declines, with less than half of the faculty receiving this assistance in 2022. Post-doctoral fellows also reported diminished support for remote work, with only a third reporting support by 2022, down from half in 2020. While financial aid remained minimal for remote work activities and logistical support decreased substantially, training and IT support increased over the period, with a fifth of fellows noting this support in 2022.

Non-academic geoscientists experienced a slight decrease in support throughout the pandemic, but by 2022, over three-quarters reported support for remote work activities. Financial support was reported by about a tenth of this group throughout the period. Logistical support was acknowledged by three-quarters of non-academic geoscientists in 2020, declining to two-thirds by 2022. However, there was an increase in the percentage reporting training and IT support over the period, from 36% to 44%. K–12 faculty witnessed a drastic drop in support, from over three-quarters to just over a third during the pandemic. There were also substantial reductions in logistical and training and IT support, with less than a quarter of faculty noting this support in 2022.

## Links to relevant survey data charts

Financial assistance received by quarter

<https://covid19.americangeosciences.org/data/charts/employer-financial-assistance-yn/>

Types of financial assistance received

<https://covid19.americangeosciences.org/data/charts/employer-financial-assistance-types/>

Changes to onboarding and new hire training during the pandemic

<https://covid19.americangeosciences.org/data/charts/employer-onboarding-hiring-changes/>

Changes to promotion and tenure guidelines to address pandemic impacts on faculty

<https://covid19.americangeosciences.org/data/charts/promotion-tenure-changes/>

Faculty promotion and tenure change opt-in

<https://covid19.americangeosciences.org/data/charts/promotion-tenure-opt-in/>

Support for remote working employees

<https://covid19.americangeosciences.org/data/charts/wah-assistance-dept/>

Support for remote working employees

<https://covid19.americangeosciences.org/data/charts/wah-assistance-emp/>

Support for remote working employees

<https://covid19.americangeosciences.org/data/charts/wah-assistance-indiv/>

Support for remote working employees

<https://covid19.americangeosciences.org/data/charts/wah-assistance-if/>

Support for remote working employees

<https://covid19.americangeosciences.org/data/charts/wah-assistance-ik/>

Support for remote working employees

<https://covid19.americangeosciences.org/data/charts/wah-assistance-ip/>

Support for remote working employees

<https://covid19.americangeosciences.org/data/charts/wah-assistance-iw/>

# Opportunities: What new opportunities arose as a result of the pandemic?

The pandemic spurred advancements in online courses, degree programs, virtual instruction, and adaptations in teaching methodologies across higher education and K–12 settings. There was a clear shift towards flexible working and learning arrangements, with changes in remote and in-office work requirements, highlighting the challenges and benefits of these arrangements. Recent graduates faced skill and knowledge gaps and had to adapt to new work and learning modes, engaging in professional development opportunities and learning new technical skills. There were significant fluctuations in hiring trends, with changes in desired skillsets, recovery, and rebound in hiring rates, modifications in requirements for potential employees, and contrasting trends between academic and geoscience employers.

## NEW OPPORTUNITIES

The pandemic has prompted the emergence of various new work and research opportunities across different cohorts. Specifically, over a third of academic departments and geoscience employers, as well as over half of the individuals surveyed, reported such opportunities. These included collaborations with other U.S. organizations, international entities, and initiatives within their own organizations. Around a third of all study cohorts reported new work or research projects. Additionally, half of the academic departments reported a shift in their work or research focus due to the pandemic, a change echoed by just under a fifth of geoscience employers and individual survey participants.

“I started really taking advantage of the virtual networking opportunities. With the transition to hybrid or fully virtual meetings that's allowed me to really stretch my travel budget to attend some meetings and connect with some colleagues virtually that I might not have the opportunity to otherwise...and that's been the other asset is certainly the switch to virtual and hybrid has really allowed not only for domestic here in the United States but also for broader connections internationally as well as with colleagues that I probably wouldn't see but you know once every four or five years if I was lucky prior to the pandemic.” —recent graduate

“We have expanded our remote partnership network, including potential for remote instruction by teaching lecturers (instructors) in disciplinary areas not locally available.” —academic department

## Links to relevant survey data charts

New opportunities for work or research due to the pandemic

<https://covid19.americangeosciences.org/data/charts/opportunities-newoppsanyyes/>

Types of new work and research opportunities due to the pandemic

<https://covid19.americangeosciences.org/data/charts/opportunities-newoppstypes/>

Change in the focus of work or research due to the pandemic

<https://covid19.americangeosciences.org/data/charts/opportunities-workfocuschange/>

## **TECHNOLOGICAL INTEGRATION INTO INSTRUCTIONAL ENVIRONMENTS**

The pandemic spurred significant advancements in incorporating new technologies into educational settings. These included fully online courses and degree programs, as well as the use of virtual modules and online activities within courses. These technologies were used in various ways by instructors to enhance their curriculum and boost student engagement, especially during the early stages of the pandemic when teaching was primarily conducted online.

Before the pandemic, two-thirds of departments offered no online options, while nearly a third provided fully online courses, and only 1% had online degree programs. However, plans for the Fall 2021 term showed a substantial shift: over half of the departments planned to offer fully online courses, and just over a tenth intended to provide fully online degree programs. The most substantial growth was observed in hybrid courses, with less than a tenth of departments offering this format pre-pandemic, but nearly two-thirds indicating they would be offering hybrid courses in Fall 2021. Interestingly, while just under a fifth of departments offered online course modules before the pandemic, none of the departments surveyed indicated plans to offer this format in Fall 2021.

From December 2020 to January 2022, academic faculty progressively utilized a range of components in virtual instruction across all course formats, including lecture courses, labs, and field activities. These components encompassed essays or papers, online tests, virtual talks, in-person field activities, at-home lab activities, video demonstrations, online discussions, and both recorded and real-time lectures. The application of datasets, maps, and third-party course modules grew overall, peaking in 2021.

“I have explored new possibilities with virtual field trips and have become more engaged in Zoom conferences, including one on diversity and equity in geoscience.”  
—academic faculty

“Many of our faculty are participating in dissemination of online teaching strategies, in particular with virtual field trips.” —academic department

“I have been exploring virtual field experiences including Virtual Reality, Augmented Reality, 360 imagery, LiDAR imagery and other resources to bring the field to students.” —academic faculty

### **Virtual instructional components**

The usage of virtual instructional components varied depending on the type of course being taught. In virtual lecture courses, essays or papers, online tests, and virtual talks were the most prevalent, followed by recorded and real-time lectures, online discussions, and video demonstrations. Fewer than half of the faculty used datasets and maps, except for a surge in September 2021. In-person field activities were



seldom used, while the utilization of at-home lab activities slightly decreased. On the other hand, the usage of third-party course modules saw a minor increase over the period. In the context of virtual lab sections and courses, the components most often used were essays or papers, at-home lab activities, video demonstrations, virtual talks, and maps. Datasets and online tests were widely used in 2021, but less than half of faculty reported using these components in 2022. For virtual field activities, faculty mainly used maps, in-person field activities, and essays or papers. Most other components were used by less than a third of the faculty over the period, with the exceptions being virtual talks in April 2021 and real-time lectures in September 2022.

It's important to note how in-person activities were integrated into virtual field courses and virtual field components to courses. While the primary mode of the field course or field component was virtual, specific activities within that course or component, such as homework or extra credit exercises, were in-person. During the early part of the pandemic, in-person field activities were usually conducted by students on their own with a faculty-provided instructional handout. Later in the pandemic, students would work together in the field on activities, sometimes in small groups with instructional handouts or accompanied by instructors.

K–12 faculty, much like academic faculty, utilized a diverse range of components in virtual instruction. The most commonly used included essays or papers, online tests, virtual talks, video demonstrations, online discussions, and both recorded and real-time lectures. At least half of the faculty used at-home lab activities in 2020 and Spring 2021, but usage decreased by Fall 2021. Components like datasets, maps, third-party course modules, and in-person field activities were less commonly used.

## Benefits of virtual instruction

While virtual instruction presented challenges, it also offered several benefits. From December 2020 to February 2022, an increasing percentage of academic faculty highlighted the flexibility that virtual instruction provided for students, with over half recognizing this benefit in February 2022. The percentage of faculty noticing improvements in teaching and learning through virtual instruction fluctuated between 20% and 30% over the period. Around one-fifth of faculty acknowledged the enhanced accessibility for students in 2021, but this proportion decreased to less than one-tenth by 2022. Only a small fraction of faculty recognized the advantages of student collaboration and grading assignments, while perceptions of increased student engagement fluctuated during the period, with between roughly one-tenth and one-fifth of faculty acknowledging the benefit. Less than one-fifth of faculty noted that virtual instruction provided new tools and resources.

“I have also a lot of alternatives now, so students are sick or something else comes up and they can't come to class. They can do an all online lab alternative. They can do an online field trip alternative. So, a lot of additional resources and supplements that are all online that weren't created before the pandemic.” —academic faculty

“Members of our department created a fully online field camp last summer. They worked with education faculty to assess the outcomes of this and are now presenting the results of that research and writing manuscripts. They are also continuing to assess student learning by taking the same cohort of students out for mapping projects (on a volunteer basis, with social distancing and masking). This work should open up a lot of interesting possibilities for accessible field instruction.” —academic department

## Preference for virtual instruction among faculty and students

Preferences for instructional formats between faculty and students varied throughout the pandemic. From September 2020 to February 2022, academic faculty consistently favored in-person instruction and showed the least preference for online instruction across all course types (i.e., introductory courses, undergraduate courses, and upper division courses). Although the preference for hybrid instruction varied over time, it was generally the second least favored format.

However, student preferences displayed a different trend. Students showed the least preference for online instruction for undergraduate and upper division courses, with a noticeable increase in this trend by February 2022. In contrast, for introductory courses, students demonstrated the least preference for both in-person and online instruction. Students most preferred in-person instruction for upper division courses and a mix of formats for introductory and undergraduate courses. By February 2022, one-third of students indicated a preference for hybrid and online formats over in-person instruction for introductory courses. For undergraduate courses, slightly more students preferred hybrid formats over in-person instruction.

## Interest in virtual teaching and learning

Throughout 2021 and 2022, varying trends emerged regarding the interest in conducting lectures, labs, and field activities in hybrid and virtual formats among academic faculty and students. However, both cohorts had a higher interest in hybrid and virtual lectures compared to hybrid or virtual field activities. For academic faculty, half expressed interest in hybrid lectures, but interest in virtual lectures decreased from nearly half of faculty in 2021 to just over a third by 2022. There was a slight uptick in faculty interest for hybrid labs and virtual labs, but this interest was expressed by less than a third of faculty. Interest in hybrid and virtual field activities remained stable, attracting approximately a quarter and slightly over a tenth of faculty, respectively.

For students, there was a general decrease in interest in all virtual and hybrid formats. Interest in hybrid lectures declined from over three-quarters to nearly two-thirds of students. Interest in virtual lectures saw a less dramatic drop, decreasing from over half to just under half of students. Interest in hybrid labs declined to just over a third, and interest in virtual labs decreased to less than a tenth of students. Interest in hybrid and virtual field activities dropped significantly to less than a fifth and less than a tenth of students respectively. Among K–12 faculty, less than a third expressed interest in hybrid or virtual formats for instruction. Similar to academic faculty and students, the highest interest was observed in virtual and hybrid lectures.

## Links to relevant survey data charts

Course format least preferred by academic faculty by format and level

<https://covid19.americangeosciences.org/data/charts/course-format-preference-least-preferred-if/>

Course format least preferred by students by format and level

<https://covid19.americangeosciences.org/data/charts/course-format-preference-least-preferred-is/>

Course format most preferred by academic faculty by format and level

<https://covid19.americangeosciences.org/data/charts/course-format-preference-most-preferred-if/>

Course format most preferred by students by format and level

<https://covid19.americangeosciences.org/data/charts/course-format-preference-most-preferred-is/>

Interest in teaching or learning via virtual modes

<https://covid19.americangeosciences.org/data/charts/interest-teach-learn-virtual-courses-ifis/>

Interest in teaching via virtual modes

<https://covid19.americangeosciences.org/data/charts/interest-teach-learn-virtual-courses-ik/>

Virtual instruction pre-pandemic and plans for Fall 2021

<https://covid19.americangeosciences.org/data/charts/online-courses-precovid-fall2021/>

Benefits to teaching courses, labs, and field activities in an online setting

<https://covid19.americangeosciences.org/data/charts/virtual-teaching-benefits/>

Components used in virtual teaching (labs, lectures, and field activities)

<https://covid19.americangeosciences.org/data/charts/virtual-teaching-components-if-any/>

Components used in virtual field courses or field components to courses

<https://covid19.americangeosciences.org/data/charts/virtual-teaching-components-if-field/>

Components used in virtual lab sections / courses

<https://covid19.americangeosciences.org/data/charts/virtual-teaching-components-if-lab/>

Components used in virtual lecture classes

<https://covid19.americangeosciences.org/data/charts/virtual-teaching-components-if-lecture/>

Components used in virtual teaching (labs, lectures, and field activities)

<https://covid19.americangeosciences.org/data/charts/virtual-teaching-components-ik-any/>

## **FLEXIBLE WORKING AND LEARNING ARRANGEMENTS**

The pandemic presented an opportunity for employers and employees to assess the advantages of remote and in-person work, as well as find a balance between the two for daily and weekly operations. In 2022, employers were surveyed about the number of days they required employees to be physically present in the office each week. In the second quarter of 2022, three-quarters of employers did not mandate any office presence, 8% required at least 5 days in the office, 12% needed 3 to 4 days, and 4% required 1 to 2 days. However, by the third quarter, the percentage of employers not requiring office presence decreased to two-thirds, and there was an increase to 12% in employers requiring at least 5 days. Equal percentages of employers (12%) required either 3 to 4 days or 1 to 2 days in the office. By the fourth quarter, the percentage of employers not requiring office presence rose to over three-quarters, with one-fifth of employers requiring employees to work from the office at least 3 days per week.

The perceived necessity of physical presence at the office varied among different groups over time. For all participants, there was a noticeable increase in those viewing office presence as moderately to extremely necessary, rising from just over a quarter of respondents at the end of 2020 to 42% by the end of 2022. Academic faculty's perceived need for being on-campus notably increased from nearly a quarter at the end of 2020 to two-thirds by the end of 2022. K–12 faculty showed a similar trend, with the percentage considering office presence as necessary doubling from one-third to two-thirds over the period. Interestingly, at the end of 2020, over a third of post-doctoral fellows deemed office presence necessary, but by the end of 2022, none felt it was necessary. This could be due to the smaller sample size of this group and the specific nature of their work. Lastly, for non-academic geoscientists, their perception of the necessity of office presence remained fairly stable near 30% throughout the period.

### **Benefits from remote work environments**

Throughout the pandemic, employers, departments, and individuals reported various challenges and benefits related to their work environments. Key advantages included increased flexibility in work location,

improved use of virtual platforms and virtual communication, and greater opportunities to attend conferences. Benefits more frequently reported by employers and individuals than departments were the flexibility in work hours, decreased work-related expenses, and increased productivity. Employers noted an improved work/life balance more than individuals or departments did. Other advantages mentioned less frequently encompassed improved employee retention, enhanced collaboration, reduced usage of active office space, increased job satisfaction, absence of scheduling conflicts, and better teaching practices.

“It's incredibly flexible, and some people are going to continue working from home. There's no reason for them to come in. And we've had some people in the office say, “Hey, if we're forced back to work, we will quit.” We want to retain them. I can't say it inhibited hiring either over this time period because we hired so many people that aren't in the office anyway. I mean, they're working from all over. And actually, I think that's kinda positive if they can do the computer work, and if they're not you know, required to do field work and stuff like that. There's a lot of things now that can be just done online. And you know, obviously you're trusting the person is working 8 hours a day and isn't taking advantage of the situation. But you know, I think you're willing to take that risk to hire good people. And a lot of the people that we hire, they don't necessarily want to move from where they are. So you know, that's been a positive. I think things have really worked out.” —geoscience employer

Between 2020 and 2022, both academic departments and geoscience employers noted substantial changes in the benefits of work environments during the pandemic. The most commonly reported benefits included improved communication through virtual platforms, increased opportunities for staff and faculty to attend conferences, and location flexibility for employees. Other benefits, though reported less frequently, encompassed improved work-life balance, reduced work-related expenses, and flexibility in employees' work hours, along with decreased active use of office spaces. However, departments recorded a decrease in benefits related to collaboration, productivity, focus, and teaching practices.

Geoscience employers highlighted substantial benefits regarding employees' work-life balance, enhanced communication through virtual platforms, flexibility in work hours and location, better use of virtual platforms, and reduced work-related expenses. Additionally, they noticed improvements in collaboration, opportunities for employees to attend more conferences, reduced active use of office spaces, and increased productivity and focus. The benefits reported in 2022 also included improved employee retention and a reduction in scheduling conflicts.

Between 2020 and 2022, study participants reported improvements in the benefits of their work environments during the pandemic. By 2022, the majority of participants noted benefits such as improved communication via virtual platforms, increased opportunities to attend conferences, reduced work-related expenses, and flexibility in work hours and location. Over a third of participants acknowledged improved productivity, focus, and work-life balance. Fewer participants reported benefits that included fewer scheduling conflicts, increased job satisfaction, and improved collaboration.

However, these benefits varied by the cohort of study participants. Most academic faculty highlighted benefits such as improved communication via virtual platforms, the ability to attend more conferences, and flexibility in work hours and location. Approximately 30% of faculty also reported improved teaching practices.

Post-doctoral fellows cited improvements in collaboration, communication through virtual platforms, flexibility in work location and hours, and better utilization of virtual platforms. In 2020, they also noticed an increase in productivity and focus.

Similarly, students acknowledged improvements in communication via virtual platforms, increased opportunities to attend conferences, reduced work-related expenses, and flexibility in work hours and location. They also reported increased productivity and focus in 2020.

Non-academic geoscientists noted enhancements in work-life balance, communication through virtual platforms, opportunities to attend more conferences, reduced work-related expenses, increased flexibility in work hours and location, and increased productivity and focus. They also mentioned improved collaboration and job satisfaction.

## Links to relevant survey data charts

Minimum number of days employees are required to work in the office per week

<https://covid19.americangeosciences.org/data/charts/physical-presence-office-emp/>

How necessary is it for you to be physically present at your employer's office to do your work duties?

<https://covid19.americangeosciences.org/data/charts/physical-presence-office-all/>

How necessary is it for you to be physically present at your employer's office to do your work duties?

<https://covid19.americangeosciences.org/data/charts/physical-presence-office-if/>

How necessary is it for you to be physically present at your employer's office to do your work duties?

<https://covid19.americangeosciences.org/data/charts/physical-presence-office-ik/>

How necessary is it for you to be physically present at your employer's office to do your work duties?

<https://covid19.americangeosciences.org/data/charts/physical-presence-office-ip/>

How necessary is it for you to be physically present at your employer's office to do your work duties?

<https://covid19.americangeosciences.org/data/charts/physical-presence-office-iw/>

Benefits from work environments during the pandemic (2020–2022)

<https://covid19.americangeosciences.org/data/charts/work-format-pros-allyears/>

Benefits to faculty and staff from work environments during the pandemic

<https://covid19.americangeosciences.org/data/charts/work-format-pros-dept/>

Benefits to employees from work environments during the pandemic

<https://covid19.americangeosciences.org/data/charts/work-format-pros-emp/>

Benefits from work environments during the pandemic

<https://covid19.americangeosciences.org/data/charts/work-format-pros-indiv/>

Benefits from work environments during the pandemic

<https://covid19.americangeosciences.org/data/charts/work-format-pros-if/>

Benefits from work environments during the pandemic

<https://covid19.americangeosciences.org/data/charts/work-format-pros-ip/>

Benefits from work environments during the pandemic

<https://covid19.americangeosciences.org/data/charts/work-format-pros-is/>

Benefits from work environments during the pandemic

<https://covid19.americangeosciences.org/data/charts/work-format-pros-iw/>

## **LEARNING NEW SKILLS**

During the pandemic, work and learning modes shifted, leading study cohorts to adapt their research and work modalities. As a result, some individuals learned new skills, driven by changes in project direction and design. Furthermore, some pandemic-era graduates found themselves with gaps in skills and knowledge due to disruptions in their academic programs. These gaps forced them to seek alternative methods to acquire the necessary skills and knowledge.

Recent geoscience graduates expressed a strong preference for technical skills they wished they had obtained before graduation. These included programming, data visualization, mapping software, machine learning, artificial intelligence, and data science, as well as field skills. Less than a third of these graduates noted that they wished they would have acquired database and lab skills, project management skills, and proficiency with virtual platforms prior to graduation. Remarkably, about one-tenth of the recent graduates felt they did not need any additional skills or knowledge.

To bridge these skills and knowledge gaps, recent graduates engaged in learning on their own or through employer-provided training. Most relied on self-taught instruction to gain the skills they wished they had acquired prior to graduation. Just over a third utilized professional training, and slightly more than a quarter turned to online training. Traditional methods, such as college courses, were used by one-fifth of recent graduates, while less than a tenth opted for topical bootcamps.

Employers played a key role in skills development, providing on-the-job training, mentorships, and apprenticeships for the majority of recent graduates. Other prevalent employer training methods included self-taught instruction, professional training, in-house workshops, and online training. Short courses were also employed, though college courses were rarely provided by employers. Of note, nearly one-fifth of recent graduates reported that their employers did not offer any skills development training at all.

## **Professional development engagement**

Throughout the pandemic, study cohorts explored various professional development opportunities. The most popular activities across all groups included attending online workshops, seminars, or conferences, and mentoring students or colleagues. Active volunteering for professional societies was a common pursuit among all cohorts except students. Writing about research for both technical and non-technical audiences was a practice often cited by recent graduates (2019–2022), geoscience retirees, and students. Active volunteering on academic campuses was frequently mentioned by recent graduates (2014–2018), academic faculty, and students.

“As far as research goes we actually had lots of undergraduates help with creating those classroom virtual activities and we were able to have them scan all of the samples that we would normally be giving out as hand samples in class but they were able to scan them so that they could be rotated in 3D for a virtual lab for a lot of our like intro and mineralogy type classes and so the students were able to learn how to use the various imaging scanners that we were using for those projects and come in on their own when nobody else was in the building to scan them for us and send them to us to make the labs out of so that ended up being counting for their undergraduate research experiences.” —academic faculty



“Being forced out of the lab I looked towards improving my statistical/data analysis skills via online courses and am now pursuing some large datasets in my research that I previously did not use.” —academic faculty

“When I was looking at post docs, they all had some sort of coding component to them and I didn't have and I enrolled in a data analytics certificate program. The skills I got I have used them and in publications So that I think that was the one thing I wouldn't have had unless I went outside of my degree program is working with Python or having formal training and doing some coding for analysis 'cause again you can always teach yourself but the scripts I wrote before I knew the rules are not exactly but most efficient or user friendly or anything like that.” —recent graduate

“Looking more into how to do things I've never done before but heard about it. I have more time to do online research and watch videos of those who do the skill that I want to learn. I've had time to do more personal research and look into working on my skillsets that I can use to teach to my students.” —K–12 faculty

When considering the subject matter of online workshops, seminars, or conferences, geoscience topics were the most frequently mentioned by almost all study cohorts, with the exception of academic faculty and K–12 faculty, who primarily focused on teaching. Interest in technical topics increased across all cohorts during 2020 and 2021. However, while academic faculty reported an increase in geoscience topics during this period, there was also a decline in total interest in geoscience topics across all other cohorts between 2020 and 2021. Career development topics gained prominence among recent graduates, academic faculty, and non-academic geoscientists but were mentioned less frequently in 2021 by K–12 faculty, retirees, students, and unemployed students. Other subjects, such as geoscience professional society meetings, diversity, equity, and inclusion, and various other themes were generally noted by less than a third of respondents across all cohorts.

## Links to relevant survey data charts

How recent graduates are acquiring the skills and/or knowledge they wished they had prior to graduation

<https://covid19.americangeosciences.org/data/charts/individual-grnr-skills-knowledge-gain/>

Types of employer-provided skills development training during new hire onboarding

<https://covid19.americangeosciences.org/data/charts/individual-grnr-skills-knowledge-train/>

Skills and/or knowledge recent graduates wished they had obtained prior to graduation

<https://covid19.americangeosciences.org/data/charts/individual-grnr-skills-knowledge-want/>

Topics of professional development webinars and online events

<https://covid19.americangeosciences.org/data/charts/profdev-webinar-topics-2014-2018/>

Topics of professional development webinars and online events

<https://covid19.americangeosciences.org/data/charts/profdev-webinar-topics-2019-2022/>

Topics of professional development webinars and online events

<https://covid19.americangeosciences.org/data/charts/profdev-webinar-topics-if/>



Topics of professional development webinars and online events

<https://covid19.americangeosciences.org/data/charts/profdev-webinar-topics-ik/>

Topics of co-curricular webinars and online events

<https://covid19.americangeosciences.org/data/charts/profdev-webinar-topics-ir/>

Topics of professional development webinars and online events

<https://covid19.americangeosciences.org/data/charts/profdev-webinar-topics-is/>

Topics of professional development webinars and online events

<https://covid19.americangeosciences.org/data/charts/profdev-webinar-topics-iu/>

Topics of professional development webinars and online events

<https://covid19.americangeosciences.org/data/charts/profdev-webinar-topics-iw/>

Engagement with professional development activities

<https://covid19.americangeosciences.org/data/charts/professional-development-2014-2018/>

Engagement with professional development activities

<https://covid19.americangeosciences.org/data/charts/professional-development-2019-2022/>

Engagement with professional development activities

<https://covid19.americangeosciences.org/data/charts/professional-development-if/>

Engagement with professional development activities

<https://covid19.americangeosciences.org/data/charts/professional-development-ik/>

Engagement with professional development activities

<https://covid19.americangeosciences.org/data/charts/professional-development-ir/>

Engagement with co-curricular activities

<https://covid19.americangeosciences.org/data/charts/professional-development-is/>

Engagement with professional development activities

<https://covid19.americangeosciences.org/data/charts/professional-development-iw/>

## **CHANGES IN HIRING PRACTICES**

Hiring trends experienced significant fluctuations during the pandemic among both academic departments and geoscience employers. These shifts led to changes in the desired skillsets and knowledge sought for new hires. For academic departments, active faculty hiring between February 2020 and December 2022 showed marked variations. There was reduced activity at the peak of the pandemic in 2020. After 2020, hiring rates became more erratic, with noticeable spikes in January and October 2021, as well as October 2022, during which nearly 40% of departments were hiring.

For geoscience employers, hiring rates for all degree levels generally increased from May 2022 to November 2022. At the Bachelor's degree level, the percentage of employers hiring dropped from three-quarters in June 2021 to under half in May 2022 but then dramatically increased to 90% in November 2022. For the Master's degree level, hiring increased from over three-quarters in June 2021 to all employers in May 2022. This was followed by a drop to just under two-thirds in July 2022 before rebounding to full hiring at that level in November 2022. Doctorate degree hiring saw a decline from over half of employers in June 2021 to just over a third in July 2022, but it recovered to over half again by November 2022.

Since the onset of the pandemic, the hiring landscape within the geoscience field has seen noticeable changes. By the end of 2020, just over a third of geoscience employers noted that they had changed what they were looking for in potential new hires since the start of the pandemic. This proportion decreased to less than a fifth by the second quarter of 2021, a level that remained consistent through the first quarter of 2022. Interestingly, only a fifth of employers believed that the preferred and required skillsets for new hires had undergone fundamental changes compared to the pre-pandemic period.

“The fundamental skills, the basic skills for each position haven't changed. What will have changed is we need people to be familiar with the online and virtual worlds in a more thorough way. We need you to know Zoom and we need you to know them all because people use all kinds of different platforms. We've actually talked about starting a Discord server because there's that immediate connection. You can just get online. You don't have to dial in. You can chat, you can talk, right? We've talked about something like that. Some sort of virtual community. It doesn't have to be Discord. There are others out there. But I think going forward, that's going to be one of the skillsets we're going to be looking for is people that are far more familiar with the online world and more familiar with virtual communities because I think that's going to be if we're going to truly be able to have a national or even global workforce. We're going to have to be more comfortable in the online realm.” —geoscience employer

## Changes in skillset preference and requirements

The preferences for specific skillsets among employers for new hires fluctuated from mid-2021 to late-2022. The preference for project management skills dropped from a majority to just over half of employers, while the percentage requiring these skills rose from less than a tenth to a third. The preference for field skills increased from a third to half of employers, with the requirement for this skillset fluctuating between about a third and a half. The preference for lab skills ranged between a third and a half of employers, with the requirement for these skills growing from less than a fifth to a quarter.

In the realm of technology, preference for data visualization and mapping skills jumped from just under half of employers to over three-quarters, even as the requirement for these skills fell from a third to just over a tenth. While the preference for database skills increased from 60% to 85% of employers, the percentage of employers requiring these skills remained near 15%. The preference for data science, machine learning, and AI skills edged up slightly from just under a third to just over a third, with less than a tenth of employers mandating these skills. Programming skills preference saw a minor decline, from half of employers to just under half, with most not requiring this skillset. Finally, the preference for virtual platforms skills grew from just over a third of employers to nearly half, with the requirement for this skillset also increasing, moving from a quarter to nearly a half of employers.

## Links to relevant survey data charts

Academic departments with active faculty searches

<https://covid19.americangeosciences.org/data/charts/department-faculty-searches/>

Degree levels at which geoscience employers are hiring

<https://covid19.americangeosciences.org/data/charts/new-grad-degree-level/>

Opportunities: What new opportunities arose as a result of the pandemic?

Employer preference for skillsets in new hires

<https://covid19.americangeosciences.org/data/charts/new-hire-skillset/>

Has what you are looking for in potential geoscience employees changed since the start of the pandemic?

<https://covid19.americangeosciences.org/data/charts/preqs-change-potential-employees/>

Are the preferred and required skillsets for new hires fundamentally different from before the pandemic?

<https://covid19.americangeosciences.org/data/charts/skillset-diff-prepost-pandemic/>



# Looking Ahead: How has the pandemic shaped the future of the geosciences?

The pandemic has led to significant and lasting changes in the geosciences, primarily through the integration of virtual technologies into work and learning environments. Within academic departments, virtual instructional activities have been permanently integrated into curricula to support student learning and most commonly as supplemental materials or for cases where students cannot attend the in-person course or activity. This has opened doors for students in terms of accessibility and improved retention of course content and has allowed faculty to leverage the resources and skills they developed during the pandemic to enhance student learning.

Employers have also integrated virtual technologies into their workflows, moving towards more flexible work environments and providing employees with more flexibility in the location and hours they work. Likewise, employees have upgraded their home workspaces to be more conducive for remote work. The increased flexibility has improved morale, as employees can more easily balance personal and work commitments, and the reduction in commute time also helps to increase work-life balance. Previously having to work in the office meant long commutes during inclement weather and employees working through being sick. With more flexible arrangements, employees can work from home during inclement weather, and if ill or caring for sick family members, employees can return to the office when they and / or family members are fully recovered.

The pandemic also provided the opportunity to learn new skills, and proficiency with technical skillsets have increased across the geosciences, including skills related to virtual work and collaboration. In part, new skills development was driven by facility and travel access restrictions and the need for employees, faculty, students, and researchers to pivot their work to computational research activities.

The need to deliver course instruction in different formats during the pandemic provided faculty with experience in new ways of designing and delivering curriculum across many different modalities. Familiarity with virtual platforms has enabled academic departments and faculty to invite guest speakers from around the world to speak in courses and colloquium, and for researchers to develop new projects and collaborate on existing research with a wider network of colleagues. While the pandemic posed many challenges over the years, it also provided new opportunities that many within the geosciences have pursued.

## **CHANGES TO ACADEMIC INSTRUCTION**

The pandemic has led to permanent changes in instructional activities within geoscience departments, with these departments integrating virtual instruction where it would be most supportive of learning. The majority of departments indicated that they had permanently integrated virtual instruction as a back-up for non-attendance in lecture courses and labs, and just under one-fifth did the same for field activities.

Virtual instructional activities were permanently integrated as supplemental material by most departments for lecture courses and labs, and by less than half of departments for field activities. Just over half of the departments reported using virtual instructional materials as preparatory exercises for in-

person labs, while just under half did so for lecture courses. Only a quarter of departments used virtual activities as preparatory materials for field activities. Virtual instructional materials were integrated by half of the departments for follow-on activities in courses, just over a third for labs, and just under a fifth for field activities.

The use of virtual course modules that could be incorporated into the curriculum was reported by over a third of departments for lecture courses and labs but was not noted by any departments for field activities. Course replacements were considered by less than a third of the departments across all course types. Additionally, less than half of departments indicated they had no plans to integrate virtual instruction into field activities, and less than a tenth indicated the same for lecture courses and labs.

“We had substantial funding to get our institution technologically ready for a post-COVID world. So we were able to integrate audio and video cameras in all of our classrooms. This concept of hyperflex classrooms, where the faculty member is there face to face with a group of students, but the students who just can't make it to class that day, childcare issues, they're sick, can still log on, see the classroom, participate, ask questions. That has been a big shift in terms of the way we do things inside the classroom. And I think that's something that will continue in a post-COVID world and may be the new standard.” —academic department

## Virtual instruction in lab courses / sections

From 2020 to 2022, the plans for the integration of virtual instruction in lab courses by academic departments experienced substantial changes. Plans for using virtual instruction as a back-up for non-attendance grew from one-fifth to just over half of the departments. The utilization of virtual instruction for supplemental materials, preparatory material, follow-up material, and course modules all peaked in 2021 before declining in 2022. The use of virtual activities for supplemental lab material rose from a fifth of departments to half in 2021 but then fell to a third by 2022. Likewise, plans for incorporating virtual instruction as preparatory material for in-person labs increased from less than a tenth of departments to just over a third in 2021, then decreased to just under a fifth of departments in 2022. Virtual follow-on activities for in-person labs, which were not noted in 2020, dropped from over a quarter of departments to less than a fifth between 2021 and 2022.

The integration of virtual instruction as course modules for labs was also not noted in 2020 but declined from about a third of departments to just over a fifth between 2021 and 2022. Plans for using virtual labs as course replacements were reported by a quarter of departments in 2020 and by just under a tenth in 2022. Approximately a third of departments reported having no plans to integrate virtual instruction into lab courses in 2020 and 2022, with a drop to under a fifth in 2021.

## Virtual instruction in field courses and components

From 2020 to 2022, academic departments reported changes in their plans to integrate virtual instruction into field courses. The use of virtual instruction as a back-up for non-attendance increased from a quarter to over one-third of departments over the period. Plans for utilizing virtual instruction for supplemental materials saw a sharp rise from under a fifth to over a half of departments by 2021 before falling to a third in 2022. Integration of virtual field activities as preparatory material, not reported in 2020, was planned by a quarter of departments in 2021, then decreased to a fifth in 2022. The use of virtual instruction as follow-on activities was not recorded in 2020 but was planned by a fifth of departments in both 2021 and 2022.

Plans for integrating virtual instruction as field activity course modules, also not noted in 2020, declined from a fifth of departments in 2021 to 16% in 2022. The use of virtual instruction as field course replacements was reported by less than one-tenth of departments in 2020 and not in subsequent years. Departments reporting no intention to integrate virtual instruction into field activities decreased from just under half in 2020 to a fifth in 2021, then rebounded to just over a third in 2022.

## Virtual instruction integration by faculty

The integration of virtual instructional activities by academic faculty into their curricula showed variation across different course types. Virtual instruction as a back-up for non-attendance was permanently adopted by over half of the faculty for lecture courses and labs, and by just under a third for field activities. Virtual activities as supplemental material were integrated by just over half of the faculty for lecture courses, a third for labs, and just under a fifth for field activities. Virtual activities used as preparatory material were incorporated by a third of the faculty for in-person lecture courses, just under a quarter for labs, and less than a tenth for field activities. The use of virtual instruction for follow-on activities was less common, being utilized by fewer than a fifth of the faculty across all course types.

Virtual course modules were integrated into lecture courses by a quarter of the faculty and into labs by a fifth, but less than a tenth chose to integrate them into field activities. Virtual courses as replacements were noted by less than a tenth of the faculty for lecture courses, labs, and field activities. Among the faculty, over half had no plans to use virtual instruction for field activities, just under a third felt the same for labs, and less than a fifth expressed similar sentiments for lecture courses.

“For the seminar series, actually I think moving forward we're planning to keep doing kind of about half of our speakers virtual and about half in person. The benefit to the in-person is the students get to have lunch with them, the faculty have dinner with the person. We have individual meetings. So it's not just their talk, but we have to be able to fly them in or, you know, pay for their travel. And so what we found is that by being able to do a mix of in-person and virtual, it gives the faculty a little bit of a break each week. It allows us to bring in speakers from broader areas, and so we've been able to have I think a bit more kind of higher profile speakers periodically because we can do that virtually. And at this point, so many people are used to doing that, but it's not a major ask.” —academic faculty

## Virtual integration by faculty for lab courses / sections

The integration of virtual instruction into lab courses by academic faculty from 2020 to 2022 exhibited variation according to the type of integration. During this period, faculty increasingly planned to use virtual instruction in various ways, such as a back-up for non-attendance, for supplemental lab materials, and for preparatory and follow-on activities in in-person labs. By 2022, just under half of the faculty planned to integrate virtual instruction as a back-up for non-attendance, while less than a third planned to use virtual instruction as supplemental materials or for preparatory or follow-on activities in labs.

Plans for employing virtual course modules in labs declined over the period, with just under a third initially to less than a fifth of faculty noting this integration by 2022. Additionally, plans for using virtual labs as course replacements substantially dropped, falling from less than a fifth to under a tenth of faculty. Concurrently, the proportion of faculty reporting no plans to integrate virtual instruction into labs increased from a quarter to just over a third.

## Virtual integration by faculty for field courses and components

Plans for integrating virtual instruction into field courses and components by academic faculty from 2020 to 2022 reveal several trends. Plans for using virtual instruction as a back-up for non-attendance more than doubled, increasing from a fifth to nearly half of faculty. Similarly, the intention to use virtual instruction as supplemental field activity material rose from about a quarter to just under half of faculty. There was also growth in plans for incorporating virtual instruction as preparatory material and follow-on activities for in-person sessions, both increasing from less than a tenth to just over a fifth and just over a tenth, respectively.

Meanwhile, the consideration for using virtual instruction as course modules or course replacements were less prominent, noted by less than a fifth of faculty, with course modules being considered by more faculty than course replacements. Throughout the period, the proportion of faculty reporting no plans to integrate virtual instruction into field courses and components remained relatively steady, staying near a third.

## Links to relevant survey data charts

Permanent integration of virtual instruction into departmental curriculum

<https://covid19.americangeosciences.org/data/charts/virtual-teaching-integration-deptperm/>

Departmental plans for integrating virtual instruction into lab activities for the long-term

<https://covid19.americangeosciences.org/data/charts/virtual-teaching-integration-deptlabplans/>

Departmental plans for integrating virtual instruction into field activities for the long-term

<https://covid19.americangeosciences.org/data/charts/virtual-teaching-integration-deptfieldplans/>

Permanent integration of virtual instruction into faculty teaching strategies

<https://covid19.americangeosciences.org/data/charts/virtual-teaching-integration-facperm/>

Faculty plans for integrating virtual instruction into lab activities for the long-term

<https://covid19.americangeosciences.org/data/charts/virtual-teaching-integration-faclabplans/>

Faculty plans for integrating virtual instruction into field activities for the long-term

<https://covid19.americangeosciences.org/data/charts/virtual-teaching-integration-facfieldplans/>

## CHANGES TO WORK ENVIRONMENTS

From February 2020 through December 2022, changes to work environments occurred across all cohorts, with varying degrees of integration into remote work. For academic faculty, in December 2022, the percentage working in the office was similar to February 2020, but nearly three-quarters also reported remote work, up from 4% in February 2020. Nearly three-quarters worked more than half-time in the office, with just over a fifth working remotely.

For K–12 faculty, the shift to remote work was less substantial. By December 2022, work in the office was similar to February 2020 levels, with just under a fifth working remotely less than half the time, an increase from 5% of K–12 faculty working remotely in February 2020.

For post-doctoral fellows, there was a substantial increase in remote work, with all fellows working remotely in some capacity in December 2022, up from 4% in February 2020, while over three-quarters worked in the office, down from 100% in February 2020. Half of the post-doctoral fellows worked at least half-time in the office, and over half indicated they were working remotely at least half of the time.



For non-academic geoscientists, by December 2022, the percentage of the cohort reporting in-office work was similar to February 2020 at just over 80%. However, there was a substantial difference in the percentage working remotely with three-quarters of the cohort working remotely in December 2022, a marked increase from just over one-tenth in February 2020. In December 2022, over half of the cohort reported spending at least half of their time in the office, with just under half working remotely for at least half the time.

“We are in a permanent hybrid work schedule now. We've got some people who come into the office every day, some will be in the office three days a week, some two days a week, but we do have people continuing to work at home at least a few days a week. I think that's the most major change that we've had because prior to that, you know, people would only work at home on very rare occasions.” —  
geoscience employer

## Links to relevant survey data charts

Academic faculty: work locations

<https://covid19.americangeosciences.org/data/charts/work-locations-if/>

Academic faculty: time spent at remote client office

<https://covid19.americangeosciences.org/data/charts/work-location-intensity-if-clrm/>

Academic faculty: time spent at field sites

<https://covid19.americangeosciences.org/data/charts/work-location-intensity-if-fld/>

Academic faculty: time spent at lab facility

<https://covid19.americangeosciences.org/data/charts/work-location-intensity-if-lab/>

Academic faculty: time spent at employer's office

<https://covid19.americangeosciences.org/data/charts/work-location-intensity-if-off/>

Academic faculty: time spent at other locations

<https://covid19.americangeosciences.org/data/charts/work-location-intensity-if-oth/>

Academic faculty: time spent at remote work location

<https://covid19.americangeosciences.org/data/charts/work-location-intensity-if-wah/>

K–12 faculty: work locations

<https://covid19.americangeosciences.org/data/charts/work-locations-ik/>

K–12 faculty: time spent at remote client office

<https://covid19.americangeosciences.org/data/charts/work-location-intensity-ik-clrm/>

K–12 faculty: time spent at field sites

<https://covid19.americangeosciences.org/data/charts/work-location-intensity-ik-fld/>

K–12 faculty: time spent at lab facility

<https://covid19.americangeosciences.org/data/charts/work-location-intensity-ik-lab/>

K–12 faculty: time spent at employer's office

<https://covid19.americangeosciences.org/data/charts/work-location-intensity-ik-off/>

K–12 faculty: time spent at other locations

<https://covid19.americangeosciences.org/data/charts/work-location-intensity-ik-oth/>

K–12 faculty: time spent at remote work location

<https://covid19.americangeosciences.org/data/charts/work-location-intensity-ik-wah/>

Post-doctoral fellows: work locations

<https://covid19.americangeosciences.org/data/charts/work-locations-ip/>

Post-doctoral fellows: time spent at remote client office

<https://covid19.americangeosciences.org/data/charts/work-location-intensity-ip-clrm/>

Post-doctoral fellows: time spent at field sites

<https://covid19.americangeosciences.org/data/charts/work-location-intensity-ip-fld/>

Post-doctoral fellows: time spent at lab facility

<https://covid19.americangeosciences.org/data/charts/work-location-intensity-ip-lab/>

Post-doctoral fellows: time spent at employer's office

<https://covid19.americangeosciences.org/data/charts/work-location-intensity-ip-off/>

Post-doctoral fellows: time spent at other locations

<https://covid19.americangeosciences.org/data/charts/work-location-intensity-ip-oth/>

Post-doctoral fellows: time spent at remote work location

<https://covid19.americangeosciences.org/data/charts/work-location-intensity-ip-wah/>

Non-academic professionals: work locations

<https://covid19.americangeosciences.org/data/charts/work-locations-iw/>

Non-academic professionals: time spent at remote client office

<https://covid19.americangeosciences.org/data/charts/work-location-intensity-iw-clrm/>

Non-academic professionals: time spent at field sites

<https://covid19.americangeosciences.org/data/charts/work-location-intensity-iw-fld/>

Non-academic professionals: time spent at lab facility

<https://covid19.americangeosciences.org/data/charts/work-location-intensity-iw-lab/>

Non-academic professionals: time spent at employer's office

<https://covid19.americangeosciences.org/data/charts/work-location-intensity-iw-off/>

Non-academic professionals: time spent at other locations

<https://covid19.americangeosciences.org/data/charts/work-location-intensity-iw-oth/>

Non-academic professionals: time spent at remote work location

<https://covid19.americangeosciences.org/data/charts/work-location-intensity-iw-wah/>

## **IMPORTANCE AND PROFICIENCY WITH NEW SKILLS**

Between 2021 and 2022, various study cohorts were surveyed to rate the importance of and their proficiency with a set of skills, including data visualization, programming, data science, database management, business skills, and graphic design. Departments were also queried about the integration of these skills into their curriculum, and the cohorts were asked to evaluate their proficiency with virtual

skills needed for working and collaborating within online environments. Overall, the study revealed a general acknowledgment of the importance of technical and business skills, albeit with some variations in perceived importance across different groups and over the period.

## Importance of skills

In academic departments, data visualization skills remained highly valued, with all respondents consistently noting their importance. Programming skills were highly regarded by all departments in 2021, but this perception decreased to 87% by Fall 2022. Data science and ML/AI skills also saw a decline over the period, with only three-quarters of departments recognizing their importance by Fall 2022. The perceived importance of database management skills dropped as well, from nearly all departments to just over two-thirds in Fall 2022. Business skills were considered important by over three-quarters of departments in Spring 2021 but decreased to just under three-quarters by Fall 2022. Graphic design skills also saw a slight decline, with the importance acknowledged by 96% of departments initially, dropping to 88% over the period.

Employers' perceptions of various skills fluctuated from Spring 2021 to Spring 2022. Data visualization skills were consistently deemed important, with an increasing percentage recognizing their growing significance. Programming skills and data science, along with ML/AI skills, were considered important by over 70% of employers but ranked the least significant among the skill sets examined. Business and database management skills were highly valued. However, there was a slight dip in the perceived importance of database skills, decreasing to just under 90% by Spring 2022, while business skills maintained high regard, noted by over 90% of employers throughout the period. The importance attributed to graphic design skills showed a marked increase, from just under three-quarters of employers recognizing their significance in Spring 2021 to over 90% in Spring 2022.

Among study participants, there was a general increase in the importance of various skills from Spring 2021 to Fall 2022. Data visualization and database management skills were deemed important by over 90% of respondents during this period. Meanwhile, the importance of programming skills, data science and ML/AI skills, business skills, and graphic design skills all increased to over 90% during the same time frame.

For academic faculty, data visualization and programming skills remained the most important over the period, with over 90% of faculty acknowledging their importance. The importance of data science and ML/AI skills, database management, and graphic design skills also increased to over 90% by Fall 2022. Business skills were considered important by about three-quarters of faculty.

For students, programming and database management skills were consistently perceived as important throughout 2021 and 2022. Data visualization skills were noted as important by over 90% of students through Spring 2022 but dropped to just over three-quarters by Fall 2022. Data science and ML/AI skills were considered important by over 80% of students during this period, with most students acknowledging the growing importance of these skills. Business skills were noted as important by over two-thirds of students in Spring 2021, increasing to 100% by Fall 2022. The perceived importance of graphic design skills also increased from 80% in Spring 2022 to 100% by the end of 2022.

For recent graduates (2014–2018), the importance of most skills either increased or remained high from Spring 2021 to Fall 2022. Data visualization skills were seen as vital by all respondents, and other skills, including programming, data science and ML/AI, database management, business skills, and graphic design, were also highly valued by this cohort. For slightly more recent graduates (2019–2022), at least 90% of the cohort consistently perceived data visualization, programming, data science and ML/AI, and database management skills as essential. The percentage recognizing the importance of business skills

increased from over three-quarters to nearly 90%, while graphic design skills were noted by over 80% of graduates during this period.

“I think the core thing that is incredibly in demand is the computational side. I cannot tell you how many CV's I have seen on lab websites that are like bachelors, masters, PhD, postdoc, that are all research-oriented and then they go on to become a data scientist at Zillow or something like that. Those skills are just so cross cutting and so useful. On the research side, I cannot tell you how many papers I have seen that used machine learning. I am glad I spent all that time teaching myself a lot of that stuff because it is the most important thing in this field right now.” —recent graduate

For post-doctoral fellows, data visualization, data science, and ML/AI were seen as critically important, valued by over 90% of respondents throughout the period. The importance of programming skills slightly declined from 100% to just under 90% by Fall 2022, while the significance of database management and graphic design skills fluctuated. Business skills saw an increase in importance from 80% in Spring 2021 to 100% by Fall 2022.

Non-academic geoscientists consistently highly valued data visualization skills, database management, and business skills, with over 90% agreement over the period. Programming skills' importance rose from over three-quarters to just under 90%, while data science and ML/AI skills fluctuated between 80% and 90%. The significance of graphic design skills rose from three-quarters to just over 90% during this period.

For K–12 faculty, by Fall 2022, all skills except for graphic design were noted as either continuing or increasing in importance by all respondents. Graphic design skills were considered important by 80% of K–12 faculty in Fall 2022. Similarly, retired geoscientists, by Fall 2022, deemed all skills as continuing and/or increasing in importance, with over 90% agreement within the cohort.

## Skill proficiency

In terms of proficiency, employers observed that from 2021 to 2022, their employees demonstrated at least intermediate proficiency in business skills, database management, graphic design, and data visualization. This means that they had the ability to practically apply these skills. Conversely, proficiency in data science and ML/AI was generally low, with less than a third of employers noting that their employees had at least intermediate ability in these areas. Likewise, between 30% and 40% of employers indicated that their employees had at least intermediate proficiency in programming skills.

Within academic departments, data visualization was the only skill set where the majority of departments expected undergraduates to have at least intermediate proficiency. More than half of the departments expected that upon graduation, undergraduates would possess basic to novice proficiency in database management, graphic design, data science, ML/AI, and programming skills. Slightly less than half of the departments held the same expectations for business skills among undergraduates. For graduate students, most departments expected at least intermediate proficiency upon graduation with skills related to database management, graphic design, data visualization, and programming. Consistent with the expectations for undergraduates, more than half of the departments expected graduate students to have basic to novice proficiency in data science and ML/AI skills, as well as business skills.

## Skillsets in the curriculum

Academic departments predominantly did not include business skills in their academic curriculum, with only about 30% of them indicating that these skills were offered outside of the department. Over the period leading up to Fall 2022, an increasing percentage of departments reported that they did not offer database management skills as part of their curriculum, reaching nearly two-thirds by that time. Among the departments that did integrate these skills into their curriculum, they were usually taught by tenure-track faculty.

Similarly, graphic design skills were not offered by just over half of the departments. Where they were available, a third of departments indicated that these skills were taught by tenure-track faculty. In contrast, data visualization skills were offered by most departments, with over half of them indicating that tenure-track faculty provided instruction in these areas. Data science and ML/AI skills were not included in the curriculum by about half of the departments, and when offered, they were primarily taught by faculty outside of the geoscience department. Programming skills, too, were increasingly omitted from departmental curriculum, with one-third of departments noting this by Fall 2022. Where these skills were taught, they were usually taught by either tenure-track faculty or faculty from outside the department.

“For my students, because we added this more computational modeling component, they have become much more willing and accepting of that kind of work and before it was really daunting to say like, “Oh I have to go take a computer science class or something if I want to learn about this new AI machine learning that's happening.” But they're interested now. They're actually taking the steps to do some online learning classes on their own which is really cool. I've been hearing them talk about it. Becoming familiar with doing a little bit of coding in MATLAB or in Python gave them just enough confidence to then push themselves to start thinking about more higher level applications. I had a student recently who just applied for this workshop on using machine learning for sparse data sets or something like this and so I was like, “Wow this is great!” I didn't teach them that. I don't do that work, but there was just enough like movement in that direction that they had the confidence to do that.”  
—academic faculty

## Skill proficiency among study participants

Among individual survey participants, over a third reported having at least intermediate proficiency in business skills, database management, and graphic design, while about half indicated the same level of proficiency in data visualization. Just over a quarter of participants claimed at least intermediate proficiency in programming, and about a tenth indicated the same proficiency level with data science and ML/AI skills.

Academic faculty reported the highest levels of proficiency in graphic design, with at least half indicating at least intermediate ability. More than half of the faculty stated basic to novice proficiency in business skills, database management, data visualization, data science and ML/AI, and programming skills.

Among students, the highest proficiency rates were seen in programming and data visualization, followed by database management. Over half of the students cited basic to novice proficiency in business skills and data science and ML/AI skills.

For recent graduates (2014–2018), about half reported at least intermediate proficiency in graphic design and data visualization, while indicating basic to novice proficiency in business skills, database management, data science and ML/AI, and programming.

Similarly for recent graduates (2019–2022), over half noted at least intermediate proficiency in data visualization and basic to novice proficiency in all other skills. Interestingly, over a third of both cohorts claimed at least intermediate proficiency in programming, and about a third of the 2014–2018 cohort also indicated at least intermediate proficiency in business skills and database management.

Among non-academic geoscientists, business and data visualization skills had the highest levels of proficiency, followed by database management and graphic design. More than half of this group noted basic or novice proficiency in data science and ML/AI, as well as programming skills.

Most post-doctoral fellows cited at least intermediate proficiency in programming over the period, and by Fall 2022, at least half indicated the same proficiency with data science and ML/AI, data visualization, and graphic design. Over half also reported basic to novice proficiency in business skills and database management.

For K–12 faculty, at least half noted basic to novice proficiency in data visualization, data science and ML/AI, and programming skills over the period, and by Fall 2022, over half indicated the same proficiency with database management. Slightly fewer than half reported similar proficiency in business skills. Retirees exhibited the highest proficiency in business skills, with over half indicating at least intermediate ability in this area.

More than a third of retirees reported the same proficiency in database management, graphic design, and data visualization, while less than a fifth indicated the same level of proficiency with data science and ML/AI and programming skills.

## Proficiency with virtual technology skills

Regarding virtual skills, from 2020 to 2021, most departments reported that their faculty and staff were moderately to extremely proficient in the use of virtual platforms, virtual tools for collaborative work, presenting research and projects via virtual platforms, and collaborating with colleagues in virtual environments. Collaboration with colleagues and using virtual tools for collaborative work saw the largest increase in departments noting at least moderate proficiency over the period.

From 2020 to 2022, employers noted a general increase in their employees' proficiency with selected virtual skills. By 2022, all employers reported that their employees had at least moderate proficiency in the use of virtual platforms, an increase from three-quarters in 2020. The proficiency levels for using virtual tools for collaborative work were reported to be the same by most employers, although the percentage of employers reporting this level of proficiency declined from under two-thirds to just over half by 2022. Employers reporting employees with at least moderate proficiency in presenting research or projects via virtual platforms increased from nearly three-quarters to over 90%. The percentage of employers noting employees with at least moderate proficiency in collaborating with colleagues via virtual platforms also increased, from just over half in 2021 to two-thirds by 2022.



“I think our LMS's were always this nice little shiny object that was attached to classes, but not that many people paid too much attention to them. I think thanks to the pandemic, all of our faculty members are extraordinarily well trained on how to integrate that into their face-to-face classes as well as a whole new kind of group of individuals who are now fluent in online teaching, which was something that, you know, we didn't really have too much to begin with. So I'm really happy to see a lot of my old timers take to online with an enthusiasm that they didn't have prior to COVID.” —academic department

“You assume people are proficient in these platforms and so you assume you can because you have to communicate with your clientele like this now and so we go down that path of having an expectation that these new folks have this ability to interact in this new post-pandemic way. The other side of the coin is we realize they may not have as much of those skillsets that we wish they could have from the coops and the real-world experience. And so I think we raise our level of expectations that new hires have some new skills that we expect, you know how to set up a Zoom or Teams meeting. You know how to record it if you need to. You know how to turn on your screen and be at least properly dressed from the waist up kind of thing. That's an added skill and I think that the takeaway is those folks who were caught in the middle of that pandemic are likely missing some skills that we ought to be cognizant that they may not have from experiential learning. But I think it's probably a good trade off as obviously they can get the experiential learning.” —geoscience employer

Individuals reported growth in their virtual abilities. Those reporting at least moderate proficiency in the use of virtual platforms increased from just over three-quarters to just under 90%. Proficiency with virtual tools for collaborative work remained near two-thirds, and there was an increase in proficiency for presenting research or projects via virtual platforms from 61% to 70%. Collaborating with colleagues via virtual platforms also increased from just under to just over two-thirds.

From 2020 to 2022, academic faculty reported an increase in at least moderate proficiency in the use of selected virtual skills. The faculty who reported at least moderate proficiency in using virtual platforms remained fairly consistent at just under 90% throughout the period. However, there was a more substantial increase in the use of virtual tools for collaborative work, rising from about two-thirds to three-quarters. The percentage of faculty reporting at least moderate proficiency in presenting research or projects via virtual platforms grew from just over half to slightly under three-quarters. Additionally, proficiency in collaborating with colleagues via virtual platforms increased from just over half to 70%.

Among students, over three-quarters reported at least moderate proficiency with virtual platforms, virtual tools for collaborative work, and with presenting research and projects via virtual platforms by 2022. Just over two-thirds in 2022 reported similar proficiency with collaboration with colleagues via virtual platforms.

From 2020 to 2022, over three-quarters of recent graduates (2014–2018) reported at least moderate proficiency with the use of virtual platforms. By 2022, at least three-quarters of these graduates also reported the same level of proficiency with the use of virtual tools for collaborative work, presenting projects and research virtually, and collaborating with colleagues via virtual platforms.



In a similar trend, over three-quarters of more recent graduates (2019–2022) reported at least moderate proficiency with the use of virtual platforms during the pandemic. By 2022, at least three-quarters of this group also reported the same level of proficiency with the use of virtual tools for collaborative work and collaborating with colleagues via virtual platforms. Additionally, just under three-quarters reported at least moderate proficiency with presenting projects and research virtually.

Post-doctoral fellows also saw increased proficiency levels with virtual skills, with over 80% reporting at least moderate proficiency with virtual platforms, using virtual tools for collaborative work, and collaborating with colleagues via virtual platforms by 2022. Over half indicated moderate proficiency with presenting research virtually.

“I think my collaborations have grown through the pandemic in part because it was easier to send people an e-mail and set-up a Zoom. It might be harder to schedule 30 minutes with someone to get a coffee or to try to meet them at a conference or a meeting when the week is jam packed already. That was certainly harder. I am happy to say that I have made a lot of great and new collaborations during the pandemic and in this more recent period as well. Those continue to grow. I think I have been able to have a fair amount of personal and professional resilience, and I acknowledge that that is a privilege that some others do not have that same experience and have struggled with it.” —recent graduate

Non-academic geoscientists showed an increase in proficiency, with over three-quarters indicating at least moderate proficiency with virtual platforms over the period. By 2022, over three-quarters reported the same proficiency level with presenting research and projects virtually. Just under three-quarters were proficient with using virtual tools for collaborative work and collaborating with colleagues virtually.

For K–12 Faculty, over three-quarters reported at least moderate proficiency with virtual platforms and virtual tools for collaborative work over the period. By 2022, just under three-quarters also reported moderate proficiency with presenting research and projects via virtual platforms and collaborating with colleagues virtually.

Over half of retired geoscientists reported at least moderate proficiency with virtual platforms, whereas less than half reported the same level of proficiency with using virtual tools for collaborative work and with presenting research and projects virtually. By 2022, over half of retirees noted at least moderate proficiency with virtual collaboration with colleagues.

## Links to relevant survey data charts

Importance of selected skills to the geoscience profession

<https://covid19.americangeosciences.org/data/charts/skillsimportance-department/>

Importance of selected skills to the geoscience profession

<https://covid19.americangeosciences.org/data/charts/skillsimportance-employer/>

Importance of selected skills to the geoscience profession

<https://covid19.americangeosciences.org/data/charts/skillsimportance-individual/>

Importance of selected skills to the geoscience profession

<https://covid19.americangeosciences.org/data/charts/skillsimportance-if/>

Importance of selected skills to the geoscience profession

<https://covid19.americangeosciences.org/data/charts/skillsimportance-is/>

Importance of selected skills to the geoscience profession

<https://covid19.americangeosciences.org/data/charts/skillsimportance-2014-2018/>

Importance of selected skills to the geoscience profession

<https://covid19.americangeosciences.org/data/charts/skillsimportance-2019-2022/>

Importance of selected skills to the geoscience profession

<https://covid19.americangeosciences.org/data/charts/skillsimportance-ip/>

Importance of selected skills to the geoscience profession

<https://covid19.americangeosciences.org/data/charts/skillsimportance-iw/>

Importance of selected skills to the geoscience profession

<https://covid19.americangeosciences.org/data/charts/skillsimportance-ik/>

Importance of selected skills to the geoscience profession

<https://covid19.americangeosciences.org/data/charts/skillsimportance-ir/>

Expected proficiency of graduate students with selected skills upon graduation

<https://covid19.americangeosciences.org/data/charts/skillsproficiency-deptgrad/>

Expected proficiency of undergraduate students with selected skills upon graduation

<https://covid19.americangeosciences.org/data/charts/skillsproficiency-deptugrad/>

Integration of selected skills into academic curriculum

<https://covid19.americangeosciences.org/data/charts/skillsintegration-deptcurr/>

Employee proficiency with selected skills

<https://covid19.americangeosciences.org/data/charts/skillsproficiency-employer/>

Proficiency with selected skills

<https://covid19.americangeosciences.org/data/charts/skillsproficiency-individual/>

Proficiency with selected skills

<https://covid19.americangeosciences.org/data/charts/skillsproficiency-if/>

Proficiency with selected skills

<https://covid19.americangeosciences.org/data/charts/skillsproficiency-is/>

Proficiency with selected skills

<https://covid19.americangeosciences.org/data/charts/skillsproficiency-2014-2018/>

Proficiency with selected skills

<https://covid19.americangeosciences.org/data/charts/skillsproficiency-2019-2022/>

Proficiency with selected skills

<https://covid19.americangeosciences.org/data/charts/skillsproficiency-ip/>

Proficiency with selected skills

<https://covid19.americangeosciences.org/data/charts/skillsproficiency-iw/>

Proficiency with selected skills

<https://covid19.americangeosciences.org/data/charts/skillsproficiency-ik/>

Proficiency with selected skills

<https://covid19.americangeosciences.org/data/charts/skillsproficiency-ir/>

Faculty and staff proficiency with selected virtual skills

<https://covid19.americangeosciences.org/data/charts/virtualskillsproficiency-dept/>

Employee proficiency with selected virtual skills

<https://covid19.americangeosciences.org/data/charts/virtualskillsproficiency-emp/>

Proficiency with selected virtual skills

<https://covid19.americangeosciences.org/data/charts/virtualskillsproficiency-indiv/>

Proficiency with selected virtual skills

<https://covid19.americangeosciences.org/data/charts/virtualskillsproficiency-if/>

Proficiency with selected virtual skills

<https://covid19.americangeosciences.org/data/charts/virtualskillsproficiency-is/>

Proficiency with selected virtual skills

<https://covid19.americangeosciences.org/data/charts/virtualskillsproficiency-2014-2018/>

Proficiency with selected virtual skills

<https://covid19.americangeosciences.org/data/charts/virtualskillsproficiency-2019-2022/>

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## **LOOKING TOWARD THE FUTURE**

The pandemic has led to significant and lasting changes in the geosciences, primarily through the integration of virtual technologies into work and learning environments. The pandemic brought to light the criticality of frequent in-person interactions, and the lasting impact on social skills has been a concern noted by employers, academic departments and faculty who have commented on the stunting of social interactions and interpersonal communication at some level. Interestingly, some participants also noted more personal connection coming out of the pandemic, namely people taking time and giving each other the space and time needed for work and interaction, and improved empathy for each other.

“They have extraordinarily poor social skills right now, and I think that can be seen at all levels of the institution. And I'm not just talking about students. I'm talking about staff and coworkers. We need to learn how to talk again to others, especially in large groups, because when you're in large groups, you're working off of other people's facial cues of when to stop and when to go. And when cameras are off, you don't have those social cues to work with.” —department head

“I think kind of on the emotional you know, skill gap, was the ability to kind of handle frustration that generally is something I've just been seeing students since the pandemic.” —academic faculty

“People are more understanding I think and flexible with one another and especially in terms of family events and personal needs and I just hope we remain understanding of one another and giving each other the space we need to not just be effective scientists but also you know good people and good family members and things like that and I think we are seeing that I just hope it's something that sticks.” —academic faculty

The pandemic also showed how virtual technologies could be leveraged to augment work and learning environments. Employers and academic departments have integrated remote work options into their workplace policies and most employees are now working remotely in some capacity, with flexibility in location and/or hours. Since the start of the pandemic, both employees and students have upgraded their work and study spaces at home, moving to more dedicated workspaces, improving internet connectivity, and acquiring the necessary equipment to facilitate better focus and productivity.

Across academic departments, faculty have integrated virtual components into their instruction or are in the process of planning these integrations. Primarily, virtual components are being integrated as supplemental materials and as backups for students who are unable to attend in-person activities, as well as preparatory materials and post-event materials for in-person instruction. Some faculty are using virtual course modules to enrich student learning. Changes to degree programs include increased flexibility in the mode of defense or final capstone project presentation and allowing course substitutions in degree plans.

Over the past few years there has been a substantial increase in the percentage of employers hiring at the doctoral level. Pre-pandemic, employers tended to primarily hire at the bachelor's and master's level, and the career pathway for doctorates was primarily into academic positions. Since the pandemic, there has also been an increased expectation from employers that new hires be proficient with virtual platforms for communication and collaboration, and an increase in those looking for new hires with database and data visualization skills, as well as project management skills.

The pandemic has left a lasting imprint on the geosciences, but also has provided new opportunities for the geosciences in support of society, shaping the future trajectory of the geosciences discipline. Integration of virtual technologies has opened many doors for research advancements, collaborations, and new ways of teaching and learning. The immense challenges posed by the pandemic in terms of the limitations on in-person activities, including lab and field work, has provided the opportunity for geoscientists, employers, and academic departments to think strategically about how to be more efficient in how they work and learn going forward.

“The pandemic has given people a broad resilience. It has given us a real-world case study of what could happen. It really has underscored that we need to change the way we think about business as usual. Before we saw tremendous, and we still see tremendous loss of life on the roads during inclement weather. But now that places have embraced virtual work, you see that people do not go out on the roads in the middle of a blizzard because there is not that same pressure. That is a privilege that might not be standard across all communities. We just have this overall change in thinking too. Let us be more strategic and efficient and all that we do I think has led to you some increases in research money or at least renewed interest in some of these areas that focus on the next grand challenges that our society's going to face. Climate change and extreme weather being one of the many. Let us put some investments into understanding this so that we are not caught up in a COVID-like situation of scrambling at the last minute to learn as we go. How do we best implement and communicate? This kind of thing. My hope is that we have this collective learning experience and come out on the other side, all the better for it.”  
—recent graduate



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