GET WITH THE TIMES! SURVEYING HAWAI‘I’S GEOSCIENCE EMPLOYERS AND SOEST GRADUATES TO UNDERSTAND EVOLVING GEOSCIENCE WORKFORCE NEEDS

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Abstract

The skills needed for the geoscience workforce change as new technology and scientific knowledge are developed. However, there is a knowledge gap concerning what specific skills are necessary for recent geoscience graduates in the U.S, and what skills those graduates have. To fill this knowledge gap specifically for the State of Hawai‘i, we surveyed geoscience employers in Hawai‘i’s public and private sectors as well as recent School of Ocean and Earth Science and Technology (SOEST) graduates on important skills for geoscientists at their organizations to have. We received survey responses from 30 local employers in public and private sectors and 30 recent SOEST graduates at the bachelor, master and doctoral levels. Survey results indicate that, overall, local employers and recent graduates agree on the importance of fieldwork, sampling and data handling skills as well as interpersonal and professional skills for current geoscience employees. While SOEST produces quality scientists, graduates also require important non-technical skills to meet geoscience workforce needs.

Definition

Geoscience: study of the composition, structure, and other physical aspects of the Earth; includes environmental science, hydrology, oceanography, atmospheric science, geology, geophysics, climate science and geochemistry (adapted from Wilson 2018)

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Introduction

Background

The demands of the geoscience workforce are constantly evolving as new technology and knowledge are developed (Summa et al. 2017). In response, many university geoscience programs have been updating and in some cases revamping their curricula (Keane & Asher 2021, Summa et al. 2017, Viskupic et al. 2021, Whelan et al. 2010). For example, in recent years, coding and machine learning have become key tools and have advanced progress in many geoscience fields (Dramsch 2020). To mirror this advancement, several geoscience university programs have begun offering, and in some cases requiring, courses in Python and other coding languages, to ensure students have these high-demand workforce skills (Jacobs et al. 2016, Christeson 2020, Chen et al. 2018).

U.S. National Geoscience Workforce

In 2018, the American Geoscience Institute (AGI) published a seminal report on the status of the geoscience workforce (Wilson 2018). This report was based on both data obtained from geoscience graduates through annual exit surveys conducted from 2013 to 2016 as well as from the Bureau of Labor Statistics (BLS). Wilson (2018) predicts an overall growth (11%) in full-time equivalent (FTE) positions in the geosciences over the next decade (2016 to 2026) as well as a natural loss of 48% of the current workforce due to retirements (BLS 2020). Thus, geoscience job availability was predicted to increase substantially, suggesting recent graduates would be able to find employment more easily. However, this has not turned out to be the case.

Instead, the national percentage of recent geoscience graduates who received an employment offer by the time of graduation has steadily decreased over the past five years, from 15% to 10% for bachelor's graduates, 43% to 30% for master's graduates, and 70% to 36% for doctoral graduates (Wilson 2018). One possible explanation for this overall decrease is that there may be a disconnect between the skill sets that recent geoscience graduates obtain during their academic preparation and current geoscience workforce needs. In other words, bachelor-, master- and doctoral-level graduates may be successfully completing their respective degree programs without acquiring the skill sets sought by prospective employers.

To investigate how well graduates across the nation are being prepared for employment, AGI surveyed graduate proficiency in relevant skills for the geoscience workforce. Annual Geoscience Student Exit Surveys (Wilson 2018) and a specific Master's Preparation Survey for geoscience master's students (Houlton 2015) were administered to recent graduates from geoscience departments, the faculty at those departments, and non-academic geoscience professionals. Students and faculty were asked to evaluate graduates' preparation in specified technical and non-technical skills. Non-academic professionals were asked to rate the importance of these same technical and non-technical skills in their jobs. Thus, these survey data enabled a direct comparison of the skills graduates were proficient in versus those desired in the workforce. Figure 1 divides these skills into two broad categories: technical vs. non-technical. The technical skills can be further broken down into academic technical skills (such as tectonic or geologic modeling, deformational history, earthquake mechanisms and seismic hazards) versus more applied skills (such as knowledge of health and safety regulations and preparing for geological investigations).

As shown in Figure 1, university geoscience graduates, on average, meet or exceed the expected standards of the academic technical skills surveyed. Technical skills of a more applied nature fall a bit short of expectations. However, overall students appear to be well-prepared for the geoscience workforce in terms of technical skills acquired by the time of graduation.

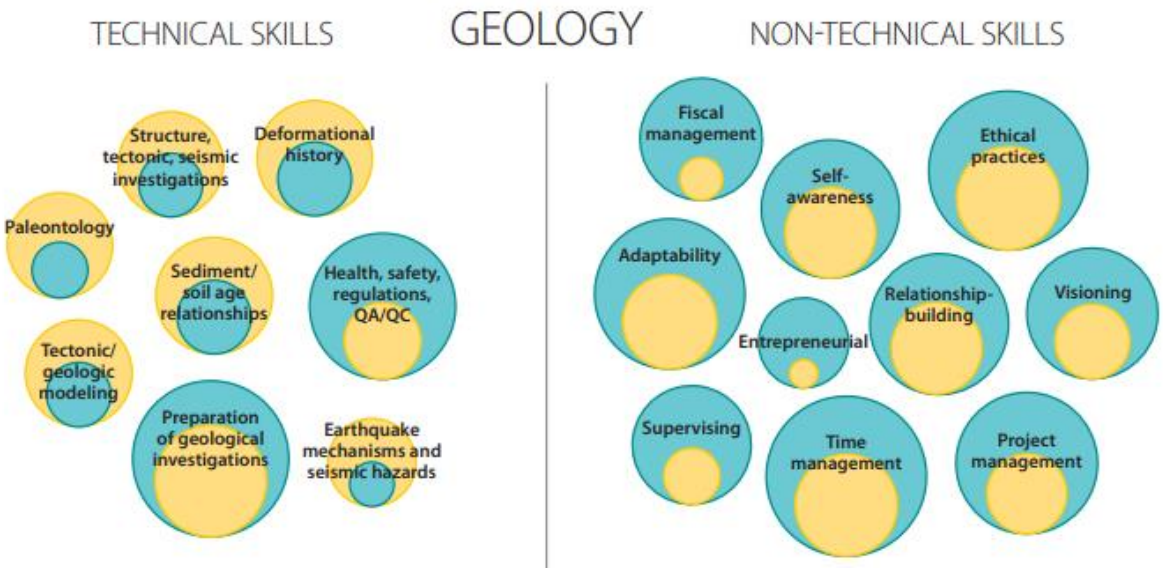

Figure 1. National data showing the disparity between skills of terminal geology master's students (yellow) versus the skills needed in geology jobs (blue) (Wilson 2018). Diameter of circles indicate magnitude of importance of those skills. While terminal master's students meet or exceed most of the technical requirements necessary for the workforce, they struggle to meet the same expectations with regards to non-technical skills. Reprinted with permission from Wilson (2018).

Survey participants were also asked to evaluate specified non-technical skills, including interpersonal skills (relationship-building, self-awareness, ethical practices), professional management skills (fiscal management, time management, project management, supervising) and self-starting skills (visioning, adaptability, entrepeneurial). In each of these 10 non-technical skills, graduates fell well short of expectations, as shown in Figure 1.

American geoscience employers in industry, government and academia agreed that an increased focus on the development of certain technical and (particularly) non-technical skills could alleviate the disconnect of employer expectations and recent graduate attributes, and thus increase their employability (Wilson 2018). The AGI report also noted a knowledge gap of exactly what skills are necessary for recent graduates to meet geoscience workforce expectations. This knowledge gap further grows with regards to state-specific needs, as workforce needs can vary considerably among states.

In this paper, we begin to fill this knowledge gap specifically for the State of Hawai‘i. Our goal is to discern Hawai‘i’s geoscience workforce needs, with the hope that this information will be used to ensure that students from the School of Ocean and Earth Science and Technology (SOEST) at the University of Hawai‘i (UH) at Mānoa are trained to meet employers’ demands.

Hawai‘i’s Geoscience Workforce

Hawai‘i’s geoscience employment landscape differs significantly from the rest of the U.S.. The top geoscientist employer in the U.S. is the petroleum industry (BLS 2021). Despite the state’s dependency on petroleum (U.S. Energy Information Administration 2021), Hawai‘i lacks crude oil, natural gas and coal reserves, and has no petroleum industry. So what industries are employing Hawai‘i’s 1,700 geoscience employees (BLS 2021)?

The industries that employ the most geoscientists in Hawai‘i are management, scientific and technical consulting services (BLS 2021). Historically, SOEST graduates who are employed in the local workforce work as scientists, specialists and consultants for governmental organizations, such as the U.S. Geological Survey (USGS) and the National Oceanic and Atmospheric Administration (NOAA), or private companies such as Architecture, Engineering, Consulting, Operations, and Maintenance (AECOM) and Environmental Science International (School of Earth and Ocean Sciences and Technology 2021).

Given Hawai‘i’s unusual workforce, national geoscience workforce data are of limited use and relevance. Instead, there is a clear need for state-specific data. Surveying Hawai‘i’s geoscience employers can help provide much-needed state-specific data regarding current geoscience workforce needs, and may also reveal struggles that employers may be currently experiencing in hiring new employees. Additionally, surveying recent SOEST graduates can provide insight into their employability and may shed light on potential obstacles to employment.

SOEST & UH Mānoa

The University of Hawai‘i (UH), the state system of public higher education, includes three universities and seven community colleges across the islands (University of Hawai‘i 2021). The

University of Hawai‘i at Mānoa is a large, urban university located in Mānoa Valley on O‘ahu, Hawai‘i with a student enrollment of 13,000 (Mānoa Institutional Research Office 2021). UH Mānoa houses various science colleges, including SOEST. As a land-, sea- and space-grant college, SOEST is renowned for its research units such as the Hawai‘i Institute of Marine Biology, Hawai‘i Institute of Geophysics and Planetology, Hawai‘i National Energy Institute and the UH Sea Grant College Program (OVCR 2021). SOEST also offers 16 undergraduate and graduate degree programs (Table 1).

Table 1. Degrees offered by SOEST

Department	Degree title	Degrees offered
Department of Atmospheric Sciences	Atmospheric Sciences	B.S., M.S., Ph.D., BAM**
Department of Earth Sciences*	Environmental Earth Sciences	B.A.
	Earth Sciences	B.S.
	Earth and Planetary Sciences	M.S., Ph.D.
Department of Oceanography	Global Environmental Science	B.S., BAM
	Marine Biology	M.S., Ph.D.
	Oceanography	M.S., Ph.D.
Department of Ocean and Resources Engineering	Ocean and Resources Engineering	M.S., Ph.D.

* = Previously, this department was called “Geology and Geophysics” and hosted a Master of Geoscience for Professionals (MGeo) degree program, designed for current geoscience employees. The MGeo degree program was discontinued in 2016.
** = Combined bachelor’s and master’s degree

As Hawai‘i’s largest producer of geoscience graduates, SOEST is poised to evaluate not only the state’s workforce needs but also their own graduates’ employability. Historically, SOEST has conducted such evaluations via alumni and employer surveys in 2001 and 2008 (Garcia 2001, Houghton 2008). However, these samples are small and out of date, reflecting neither current workforce needs nor the employability of recent graduates.

To evaluate recent SOEST graduate employability, this study collects and analyzes survey data from recent SOEST geoscience graduates as well as Hawai‘i’s geoscience employers in the private and public sector. Our goals are three-fold: (1) to gather information on Hawai‘i’s geoscience workforce needs; (2) to assess whether recent SOEST graduates have the requisite

technical and non-technical skill sets; and (3) to gain insight into any employment challenges that students and/or local employers may be experiencing. It is our hope that such data will be discussed by SOEST students, faculty and administrators, and that any necessary curricular changes will be made to improve the employability of future graduates who wish to enter the geoscience workforce.

Methods

Survey instruments

To obtain information on the employability of recent graduates and the needs of the local workforce, we conducted two surveys. The *Hawai'i Geoscience Employer Survey* was sent to local geoscience employers and is referred to as the "employer survey" in this paper (Appendix 1). The *SOEST Alumni Employment in Geosciences Survey* was sent to SOEST alumni and is referred to as the "alumni survey" in this paper (Appendix 2).

The first section of both surveys requests information about the respondent using open-ended questions regarding their job title, organization, and location. In the employer survey, we asked multiple choice and open-ended questions regarding the types of geoscientists employed at the respondent's organization. We also asked respondents to estimate the number of local and SOEST graduates employed as geoscientists at their organization. In the alumni survey, we asked multiple choice questions regarding SOEST degree(s) earned, under which majors these degrees were earned, and year(s) of graduation.

The latter half of the first section asks respondents about obstacles to employment in hiring geoscience employees (employer survey) or in gaining employment in the geosciences (alumni survey) using multiple choice questions. Respondents were also given a choice to write in a response ('Other') if the multiple-choice options did not alight with obstacles they experienced. Additionally, in the employer survey, we asked multiple choice questions regarding internships at their organization (e.g., if they hosted interns recently, if they have interest in hosting interns in the future) and respondents were asked to describe those internships if applicable.

The second section of the survey asks respondents about geoscience skills they believe are important for geoscience employees. To evaluate this, we asked respondents to rate the importance of 20 specified skills for a geoscientist at their organization. Respondents indicated their agreement on a skill's importance using a five-point Likert scale with 1 being 'Strongly disagree', 3 being 'Not sure' and 5 being 'Strongly agree'. The 20 specified skills include 9 technical and 11 non-technical skills.

The 9 technical skills listed include data management, Geographic Information System (GIS) skills/mapping, computer modeling, data analysis, programming/coding, data visualization, fieldwork/sampling, laboratory skills and other data science. We determined this list by compiling skills evaluated in past SOEST surveys (Garcia 2001, Houghton 2008) and exit surveys by AGI (Houlton 2015). The list was further revised based on feedback provided by SOEST faculty members, particularly Drs. Scott Rowland and Deborah Eason.

The 11 non-technical skills listed include technical report writing, grant writing, problem-solving, presenting/public speaking, interpersonal communication, teamwork, working independently, time management, leadership, working well under pressure and flexibility. In addition to the non-technical skills evaluated by past SOEST surveys and AGI exit surveys, we looked at national and international studies on non-technical skills and STEM graduate employability (Coll et al. 2002, Rayner & Papakonstantinou 2015) to create this list of skills. We note that 'technical report writing' contains the word 'technical', but is not a technical skill.

The surveys concluded with four open-ended questions:

- What type of data analysis do you or your colleagues most commonly perform, if any?
- What programming/coding languages do you or your colleagues commonly use, if any?
- What specialized software do you or your colleagues commonly use, if any?
- Please described any trainings or certifications that you believe are useful to have at your organization, if any.

Though the surveys are anonymous, respondents could optionally provide their contact information if they wished to be contacted for possible follow-up questions. Respondents were

not required to answer any questions on these surveys, and thus the number of responses per question varies on both surveys.

Additionally, survey respondents were offered SOEST baseball caps as a token of gratitude for participation. In 2001, SOEST offered SOEST t-shirts to alumni who responded to their alumni survey, and 12 out of 15 (80%) alumni responded (Garcia 2001). In 2008, a SOEST t-shirt was not offered, and only 16 of 33 (48%) alumni responded (Houghton 2008). The higher response rate in 2001 may have been due to the token gift offered. Thus, we offered SOEST caps to incentivize participation.

Survey distribution

To distribute the employer survey, first we crafted a list of Hawai‘i non-academic geoscience employers in both the public and private sectors. We invited SOEST faculty and staff to add more employers to the list and many faculty responded with suggestions, including Drs. Deborah Eason, Michael Guidry, Margaret McManus, Alison Nugent and Scott Rowland. In Fall 2020, we telephoned every employer on the list to ask if they were willing to complete the employer survey. Employers who agreed were sent a link to the Google Forms survey via e-mail. If the organization did not complete the survey within a week of receipt, we contacted them again via phone call with a reminder to take the survey. Data were kept in an automatically generated Google Sheets spreadsheet.

The alumni survey was first distributed on July 7th, 2021. A link to the Google Forms survey was sent through the SOEST alumni listserv, which contains the e-mails of all SOEST alumni who provided their contact information. Access to the SOEST alumni listserv was provided by Heather Saito, the SOEST Director of Academic Advising. Participants were asked to respond to the survey within a week (by July 14th, 2021). In the e-mail, we requested that only current or former geoscience employees complete the survey. Data were again kept in an automatically generated Google Sheets spreadsheet.

Institutional Review Board

Review by the Institutional Review Board (IRB) is required for any research conducted by a U.S. institution that involves human subjects. Such IRB review protects human subjects participating in said research by approving and monitoring research protocol and any related materials (such as informed consent documents and survey instruments). An IRB analyzes risks to human subjects and may request modifications to research protocols before granting IRB approval (Office for Human Research Protections 2021).

At UH Mānoa, the Office of Research Compliance (ORC) oversees all human subjects research and serves as the IRB for all research at this institution. However, the ORC determined that our surveys are Not Human Subjects Research (NHSR), but rather program evaluation aimed to inform curriculum changes. Such surveys do not require IRB review, and we were given the green light to proceed.

Data analysis

To evaluate the Likert scale data, we first calculated the mean ratings and standard errors of the mean (SEMs) for each of the 20 technical and non-technical skills. We then used analysis of variance (ANOVA) tests to identify any significant differences between mean ratings across different groupings. A difference was considered significant if $p < 0.05$.

We compared the data sets in two ways. First, we looked for any significant differences in mean ratings between the employer and alumni survey. Then, we looked at the job groupings in each survey and identified if mean rating differences existed between job groupings (see Table 4). For these ANOVA tests, our null hypothesis is that there is no statistically significant difference between mean skill ratings among the various job groups and/or between respondent types (alumni or employer).

Data

Our dataset includes 30 alumni survey responses obtained in July 2021, and 30 employer survey responses obtained from October 2020 to December 2020.

Employer survey

For the employer survey, 30 of the 55 contacted organizations completed the survey, resulting in a 55% response rate. Twenty respondents were from government agencies and ten were from private companies. We recognize that this small sample size becomes a key limitation, particularly as these 30 respondents are not necessarily representative of Hawai‘i’s geoscience employers.

Alumni survey

For the alumni survey, we received a total of 119 responses from alumni who graduated between 1977 and 2021. As this particular report aims to extract information about current employment trends, it only analyzes responses from alumni who graduated in the past six years, between 2015 and 2021. There were 30 alumni responses during this six-year period, representing 25% of the total responses received and 8% of all SOEST alumni who graduated between 2015 and 2021. For the rest of this evaluation, we use the term ‘alumni’ to signify the subset of alumni respondents who graduated between 2015 and 2021.

Table 2. SOEST degrees earned by alumni survey respondents (n = 30[1])

SOEST degrees earned	Number of respondents
Bachelor of Arts (BA)	4
Bachelor of Science (BS)	14
Master of Science (MS)	7
Joint bachelor and master (BAM)	1
Master of geoscience for professionals (MGeo)	1
Doctorate (PhD)	7

[1]Some respondents earned more than one SOEST degree. Thirty respondents reported a total of 34 degrees earned.

Respondents were asked to indicate all degrees earned and the majors of those degrees. Over half of respondents (63%) earned a bachelor’s degree at SOEST, while 30% earned a master’s degree and 23% earned a doctoral degree (Table 2). Over two-thirds (70%) of respondents graduated with Earth Science degrees while only 3% (1 person each) held Marine Biology, Ocean and

Resources Engineering or Atmospheric Science degrees (Table 3). The greater volume of Earth Sciences respondents impacts the types of jobs secured and may also impact the necessary skill sets reported. Therefore, while this report may provide important insights into current geoscience jobs available and important skill sets for geoscience employees, it should not be viewed as comprehensive.

Table 3. SOEST majors of alumni survey respondents (n = 30[1])

Majors of SOEST degrees earned	Number of respondents
Earth Science (EARTH/G&G)	21
Global Environmental Science (GES)	4
Oceanography (OCN)	3
Ocean and Resources Engineering (ORE)	1
Atmospheric Science (ATMO)	1
Marine Biology (MBIO)	1

[1]Some respondents earned more than one SOEST degree in different majors. Thirty respondents reported a total of 34 degrees earned across the six majors.

Bureau of Labor Statistics job classifications

A key difference between the two surveys lies in job classification representation. For the employer survey, we asked employers which geoscientists they employed at their organization from a list of predetermined job classifications from the Bureau of Labor Statistics (BLS 2021). For the alumni survey, each respondent provided their current job title and, to preserve anonymity, we categorized responses following the same predetermined job classifications from BLS.

The sample sizes (n) for each job grouping vary between the surveys. Any given respondent to the employer survey could select multiple job classifications. However, each respondent to the alumni survey could only provide a single job title. The employer survey's job classifications are thus more expansive and representative of the overall geoscience workforce than those of the alumni survey.

Lastly, the job classifications within each job grouping vary between the two surveys. For example, Geographers & Surveyors have an independent group in the employer survey, but, in the alumni survey, Geographers are grouped with Geologists & Hydrologists. Groupings changed for the alumni survey due to the small sample size. For the employer survey job groupings, some job classifications can be found in more than one. For example, Environmental Engineers can be found under Environmental and Engineers as their job classification applies to both.

Table 4. Job groupings and component job classifications

Job grouping	Employer survey job classifications	Alumni survey job classifications
Environmental	• Environmental Scientists & Specialists • Environmental Science & Protection Technicians • Environmental Engineers • Environmental Engineering Technologists & Technicians	• Environmental Scientists & Specialists • Environmental Science & Protection Technicians • Oceanographers
Engineers	• Environmental Engineers • Marine/Ocean Engineers • Environmental Engineering Technologists & Technicians	N/A
Geologists & Hydrologists	• Geologists • Hydrologists • Geological & Hydrological Technicians	• Hydrologists • Geologists • Geophysicists • Geographers • Geological & Hydrological Technicians
Marine Biologists & Oceanographers	• Marine Biologists • Oceanographers • Marine/Ocean Engineers	N/A
Geographers & Surveyors	• Geographers • Surveying & Mapping Technicians	N/A
Conservation Scientists & Soil Scientists	• Conservation Scientists • Soil & Plant Scientists	N/A
Other	N/A	• Marine Biologists • Engineers • Other

Results

Respondent demographics & information

Employer survey respondents were asked to estimate the percentage of their geoscience employees who were born and/or raised in Hawai‘i (“local”, Figure 2a) and the percentage of their employees who attended SOEST (Figure 2b). A large majority (73%) of employers reported less than a quarter of their geoscience employees attended SOEST, though only a minority (38%) reported less than a quarter of their geoscience employees were local (born and/or raised in Hawai‘i). Encouragingly, most respondents (62%) reported that more than half of their geoscience employees are local, which suggests that employers are hiring locally. However, few of these local hires are SOEST graduates.

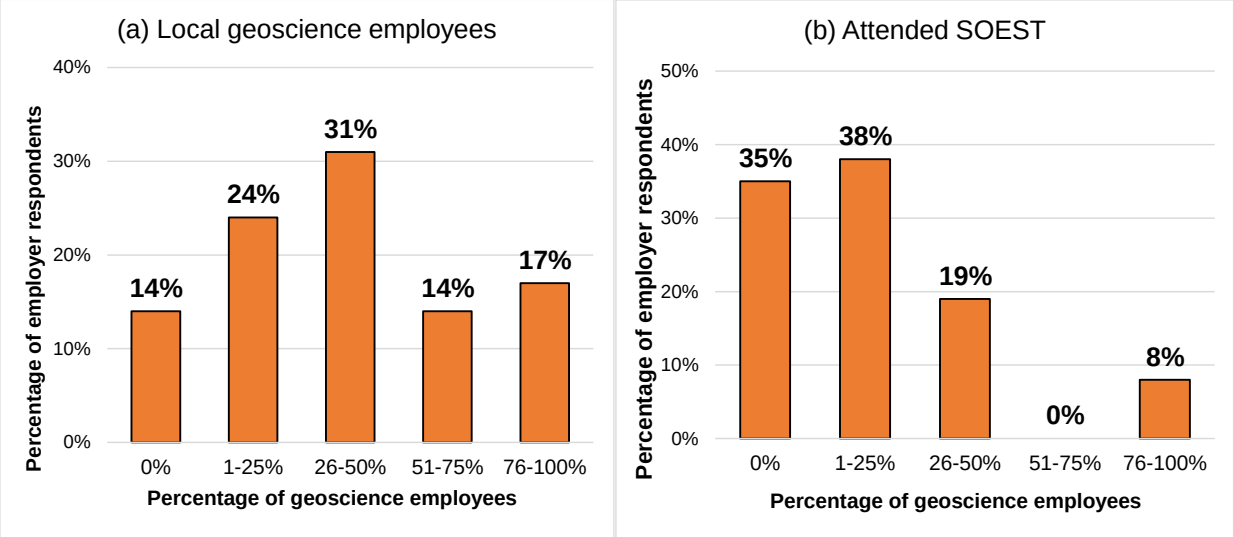

Figure 2. Percentage of geoscience employees at local organizations that (a) are local (born and/or raised in Hawai‘i) (n = 29); and (b) attended SOEST (n = 26). Few employer respondents (38%) reported that less than a quarter of their geoscience employees are local. Most respondents (62%) reported that at least half of their geoscience employees are local. A large percentage of employer respondents (92%) reported that less than a quarter of their organization’s geoscience employees attended SOEST. The remaining respondents (8%) reported more than half of their geoscience employees attended SOEST.

We asked alumni survey respondents to provide the locations of their primary workplace (Figure 3a) as well as the location of their organization’s headquarters (Figure 3b). Nearly half (47%) of

the respondents work locally, but less than a third (30%) work for employers with local headquarters. We did not ask respondents if this location difference was due to pandemic-related work-from-home orders. These data suggest that about half of alumni survey respondents stay in Hawai‘i and find jobs locally, even if their employer’s headquarters are not local.

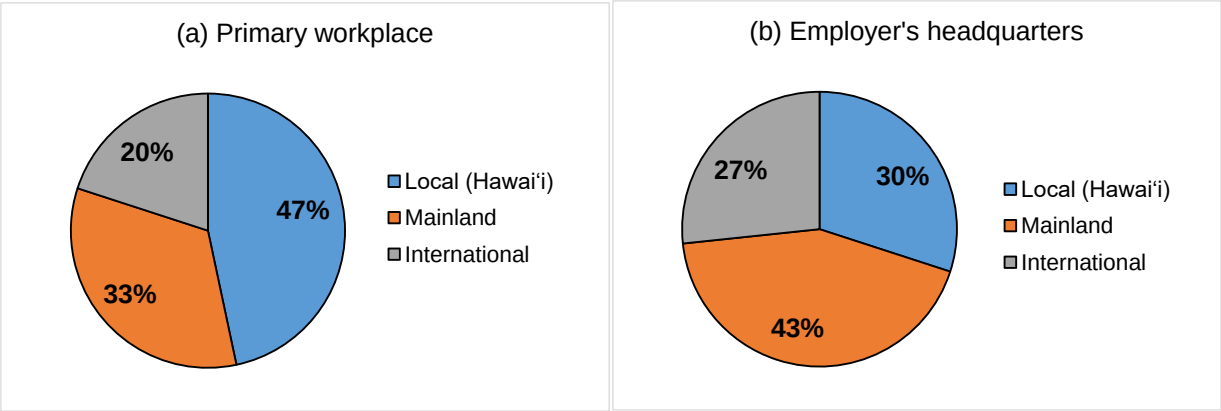

Figure 3. Locations of alumni survey respondents’ (a) primary workplace (n = 30) and (b) organization’s headquarters (n = 30). Nearly half of respondents (47%) work locally, and the other half work on the mainland (33%) and internationally (20%). Less than a third (30%) of respondents have employer headquarters located locally, while a larger portion of respondents have employer headquarters on the mainland (43%) and internationally (27%).

Alumni survey respondents were asked to provide their starting annual salary in four categories: $0-50,000; $50,000-99,999; $100,000-149,999 and $150,000 or over (Figure 4). An overwhelming majority (94%) earned less than $100,000 annually, including over a third (36%) who earned less than $50,000 annually. Since data were presented in categories, mean or median salary could not be calculated. Nevertheless, these data indicate starting salaries for Hawai‘i’s geoscientists would appear to fall short of $93,580 national median pay for geoscientists as of May 2020 (BLS 2021).

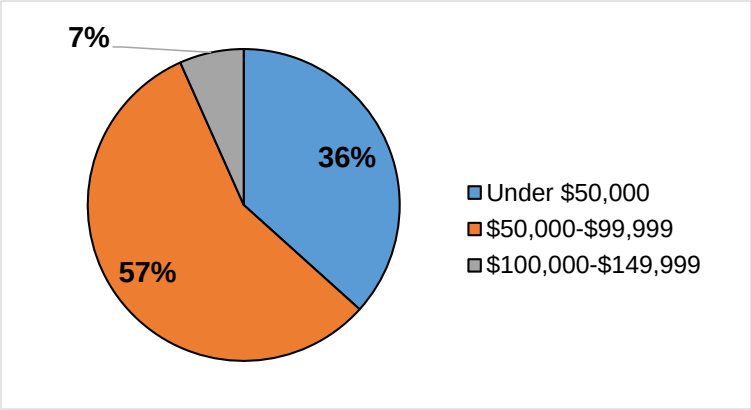

Figure 4. Starting annual salaries of alumni survey respondents (n = 30). More than half (57%) of respondents reported starting salaries in the range of $50,000 to $99,999. About a third (36%) reported a starting salary under $50,000, and only 7% of respondents reported a starting salary of over $100,000. No respondents reported starting salaries exceeding $150,000.

Challenges to employment

When asked about barriers to hiring geoscience employees (Figure 5), more than half (60%) of employer respondents indicated that the low number of applicants from Hawai‘i is a challenge. However, fewer respondents (40%) indicated a low number of applicants overall. These data suggest that local geoscience employers are looking to hire locally, but do not receive enough applications from local geoscientists to do so.

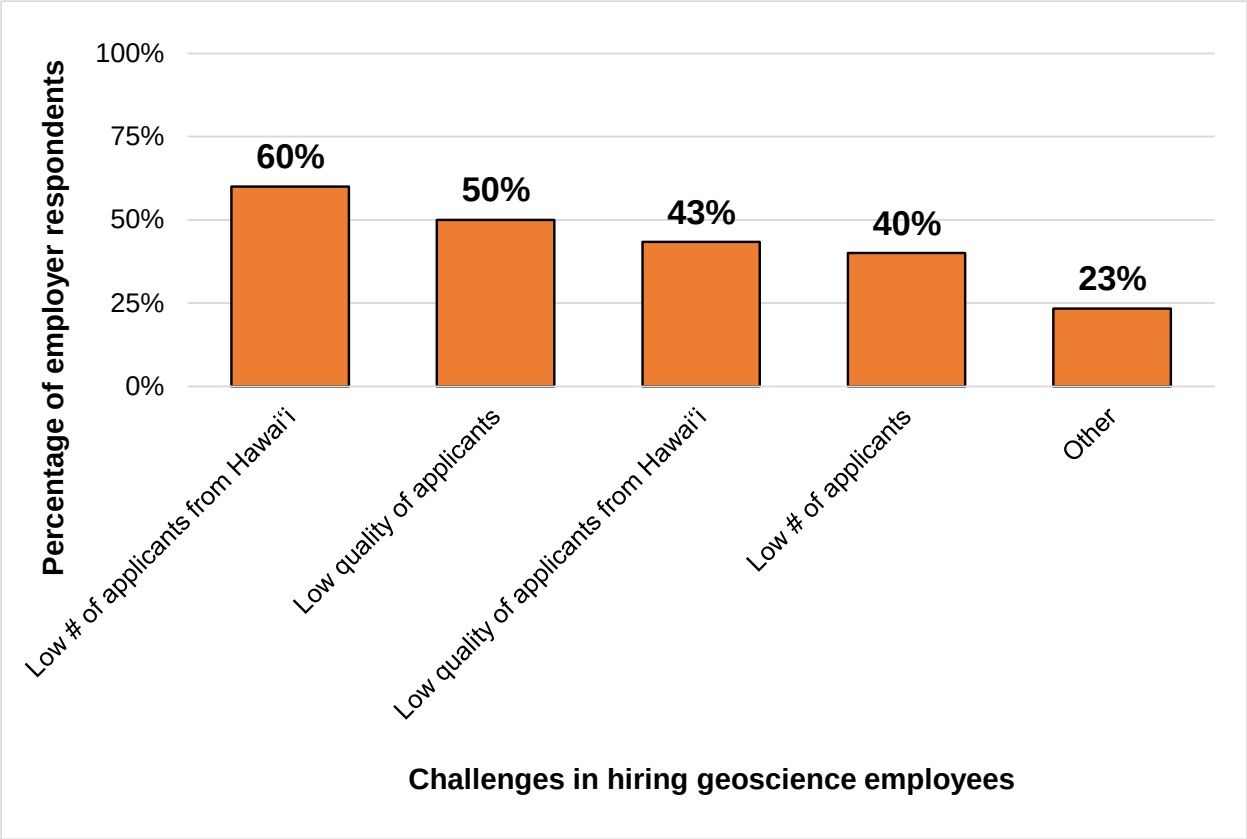

Figure 5. Challenges commonly experienced in hiring geoscience employees (n = 30). More than half (60%) of employer respondents reported a low number of applicants from Hawai‘i, and 40% reported a low number of applicants overall. Half (50%) of employer respondents reported that overall applicant quality is low; slightly fewer employer respondents (43%) indicated that there is a low quality of applicants from Hawai‘i. Other (23%) challenges reported include high numbers of overqualified applicants causing competition and the inability to pay competitive or livable wages.

As shown in Figure 6, we asked alumni survey respondents to indicate current obstacles to obtaining geoscience employment Hawai‘i for themselves and their peers. The top two obstacles reported were inadequate compensation and benefits (61%) and a general (unrelated to the COVID-19 pandemic) scarcity of geoscience jobs in Hawai‘i (57%). COVID-19 pandemic-related issues were a distant third (39%). Only 11% of alumni respondents indicated that local employers lack interest or are unwilling to hire locally. These results suggest that recent SOEST graduates are aware that local geoscience employers want to hire them. However, the number of jobs available and their compensation are common obstacles to finding local employment.

Encouragingly, only 18% of alumni respondents reported insufficient preparation as an obstacle to employment, suggesting that SOEST prepares graduates well for the geoscience workforce. Legacy alumni survey reports recommended that SOEST should better prepare students for the workforce after graduation (Garcia 2001, Houghton 2008). The paucity of alumni respondents reporting that they were insufficiently prepared for the workforce suggests that SOEST has improved in this regard in recent years.

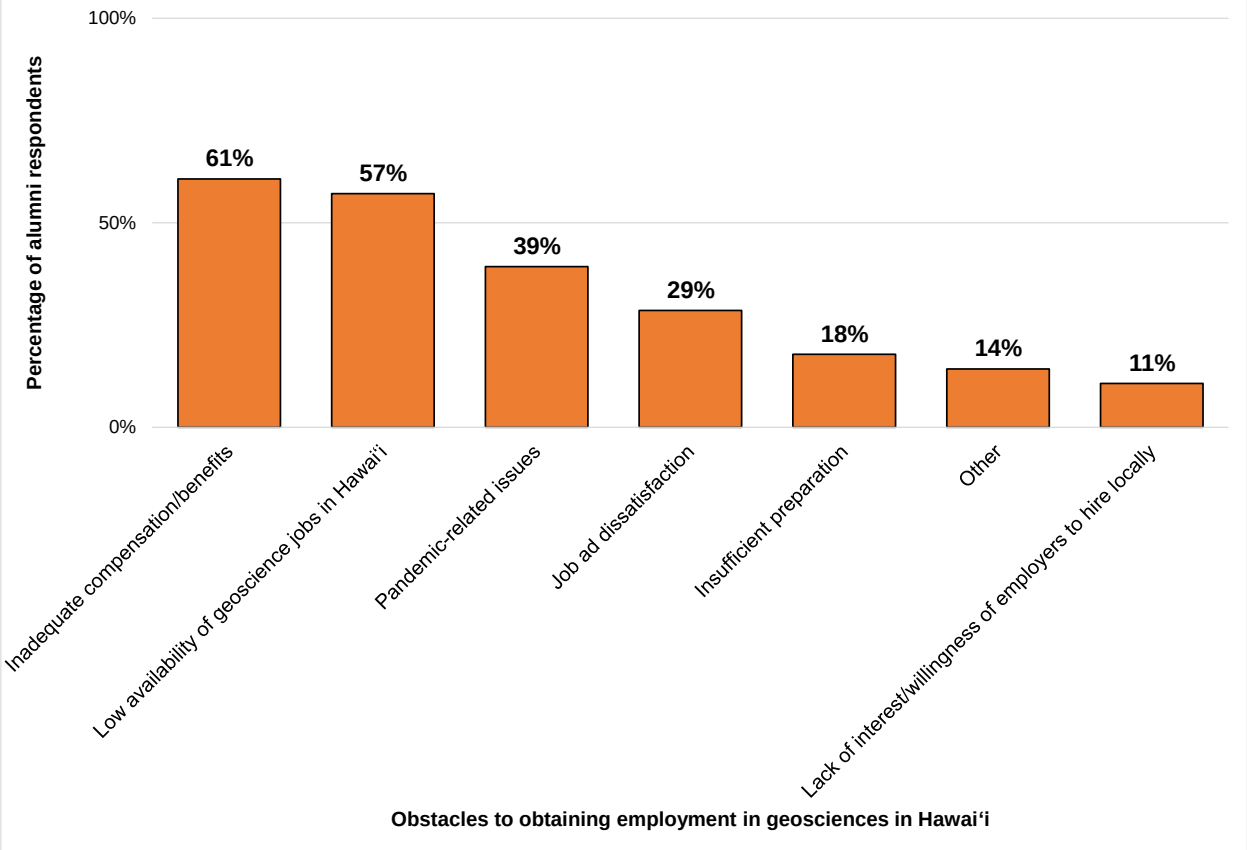

Figure 6. Obstacles to obtaining employment in the geosciences in Hawai‘i (n = 30). The top obstacles were inadequate compensation/benefits (61%) and low availability of geoscience jobs in Hawai‘i (57%). Only 18% of respondents reported that insufficient preparation was an obstacle to employment. Even fewer respondents (11%) reported a lack of interest or willingness of employers to hire locally. Other responses (14%) included lack of experience in contracting, navigating federal government and military contracts, and degree title complications.

We asked alumni to indicate what factors helped them obtain their geoscience positions (Figure 7). The top three factors reported were: networking and personal contacts (77%); previous geoscience employment (53%) and faculty advisor and mentors (37%). This is consistent with historic alumni survey data, which indicated that networking, personal contacts and faculty advisors have been key in helping SOEST alumni in obtaining employment after graduation (Garcia 2001, Houghton 2008).

Interestingly, internships – both paid (20%) and unpaid (10%) – were ranked low. However, given the way the survey questions were administered, it is unclear if this indicates that few respondents participated in an internship (as opposed to participating in an internship but not finding it valuable in obtaining employment).

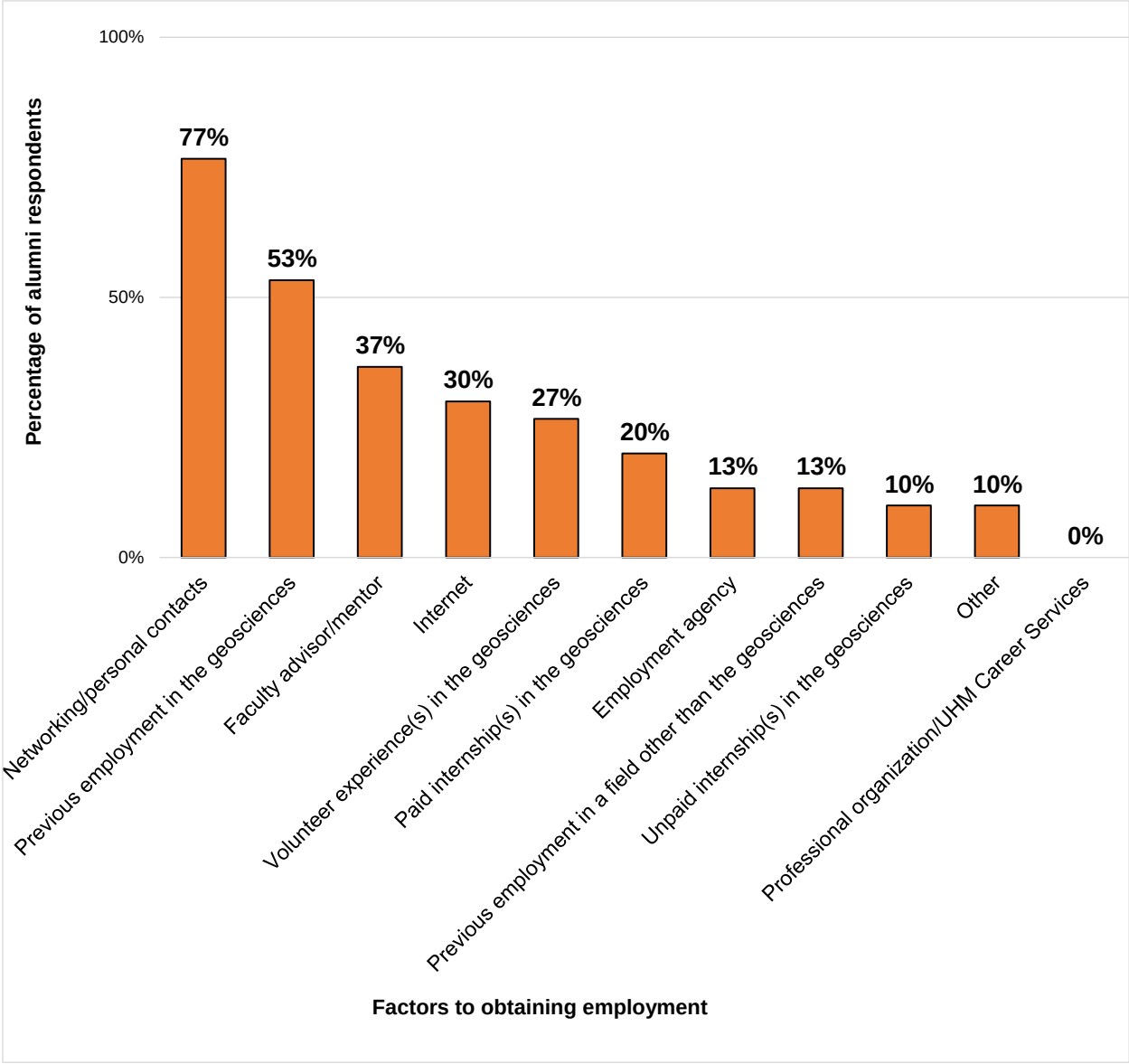

Figure 7. Factors that helped SOEST alumni obtain employment in the geosciences (n = 30). The top factors were networking/personal contacts (77%) and previous employment in the geosciences (53%). Other (10%) responses include veteran status, fieldwork experience, and having local knowledge. No respondents used a professional organization or UHM Career Services to obtain employment.

We asked employers about their internship programs in the past three years (Figure 8a), and their future plans with regards to hosting interns at their organization (Figure 8b). Almost all respondents (90%) hosted interns recently, and 85% of those organizations indicated they offered

paid internships. Encouragingly, nearly all respondents (93%) expressed some interest in hosting interns soon.

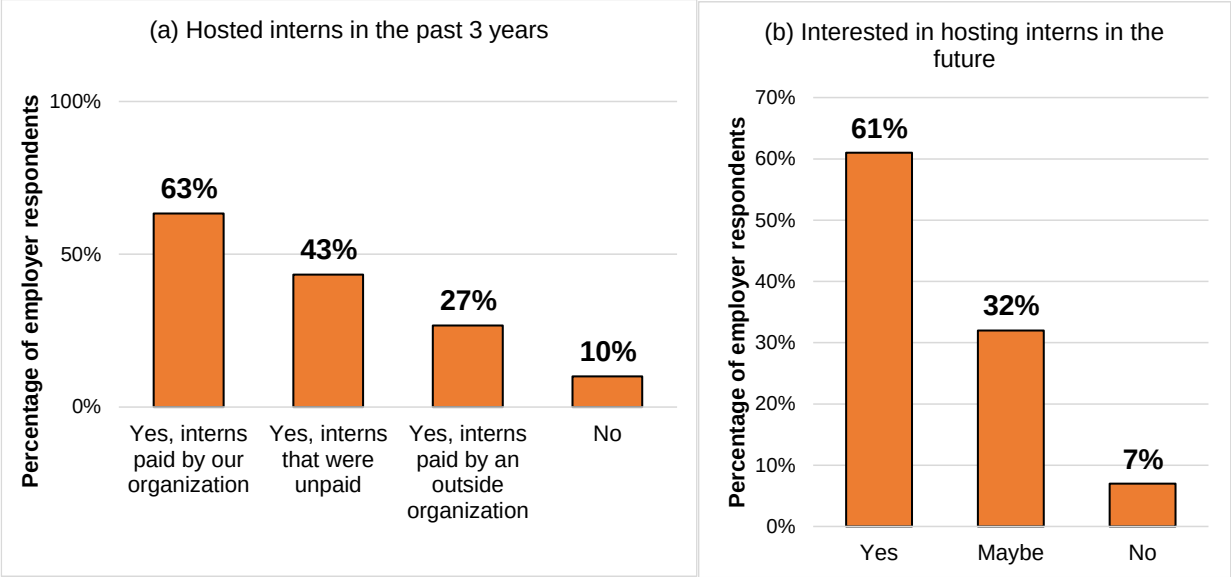

Figure 8. Percentage of employer survey respondents who (a) indicated that they hosted interns in the past three years and their pay status (n = 30) (b) would be interested in hosting interns in the future (n = 28). (a) Employer survey respondents could select more than one option if their organization hosts multiple types of internships (e.g. an unpaid internship and a paid internship funded by an outside organization). Only 10% of employers reported that they did not host interns, and only 7% of employers said they would not be interested in hosting interns in the future.

Skill ratings: technical skills

Table 5 and Figure 9 summarize the mean ratings obtained for technical skills from both the alumni and employer surveys. Across surveys, fieldwork/sampling (4.6), data management (4.4) and data analysis (4.4) are the most highly rated skills (mean ratings >4.3, green stripes). Data visualization (4.1) and GIS skills/mapping (4.1) were also rated as important (mean ratings >4.0, yellow stripes) but significantly less so ($p = 2.2 \times 10^{-4}$). Four skills received mean ratings <4.0 (red stripes): laboratory skills (3.7); computer modeling (3.4); other data science (3.3); and programming/coding (3.2). These four skills were rated significantly less important (p = 5.95 x

10^{-15}). There was no statistically significant difference in the mean ratings of technical skills between surveys, suggesting a broad agreement between alumni and employers.

Table 5. Technical skills mean ratings across the surveys. Respondents were asked to rate the importance of these skills for a geoscientist at their organization to have on a scale of 1 (Strongly Disagree) to 3 (Not Sure) to 5 (Strongly Agree).

Technical skills							
	Both surveys		**Alumni survey**		**Employer survey**		
Skill	**Mean**	**SEM[1]**	**Mean**	**SEM[1]**	**Mean**	**SEM[1]**	**p**
Fieldwork/Sampling	4.58	0.08	4.63	0.10	4.53	0.12	0.19
Data management	4.37	0.09	4.43	0.10	4.30	0.15	0.77
Data analysis	4.37	0.08	4.40	0.11	4.33	0.12	0.92
Data visualization	4.05	0.11	4.30	0.15	3.79	0.14	0.06
GIS skills/Mapping	4.05	0.12	4.10	0.19	4.00	0.15	0.91
Laboratory skills	3.66	0.15	3.83	0.17	3.50	0.24	0.54
Computer modeling	3.41	0.15	3.50	0.22	3.31	0.20	0.81
Other data science	3.30	0.15	3.20	0.23	3.40	0.18	0.79
Programming/coding	3.24	0.18	3.57	0.26	2.90	0.23	0.16

SEM = Standard error of the mean

p = Probability value. For each skill, p is calculated using a one-tailed F-test.

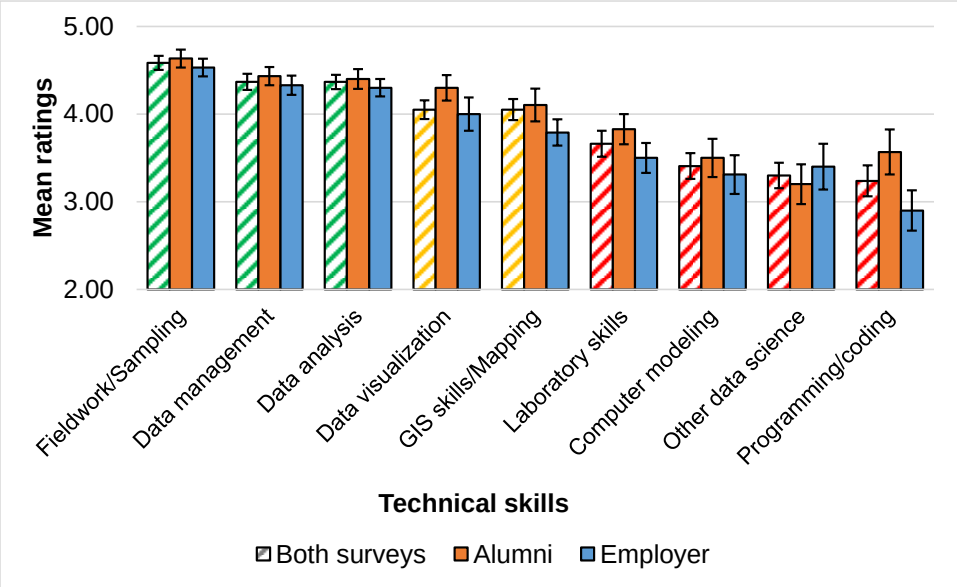

Figure 9. Overall mean ratings of each technical skill by both surveys (striped), alumni survey (orange) and employer survey (blue). Green stripes indicate highly important skills (mean rating ≥4.3) as rated by alumni and employer survey respondents. Yellow stripes indicate important skills (mean rating between 4.3 and 4.0) as rated by alumni and employer survey respondents. Red stripes indicate somewhat important skills (mean rating <4.0) as rated by alumni and employer survey respondents.

As shown in Figure 10, for the employer survey, respondents rated three technical skills highly (mean ratings ≥4.3, green stripes): fieldwork/sampling (4.5), data analysis (4.3), and data management (4.3). Also rated as important (>3.5, yellow stripes) but significantly less so ($p = 2.20 \times 10^{-3}$) by employer survey respondents are GIS skills/mapping (4.0) and data visualization (3.8). The remaining four of the nine received mean ratings ≤3.5 (red stripes) and were statistically rated lower than all other skills ($p = 2.14 \times 10^{-3}$): laboratory skills (3.5); other data science (3.4); computer modeling (3.3); and programming/coding (2.9). Among the different job groupings, there were no statistically significant differences in the mean ratings of these technical skills. This suggests that employers agree on the importance of these skills regardless of geoscience job. Mean ratings, SEMs and p-values can be viewed in Appendix 3.

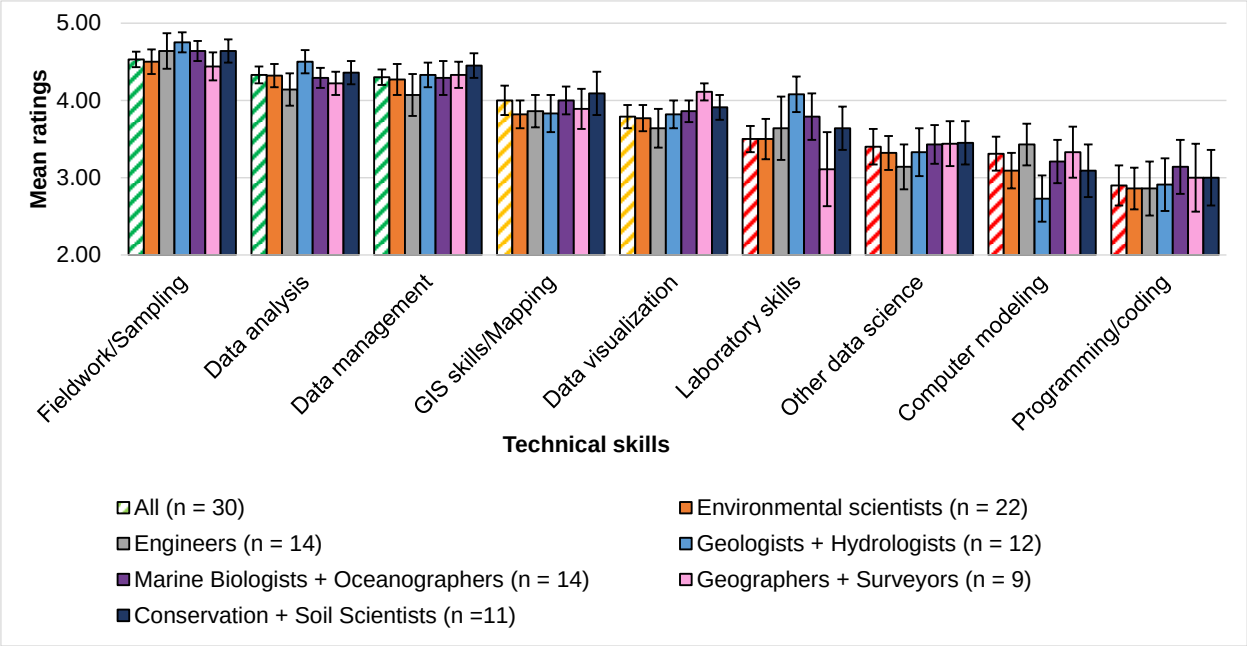

Figure 10. Mean ratings of each technical skill by job grouping from the employer survey. The mean rating for all job groupings is shown at the left of each column, with stripes. Green stripes indicate highly important skills (mean rating ≥4.3) as rated by employer survey respondents. Yellow stripes indicate important skills (mean rating between 4.0 and 3.8) as rated by employer survey respondents. Red stripes indicate somewhat important skills (mean rating ≤3.5) as rated by employer survey respondents.

In Figure 11, for the alumni survey, only fieldwork/sampling (4.6) received a mean rating >4.5, which suggests that alumni find fieldwork/sampling a very important skill for all geoscientists to have. Respondents generally agreed that data management (4.4), data analysis (4.4), data visualization (4.3) and GIS skills/mapping (4.1) are also highly important skills (mean rating >4.0, green stripes). Like the employer survey, laboratory skills (3.8), programming/coding (3.6) and computer modeling (3.5) had significantly lower mean ratings, all <4.0 (yellow stripes, $p = 1.38 \times 10^{-6}$). Other data science (3.2) had the lowest rating (red stripes) and was rated significantly lower than all other skills ($p = 0.04$). Mean ratings, SEMs and p-values can be viewed in Appendix 5.

Only one technical skill (GIS skills/mapping) showed a statistically significant difference ($p = 0.03$) in mean rating among job groupings (Figure 11). This difference may be due to those who

work in geology and hydrology needing to use GIS and other mapping programs more than other job groupings. None of the other skill sets displayed a significant difference among job groupings (p-values range from 0.08 – 0.63, see Appendix 5). This suggests that alumni agree on the importance of the remaining skills regardless of geoscience job.

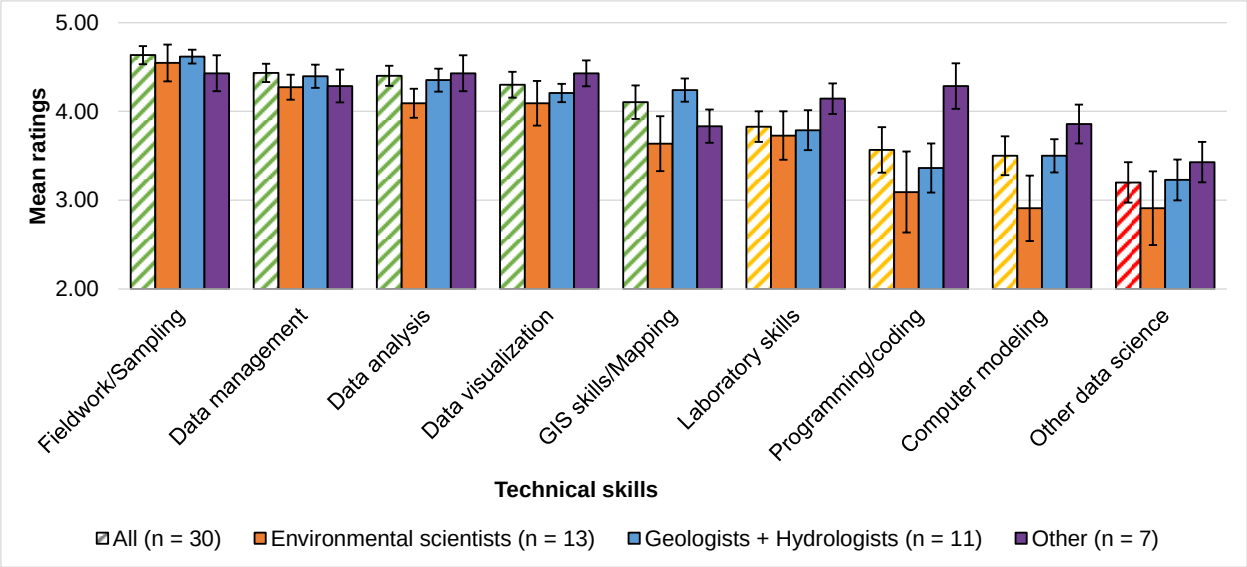

Figure 11. Mean ratings of each technical skill by job grouping from the alumni survey. The mean rating for all job groupings is shown at the left of each column, with stripes. Green stripes indicate highly important skills (mean rating >4.0) as rated by alumni survey respondents. Yellow stripes indicate important skills (mean ratings between 3.8 as rated by alumni survey respondents. Red stripes indicate somewhat important skills as rated by alumni survey respondents.

Skill ratings: non-technical skills

Table 6 and Figure 12 summarize the mean ratings obtained for non-technical skills from both the alumni and employer surveys. Across surveys, six of the eleven non-technical skills had mean ratings ≥4.7 (green stripes): technical report writing (4.8); time management (4.8); teamwork (4.7); problem-solving (4.7); interpersonal communication (4.7); and working independently (4.7). Flexibility (4.5), working well under pressure (4.4), presenting/public speaking (4.3) and leadership (4.0) were overall rated as important (mean rating >3.5, yellow stripes) but significantly less so ($p = 1.03 \times 10^{-16}$). Grant writing (3.0) was the lowest rated skill

(red stripes) and was rated significantly lower than all other skills ($p = 2.91 \times 10^{-19}$). There was no statistically significant difference in the ratings of non-technical skills between surveys. This suggests that, overall, alumni and employers agree on the importance of these non-technical skills for new geoscience employees.

We received written-in comments on the importance of professional interpersonal skills by alumni survey respondents. Some listed emotional intelligence and project and people management as important non-technical skills. Other comments suggested knowledge about working in federal and state government agencies, which tend to operate differently than private companies.

Table 6. Comparison of non-technical skills mean ratings across both surveys. Respondents were asked to rate the importance of these skills for a geoscientist at their organization to have on a scale of 1 (Strongly Disagree) to 3 (Not Sure) to 5 (Strongly Agree).

Non-technical skills							
	Both surveys		**Alumni survey**		**Employer survey**		
Skill	**Mean**	**SEM[1]**	**Mean**	**SEM[1]**	**Skill**	**Mean**	**SEM[1]**
Technical report writing	4.75	0.06	4.77	0.08	4.73	0.10	0.96
Time management	4.75	0.06	4.77	0.09	4.73	0.15	0.96
Teamwork	4.73	0.07	4.77	0.08	4.70	0.11	0.88
Problem-solving	4.73	0.06	4.76	0.08	4.70	0.19	0.88
Interpersonal communication	4.70	0.06	4.77	0.08	4.63	0.10	0.54
Working independently	4.70	0.06	4.73	0.08	4.67	0.17	0.86
Flexibility	4.47	0.09	4.57	0.10	4.37	0.22	0.52
Working well under pressure	4.38	0.10	4.57	0.12	4.20	0.26	0.17
Presenting/Public speaking	4.25	0.09	4.40	0.16	4.10	0.23	0.28
Leadership	4.02	0.10	4.20	0.14	3.83	0.00	0.18
Grant writing	3.02	0.17	3.17	0.24	2.86	0.00	0.65

SEM = Standard error of the mean

p = Probability value. For each skill, p is calculated using a one-tailed F-test.

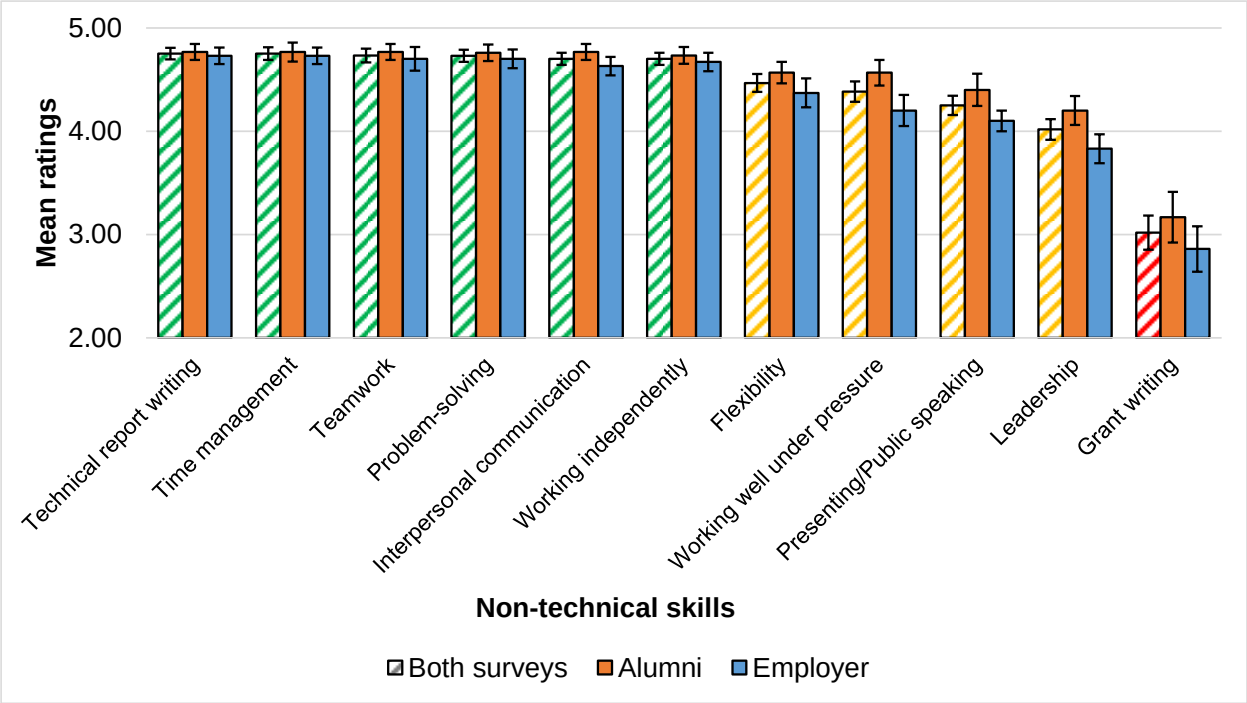

Figure 12. Overall mean ratings of each non-technical skill by both surveys (striped), alumni survey (orange) and employer survey (blue). Green stripes indicate highly important skills (mean rating ≥4.7) as rated by alumni and employer survey respondents. Yellow stripes indicate important skills (mean ratings between 4.5 and 4.0) as rated by alumni and employer survey respondents. Red stripes indicate a somewhat important skill (mean rating ≤3.0) as rated by alumni and employer survey respondents.

For the employer survey (Figure 13), six of the eleven non-technical skills received a mean rating ≥4.7 (green stripes): technical report writing (4.7); time management (4.7); problem-solving (4.7); teamwork (4.7); and working independently (4.7). These data suggest that those six skills are very important for new geoscience employees to have. Employers rated four non-technical skills as important (mean rating <4.5, yellow stripes) but significantly less so ($p = 1.33 \times 10^{-9}$): flexibility (4.4) working well under pressure (4.2); presenting/public speaking (4.1); and leadership (3.8). Grant writing (2.9) received the lowest rating (red stripes) and was rated significantly lower than all other skills ($p = 9.9 \times 10^{-12}$). This suggests that grant writing is a less important skill for most geoscience employees. Overall, among the different job groupings, there were no statistically significant differences in the mean ratings of these non-technical skills.

These data indicate that employers agree on the importance of these skills regardless of geoscience job. Mean ratings, SEMs and p-values can be viewed in Appendix 4.

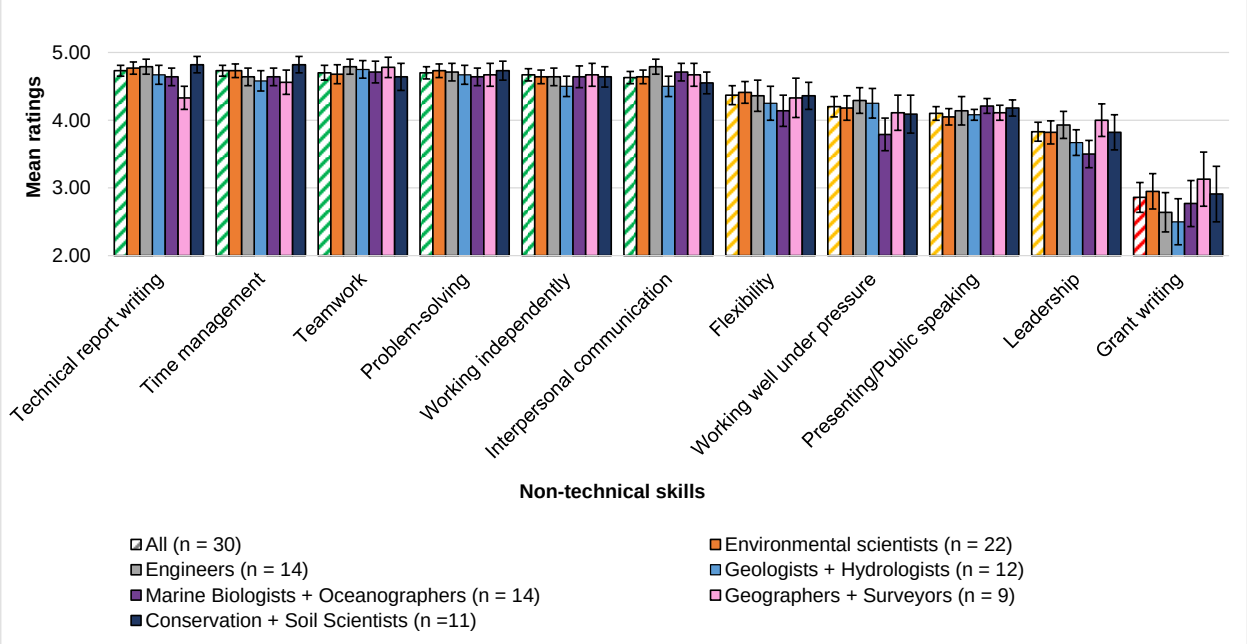

Figure 13. Mean ratings of each non-technical skill by job grouping from the employer survey. The mean rating for all job groupings is shown at the left of each column, with stripes. Green stripes indicate highly important skills (mean ratings ≥4.7) as rated by employer survey respondents. Yellow stripes indicate important skills (mean ratings between 4.4 and 3.8) as rated by employer survey respondents. Red stripes indicate a somewhat important skill (mean rating <3.0) as rated by employer survey respondents.

As shown in Figure 14, for the alumni survey, eight of the eleven non-technical skills (all mean ratings ≥4.5, green stripes) were most highly rated by respondents: technical report writing (4.8); time management (4.8); problem-solving (4.8); teamwork (4.8); interpersonal communication (4.8); working independently (4.7); flexibility (4.6); working well under pressure (4.6); and presenting/public speaking (4.5). Respondents also considered leadership (4.2, yellow stripes) an important skill, but significantly less important ($p = 3.88 \times 10^{-4}$). Grant writing (3.2) once again received the lowest rating (red stripes) and was rated significantly lower than all other non-technical skills ($p = 1.46 \times 10^{-5}$). Mean ratings, SEMs and p-values can be viewed in Appendix 6.

Of the non-technical skills, only grant writing showed a statistically significant difference ($p = 0.03$) among job groupings. This may be due to the importance of grant writing in academia, which formed a large component of the 'Other' category. None of the other skills displayed a significant difference among job groupings (p-values range from 0.07 – 0.99, see Appendix 6). This suggests that alumni agree on the importance of all other non-technical skills regardless of geoscience job.

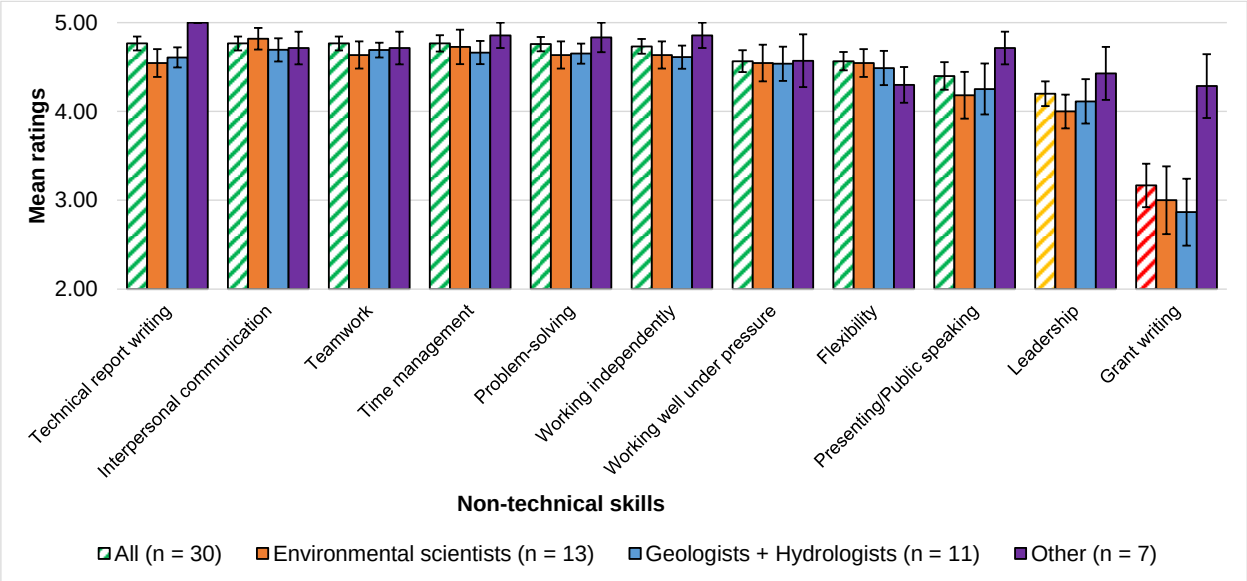

Figure 14. Mean ratings of each non-technical skill by job grouping from the alumni survey. The mean rating for all job groupings is shown at the left of each column, with stripes. Green stripes indicate highly important skills as rated by alumni survey respondents. Yellow stripes indicate important skills as rated by alumni survey respondents. Red stripes indicate somewhat important skills as rated by alumni survey respondents.

Other important skills and knowledge

We concluded the surveys with four open-ended questions. These questions asked respondents to share different data analyses methods, programming/coding languages, specialized software and trainings and certifications used by geoscientists at their organization. The full questions can be viewed in Appendices 1 and 2.

We asked respondents in both surveys to provide the types of data analysis commonly performed at their organizations, if any. Statistical (68% of employer respondents and 60% of alumni respondents) and geospatial (55% of employer respondents and 68% of alumni respondents) analyses were the most common types of data analysis across all geoscience jobs. Modeling (18% of employer respondents and 12% of alumni respondents) was the least common type of data analysis used. Other types of data analyses indicated by alumni included cost analysis, time series analysis, and signal processing.

We also asked respondents in both surveys to share what programming and coding languages are commonly used at their organizations, if any. Most respondents (65% of employer respondents and 57% of alumni respondents) indicated that geoscientists at their organization use Microsoft Suite (Word, Excel, Teams, etc.). Respondents (30% of employer respondents and 46% of alumni respondents) also indicated that Python is used commonly, and alumni respondents heavily emphasized that Python skills were valuable in subsequent comments. These data suggest that coding and programming are becoming increasingly more relevant skills for geoscientists.

Respondents identified specialized software commonly used at their organizations. An overwhelming majority of employer survey respondents (87%) and alumni survey respondents (78%) indicated that their organization used ArcGIS. Other common responses included AutoCAD and Adobe Suite. These responses suggest that ArcGIS remains a relevant and useful tool for geoscientists.

When asked about useful certifications or trainings for geoscientists at their organizations, respondents gave highly variable answers in both surveys. Alumni often wrote that these trainings and certifications were dependent on the position and employer. They also noted that employers generally provide funding or cover the costs for relevant certifications or trainings necessary for job positions. This may suggest that SOEST does not need to turn its focus to offering trainings or certifications for graduates currently.

Conclusions

We conclude this report with a summary of key take-aways from the employer and alumni survey data and offer a few recommendations to improve SOEST graduate success in the geoscience workforce. We also hope to bolster the local workforce by providing recommendations for increasing the hiring of local geoscientists.

Key take-aways from employer and alumni survey data

Compensation & hiring locally. According to alumni survey respondents, about half of SOEST graduates find geoscience jobs in Hawai‘i following graduation. Hawai‘i’s geoscience employers want to hire locally, and most employer respondents (62%) reported that more than half of their geoscience employees are local. This is corroborated by alumni survey data: only 11% of alumni respondents indicated that employers lack willingness or interest to hire locally. However, most employers (60%) shared that the low number (not quality) of applicants from Hawai‘i is the major obstacle to hiring local geoscientists. Alumni reported inadequate compensation benefits and low availability of jobs in Hawai‘i as the most common obstacles to employment in Hawai‘i.

SOEST training & preparation. Encouragingly, only 18% of respondents reported insufficient preparation as an obstacle to employment, suggesting that SOEST prepares graduates well for the geoscience workforce. Legacy alumni survey reports recommended that SOEST should better prepare students for the workforce after graduation (Garcia 2001, Houghton 2008). The paucity of respondents reporting that they were insufficiently prepared for the workforce suggests that SOEST has improved in this regard in recent years. As in past SOEST surveys, most respondents reported networking and personal contacts as helpful for obtaining employment after graduation.

Technical and non-technical skillsets. Hawai‘i geoscience employers and SOEST alumni, regardless of job groupings, agree on which skills are important for geoscience employees to have. Both groups indicated fieldwork and sampling experience and knowledge as important for all geoscience employees. Data handling skills (data management, data analysis, data visualization) were also commonly rated as important. Additionally, both groups agreed on the importance of many non-technical skills, including technical report writing, interpersonal skills

(teamwork, interpersonal communication) and other professional skills (problem-solving, time management, working independently).

Recommendations

1. Provide more hands-on, workforce-relevant experiences and opportunities for students to gather relevant skill sets. With hands-on experiences, students will have the opportunity to gain high-demand skills, such as conducting fieldwork and sampling, data handling skills, and non-technical skills such as technical report writing, teamwork, interpersonal communication, problem-solving, time management and working independently.
2. Help students connect to local employers and expand their professional network. As the state's largest producer of geoscience graduates, SOEST has ample opportunity to foster relationships with local employers. While students are exiting SOEST as qualified scientists, networking and connections are essential to increasing employment opportunity. Networking events, such as career days with local companies and organizations, may help SOEST graduates get their foot in the door with local employers. Advertise existing networking opportunities in the Hawai‘i geoscience community and consider organizing events specifically for SOEST graduates. At a minimum, emphasize to students the importance of developing a professional network prior to graduation.

Acknowledgments

I would like to start with thanking my advisor, Dr. Barb Bruno, for the opportunity to work with her and for her unflinching guidance, support, positivity and patience. I would also like to thank Heather Saito, who was key in the distribution of the alumni survey and also key in my success as my professional development mentor, and Cherryle Heu, who was integral in the inception, distribution and analysis of the employer survey. Additionally, I would like to thank my committee members, Drs. Henrietta Dulai, Deb Eason and Jenny Engels for providing valuable feedback, being incredibly supportive throughout my master's studies, and inspiring me to make a difference wherever I go. Lastly, I'd like to thank my wonderful partner, Henry, our whacky dog, Diego, and my two best friends, Nasim and Sarah, for keeping me together every time.

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Appendices

Appendix 1: Employer survey instrument (Google Form)

Hawai‘i Geoscience Employer Survey

Mahalo for participating. This survey will gather information from Hawai‘i’s employers in the ‘geosciences’, which we broadly define to include geotechnical, environmental, earth, ocean, atmospheric and space science. Our questions seek basic information about the types of work that your company or organization does, and the skills and experiences that you seek in new employees. Your specific responses will only be seen by the University of Hawai‘i (UH) at Mānoa and School of Ocean and Earth Science and Technology (SOEST) personnel to help better understand Hawai‘i’s workforce needs. The survey responses as a whole will be compiled, and the combined data may be shared more broadly. It is our hope that once these data are available, SOEST faculty, staff and students will work together to ensure that students have the opportunity to acquire the necessary training before they graduate to maximize their employability.

If someone else in your company or organization would be more appropriate to complete this survey, please forward this survey link (https://forms.gle/LBGaoKfHALmfGuHR7) to that person.

The survey should take about 15-20 minutes to complete. If you don’t feel comfortable answering any questions, or if you don’t have answers to certain questions, feel free to leave them blank. Providing rough estimates is fine – just take your best guess. You may stop taking the survey at any time.

If you have any questions about this survey, please contact Dr. Barbara Bruno at (808) 956-0901 (barb@hawaii.edu). You may contact the UH Human Studies Program at (808) 956-5007 or uhirb@hawaii.edu to discuss problems, concerns and questions, obtain information, or offer input with an informed individual who is unaffiliated with the specific research protocol. Please visit http://go.hawaii.edu/jRd for more information on your rights as a research participant.

Thank you for your participation!

<u>Part 1: About you & your organization</u>
In this survey, we define ‘geoscience employees’ to be scientists and technicians in any area of ocean, earth, environmental, atmospheric or space science, including geotechnical.

1. Your organization:

2. Your department/division:

3. Your job title:

4. Location of your organization’s headquarters (city and state):

5. Please describe your role in recruiting or selecting new employees (check all that apply):
   - o Create or revise position descriptions
   - o Recruit applicants (e.g., attend job fairs)
   - o Review resumes
   - o Interview applicants
   - o Make hiring decisions
   - o None of the above
   - o Other: _____

6. About how many geoscience employees are usually employed in your department/division of your organization? Please include both full-time and part-time employees on your payroll, but exclude self-employed persons and outside contractors.
   - o More than 100
   - o 51-100
   - o 26-50
   - o 10-25
   - o Fewer than 10

7. About what percentage of these geoscience employees were born and/or raised in Hawai‘i? (please do not type the % sign)

   _____

8. About what percentage of these geoscience employees attended the UH Mānoa School of Ocean and Earth Science and Technology (SOEST)? (please do not type the % sign)

   _____

9. Which of the following job classifications do you employ? (check all that apply)
   - o Astronomers
   - o Atmospheric and Space Scientists
   - o Foresters
   - o Conservation Scientists
   - o Soil and Plant Scientists
   - o Marine/Ocean Engineers
   - o Marine Biologists
   - o Oceanographers
   - o Mining and Geological Engineers
   - o Environmental Engineers
   - o Environmental Engineering Technologists and Technicians
   - o Environmental Science and Protection Technicians
   - o Environmental Scientists and Specialists
   - o Geographers
   - o Surveying and Mapping Technicians
   - o Geological and Hydrological Technicians
   - o Hydrologists

- Geologists
- Geophysicists
- Geochemists
- Other: _____

10. What challenges do you commonly experience when trying to hire geoscience employees? (check all that apply)
    - Low number of applicants
    - Low quality of applicants
    - Low number of applicants from Hawai‘i
    - Low quality of applicants from Hawai‘i
    - None of the above
    - Other: _____

11. About how many geoscience employees do you expect to hire PER YEAR in the next decade? (just take your best guess)
    - 0
    - 1-5
    - 6-10
    - 11-24
    - 25-49
    - >50

12. In the past 3 years, has your organization hosted interns that are students or recent graduates? (check all that apply)
    - Yes, interns paid by our organization
    - Yes, interns paid by an outside organization
    - Yes, interns that were unpaid
    - No

13. Would you be interested in hosting interns in the near future (within the next several years)?
    - Yes
    - No
    - Maybe
    - Other: _____

14. If you have hosted interns, please share details (such as duration of internship, academic level of interns, names of any partners, etc.)

<u>Part 2: Which skills are important for geoscience employees?</u>
In this survey, we define ‘geoscience employees’ to be scientists and technicians in any area of ocean, earth, environmental, atmospheric or space science, including geotechnical.

15. Do you agree or disagree that the NON-TECHNICAL skills below are important for a geoscientist at your organization to have?

	(1) Strongly disagree	(2) Disagree	(3) Not Sure	(4) Agree	(5) Strongly Agree
Technical report writing	☐	☐	☐	☐	☐
Grant writing	☐	☐	☐	☐	☐
Presenting/public speaking	☐	☐	☐	☐	☐
Interpersonal communication	☐	☐	☐	☐	☐
Problem-solving	☐	☐	☐	☐	☐
Teamwork	☐	☐	☐	☐	☐
Working independently	☐	☐	☐	☐	☐
Time management	☐	☐	☐	☐	☐
Leadership	☐	☐	☐	☐	☐
Working well under pressure	☐	☐	☐	☐	☐
Flexibility	☐	☐	☐	☐	☐

Other non-technical skills? Comments?

16. Do you agree or disagree that the TECHNICAL skills below are important for a geoscientist at your organization to have?

	(1) Strongly disagree	(2) Disagree	(3) Not Sure	(4) Agree	(5) Strongly Agree
Data management	☐	☐	☐	☐	☐
Data analysis	☐	☐	☐	☐	☐
GIS skills/Mapping	☐	☐	☐	☐	☐
Programming/coding	☐	☐	☐	☐	☐
Data visualization	☐	☐	☐	☐	☐
Computer modeling	☐	☐	☐	☐	☐
Other data science (e.g., cloud computing, machine learning, etc)	☐	☐	☐	☐	☐
Fieldwork/sampling	☐	☐	☐	☐	☐
Laboratory skills	☐	☐	☐	☐	☐

Other technical skills? Comments?

17. What type of data analysis does your organization most commonly perform, if any? (e.g. statistical, geospatial, etc.)

18. What programming/coding languages does your organization commonly use, if any? (e.g. Python, R, Matlab, Excel, etc.)

19. What specialized software does your organization commonly use, if any? (e.g., ArcGIS, ENVI, etc.)

20. Please describe any trainings or certifications that you look for when hiring geoscience employees, if any.

Closing section

If you are willing to be contacted in case we have additional follow-up questions, please provide your contact information. We will not release this information to a third party.

Name:

Email:

Phone:

Thank you for completing the survey! If you would like to receive a SOEST hat as a token of our gratitude, please provide your name and mailing address, either here or by emailing barb@hawaii.edu. Gifts will be distributed as supplies last.

Name and mailing address for gift:

Appendix 2: Alumni survey instrument (Google Form)

SOEST Alumni Survey of Geoscience Employment

Aloha. This anonymous survey will gather information from alumni of the University of Hawai‘i (UH) at Mānoa School of Ocean and Earth Science and Technology (SOEST) who are currently or have been previously employed in the ‘geosciences’. We broadly define geosciences to include geotechnical, environmental, Earth, ocean, atmospheric and space science. Our questions seek basic information about the type of work that you do, and the skills and experiences that you believe are useful to the geoscience workforce. Graduate assistants should not complete this survey, unless they have another geoscience job.

Your specific responses will only be seen by UH Mānoa and SOEST personnel to help better understand Hawai‘i’s workforce needs. The survey responses as a whole will be compiled, and the combined data may be shared more broadly. It is our hope that once these data are available, SOEST faculty, staff and students will work together to ensure that students have the opportunity to acquire the necessary training before they graduate to maximize their employability.

The survey should take about 10-15 minutes to complete. If you don’t feel comfortable answering any questions, or if you don’t have answers to certain questions, feel free to leave them blank. Providing rough estimates is fine – just take your best guess. You may stop taking the survey at any time.

If you have any questions about this survey, please contact Dr. Barbara Bruno at (808) 956-0901 (barb@hawaii.edu). You may contact the UH Human Studies Program at (808) 956-5007 or uhirb@hawaii.edu to discuss problems, concerns and questions, obtain information, or offer input with an informed individual who is unaffiliated with the specific research protocol. Please visit http://go.hawaii.edu/jRd for more information on your rights as a research participant.

Thank you for your participation!

Preliminary question: How would you best describe your employment situation? (Select the best answer)
In this survey, we define ‘geoscience employees’ to be scientists and technicians in any area of geotechnical, ocean, Earth, environmental, atmospheric or space science.

If you were never employed in the geosciences, or if your only employment in the geosciences has been a graduate assistantship, please do NOT take this survey.

- Current geoscience employee (Proceed to part 1A)
- Previous geoscience employee (Proceed to part 1B) [these will be similar questions to 1A but slightly reworded)

Part 1A: About you & your employer
This section is for SOEST alumni who are current geoscience employees.

1. Your employer:

2. Your department/division:

3. Your job title:

4. Location of your primary workplace (city & state; also state country if not USA):

5. Location of your employer's headquarters, if different from primary workplace (city & state; also state country if not USA):

6. Type of job:
    - Part-time
    - Full-Time
    - Other

7. Starting annual salary:
    - Under $50,000
    - $50,000-$99,999
    - $100,000-$149,999
    - $150,000+

8. What SOEST degree(s) did you earn? (Select all that apply)
    - BA
    - BS
    - MS
    - BAM
    - PhD
    - Other (please specify)

9. What was your major? (Select all that apply)
    - ATMO
    - GES
    - OCEAN
    - EARTH or GG
    - ORE
    - MARINE BIO
    - Other (please specify)

10. Year(s) of graduation:

11. Year of hire with your current employer:

12. Which do you believe helped you obtain your present position? (Select all that apply)
    - Internet

- Professional organization/UHM Career Services
- Networking/personal contacts
- Faculty advisor/mentor
- Employment agency
- Volunteer experience(s) in the geosciences
- Paid internship(s) in the geosciences
- Unpaid internship(s) in the geosciences
- Previous employment in the geosciences
- Previous employment in a field other than the geosciences
- Other (please specify)

13. Which do you believe is currently an obstacle for you and/or your peers to obtain employment in geosciences in Hawai‘i? (Select all that apply)
    - Pandemic-related issues (job scarcity, family/personal health)
    - Low availability of geoscience jobs in Hawai‘i unrelated to the pandemic
    - Lack of interest/willingness of employers to hire locally
    - Inadequate compensation benefits
    - Job ad dissatisfaction (lack of interest in/low quality of available jobs)
    - Insufficient preparation (failure to meet minimum or desired qualifications)
    - Other (please specify)

<u>Part 2A: About geoscience workforce skills</u>

14. Do you agree or disagree that the NON-TECHNICAL skills below are important for a geoscientist at your organization to have?

	(1) Strongly disagree	(2) Disagree	(3) Not Sure	(4) Agree	(5) Strongly Agree
Technical report writing	□	□	□	□	□
Grant writing	□	□	□	□	□
Presenting/public speaking	□	□	□	□	□
Interpersonal communication	□	□	□	□	□
Problem-solving	□	□	□	□	□
Teamwork	□	□	□	□	□
Working independently	□	□	□	□	□
Time management	□	□	□	□	□
Leadership	□	□	□	□	□
Working well under pressure	□	□	□	□	□
Flexibility	□	□	□	□	□

Other NON-TECHNICAL skills? Comments?

15. Do you agree or disagree that the TECHNICAL skills below are important for a geoscientist at your organization to have?

	(1) Strongly disagree	(2) Disagree	(3) Not Sure	(4) Agree	(5) Strongly Agree
Data management	☐	☐	☐	☐	☐
Data analysis	☐	☐	☐	☐	☐
GIS skills/Mapping	☐	☐	☐	☐	☐
Programming/coding	☐	☐	☐	☐	☐
Data visualization	☐	☐	☐	☐	☐
Computer modeling	☐	☐	☐	☐	☐
Other data science (e.g., cloud computing, machine learning, etc)	☐	☐	☐	☐	☐
Fieldwork/sampling	☐	☐	☐	☐	☐
Laboratory skills	☐	☐	☐	☐	☐

Other TECHNICAL skills? Comments?

16. What type of data analysis does you or your colleagues most commonly perform, if any? (e.g. statistical, geospatial, etc.)

17. What programming/coding languages does you or your colleagues commonly use, if any? (e.g. Python, R, Matlab, Excel, etc.)

18. What specialized software does you or your colleagues commonly use, if any? (e.g., ArcGIS, ENVI, etc.)

19. Please describe any trainings or certifications that you believe are useful to have at your organization, if any.

<u>Part 1B: About you & your former employer</u>

This section is for SOEST alumni who were previous (but not current) geoscience employees. Please answer all questions below based on your former geoscience employer. If you had more than one former geoscience employer, please answer these questions based on your FIRST geoscience employment following graduation from SOEST.

1. Your employer:

2. Your department/division:

3. Your job title:

4. Location of your primary workplace (city & state; also state country if not USA):

5. Location of your employer's headquarters, if different from primary workplace (city & state; also state country if not USA):

6. Type of job:
    - Part-time
    - Full-Time
    - Other

7. Starting annual salary:
    - Under $50,000
    - $50,000-$99,999
    - $100,000-$149,999
    - $150,000+

8. What SOEST degree(s) did you earn? (Select all that apply)
    - BA
    - BS
    - MS
    - BAM
    - PhD
    - Other (please specify)

9. What was your major? (Select all that apply)
    - ATMO
    - GES
    - OCEAN
    - EARTH or GG
    - ORE
    - MARINE BIO
    - Other (please specify)

10. Year(s) of graduation:

11. Year of hire:

12. Which do you believe helped you obtain your position? (Select all that apply)
    - Internet
    - Professional organization/UHM Career Services
    - Networking/personal contacts
    - Faculty advisor/mentor
    - Employment agency
    - Volunteer experience(s) in the geosciences
    - Paid internship(s) in the geosciences
    - Unpaid internship(s) in the geosciences
    - Previous employment in the geosciences
    - Previous employment in a field other than the geosciences
    - Other (please specify)

13. Which do you believe is currently an obstacle for you and/or your peers to obtain employment in geosciences in Hawai‘i? (Select all that apply)
    - o Pandemic-related issues (job scarcity, family/personal health)
    - o Low availability of geoscience jobs in Hawai‘i unrelated to the pandemic
    - o Lack of interest/willingness of employers to hire locally
    - o Inadequate compensation benefits
    - o Job ad dissatisfaction (lack of interest in/low quality of available jobs)
    - o Insufficient preparation (failure to meet minimum or desired qualifications)
    - o Other (please specify)

Part 2B: About geoscience workforce skills

14. Do you agree or disagree that the NON-TECHNICAL skills below were important for a geoscientist at your organization to have?

	(1) Strongly disagree	(2) Disagree	(3) Not Sure	(4) Agree	(5) Strongly Agree
Technical report writing	□	□	□	□	□
Grant writing	□	□	□	□	□
Presenting/public speaking	□	□	□	□	□
Interpersonal communication	□	□	□	□	□
Problem-solving	□	□	□	□	□
Teamwork	□	□	□	□	□
Working independently	□	□	□	□	□
Time management	□	□	□	□	□
Leadership	□	□	□	□	□
Working well under pressure	□	□	□	□	□
Flexibility	□	□	□	□	□

Other NON-TECHNICAL skills? Comments?

15. Do you agree or disagree that the TECHNICAL skills below were important for a geoscientist at your organization to have?

	(1) Strongly disagree	(2) Disagree	(3) Not Sure	(4) Agree	(5) Strongly Agree
Data management	□	□	□	□	□
Data analysis	□	□	□	□	□
GIS skills/Mapping	□	□	□	□	□
Programming/coding	□	□	□	□	□
Data visualization	□	□	□	□	□
Computer modeling	□	□	□	□	□
Other data science (e.g., cloud computing, machine learning, etc)	□	□	□	□	□

Fieldwork/sampling	□	□	□	□	□
Laboratory skills	□	□	□	□	□

Other TECHNICAL skills? Comments?

16. What type of data analysis did you or your colleagues most commonly perform, if any? (e.g. statistical, geospatial, etc.)

17. What programming/coding languages did you or your colleagues commonly use, if any? (e.g. Python, R, Matlab, Excel, etc.)

18. What specialized software did you or your colleagues commonly use, if any? (e.g., ArcGIS, ENVI, etc.)

19. Please describe any trainings or certifications that you believe are useful to have at your organization, if any.

Closing section

If you are willing to be contacted in case we have additional follow-up questions, please provide your contact information. We will not release this information to a third party.

Name:

Email:

Phone:

Thank you for completing the survey! If you would like to receive a SOEST hat as a token of our gratitude, please provide your name and mailing address, either here or (to protect your anonymity) by emailing barb@hawaii.edu. Gifts will be distributed as supplies last.

Name and mailing address for gift:

Appendix 3: Employer survey mean ratings of technical skill sets for each job grouping plus and minus the standard error of the mean (see Table 4 for job classifications within each grouping)

Skills	All	Environmental	Engineers	Geologists +Hydrologists	Ocean Scientists + Engineers	Geographers + Surveyors	Conservation Scientists + Soil Scientists	p
Fieldwork /Sampling	4.53 ±0.12	4.50 ±0.10	4.64 ±0.13	4.75 ±0.15	4.64 ±0.13	4.44 ±0.18	4.64 ±0.15	0.86
Data analysis	4.33 ±0.12	4.32 ±0.26	4.14 ±0.29	4.50 ±0.34	4.29 ±0.34	4.22 ±0.15	4.36 ±0.15	0.78
Data management	4.30 ±0.15	4.27 ±0.12	4.07 ±0.21	4.33 ±0.08	4.29 ±0.11	4.33 ±0.26	4.45 ±0.28	0.92
GIS skills/Mapping	4.00 ±0.14	3.82 ±0.10	3.86 ±21	3.83 ±0.08	4.00 ±0.11	3.89 ±0.26	4.09 ±0.28	0.95
Data visualization	3.79 ±0.14	3.77 ±0.10	3.64 ±0.13	3.82 ±0.14	3.86 ±0.13	4.11 ±0.11	3.91 ±0.16	0.73
Laboratory skills	3.50 ±0.24	3.50 ±0.17	3.64 ±0.20	4.08 ±0.19	3.79 ±0.20	3.11 ±0.48	3.64 ±0.28	0.86
Other data science	3.40 ±0.18	3.32 ±0.10	3.14 ±0.13	3.33 ±0.15	3.43 ±0.13	3.44 ±0.29	3.45 ±0.28	0.97
Computer modeling	3.31 ±0.20	3.09 ±0.14	3.43 ±0.11	2.73 ±0.13	3.21 ±0.16	3.33 ±0.33	3.09 ±0.34	0.67
Programming/coding	2.90 ±0.23	2.86 ±0.10	2.86 ±0.11	2.91 ±0.15	3.14 ±0.13	3.00 ±0.44	3.00 ±0.36	0.99

p = Probability value. For each skill, p is calculated using a one-tailed F-test.

Appendix 4. Employer survey mean ratings of non-technical skill sets for each job grouping plus and minus the standard error of the mean (see Table 4 for job classifications within each grouping)

Skill	All	Environmental	Engineers	Geologists +Hydrologists	Ocean Scientists + Engineers	Geographers + Surveyors	Conservation Scientists + Soil Scientists	p
Technical report writing	4.73 ±0.08	4.77 ±0.09	4.79 ±0.11	4.67 ±0.14	4.64 ±0.13	4.33 ±0.17	4.82 ±0.12	0.17
Time management	4.73 ±0.08	4.73 ±0.10	4.64 ±0.13	4.58 ±0.15	4.64 ±0.13	4.56 ±0.18	4.82 ±0.12	0.80
Problem-solving	4.70 ±0.09	4.73 ±0.10	4.71 ±0.13	4.67 ±0.14	4.64 ±0.13	4.67 ±0.17	4.73 ±0.14	0.99
Teamwork	4.70 ±0.11	4.68 ±0.14	4.79 ±0.11	4.75 ±0.13	4.71 ±0.16	4.78 ±0.15	4.64 ±0.20	0.98
Working independently	4.67 ±0.09	4.64 ±0.10	4.64 ±0.13	4.50 ±0.15	4.64 ±0.13	4.67 ±0.17	4.64 ±0.15	0.97
Interpersonal communication	4.63 ±0.09	4.64 ±0.10	4.79 ±0.11	4.50 ±0.15	4.71 ±0.13	4.67 ±0.17	4.55 ±0.16	0.70
Flexibility	4.37 ±0.14	4.41 ±0.16	4.36 ±0.23	4.25 ±0.25	4.14 ±0.23	4.33 ±0.29	4.36 ±0.20	0.95
Working well under pressure	4.20 ±0.15	4.18 ±0.18	4.29 ±0.19	4.25 ±0.22	3.79 ±0.24	4.11 ±0.26	4.09 ±0.28	0.66
Presenting/ Public speaking	4.10 ±0.10	4.05 ±0.12	4.14 ±0.21	4.08 ±0.08	4.21 ±0.11	4.11 ±0.11	4.18 ±0.12	0.95
Leadership	3.83 ±0.14	3.82 ±0.17	3.93 ±0.20	3.67 ±0.19	3.50 ±0.20	4.00 ±0.24	3.82 ±0.26	0.62
Grant writing	2.86 ±0.22	2.95 ±0.26	2.64 ±0.29	2.50 ±0.34	2.77 ±0.34	3.13 ±0.40	2.91 ±0.40	0.86

p = Probability value. For each skill, p is calculated using a one-tailed F-test.

Appendix 5. Alumni survey mean ratings of technical skill sets for each job grouping plus and minus the standard error of the mean (see Table 4 for job classifications within each grouping)

Skills	All	Environmental	Geologists, Hydrologists & Geographers	Other	p
Fieldwork/Sampling	4.63 ±0.10	4.55 ±0.21	4.62 ±0.37	4.43 ±0.20	0.26
Data management	4.43 ±0.10	4.27 ±0.14	4.40 ±0.38	4.29 ±0.18	0.19
Data analysis	4.40 ±0.11	4.09 ±0.16	4.35 ±0.38	4.43 ±0.20	0.08
Data visualization	4.30 ±0.15	3.09 ±0.25	4.21 ±0.37	4.43 ±0.15	0.56
GIS skills/Mapping	4.10 ±0.19	3.64 ±0.31	4.24 ±0.39	3.83 ±0.19	0.03
Laboratory skills	3.83 ±0.17	3.73 ±0.27	3.79 ±0.41	4.14 ±0.17	0.60
Programming/coding	3.57 ±0.26	3.09 ±0.46	3.36 ±0.43	4.29 ±0.26	0.22
Computer modeling	3.50 ±0.22	2.91 ±0.37	3.30 ±0.41	3.86 ±0.22	0.12
Other data science	3.20 ±0.23	2.91 ±0.41	3.23 ±0.42	3.43 ±0.23	0.63

p = Probability value. For each skill, p is calculated using a one-tailed F-test.

Appendix 6. Alumni survey mean ratings of non-technical skill sets for each job grouping plus and minus the standard error of the mean (see Table 4 for job classifications within each grouping)

Skills	All	Environmental	Geologists, Hydrologists & Geographers	Other	p
Technical report writing	4.77 ±0.08	4.55 ±0.16	4.61 ±0.37	5.00 ±0.00	0.07
Time management	4.77 ±0.08	4.82 ±0.12	4.69 ±0.37	4.71 ±0.18	0.87
Problem-solving	4.77 ±0.08	4.64 ±0.15	4.69 ±0.37	4.71 ±0.18	0.51
Teamwork	4.77 ±0.09	4.73 ±0.19	4.66 ±0.37	4.86 ±0.14	0.29
Interpersonal communication	4.76 ±0.08	4.64 ±0.15	4.65 ±0.37	4.83 ±0.17	0.88
Working independently	4.73 ±0.08	4.64 ±0.15	4.61 ±0.37	4.86 ±0.14	0.61
Flexibility	4.57 ±0.12	4.55 ±0.21	4.54 ±0.37	4.57 ±0.30	0.99
Working well under pressure	4.57 ±0.10	4.55 ±0.16	4.49 ±0.37	4.30 ±0.20	0.99
Presenting/Public speaking	4.49 ±0.16	4.18 ±0.26	4.25 ±0.39	4.71 ±0.18	0.45
Leadership	4.20 ±0.14	4.00 ±0.19	4.11 ±0.38	4.43 ±0.30	0.50
Grant writing	3.17 ±0.24	3.00 ±0.38	2.87 ±0.42	4.29 ±0.36	0.03

p = Probability value. For each skill, p is calculated using a one-tailed F-test.