Results of the National Geoscience Faculty Survey (2004 - 2016)

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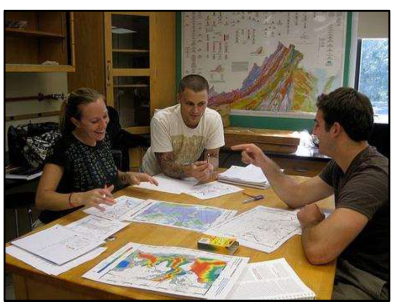

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Professional Development for Geoscience Faculty

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Additional information
More details about the survey, including all four survey instruments, can be found on the website: https://serc.carleton.edu/NAGTWorkshops/CE_geo_survey/index.html

Acknowledgements
The 2004, 2006, and 2009 surveys were developed and administered by leaders of the On The Cutting Edge professional development program: R. Heather Macdonald, Rachel Beane, Cathryn Manduca, David McConnell, David Mogk, Barbara Tewksbury, Katryn Wiese, and Michael Wysession, in consultation with statistical personnel and project evaluators. The 2016 survey was developed by a research team involving leadership of the professional development programs On the Cutting Edge, InTeGrate, and SAGE 2YC: Cathryn Manduca, R. Heather Macdonald, Anne Egger, Karen Viskupic, and Ellen Iverson with help from Becky Lien of Professional Data Analysts and Lija Greenseid of Greenseid Consulting Group. In addition, data from the 2016 survey were analyzed by a National Geoscience Faculty Survey Research Team whose work and discussions informed this report: Rachel Beane, Anne Egger, Cory Forbes, Kusali Gamage, Ellen Iverson, Kim Kastens, R. Heather Macdonald, Cathryn Manduca, Rory McFadden, Karen McNeal, Kathleen Quardokus Fisher, Catherine Riihimaki, and Karen Viskupic.

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Introduction

The purpose of this report is to summarize the responses to the core questions of the National Geoscience Faculty Survey. This report will be useful to researchers interested in related studies, education stakeholders interested in understanding the current state of the discipline, and future development of national surveys.

Our use of the word *geoscience* follows the sense of the National Science Foundation, and is inclusive of Earth, atmospheric, and ocean sciences. Our use of the word *faculty* is inclusive of all college-level instructors, including tenured and tenure-track faculty, non-tenure track lecturers/instructors, and adjunct/part-time instructors.

Our approach to writing this report was to present frequencies of question responses with minimal interpretation or statistical analysis. Members of the 2016 National Geoscience Faculty Survey Research Team are publishing papers with more detailed analyses; our focus is on presenting frequencies that may be of high value to the geoscience and broader STEM education communities, and that may generate new research questions that can be addressed with further interrogation of survey results. With this philosophy in mind, we included computed variables only in service to demonstrating the representativeness of the survey sample (e.g. state, course topics), and left other computed variables (e.g. sums, cluster analyses) to be reported in journal publications with more detailed analyses.

All questions described in this report were asked in the 2016 survey, and many were asked in prior surveys administered in 2012, 2009, and 2004. We do not report responses to any questions that were asked in pre-2016 surveys that were discontinued. We also excluded questions about the use of SERC resources or websites.

Data frequencies are reported as percentages of survey respondents and can be found in both Tables and figures. Histograms are used when more than one year of survey responses are available in order to illustrate any trends over time, otherwise, data are presented in Tables.

Chapter 1: Survey design

Overview

The National Geoscience Faculty Survey was designed to gather information about how faculty teach in undergraduate geoscience courses, learn about pedagogy and content, and participate in the geoscience education and research communities. The survey has been administered four times: in 2004, 2009, 2012, and 2016. The original 2004 survey was developed as part of On the Cutting Edge, a National Science Foundation (NSF)-funded professional development program for geoscience faculty sponsored by the National Association of Geoscience Teachers (NAGT). Subsequent surveys preserved core questions while adding, deleting, and revising questions to collect information to address new areas of interest. The first three surveys were developed by the leadership of On the Cutting Edge. The 2016 survey was developed by a research team involving leadership of the professional development programs On the Cutting Edge, InTeGrate, and SAGE 2YC, with support from their NSF grants (see Appendix A).

Survey design and testing

In all four surveys, after a set of demographic questions, faculty were asked to respond to a set of questions related to their teaching responsibilities (e.g., introductory, majors, or graduate courses) in the previous year. In all four survey administrations, the answers to these questions served as conditional branching. Respondents who only taught introductory courses were presented questions about the most recent introductory course they taught; those who only taught majors courses were presented with questions related to the most recent majors course. Respondents who indicated that they taught both introductory and majors courses were randomly assigned to answer questions in either the introductory or majors course section. Following these items were an additional set of questions related to professional development. In the last three administrations, faculty who only taught graduate courses were directly presented the professional development items. In the 2004 and 2009 surveys, the conditional branching questions asked respondents to report how many of each type of course they taught in the previous year. Respondents in these years also had the option of answering questions on multiple introductory courses or multiple majors courses. In the 2012 and 2016 administrations, conditional branching depended on responses to two questions. The first asked whether or not they taught undergraduate courses in the previous year, and the second asked more about the courses they taught for undergraduates (if applicable): specifically, whether they taught introductory courses, majors courses, or both introductory and majors.

For all four administrations, content validity and face validity were established first by the development of question items through a team of experts, and then by piloting with a sample of non-experts. The 2004 survey was developed by the principal investigators of On the Cutting

Edge in collaboration with the external evaluator, Dr. John McLaughlin, and the Statistical Research Group at the American Institute of Physics (AIP). This same group modified the instrument in 2009 based on the results of the 2004 administration. In 2012, the survey was modified by On the Cutting Edge leadership and evaluators in consultation with Professional Data Analysts, which was contracted to complete the data analysis of the 2009 survey, administer the 2012 survey, and help to analyze the results. The revisions for the 2016 survey were developed by a research team involving leadership from On the Cutting Edge, InTeGrate, and SAGE 2YC, with additional input from Greenseid Consulting Group, LLC., and Professional Data Analysts.

The items for the 2004 survey were tested for clarity in a pilot survey administered to 16 faculty as well as through interviews with five faculty at the American Geophysical Union (AGU) Fall 2002 meeting. For the 2009 survey, revised items were tested using a written survey and associated interviews conducted by the internal and external evaluators with 37 faculty at the AGU Fall 2007 meeting. A separate field test of 12 question items related to what influences faculty to change their teaching was completed by 53 participants in the Teaching Introductory Geoscience in the 21st Century workshop via an online form. A full pilot was administered to 30 randomly selected faculty from the survey sample. For the 2012 survey, expert reviews and think-aloud administrations were conducted with four faculty. The 2016 survey was administered as a pilot to 200 faculty who were randomly selected from the survey sampling frame with 33 responses to the pilot. The pilot included feedback questions about the survey but no common themes emerged and only minor changes were made to the final survey (see Appendix B).

Survey administration and response rate

All four surveys were administered by email to lists of identifiable geoscience faculty who taught undergraduate courses in the United States. With each administration, efforts were made to reach the most complete sample. All surveys were based on lists developed with the help and permission of the American Geosciences Institute (AGI). From each administration email list, full names, email addresses, and institutional names corresponding to a respondent ID were kept in a separate password protected file that is not part of the analyzed survey data set.

Table 1.1. Survey response rate

	2004	2009	2012	2016
Email requests	5700	5917	7784	9496
Total responses	2207	2874	2466	2615
Response rate	39%	49%	32%	27%

The 2004 survey was emailed to a list of 7435 emails developed with the assistance of the AGI. Approximately 1200 emails were returned as bad or invalid. 520 faculty indicated that they either had retired or did not teach undergraduate courses. Of the approximately 5700 remaining faculty who received the survey, 2207 faculty participated (Table 1.1).

The 2009 survey was sent by email to 5107 faculty in March from a list developed with the help of AGI, and sent to an additional 810 faculty in September, including On the Cutting Edge geoscience faculty workshop participants who had not been part of the original invitation list. The responses to the two survey administrations in 2009 were combined following a comparative analysis of the two respondent pools, with a total of 2874 faculty participating (Table 1.1). In comparing the original 2009 survey sample with the supplementary sample, the supplementary group was far more likely to have a master's degree as their highest degree, was far more likely to have earned their degree within the last five years, and was less likely to be teaching. For questions about teaching practice, the analysis between the two pools of survey respondents demonstrated no significance statistically based on the populations. In short, the supplemental group appeared to be younger and less likely to be teaching than the original group, but their behavior in the classroom seemed the same.

The 2012 survey was sent to 7784 faculty. This email list was created from records from four sources: 1) AGI list obtained with permission for this use, 2) email list of two-year college geoscience faculty compiled from institutional data sources and augmented by two-year college instructors who requested being included in such a list, 3) email list of atmospheric science or meteorology faculty generated from list of institutions offering degree programs listed on the American Meteorological society website, and 4) On the Cutting Edge participants. A separate listing of oceanography faculty, while sought, was not available for the survey, although many oceanography programs are included in the AGI Directory. From this list, 182 individuals formally opted out of the survey, and 2466 faculty participated (Table 1.1).

The 2016 survey was sent by email to 10,910 faculty from the following geoscience faculty lists: AGI list obtained with permission for this use; a list of faculty at Texas Two-Year Colleges generated from public websites of two year colleges; the Supporting and Advancing Geoscience Education at Two-Year Colleges (SAGE2YC) list obtained with permission from the PIs, a geosciences two-year colleges list comprising instructors from two-year colleges generated from public institutional websites with guidance from regional contacts in New York, Wisconsin, Oregon, Washington State, Idaho, and Illinois; a list of atmospheric science faculty generated from public institutional websites linked from the American Meteorological Society website; the On the Cutting Edge participant list; and an additional set of On the Cutting Edge participants specific to the Early Career workshop obtained with permission from the PIs. Duplicates were removed in compiling these lists. A total of 2615 faculty completed one or more questions to the survey (Table 1.1). See Appendix B for more details on the response rate for the 2016 survey.

The total number of email survey invitations has increased over the four administrations; the number of responses has not increased commensurately, and the overall response rate has decreased (Table 1.1).

Limitations

Coverage, sampling, and nonresponse bias are limitations of the survey methods used. In all four administrations, the project team attempted to develop a census sample that included all faculty who teach undergraduates in the geosciences. Developing a census approach for surveying large populations is difficult and with each administration efforts were made to identify a more complete sample. For example, in 2012, the inclusion of faculty in two-year colleges was substantially enhanced. Each of the contributing lists to the sample may bring limitations. For instance, the AGI list is constantly updated via contacts that the organization uses for the Directory of Geoscience Departments, but the completeness of the list is dependent on those contacts (Christopher Keane, personal communication, 2012). The On the Cutting Edge participant list only includes faculty who have participated in a particular national professional development program, and these faculty may have more of an affinity to improved teaching than the full geoscience faculty population.

Moreover, nonresponse error occurs in each administration. For the 2016 administration, two response-bias analyses were conducted to determine the representativeness of survey respondents compared to non-respondents (see Appendix B).

With any survey approach, there are limitations to self-reported data. By design, the survey asks faculty to report on teaching approaches for a single introductory or majors course. However, their teaching behaviors may vary across the courses they teach. Additionally, like any survey approach, participants are asked to recall and report on their behaviors which could introduce error due to faulty recall or unintentionally responding in ways that would be viewed favorably by others (e.g., social desirability bias).

Finally, the survey item design may introduce limitations. The survey items varied by administration year with only a subset of questions held constant. Longitudinal study of participants over time is not feasible as respondents may be reporting on a different type of course (introductory vs majors) with each administration and their identifying information may change (emails, names). The survey makes use of single-item measures for particular constructs such as metacognition which may limit the predictive validity of the measure. Some of the survey items rely on a dichotomous scale (“select all that apply”) rather than a Likert scale. Dichotomous scales may limit the type of analyses that are possible.

Chapter 2: Characteristics of geoscience faculty

This chapter describes survey questions that characterize respondents in terms of their degree, disciplinary focus, academic position, time spent teaching, types of courses taught, and engagement in the scientific and education communities through dissemination of research and education products. In addition, institution type and geographic location of respondents were derived from survey administration data. When possible, these demographic characteristics are compared to those of the larger population of geoscience faculty in the United States to establish the representativeness of the survey samples.

Demographics of survey respondents

This section describes who responded to the survey according to several parameters. As noted in Table 1.1, n = 2207 in 2004, n = 2874 in 2009, n = 2466 in 2012, and n = 2615 in 2016. The totals given in each of the following Tables may be less than these numbers, and indicate how many of the respondents answered that particular question.

The American Geosciences Institute (AGI) maintains a database of geoscience departments in the United States. To assess the extent to which we are reaching a representative subsample of the full population of geoscience faculty in the United States, we compare our demographic distribution with published data from AGI and other organizations where possible.

Disciplinary focus

Respondents were asked to indicate their disciplinary focus (Table 2.1). In the 2004, 2009, and 2012 administrations, possible options were Geology or Geophysics, Oceanography or Marine Sciences, Atmospheric Science or Meteorology, and Other, with an open-response box if "other" was selected. In 2016, the option of Geoscience Education/Science Education was added.

Table 2.1. Respondents' disciplinary focus

Disciplinary focus	2004 (n = 2094)	2009 (n = 2785)	2012 (n = 2348)	2016 (n = 2600)	2017 AGI data**
Geology or geophysics	64.5%	62.8%	65.5%	58.1%	55.4%
Oceanography or marine sciences	12.6%	11.3%	8.6%	9.3%	8.5%
Atmospheric science or meteorology	5.6%	6.5%	9.1%	9.5%	7.6%
Other	17.3%	19.4%	16.7%	23.2%*	28.5%

* Includes 7.1% who selected Geoscience Education/Science Education as their discipline.

** See text for explanation

In all four administrations, the majority of respondents selected Geology or Geophysics as their disciplinary focus, although it dropped from 65.5% in 2012 to 58.1% in 2016. This could be partly attributed to the addition of the option of Geoscience Education/Science Education, which was selected by 7.1% of respondents in 2016 (and is grouped with Other in Table 2.1).

In all four administrations, a substantial proportion of respondents filled in the open-response box with another discipline. These open responses generally fall into three categories:

- More specific subdisciplines within the larger categories (e.g., geochemistry, mineralogy)
- More than one of the categories (e.g., "all of the above," Earth science)
- Disciplines that are not represented in the choices (e.g., archaeology, astronomy, engineering, environmental science)

AGI defines "geoscientist" as including the subfields of "Environmental Science, Hydrology, Oceanography, Atmospheric Science, Geology, Geophysics, Climate Science, Geochemistry, Paleontology" (Wilson, 2018, p. 161), and their database includes faculty research specialties. We combined their 2017 research specialty categories to match our four disciplinary categories in order to compare them (Table 2.1). Specifically, we combined their categories of geology, economic geology, geochemistry, geophysics, and paleontology to match our "geology and geophysics" category and combined their categories of other, hydrology, soil science, engineering geology, astronomical sciences, geoscience and society, and not elsewhere classified to match our "Other" category. Our 2016 disciplinary focus data match AGI's proportions reasonably well (Table 2.1), and suggest that we are reaching a representative sample of faculty across the subdisciplines of geoscience.

Institution type

Respondents' institution names were part of the email lists generated from the sampling source lists for each survey administration. Institution names were recoded based on the Basic Classification of the Carnegie Commission on Higher Education (Carnegie Classification of Institutions of Higher Education, n.d.) to institution type (Table 2.2).

Table 2.2. Distribution of survey respondents by institution type

Type of institution by highest degree granted	2004 (n = 2139)	2009 (n = 2826)	2012 (n = 2450)	2016 (n = 2462)
Associate's (AA/AS)	0.2%	2.0%	13.4%	12.8%
Baccalaureate (BA/BS)	8.1%	9.7%	10.7%	9.4%
Master's (MS)	19.4%	20.0%	20.6%	17.9%
Doctoral (PhD)	72.2%	67.7%	54.5%	59.5%
Special focus/other	0.1%	0.5%	0.8%	0.3%

The distribution of responses by institution type has changed considerably over the four administrations: responses from instructors teaching at Associate's institutions have increased from near-zero in the first survey administration to around 13% in the 2012 and 2016 surveys, while the responses from Doctoral institutions have dropped from 72.2% to 59.5% (Table 2.2). The proportions of respondents from Baccalaureate and Master's institutions have not changed appreciably.

AGI reports the total number of faculty in four-year colleges, which combines our categories of Baccalaureate, Master's, and Doctoral institutions, as 10,048 in 2015 and 9075 in 2017 (Wilson, 2018). Our total of 2138 faculty at four-year colleges in 2016 represents 23.5% of the 2017 population and 21.3% of the 2015 population.

AGI does not report the total number of faculty at two-year colleges. However, they note that 327 two-year colleges have geoscience programs *or* offer at least one geoscience course (Wilson, 2018). For the 229 colleges that have geoscience programs or departments and report the number of geoscience faculty, the total is 733 faculty teaching at two-year colleges in the geosciences—undoubtedly a minimum. Given the large number of adjunct instructors and instructors teaching out of field at two-year colleges, we conservatively suggest that our 300+ respondents from Associate's institutions in 2012 and 2016 represent 20-25% of the two-year college geoscience faculty—a proportion similar to the four-year college faculty.

Current position

In each of the four administrations, the survey asked, "Which of the following best describes your current position?" (Table 2.3). In 2012 and 2016, respondents who selected "other" could also specify their position in an open-ended response.

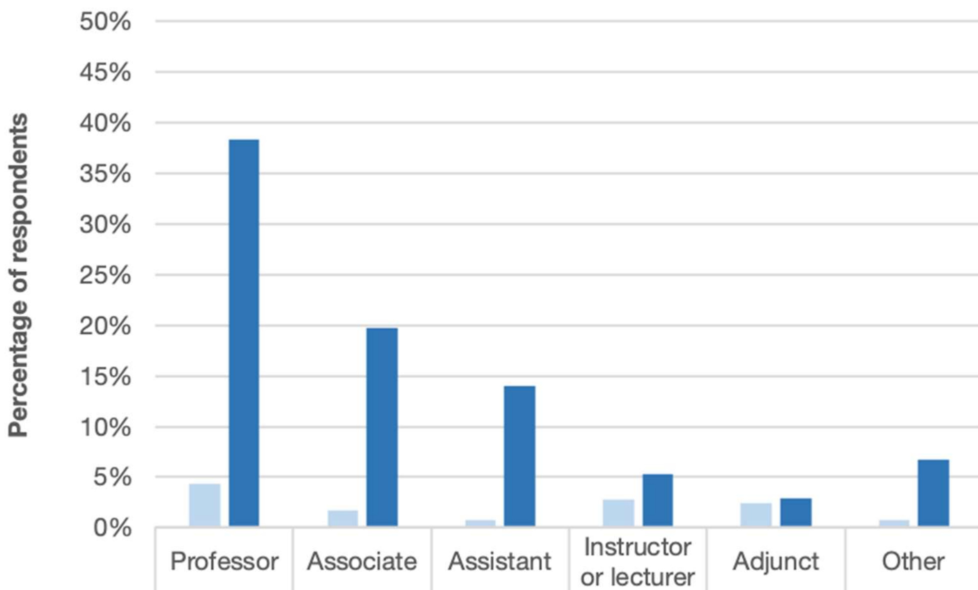
Table 2.3. Distribution of survey respondents by current position

Current position	**2004** (n = 2107)	**2009** (n = 2848)	**2012** (n = 2346)	**2016** (n = 2593)
Professor	49.6%	42.8%	39.9%	41.5%
Associate professor	23.8%	24.4%	23.2%	21.2%
Assistant professor	11.8%	15.4%	13.9%	14.8%
Instructor or lecturer	3.2%	3.9%	8.0%	8.0%
Adjunct professor	4.1%	1.1%	4.8%	6.2%
Other	7.5%	12.5%	10.2%	8.4%

The proportion of full professor respondents was near 50% in 2004, and dropped by about 10% in subsequent survey administrations (Table 2.3). The decrease in full professors was complemented by a proportional increase in both lecturers (typically full-time, non-tenure track) and adjunct faculty (typically part-time, also including visiting professors). In 2016, open responses in the "other" category were middle and high school teachers, research scientists (in industry, government, and academic settings), emeritus/retired professors, administrators (deans, directors, chairs), informal educators, and research professors.

AGI reports faculty rank (equivalent to our current position data) separately for two-year and four-year colleges, and we conducted a similar analysis on our 2016 data. To match their classification, we combined our categories of Baccalaureate, Master's, and Doctoral institutions, and did not include the special focus/other category.

Figure 2.1 shows the distribution of the total population of 2016 respondents by current position, subdivided into two-year and four-year institutions. The relative height of the bars reflects the fact that two-year college respondents make up 12.8% of the total (Table 2.2), but nearly half of the adjunct respondents and about a third of the instructor/lecturer respondents (Figure 2.1).

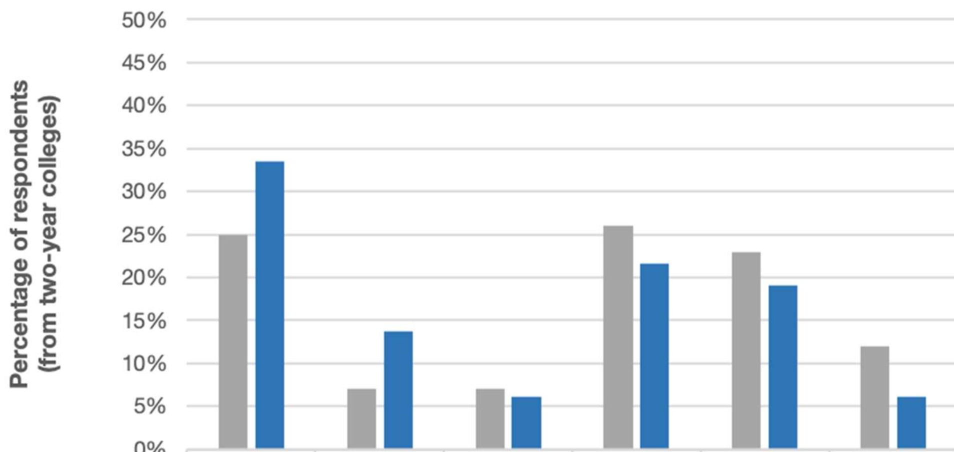


	Professor	Associate	Assistant	Instructor or lecturer	Adjunct	Other
Two-year	4.3%	1.8%	0.8%	2.8%	2.5%	0.8%
Four-year	38.3%	19.8%	14.0%	5.3%	3.0%	6.8%

Figure 2.1. Distribution of 2016 respondents by current position and institution type.

Similar analyses on the 2004, 2009, and 2012 data show that the increase in adjunct and instructor respondents from 2009 to 2012 (Table 2.3) is attribuTable to the increase in responses from two-year colleges (Table 2.2).

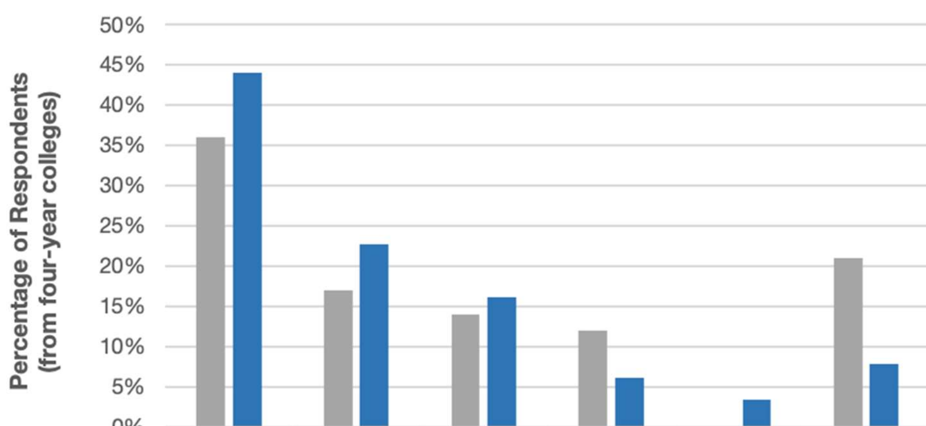
Figure 2.2 compares the current position of our two-year college respondents with rank reported by AGI for geoscience faculty at two-year colleges. This comparison suggests that full and associate professors are somewhat overrepresented in our sample, while instructors and adjuncts are somewhat underrepresented.



	Professor	Associate	Assistant	Instructor or lecturer	Adjunct	Other
Two-year (AGI)	25%	7%	7%	26%	23%	12%
Two-year	33.4%	13.7%	6.1%	21.7%	19.1%	6.1%

Figure 2.2. Comparison between current position of 2016 respondents from two-year colleges and AGI faculty rank data.

Figure 2.3 compares the current position of our four-year college respondents with rank reported by AGI for geoscience faculty at four-year colleges. As with the two-year data, full and associate professors are somewhat overrepresented in our population, while instructors/lecturers are underrepresented. Seventeen percent of AGI's "other" category is emeritus faculty; our significantly lower proportion of "other" may reflect that many emeritus professors are no longer teaching and thus may not have filled out the survey.



	Professor	Associate	Assistant	Instructor or lecturer	Adjunct	Other
Four-year (AGI)	36%	17%	14%	12%		21%
Four-year	43.9%	22.7%	16.1%	6.1%	3.4%	7.8%

Figure 2.3. Comparison between current position of 2016 respondents from four-year colleges with AGI faculty rank data.

Both comparisons suggest that the distribution of our 2016 population is slightly skewed towards the more senior, tenured faculty, over-representing full professors by about 8% and associate professors by about 6%. Assistant professors are proportionally represented, whereas non-tenure track instructors are underrepresented by about 6%.

Highest degree completed

In each of the four administrations, respondents were asked their highest degree completed (Table 2.4). In 2012 and 2016, respondents who selected "other" could also specify their highest degree in an open-ended response.

Table 2.4. Respondents' highest degree completed

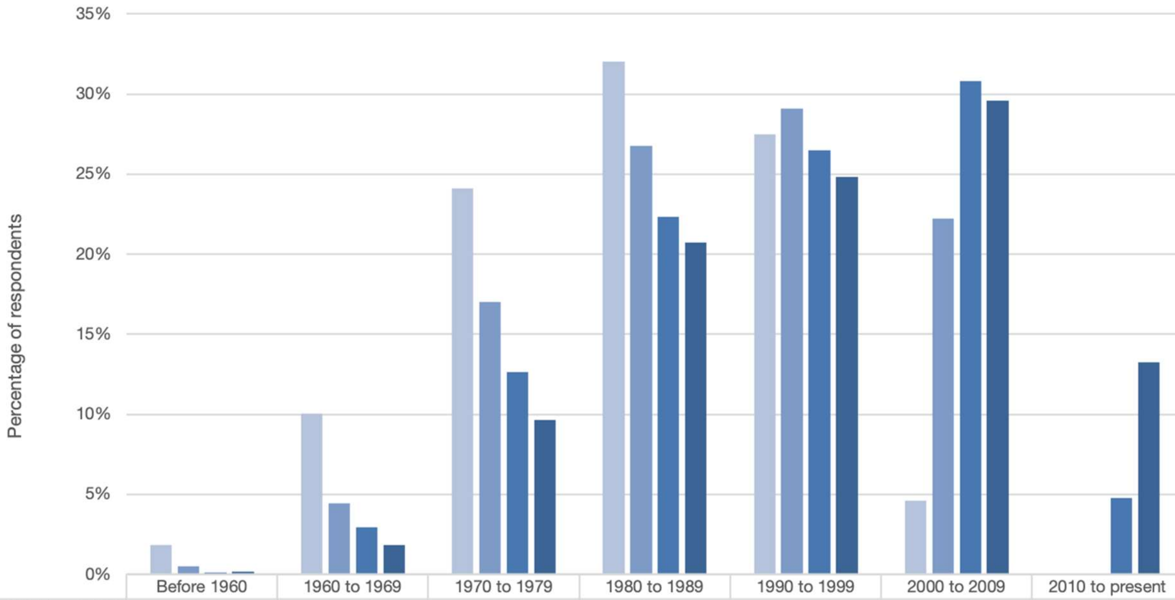
Degree	2004 (n = 2149)	2009 (n = 2856)	2012 (n = 2338)	2016 (n = 2570)
Masters	2.8%	3.8%	12.1%	11.1%
PhD or doctorate	96.7%	95.7%	86.7%	88.9%
Other	0.5%	0.5%	1.2%	0.0%

The large majority of respondents hold doctorate degrees, but this proportion drops by 8-10% from 2004/2009 to 2012/2016 (Table 2.4).

AGI only reports terminal degree data for two-year college faculty. In 2017, approximately 61% of two-year college instructors held MS degrees as their terminal degrees, and 39% held PhD degrees (Wilson, 2018). Our 2016 data are similar: 53.9% of respondents from two-year colleges hold MS degrees; 46.1% hold PhDs. At four-year colleges, 3.6% of respondents hold MS degrees and 96.4% hold PhDs. Similar analyses on the 2004, 2009, and 2012 surveys show that these proportions are consistent and the increase in the proportion of respondents with MS degrees as their highest degree from 2009 to 2012 (Table 2.4) can be attributed to the increase in respondents from Associate's institutions (Table 2.2).

Year of highest degree

In each of the four administrations, respondents were asked to enter a number indicating the year their highest degree was completed. We grouped these numeric entries by decade (Figure 2.4) and calculated the mean. In 2004, the mean year of highest degree was 1983 (SD = 11 years); in 2009 the mean was 1989 (SD = 11 years); in 2012, the mean was 1993 (SD = 12 years); in 2016, the mean was 1995 (SD = 12 years).



	Before 1960	1960 to 1969	1970 to 1979	1980 to 1989	1990 to 1999	2000 to 2009	2010 to present
2004 (n = 2137)	1.8%	10.0%	24.1%	32.0%	27.5%	4.6%	0.0%
2009 (n = 2858)	0.5%	4.4%	17.0%	26.8%	29.1%	22.2%	0.0%
2012 (n = 2334)	0.1%	2.9%	12.6%	22.3%	26.5%	30.8%	4.8%
2016 (n = 2579)	0.2%	1.8%	9.6%	20.7%	24.8%	29.6%	13.2%

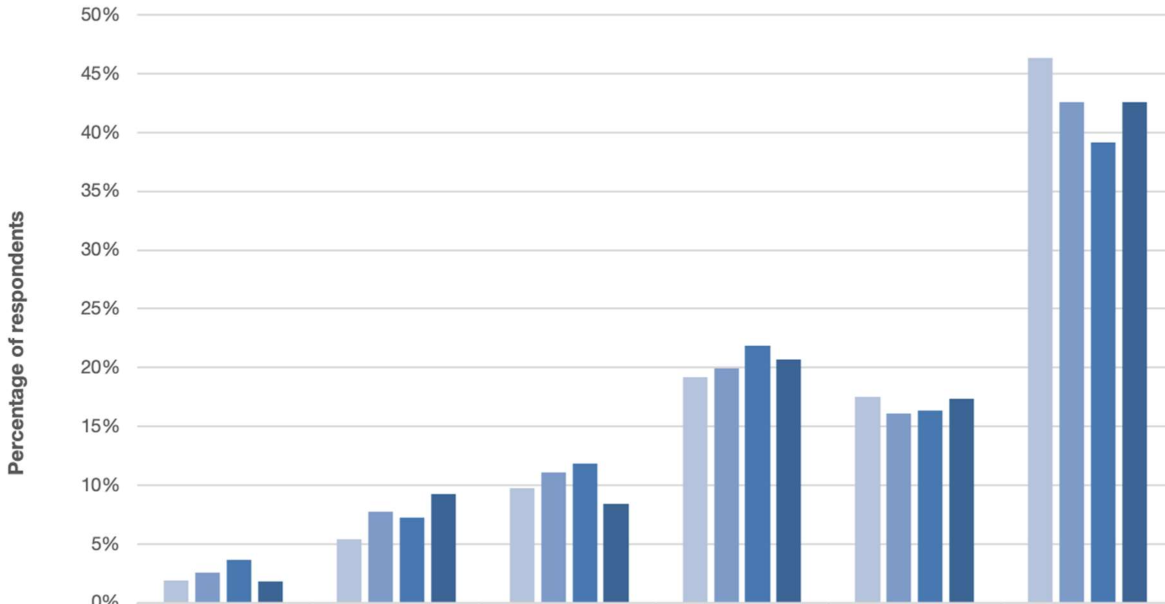
Figure **2.4.** Year of highest degree of survey respondents.

The modal decade shifts forward in each of the first three survey administrations, but the modal decade of the 2012 and 2016 surveys remains 2000 to 2009 (Figure 2.4). The mean also shifts forward, but by a decreasing amount with each survey administration, and by only two years between the 2012 and 2016 administrations. In both the 2012 and 2016 administrations, over 60% of respondents received their highest degree in 1990 or later.

AGI does not report the year of highest degree, but they do report the age distribution of faculty at four-year colleges. They report a decrease in the proportion of faculty in the under 36 and 36-40 age ranges between 2015 and 2017, and an increase in all other (older) age groups, pointing to a slowdown in faculty hiring as the cause (Wilson, 2018). Our data may reflect a similar trend, but are not directly comparable.

Number of years teaching

In each of the four administrations, respondents were asked "How many years have you taught at the college or university level?" Respondents entered a number; we grouped these numbers into ranges on the basis of natural breaks and likely milestones in tenure-track positions (e.g. tenure and promotion from assistant to associate professor after six years of teaching) (Figure 2.5).



	< 1	1 to 3	4 to 6	7 to 12	13 to 18	> 18
2004 (n = 2140)	1.9%	5.4%	9.8%	19.2%	17.5%	46.4%
2009 (n = 2859)	2.6%	7.8%	11.1%	20.0%	16.1%	42.6%
2012 (n = 2339)	3.6%	7.3%	11.8%	21.8%	16.3%	39.1%
2016 (n = 2581)	1.8%	9.2%	8.4%	20.7%	17.4%	42.5%

Figure 2.5. Number of years teaching of survey respondents.

In all four administrations, the largest proportion of respondents has been teaching for more than 18 years (Figure 2.5). The mean number of years teaching was 18.2 (SD = 11.1) in 2004, 17.3 (SD = 11.4) in 2009, 16.7 (SD = 11.6) in 2012, and 17.6 (SD = 11.8) in 2016, whereas the mode was 10 years in all four administrations. Given the distribution of year of highest degree (Figure 2.1) and the wording of the question, it is possible that respondents are also including experiences teaching during graduate school, which may include both serving as a teaching assistant, instructor of record for laboratory classes, and/or serving as an adjunct or lecturer while also completing a degree. In the 2016 survey, the following phrase was added to the question text, "Please do not include any experiences as a graduate teaching assistant." Regardless of this addition, however, the proportion of respondents who indicated that they had been teaching at the college or university level for more than 18 years was 42.5% (Figure 2.5).

Geographic distribution

We coded responses by state on the basis of respondents' institutions. The state-by-state distribution of 2016 respondents is shown in Figure 2.6. Respondents come from all 50 states, the District of Columbia (DC), Puerto Rico (PR), and a small number of non-US entities. The overall distribution is roughly similar in all four administrations, and the three states with the most respondents in all four administrations are California, New York, and Texas (Figure 2.6).

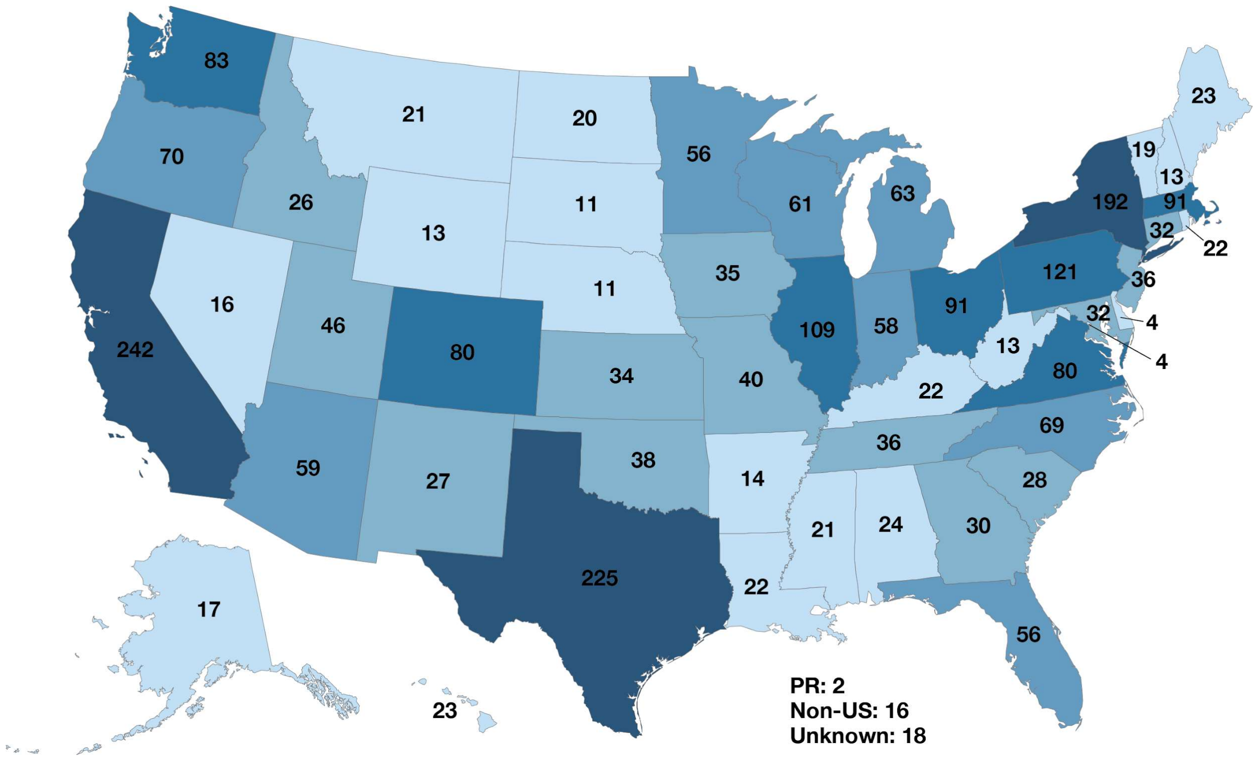


Figure 2.6. Distribution of 2016 responses by state.

AGI reports the number of geoscience departments by state, cataloguing departments/programs at two-year colleges separately from four-year colleges, providing a proxy for comparison with our geographic data. As of 2017, the number of two-year college departments/programs per state ranged from 0 (eight states plus DC) to 65 (California), with a mean of six and a mode of one; the number of four-year college departments per state ranged from one (DC, PR, and WY) to 53 (California), with a mean of 12 and a mode of six (calculated from data presented in Wilson (2018)). The three states with the largest total number of departments/programs are California (118), Texas (80), and New York (59). Overall, the geographic distribution of our 2016 respondents largely correlate with the combined number of departments.

Type and amount of teaching

In 2012 and 2016, the survey included a set of questions that address the type and amount of teaching. Respondents were asked two questions about their teaching in the previous academic term: how many hours per week they spent teaching in class and/or lab (Table 2.5), and how many unique courses they taught (Table 2.6).

Respondents were asked to enter a one- or two-digit number in response to the question “In the past academic term, how many hours per week did you spend teaching in class and/or lab?” We grouped these responses in three-hour increments to reflect typical course schedules and to match the grouping used in the Faculty Survey of Student Engagement (FSSE) (Center for Postsecondary Research, 2019) (Table 2.5).

Table 2.5. Time spent teaching per week (2012, 2016)

Time spent teaching (per week)	2012 (n = 2324)	2016 (n = 2575)
0	10.6%	8.7%
1 to 4 hours	16.5%	18.2%
5 to 8 hours	25.4%	25.9%
9 to 12 hours	24.4%	23.6%
13 to 16 hours	11.3%	11.1%
17 to 20 hours	7.8%	7.2%
More than 20 hours	3.9%	5.2%

The largest proportion of respondents in both 2012 and 2016 spent 5 to 8 hours teaching per week, and these proportions did not differ significantly between the survey years (Table 2.5). The mean was 9.1 hours per week (SD = 7.4) in 2012 and 9.4 hours (SD = 8.5) in 2016, and the mode was six hours per week in both years.

In the 2016 FSSE aggregate report, which includes faculty from *all* disciplines, 35% of faculty spent 9 to 12 hours teaching per week and 28% spent 5 to 8 hours per week (Center for Postsecondary Research, 2016). No disciplinary breakdown of those data is available, however, so it is difficult to compare the teaching load of our respondents to FSSE respondents; the 119 institutions that participated in the 2016 FSSE are also more heavily weighted towards Baccalaureate and Master's institutions in comparison with the institutions of our respondents.

Respondents were also asked "In the past academic term, how many unique courses did you teach?", and they could respond by entering a one- or two-digit number (Table 2.6).

Table 2.6. Number of unique courses taught in the previous term (2012, 2016)

Number of courses	2012 (n = 2310)	2016 (n = 2569)
0	10.7%	9.1%
1	23.4%	26.2%
2	35.8%	34.6%
3	18.7%	18.0%
4	7.6%	7.3%
5	2.0%	2.5%
6	1.0%	1.2%
7 or more	0.8%	1.0%

About a third of respondents in both 2012 and 2016 taught two unique courses in the previous term, about a quarter taught one, and about a fifth taught three (Table 2.6).

A follow-up pair of questions served as a branching point in the 2012 and 2016 surveys. The first question asked how many of the courses taught *in the past academic year* were for undergraduates. In 2012, 12.7% did not teach any courses at all and 5.1% taught only graduate-level courses; in 2016, 11.0% did not teach any courses and 4.8% taught only graduate-level courses. These respondents were not asked further questions about their teaching.

In 2012, 82.2% respondents indicated that they had taught one or more courses for undergraduates in the previous academic year; 84.2% indicated they had done so in 2016. These respondents were asked a second question: “What type of undergraduate geoscience courses did you teach?” Response options were: introductory courses, courses for majors, or both introductory and majors courses (Table 2.7).

Table 2.7. Type of undergraduate geoscience courses taught in the past academic year (2012, 2016)

Type of course	**2012** (n = 1908)	**2016** (n = 2163)
Introductory courses	28.0%	24.9%
Majors courses	21.3%	26.4%
Both	50.6%	48.7%

About half of respondents in both 2012 and 2016 taught courses at both the introductory level and for geoscience majors in the previous academic year; about a quarter taught only one or the other. It is worth emphasizing that the question refers only to the previous year, and not to the teaching load of the respondent as a whole, which can vary considerably from year to year.

In the 2004 and 2009 surveys, a single question was asked to serve as the branching point. Respondents were asked “Please indicate the number of each of the following courses you taught during spring [previous year] and fall [previous year],” where [previous year] was replaced with the actual year (2003 or 2008) and respondents entered a two-digit number for introductory courses, courses for majors, and graduate-level courses. These data are not directly comparable with the 2012 and 2016 data and are thus not reported here, but they were also used to distribute respondents to different portions of the survey. If respondents entered 0 for introductory *and* majors courses, they were not asked further questions about their teaching.

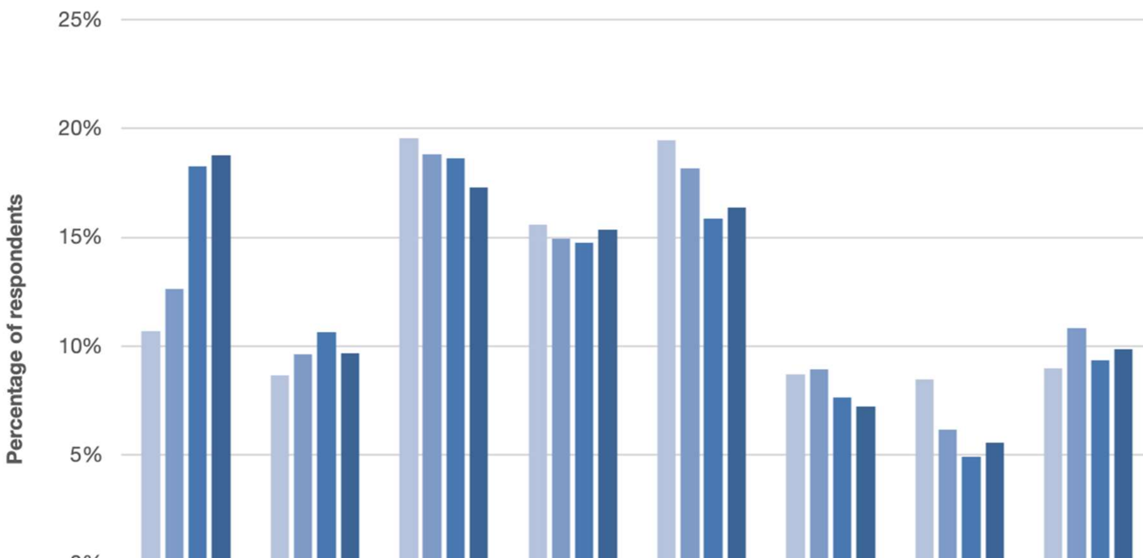
In all four administrations, respondents who taught only introductory courses were presented with a set of questions about the most recent introductory course that they taught. Respondents who taught only majors courses were presented with a set of questions about the most recent majors course that they taught. Respondents who indicated that they taught both introductory and majors courses were randomly assigned to answer questions either about the most recent introductory or majors course that they taught. The responses to these course-specific questions are presented in Chapter 3, Chapter 4, and the first part of Chapter 5.

Dissemination of research and educational materials

College and university faculty are typically expected to present and publish their research regularly to achieve tenure and promotion. Publishing or presenting about educational innovations and practices may or may not be part of the criteria for tenure and promotion, but many instructors engage in these activities as well. In general, publications and presentations are a hallmark of engagement in the scientific community. In all four administrations, a set of questions asked about the extent to which respondents were engaged in presenting their scientific research, presenting research on teaching methods, and sharing curricular materials. We consider all of these together as dissemination of research and educational materials.

Presenting and publishing scientific research

In all four administrations, respondents were asked "At how many meetings have you presented your scientific research within the past two years?" In the 2004 survey, respondents could enter a one- or two-digit number; subsequent surveys provided options from "none" to "7 or more" and the 2004 data were recoded to be compatible with these forced responses; the relatively low n for 2004 may be a consequence of the open-ended response. The results are shown in Figure 2.7.



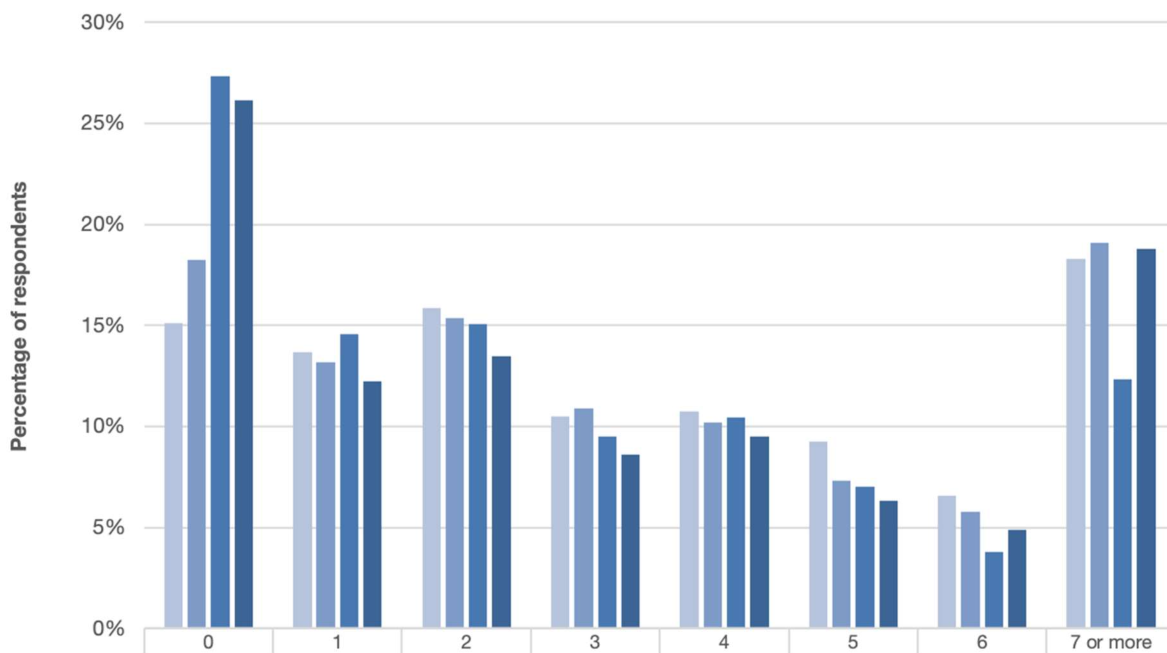
	0	1	2	3	4	5	6	7 or more
2004 (n = 1574)	10.7%	8.6%	19.6%	15.6%	19.4%	8.7%	8.4%	9.0%
2009 (n = 2475)	12.6%	9.6%	18.8%	14.9%	18.1%	8.9%	6.1%	10.8%
2012 (n = 2132)	18.2%	10.6%	18.6%	14.7%	15.9%	7.6%	4.9%	9.3%
2016 (n = 2414)	18.8%	9.7%	17.3%	15.3%	16.4%	7.2%	5.6%	9.9%

Figure 2.7. Number of meetings at which scientific research was presented in the previous two years.

The large majority of respondents (80-90%) presented their research at a minimum of one meeting in the previous two years. The proportions of respondents who presented their research at meetings one or more times did not change substantially over the four survey administrations, with the greatest proportion of respondents (~17-20%) in each administration reporting that they presented twice (Figure 2.7).

However, the percentage of respondents who had not presented their research at *any* meetings in the previous two years was 6-8% higher in 2012 and 2016 compared to 2004 and 2009, and reflects the increase in respondents from Associate's institutions and a decrease in respondents from Doctoral universities: in 2012 and 2016, respondents from Associate's institutions accounted for 51.2% and 44.2% of those who indicated they had presented their research zero times in the previous two years, respectively, while representing about 13% of the respondent population (Table 2.2).

Respondents were also asked to report the number of articles that they had published about their research in the past two years. As with the question about presentations, in the 2004 survey respondents could enter a one- or two-digit number; subsequent surveys provided options from "none" to "7 or more" and the 2004 data were recoded to be compatible with these forced responses; the results are shown in Figure 2.8.



	0	1	2	3	4	5	6	7 or more
2004 (n = 1570)	15.1%	13.7%	15.9%	10.5%	10.8%	9.2%	6.6%	18.3%
2009 (n = 2475)	18.2%	13.2%	15.4%	10.9%	10.2%	7.3%	5.8%	19.1%
2012 (n = 2130)	27.3%	14.6%	15.1%	9.5%	10.4%	7.0%	3.8%	12.3%
2016 (n = 2412)	26.2%	12.2%	13.5%	8.6%	9.5%	6.3%	4.9%	18.8%

Figure 2.8. Number of articles published about scientific research in the previous two years.

As with research presentations, the large majority (72-85%) of respondents published at least one research article in the previous two years, and the proportions of respondents who published one or more research articles in the previous two years did not change substantially over the four administrations (Figure 2.8).

Again, as with research presentations, the percentage of respondents who had not published any research articles in the previous two years was 8-12% higher in 2012 and 2016 compared to 2004 and 2009. Similarly, respondents from Associates-granting institutions accounted for 41.5% of "none" responses in 2012 and 38.3% of "none" responses in 2016, while representing about 13% of the respondent population (Table 2.2).

In a 2004 survey of post-secondary faculty in all fields, the National Center for Education Statistics reported an average of 2.6 refereed or juried publications in the previous two years across all institution types, ranging from a low of 0.2 at two-year colleges to 3.8 at private doctoral universities (Cataldi, Bradburn, & Fahimi, 2005). Our data are not directly comparable, particularly in the years after the 2004 survey. However, our data suggest that the population of geoscientists responding to our survey are not unusual in terms of their research productivity in comparison to the general population of post-secondary faculty.

Presenting and publishing education-related research

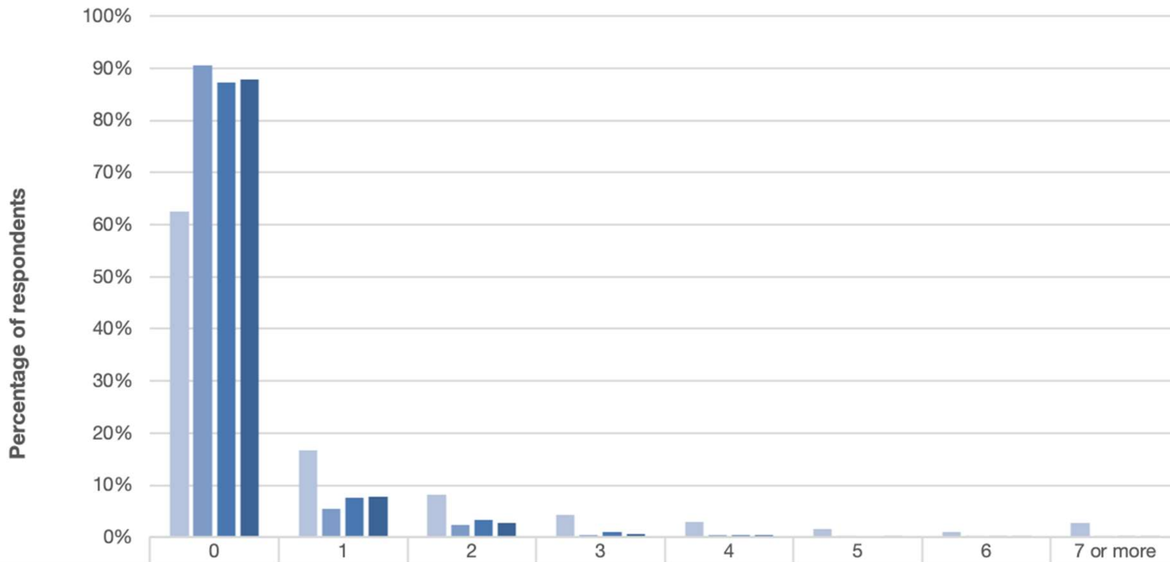
Respondents were asked if they presented research on teaching methods or student learning at meetings in the past two years and could select "yes" or "no;" the results are shown in Table 2.8.

Table 2.8. Presentations about teaching methods or student learning in the previous two years

	2004 (n = 1557)	2009 (n = 2383)	2012 (n = 2114)	2016 (n = 2404)
Yes	19.1%	17.2%	25.5%	23.2%
No	80.9%	82.8%	74.5%	76.8%

In all four administrations, the large majority of respondents (75-83%) had not made presentations about teaching methods or student learning, but the proportion that responded "yes" increased by 8.3% from 2009 to 2012 and dropped off by 2.3% in 2016, but did not return to the 2004/2009 level. As with the change in proportions of research presentations, the increase is largely accounted for by respondents from Associates-granting institutions, who make up 0% of yes responses in 2004, 4% in 2009, 16.7% in 2012, and 15.4% in 2016.

Respondents were asked to report the number of articles that they had published about educational topics in the past two years. As with the questions about scientific research publications, in the 2004 survey, respondents could enter a one- or two-digit number; subsequent surveys provided options from "none" to "7 or more" and the 2004 data were recoded to be compatible with these forced responses; the results are shown in Figure 2.9.

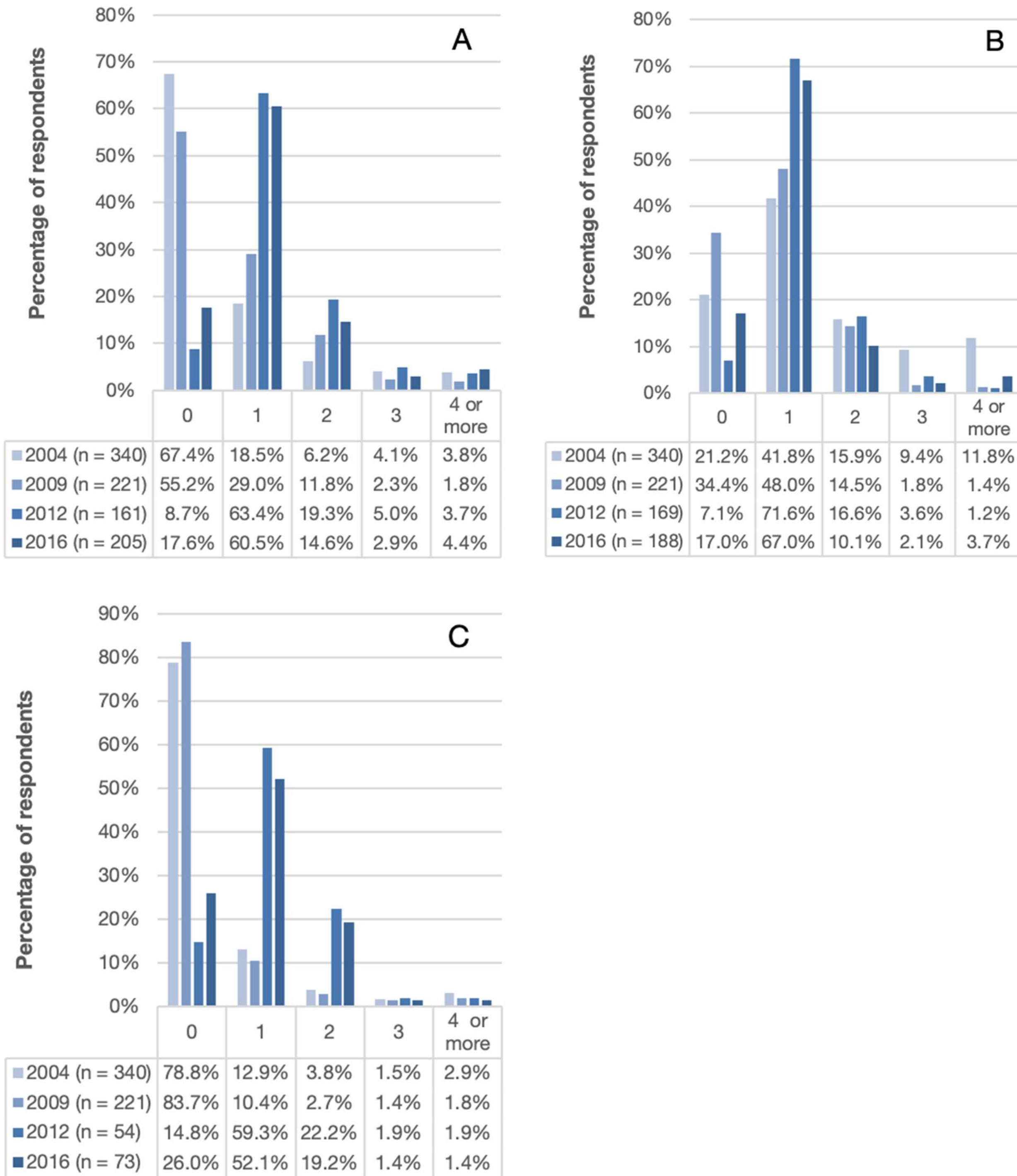


	0	1	2	3	4	5	6	7 or more
2004 (n = 934)	62.5%	16.7%	8.1%	4.3%	2.9%	1.6%	1.1%	2.8%
2009 (n = 2475)	90.6%	5.5%	2.4%	0.5%	0.4%	0.2%	0.0%	0.2%
2012 (n = 2129)	87.2%	7.6%	3.3%	1.0%	0.4%	0.0%	0.2%	0.2%
2016 (n - 2409)	87.8%	7.8%	2.8%	0.7%	0.4%	0.1%	0.1%	0.2%

Figure 2.9. Articles published about educational topics in the previous two years

The large majority—around 90% in the last three administrations—reported that they did not publish any articles about educational topics in the last two years. The 2004 data, which look noticeably different from other years, should be interpreted with caution; the low *n* may indicate that many respondents who had not published any articles simply did not respond rather than enter "0." In the three later administrations, the percentages remain low and relatively consistent, with the highest non-zero proportion (5-8%) publishing one article about educational topics in the previous two years (Figure 2.9).

Respondents were asked, of those articles, how many described their research on teaching methods or student learning (Figure 2.10a), their classroom or curriculum innovations (Figure 2.10b), and other educational topics (Figure 2.10c).



A

	0	1	2	3	4 or more
2004 (n = 340)	67.4%	18.5%	6.2%	4.1%	3.8%
2009 (n = 221)	55.2%	29.0%	11.8%	2.3%	1.8%
2012 (n = 161)	8.7%	63.4%	19.3%	5.0%	3.7%
2016 (n = 205)	17.6%	60.5%	14.6%	2.9%	4.4%

B

	0	1	2	3	4 or more
2004 (n = 340)	21.2%	41.8%	15.9%	9.4%	11.8%
2009 (n = 221)	34.4%	48.0%	14.5%	1.8%	1.4%
2012 (n = 169)	7.1%	71.6%	16.6%	3.6%	1.2%
2016 (n = 188)	17.0%	67.0%	10.1%	2.1%	3.7%

C

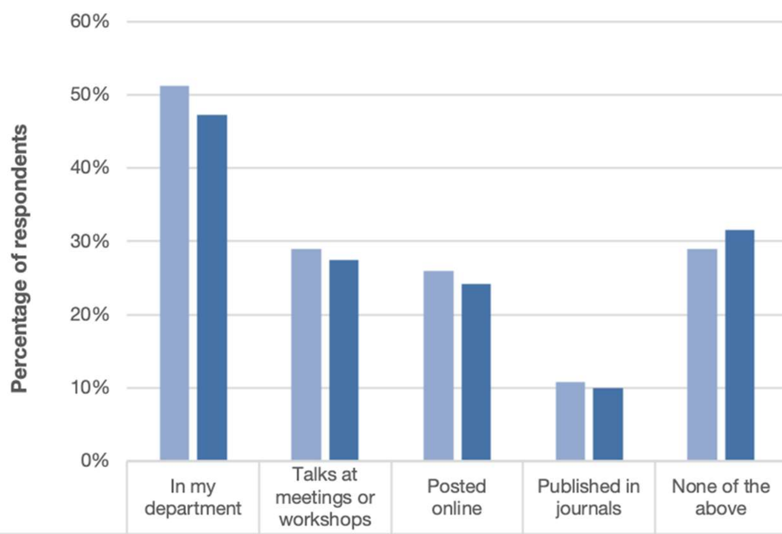
	0	1	2	3	4 or more
2004 (n = 340)	78.8%	12.9%	3.8%	1.5%	2.9%
2009 (n = 221)	83.7%	10.4%	2.7%	1.4%	1.8%
2012 (n = 54)	14.8%	59.3%	22.2%	1.9%	1.9%
2016 (n = 73)	26.0%	52.1%	19.2%	1.4%	1.4%

Figure 2.10. Articles published in the previous two years about (A) research on teaching methods or student learning, (B) classroom or curricular innovations, and (C) other educational topics.

Of those who had published articles about educational topics (note the small *n* in each year), the highest percentage published one article about classroom or curricular innovations (Figure 2.10b), followed by one article about research on teaching methods or student learning (Figure 2.10a) and other topics (Figure 2.10c). There is a substantial difference between responses to the 2009 survey and the 2012/2016 surveys, with a slight increase in the total number of articles reported being published (Figure 2.9), and in the types of articles, with increases in research on teaching methods or student learning and other educational topics.

Sharing teaching materials

In the 2012 and 2016 surveys, respondents were asked, "Which of the following ways have you shared or published materials from your courses in the last two years?" They could select as many options as applied from "in my department," "talks at meetings or workshops", "posted online," "published in journals," and "none of the above" (Figure 2.11).



	In my department	Talks at meetings or workshops	Posted online	Published in journals	None of the above
2012 (n = 2109)	51.2%	29.0%	26.0%	10.8%	29.0%
2016 (n = 2439)	47.2%	27.4%	24.2%	10.0%	31.5%

Figure 2.11. Ways in which respondents report sharing course materials in the previous two years (2012, 2016).

About half of respondents have shared their teaching materials within their departments, and about a quarter have shared them beyond their department through talks and/or posting the materials online. About 10% report having published their teaching materials in journals, which approximately matches the percentage of respondents who indicated that they had published one or more papers about educational topics in the last two years (Figure 2.9). Around 30% of respondents in both years report not sharing their course materials in any of the ways listed (Figure 2.11).

Further research

Manduca et al. (2017) used a clustering algorithm on the responses to the questions about dissemination of research and educational materials to identify three groups of faculty: education-focused faculty (significant activity in improving teaching), geoscience research-focused faculty (significant activity in presenting and publishing geoscience research), and teaching faculty (low levels of activity related to research or improving teaching).

Summary of characteristics of geoscience faculty

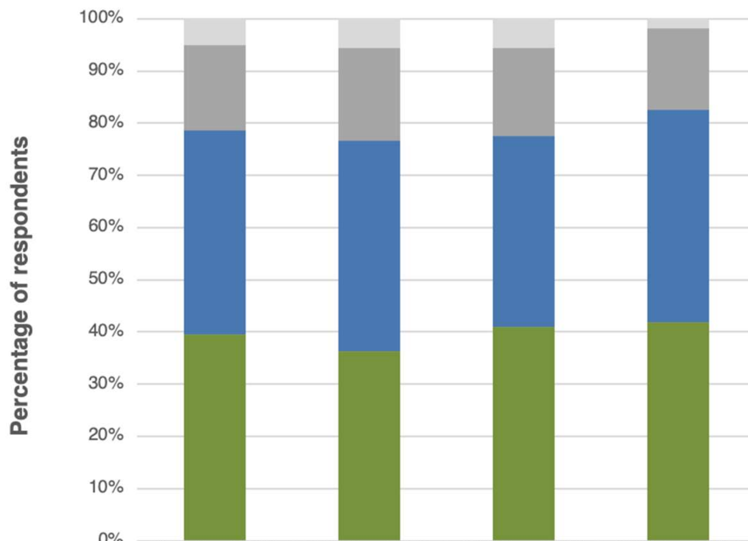
The 2016 survey respondents represent about 25% of the population of geoscience faculty in the United States. The distribution of 2012 and 2016 respondents proportionally represent the range of disciplines, institution types, and geographic location when compared to the larger population, but slightly overrepresent more senior faculty (professors and associate professors) compared to non-tenure track instructors.

About half of respondents spend 5 to 12 hours per week teaching 2 or 3 unique courses per term. For 82-84% of respondents, at least one of those courses was at the undergraduate level. About half of respondents who taught courses for undergraduates taught courses both at the introductory level and for majors.

The large majority of survey respondents are active in presenting and publishing their research, while few are active in presenting and publishing education-related topics. These proportions differ by institution type, however, as less than a third of instructors at two-year colleges are involved in publishing and presenting scientific research and 85-90% of respondents from four-year institutions are. In contrast, instructors at two-year colleges are more likely than their four-year colleagues to make presentations at meetings about educational topics, and equally likely to have published about educational topics. Although few respondents are publishing about educational topics, most share their course materials within their department.

Chapter 3: Characteristics of undergraduate geoscience courses

In each year of the survey, after responding to a set of demographic questions, respondents were asked questions about the nature of their teaching in the previous academic year. The answers to these questions (described in Chapter 2) served as a branch point in the survey that directed respondents to different sections to answer further questions about their teaching in either a specific introductory course or a specific course for majors, or sent them to the last section of the survey if they did not do any undergraduate teaching. The percentage of respondents who were sent to the different survey sections is shown in Figure 3.1.



	2004 (n = 2154)	2009 (n = 2863)	2012 (n = 2456)	2016 (n = 2615)
Unable to determine	5.1%	5.6%	5.5%	1.8%
Neither section	16.3%	17.7%	16.9%	15.6%
Section about course for majors	39.0%	40.4%	36.7%	40.8%
Section about introductory course	39.6%	36.4%	41.0%	41.9%

Figure 3.1. Distribution of respondents sent to different sections of the survey.

The descriptions in Chapters 3 and 4 focus on the responses to the introductory and majors survey sections—about 80% of total responses in each survey year (Figure 3.1)—and compare the two groups of responses. Throughout, we use the colors introduced in Figure 3.1 to visually distinguish the two groups: responses about introductory courses are presented in shades of green, and responses about courses for majors are presented in shades of blue.

Most questions in the two survey sections were the same, but a few questions were asked only in the introductory section or only in the majors section; these are highlighted as appropriate.

Course characteristics

Course structure and delivery mode

In 2016, respondents were asked two questions about the nature of their course. The first of these addressed the course structure: lecture, lecture plus lab, or integrated lecture and lab (Table 3.1). The second addressed the course delivery mode: in-person, online, or hybrid (Table 3.2).

Table 3.1. Structure of introductory and majors courses (2016)

Is your course...	Introductory (n = 1063)	Majors (n = 1038)
Lecture	31.7%	23.0%
Lecture plus lab	46.3%	41.1%
Integrated lecture and lab	22.0%	35.8%

A greater proportion of introductory courses are described as "lecture" or "lecture plus lab" than courses for majors, whereas a greater proportion of courses for majors are described as "integrated lecture and lab" (Table 3.1). Lecture plus lab is the most common course structure for both introductory and majors courses.

Table 3.2. Delivery mode of introductory and majors courses (2016)

Is your course...	Introductory (n = 1065)	Majors (n = 1040)
In-person only	90.0%	96.3%
Online only	5.1%	0.5%
Hybrid	5.0%	3.3%

Nearly all courses for geoscience majors are in-person only, and 90% of introductory courses are in-person; only a handful of majors courses are online only, and just over 5% of introductory courses are online only. A small percentage of both introductory and majors courses are hybrid, including both online and in-person components (Table 3.2). We do not have longitudinal data for this question to assess the growth of online and hybrid teaching in undergraduate geoscience teaching. However, the National Center for Education Statistics reports that approximately 18% of undergraduate students were enrolled in at least one (but not all) distance education courses in the fall of 2016, and approximately 13% were enrolled in exclusively distance education courses (Ginder, Kelly-Reid, & Mann, 2017). These proportions of students suggest that the offering of online-only geoscience courses may not be keeping pace with the general demand for online courses.

Class size

Respondents were asked how many students were in their most recent course, and could enter a number. These numbers were recoded into the three class sizes: small (≤ 30), medium (31–80), and large (> 80) (Figure 3.2).

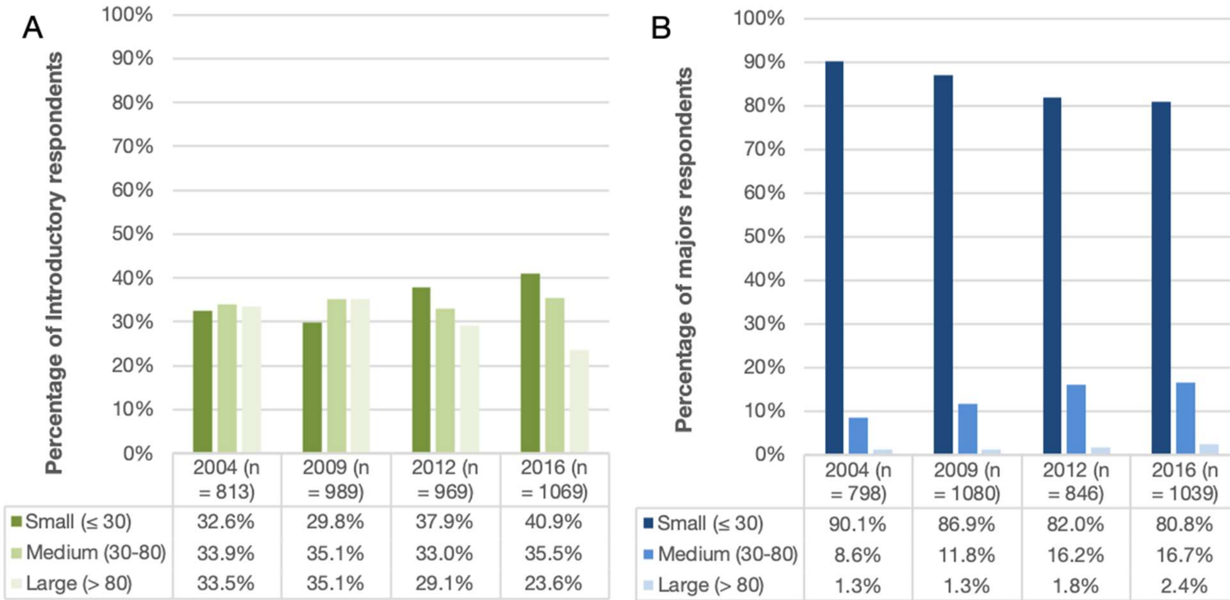


Figure 3.2. Recoded class sizes reported by respondents for introductory courses (A) and courses for majors (B).

Overall, courses for majors are two to three times more likely to be small (≤ 30 students enrolled) than introductory courses (Figure 3.2).

In introductory courses, the proportion of small classes increased from 2009 to 2012 and 2016; the proportion of large classes decreased over the same period (Figure 3.2A). As with many other apparent differences between the earlier and later surveys, this shift is explained by the increase in the number of respondents from Associate's institutions in the later administrations (Table 2.2), which constituted <2% of the total of small classes in 2004 and 2009 and 8-10% of the total of small classes in 2012 and 2016.

In courses for majors, the proportion of small classes decreased by about 10% from 2004 to 2016; the proportion of medium classes increased over the same time period, whereas the proportion of large classes remained very low (< 2.5%) (Figure 3.2B).

Enrollment in introductory courses

For introductory courses, the enrollment numbers entered by respondents were also totaled. The total number of students reported as enrolled in introductory courses was 66,725 in 2004; 81,636 in 2009; 68,170 in 2012; and 70,198 in 2016. On the basis of responses to a departmental survey, AGI estimated total enrollment in introductory geoscience courses (described as physical geology, environmental geology, and national parks) in 2005 at 403,200, or 2.7% of total undergraduate enrollment reported by the National Center for Education Statistics (NCES) in that year (Martinez & Baker, 2006). Both our total enrollment numbers and AGI's estimates could double-count students if they enrolled in more than one introductory geoscience course in a given term, but we assume these numbers are small. AGI has a more limited definition of introductory geoscience courses than we do—our definition also includes ocean and atmospheric sciences—so their estimate can be considered a minimum for comparison. In the fall of 2015, total undergraduate enrollment was 17,036,778 (National Center for Education Statistics, 2017); applying AGI's estimate from 2005, we calculate that approximately 460,000 undergraduate students were enrolled in introductory geoscience courses (as defined by AGI) in 2015 (2.7% of the total enrollment). On the basis of this calculation, our enrollment numbers suggest that the 2016 survey reached instructors who teach 15% of undergraduate students enrolled in introductory geoscience courses nationwide.

In the 2016 survey, respondents describing an introductory course were asked to select the option that best described the majority of the students enrolled in their course (n=1065). The majority (67.7%) indicated that students were fulfilling a general education requirement, 17.9% indicated that students were fulfilling a requirement for a non-geoscience major, 7.9% indicated that students in their courses were already or planned to become geoscience majors, 1.8% indicated that students were pre-service teachers, and 1.8% indicated that they did not know. The large proportion of introductory courses that fulfill general education requirements appears to reflect university-wide trends: aggregate data from the 2016 FSSE indicate that 70% of lower-division courses fulfill general education requirements (Center for Postsecondary Research, 2016).

Instructor characteristics

Experience teaching the course

In the 2016 survey, respondents were asked how many times they had taught the specific introductory course or course for majors (Table 3.3).

Table 3.3. Number of times respondents have taught their course (2016)

Number of times	Introductory (n = 1069)	Majors (n = 1038)
1-2 times	15.4%	18.5%
3-5 times	16.9%	24.5%
6 or more times	67.6%	57.0%

About two-thirds of respondents had taught their introductory course six or more times, and a majority had taught their course for majors six or more times. This level of experience teaching the course aligns well with the reported number of years teaching, as 80.6% of respondents have been teaching for seven years or more (Figure 2.2).

Alignment of course and disciplinary training

In 2016, the majors section of the survey included a question about how well the subject area of respondents' most recent course for majors aligns with their disciplinary training (Table 3.7).

Table 3.7. Alignment of majors course topic and respondents' disciplinary training (2016)

The course subject area and my disciplinary training are… (n = 1039)	**Selected**
In good alignment	80.3%
Somewhat aligned	15.3%
Marginally aligned	3.8%
Not aligned	0.7%

The large majority of respondents indicated that the course topic and their disciplinary training are "in good alignment." Far fewer respondents indicated that the course subject and their disciplinary training are "somewhat aligned," and few respondents indicated that the course subject and their disciplinary training are "marginally aligned," or "not aligned" (Table 3.7).

Who is involved in teaching

In 2016, respondents were asked if anyone else taught the same course at their institution; 65.3% of instructors teaching introductory courses and 25.0% of instructors teaching courses for majors responded "yes." For introductory courses, the proportion is similar at Associate's institutions (67.8%), Master's institutions (68.1%), and Doctoral institutions (64.8%), but is lower for Baccalaureate institutions (56.6%). For majors courses, the proportion is similar for Master's (21.7%) and Doctoral institutions (27.8%), and is lower for Baccalaureate institutions (11.9%). Very few respondents from Associate's institutions answered questions about majors courses.

Another question asked if anyone else was involved in teaching the same course *at the same time*, and respondents could select as many responses as applied from the selections provided (Table 3.4).

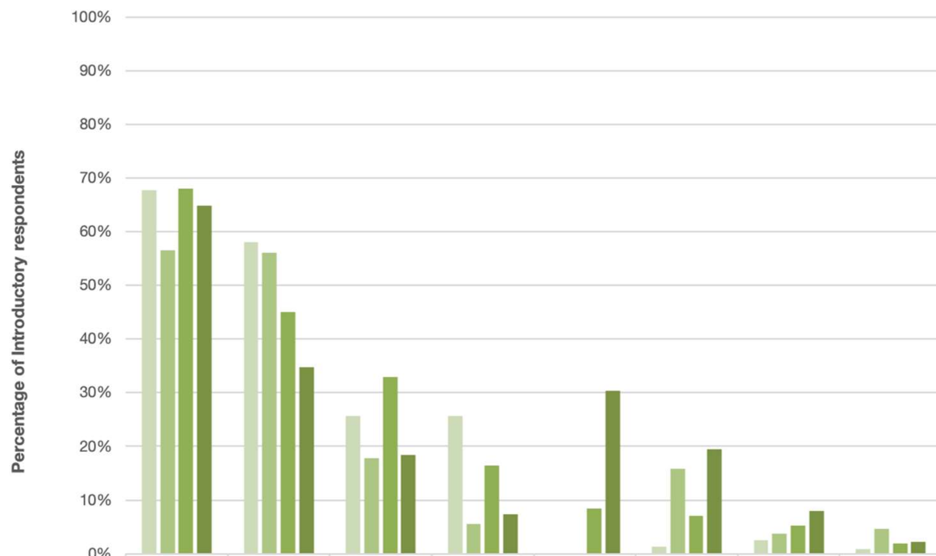
Table 3.4. Involvement of others in teaching introductory and majors courses (2016)

When you taught this course, was anyone else involved in teaching the same course?*	Introductory (n = 1074)	Majors (n = 1044)
No one else was involved in teaching this course	44.8%	61.0%
One or more full-time faculty during the same term	23.0%	4.7%
One or more adjunct faculty during the same term	13.5%	0.7%
Graduate teaching assistant(s) taught the lab section	14.8%	15.7%
Graduate and/or undergraduate teaching assistant(s) in class with me	12.3%	14.6%
Co-taught with another faculty member	5.7%	6.7%
None of the above	2.1%	1.3%

* Note that respondents could select more than one answer, so percentages total > 100%.

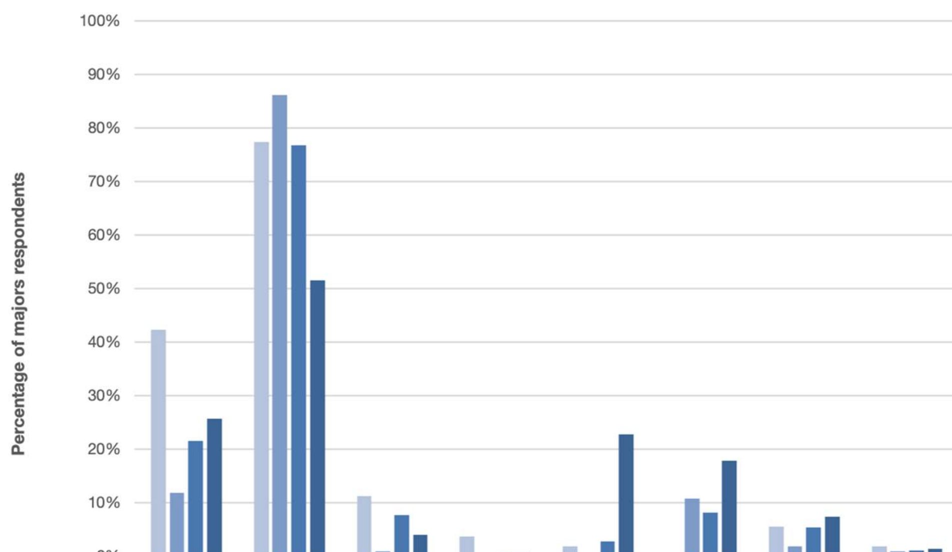
Responses about introductory courses were remarkably different from those for majors courses (Table 3.4). Instructors are more often teaching majors courses independently—61.0% report that no one else is involved in teaching the majors course at the same time, compared to 44.8% of introductory course instructors. In introductory courses, nearly a quarter of respondents reported that another full-time instructor taught the same course at the same time and 13.5% reported that an adjunct faculty taught the same course at the same time; very few adjunct instructors are reported teaching courses for majors, nor are majors courses frequently reported as taught by two faculty members at the same time. Graduate teaching assistants are utilized to teach lab sections in similar proportions in both introductory and majors courses; in-class teaching assistants are reported slightly more frequently in courses for majors. However, these proportions differ between institution types (Figures 3.3 and 3.4).

Instructors describing introductory courses at Associate's and Master's institutions more commonly report that multiple full-time and/or adjunct faculty taught the same course during the same term than instructors at Baccalaureate and Doctoral institutions (Figure 3.3). Graduate teaching assistants play a role in teaching classes at Doctoral institutions, an option that is not available at Associate's or Baccalaureate institutions.



	Other people at my institution teach this course	No one else was involved in teaching the course	One or more full-time faculty taught the same course during the same term	One or more adjunct faculty taught the same course during the same term	Graduate teaching assistant(s) taught the lab section(s)	I had graduate and/or undergraduate teaching assistant(s) in class with me	I co-taught this course with another faculty member	None of the above
Associate's (n = 234)	67.8%	58.1%	25.6%	25.6%	0.0%	1.3%	2.6%	0.9%
Baccalaureate (n = 107)	56.6%	56.1%	17.8%	5.6%	0.0%	15.9%	3.7%	4.7%
Master's (n = 213)	68.1%	45.1%	32.9%	16.4%	8.5%	7.0%	5.2%	1.9%
Doctoral (n = 452)	64.8%	34.7%	18.4%	7.3%	30.3%	19.5%	8.0%	2.2%

Figure 3.3. Involvement of others in teaching introductory courses by institution type (2016).



	Other people at my institution teach this course	No one else was involved in teaching the course	One or more full-time faculty taught the same course during the same term	One or more adjunct faculty taught the same course during the same term	Graduate teaching assistant(s) taught the lab section(s)	I had graduate and/or undergraduate teaching assistant(s) in class with me	I co-taught this course with another faculty member	None of the above
Associate's (n = 53)	42.3%	77.4%	11.3%	3.8%	1.9%	0.0%	5.7%	1.9%
Baccalaureate (n = 101)	11.9%	86.1%	1.0%	0.0%	0.0%	10.9%	2.0%	1.0%
Master's (n = 181)	21.7%	76.8%	7.7%	0.6%	2.8%	8.3%	5.5%	1.1%
Doctoral (n = 666)	25.8%	51.7%	4.1%	0.6%	22.8%	17.9%	7.5%	1.5%

Figure 3.4. Involvement of others in teaching courses for majors by institution type (2016).

In courses for majors, Doctoral institutions look quite different from other institution types, with more involvement of graduate students and greater involvement of others in general (Figure 3.4).

Course topics

Survey respondents were asked to provide the name of their most recently taught introductory or majors course. Provided course names were grouped and binned by topic or subject area.

Introductory course subject areas

Introductory course names were analyzed in three stages. First, course titles that differed only by capitalization (physical geology vs. Physical Geology), misspelling (physcal geology), or abbreviations (Intro to physical geology vs. Introduction to physical geology) were grouped together and considered to be the same title. Second, course titles that appeared to address similar subject areas were combined (e.g. physical geology, introduction to geology, the solid Earth). Finally, similar subject areas (e.g. atmospheric science, meteorology, weather) were combined into broader disciplinary areas (e.g. atmosphere); these broad subject areas are shown in Table 3.5.

Table 3.5. Broad subject areas of introductory courses

Subject area	Example course names	2004 (n = 852)	2009 (n = 1041)	2012 (n = 1007)	2016 (n = 1096)
Atmosphere	Climate and Climate Change, Intro to Meteorology, Oceans and Atmosphere, Weather and Climate	6.3%	6.7%	6.6%	9.2%
Earth science	Earth and Space Science, Earth Science	4.2%	3.7%	7.3%	6.4%
Earth systems	Earth Systems Science, Intro to the Earth System	2.1%	1.9%	1.2%	2.2%
Environmental	Environmental Geology, Environmental Science	9.7%	7.7%	7.6%	6.6%
Geography	Physical Geography, World Regional Geography	3.2%	3.4%	3.9%	4.7%
Geology	Physical Geology, Dynamic Earth, Geology of National Parks	29.0%	30.9%	40.3%	36.5%
Hazards	Earthquakes and Volcanoes, Natural Hazards	4.2%	4.4%	3.7%	4.5%
Historical	Historical Geology, Earth and Life through Time, Evolution of Earth, Dinosaurs	10.1%	9.7%	7.3%	6.6%
Oceans	Intro to Oceanography, Intro to Marine Science	9.0%	7.5%	5.8%	7.4%
Other	Courses in astronomy, biology, chemistry, computer programming, engineering, GIS, planetary geology, resources, general science, soil science, water, etc.	15.3%	17.2%	9.9%	12.2%
Unknown	No course title, or unclear response	6.8%	6.9%	6.4%	3.8%

In all four survey administrations, geology is the most common subject area by a wide margin. Historical geology was the second-most common subject area in 2004, but the proportion declined in subsequent administrations: in 2016, historical geology was the fourth-most common subject area after atmosphere and oceans.

Majors course topics

Courses for majors were sorted by course title into 34 topics (Table 3.6) using the same procedure as for introductory courses.

Table 3.6. Topics of courses for majors

Course topic	Example course names	2004 (n = 840)	2009 (n = 1156)	2012 (n = 901)	2016 (n = 1066)
Atmosphere	Atmospheric Dynamics, Atmospheric Science	2.0%	1.5%	2.2%	2.5%
Biology	Geobiology, Environmental Microbiology, Marine Biology	1.3%	2.2%	1.3%	2.3%
Climate	Climatology, Earth's Climate, Paleoclimatology	2.4%	2.6%	2.6%	3.2%
Data analysis	Data Methods in Geosciences, Earth System Modeling	0.7%	1.0%	1.2%	1.5%
Earth Materials	Earth Materials, Rocks & Minerals, Mineralogy & Petrology	2.9%	2.1%	3.0%	3.2%
Engineering	Engineering Geology, Petroleum Engineering	1.4%	1.0%	0.4%	0.9%
Environment	Environmental Geology, Environmental Science	1.8%	2.9%	2.7%	3.2%
Field	Field Geology, Field Methods, Geologic Mapping	2.6%	3.0%	2.8%	3.5%
Geochemistry	Geochemistry, Environmental Chemistry	5.6%	4.2%	3.4%	4.6%
Geography	Physical Geography, Economic Geography	1.1%	1.4%	0.9%	0.7%
Geology	Physical Geology, The Solid Earth, Dynamic Earth	3.0%	1.6%	3.8%	4.4%
Geomorphology	Geomorphology, Earth Surface Processes	3.5%	5.2%	4.4%	4.7%
Geophysics	Physics of the Earth, Geophysics, Seismology	5.2%	6.1%	4.6%	5.7%
GIS	GIS, Applied GIS, Environmental GIS, Principles of GIS	1.9%	1.6%	1.3%	2.2%
Historical	Historical Geology, Earth History, Evolution of the Earth	2.5%	2.6%	2.9%	2.8%
Hydrology	Hydrology, Hydrogeology, Physical Hydrology	6.0%	6.3%	6.2%	5.3%
Meteorology	Meteorology, Dynamic Meteorology	1.8%	2.3%	4.4%	3.0%
Mineralogy	Mineralogy, Optical Mineralogy, Crystallography	5.1%	5.4%	6.8%	4.8%
Oceanography	Oceanography, Marine Geology, Marine Science	2.1%	2.7%	2.4%	2.9%
Paleontology	Paleontology, Invertebrate Paleontology, Paleobiology	4.2%	3.6%	3.6%	3.5%
Petrology	Petrology, Igneous & Metamorphic Petrology	7.7%	5.0%	4.0%	4.9%
Planets	Planetary Geology, Planetary Science, Solar System	0.6%	1.0%	0.9%	0.7%
Professional	Communication in the Geosciences, Ethics in Research	1.5%	0.7%	0.7%	1.3%
Remote Sensing	Remote Sensing, Environmental Remote Sensing	0.7%	1.4%	0.8%	1.8%
Research/Capstone	Research Design, Senior Thesis, Undergrad. Research	0.8%	0.8%	1.1%	0.9%
Resources	Petroleum Geology, Ore Deposits, Geothermal Energy	1.2%	2.1%	1.6%	2.1%
Sed/Strat	Sedimentology & Stratigraphy, Depositional Systems	8.2%	6.4%	6.4%	6.1%
Soils	Soils, Soil Science, Soil Physics, Soil Genesis	2.7%	1.6%	1.0%	1.5%
Structure	Structural Geology, Structural Geology & Tectonics	6.7%	6.3%	5.9%	5.7%
Systems	Earth Systems, Earth System Science	0.2%	0.7%	0.4%	0.9%
Techniques	Digital Image Analysis, X-Ray Analytical Methods,	0.4%	0.7%	0.8%	1.3%
Tectonics	Tectonics, Global Tectonics, Active Tectonics	1.0%	1.0%	1.2%	0.9%
Volcanology	Volcanology, Magmas and Magmatic Systems	0.1%	0.5%	0.4%	0.8%
Other	Geology Seminar, Land Use Planning, Speleology	6.2%	5.8%	5.3%	3.4%
Unknown	No course title, or unclear response	4.9%	6.9%	8.5%	2.7%

In all four survey administrations, a variety of courses are represented and no substantial differences between the four years (Table 3.6). Responses categorized as mineralogy, structure, and sedimentology/stratigraphy have a narrow range of associated course names, whereas the categories of hydrology and geophysics have a wider variety of course names.

To determine if survey respondents were describing courses that represented the full range of courses offered to geoscience majors, we compared the course topics in Table 3.6 with the names of required and elective courses in 67 undergraduate geoscience degree programs profiled on the Building Strong Geoscience Departments website (National Association of Geoscience Teachers, n.d.). Our comparison suggests that the proportion of respondents for each topic is similar to the frequency with which courses in each bin are offered by geoscience programs (Figure 3.5).

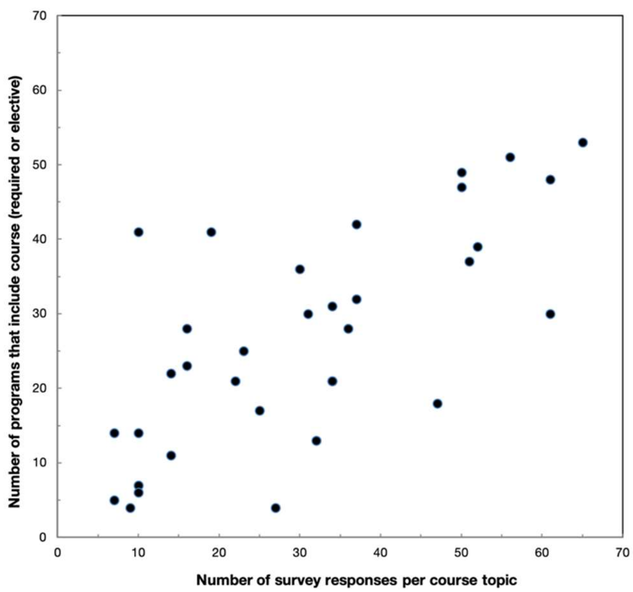


Figure 3.5. Comparison of majors course topics in survey responses and undergraduate degree programs.

AGI reports a total of 635 geoscience departments at four-year institutions in 2016 (Wilson, 2018). Although the number of degree program profiles is about 10% of departments, they span the range of institution types and geographic locations represented by survey respondents and thus we consider them a reasonable comparison.

Summary of characteristics of undergraduate geoscience courses

Introductory and majors courses differ in their structure and size. Courses for geoscience majors are generally smaller and more commonly integrate lecture and lab, whereas introductory courses are generally larger and more commonly consist of lecture with or without a separate lab. Few instructors of either type of course report delivering their course online only. The students in most introductory courses are fulfilling general education requirements and represent a large proportion of total enrollment in introductory geoscience courses nationwide.

Instructors of undergraduate geoscience courses that responded to the survey are largely experienced teachers, 80% of whom have taught the course they are describing three or more times, and those describing courses for majors report their disciplinary preparation is well aligned with the course topic. In general, more people are involved in introductory course instruction at the same time across all institution types, but the involvement of adjunct instructors and graduate students differs across institution types. Courses for majors are more commonly taught independently.

Course topics derived from course titles represent the full range of introductory course offerings, courses for majors in geoscience degree programs, and reasonably reflect the relative frequency at which courses are offered.

Further research

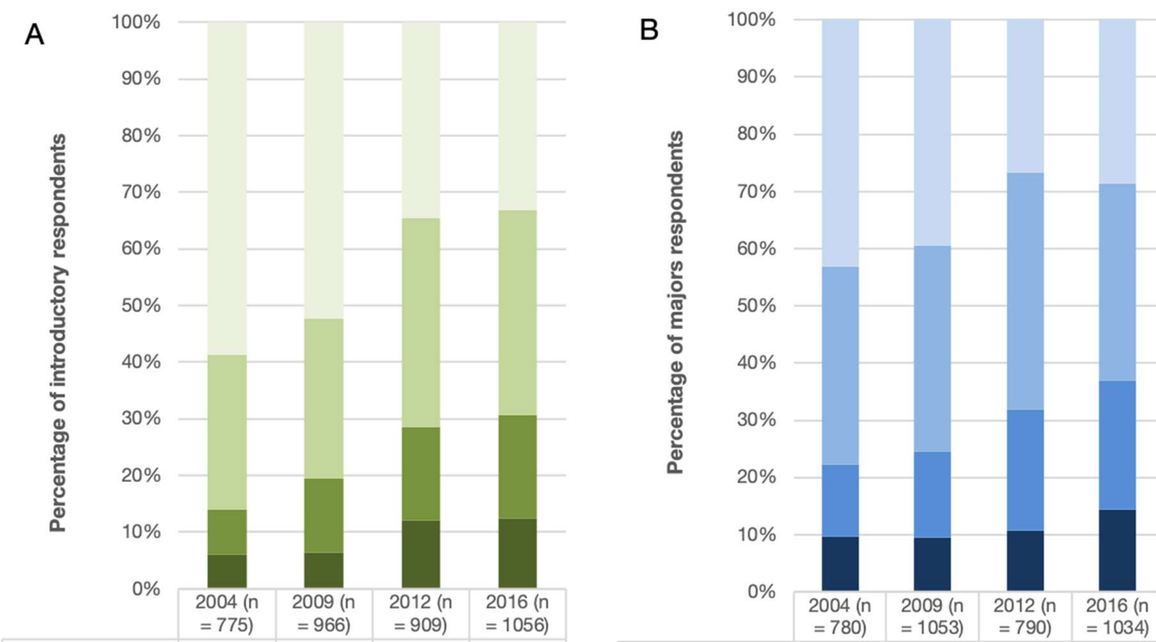
Additional analysis of course subject areas in survey responses can be found for introductory courses in Egger (2019) for introductory courses and in Viskupic, Egger, McFadden, and Schmitz (in review) for majors courses.

Chapter 4: Nature of teaching in undergraduate geoscience courses

Teaching strategies that actively engage students in learning (called student-centered teaching or active learning) have been shown to increase student learning in all STEM disciplines as well as in the geosciences (Freeman et al., 2014; McConnell et al., 2017). In both the introductory and majors sections of the surveys, and in all four survey administrations, a series of questions addressed the use of teaching strategies related to active learning. Because these same questions were asked in all four survey years, these allow us to identify trends and changes in the undergraduate geoscience classroom over time.

Class time spent in active learning

In all four years and in both sections of the survey, respondents were asked to estimate the proportion of class time spent on student activities, questions, and discussion—all generally considered active learning strategies. The question asked respondents to consider the "lecture" portion of their class, and they could enter a number between 0 and 100. For this report, we calculated means and binned responses into four categories based on natural breaks in the open responses: less than 20%, 20-30%, 31-50%, and greater than 50% (Figure 4.1).



A	2004 (n = 775)	2009 (n = 966)	2012 (n = 909)	2016 (n = 1056)
Less than 20%	58.7%	52.3%	34.5%	33.0%
20-30%	27.2%	28.3%	36.9%	36.3%
31-50%	8.1%	13.1%	16.6%	18.3%
Greater than 50%	5.9%	6.3%	12.0%	12.4%

B	2004 (n = 780)	2009 (n = 1053)	2012 (n = 790)	2016 (n = 1034)
Less than 20%	43.1%	39.5%	26.7%	28.6%
20-30%	34.7%	36.1%	41.5%	34.5%
31-50%	12.6%	15.0%	21.0%	22.5%
Greater than 50%	9.6%	9.4%	10.8%	14.3%

Figure 4.1. Percentage of class time spent on student activities, questions, and discussion in (A) introductory courses and (B) courses for geoscience majors (right).

Overall, the amount of class time spent on student activities, questions, and discussion in both introductory and majors courses has increased from 2004 to 2016 (Figure 4.1). Across the four administrations, the largest decrease occurred in the percentage of respondents reporting less than 20% of class time in these activities, particularly in introductory courses (Figure 4.1).

The mean percentage for all respondents was 23.2% (SD = 20.4) in 2004, 24.4% (SD = 20.4) in 2009, 29.4% (SD = 21.6) in 2012, and 30.8% (SD = 22.4) in 2016. The mean percentage for all years was 25.5% (SD = 21.1) in introductory courses and 28.8% (SD = 21.8) in courses for majors; in general, more time is spent on student activities, questions, and discussion in courses for majors than in introductory courses (Figure 4.1).

Use of teaching strategies in courses

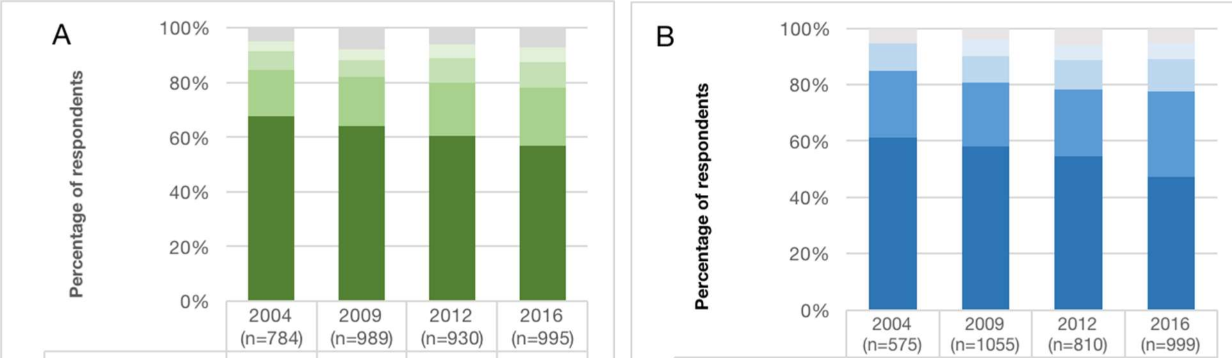
In all four years of the survey administration, both introductory and majors section respondents were asked how often they used specific teaching strategies in the "lecture portion" of their course:

- Traditional lecture
- Lecture with demonstration
- Lecture in which questions posed by instructor are answered by individual students (the 2016 survey administration included the parenthetical clarification (e.g. professor calls on individual students))
- Lecture in which questions posed by instructor are answered simultaneously by the entire class (the 2016 survey administration included the parenthetical clarification (e.g. students vote using cards or electronic response systems))
- Small group discussion or think-pair-share
- Whole-class discussions
- In-class exercises

The response options for each teaching strategy were "never," "once or twice," "several times," "weekly," and "nearly every class."

Traditional lecture

Traditional lecture involves an instructor talking, writing on the board, and presenting slides to students seated in a classroom. It is how many instructors were taught, and the frequency with which geoscience instructors use it in their teaching is shown in Figure 4.2.



(A)

	2004 (n=784)	2009 (n=989)	2012 (n=930)	2016 (n=995)
Never	5.0%	7.8%	6.1%	7.3%
Once or Twice	3.6%	4.2%	5.2%	5.4%
Several Times	7.0%	5.9%	8.8%	9.1%
Weekly	16.8%	18.2%	19.6%	21.5%
Nearly Every Class	67.6%	63.9%	60.3%	56.6%

(B)

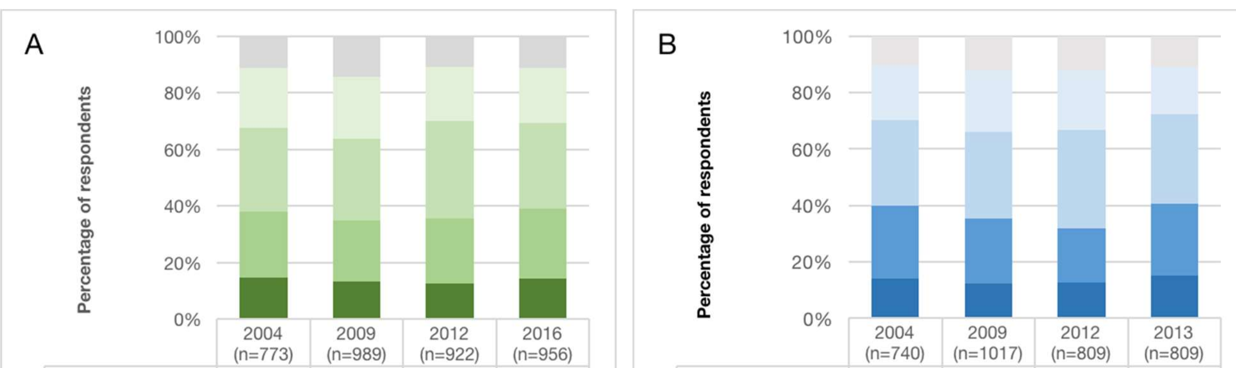
	2004 (n=575)	2009 (n=1055)	2012 (n=810)	2016 (n=999)
Never	4.9%	4.0%	6.0%	5.2%
Once or Twice	0.2%	5.7%	5.4%	5.6%
Several Times	9.5%	9.5%	10.4%	11.6%
Weekly	23.2%	22.8%	23.7%	30.4%
Nearly Every Class	59.2%	58.0%	54.4%	47.1%

Figure 4.2. Frequency of use of traditional lecture in (A) introductory courses and (B) courses for majors.

Traditional lecture is used in nearly every class by at least half of respondents in both course types, but that percentage has decreased by 11-12% from 2004 to 2016.

Lecture with demonstration

Lecture with demonstration is similar to traditional lecture, but involves the instructor conducting a demonstration that students observe. Demonstrations can promote active learning when students are asked to make predictions prior to observing the demonstration, but the survey question did not include any suggestion of *how* the demonstration was used. The frequency with which respondents use demonstrations is shown in Figure 4.3.



(A)

	2004 (n=773)	2009 (n=989)	2012 (n=922)	2016 (n=956)
Never	0.113	0.142	0.108	0.113
Once or Twice	0.21	0.218	0.19	0.192
Several Times	0.296	0.29	0.346	0.302
Weekly	0.234	0.215	0.228	0.247
Nearly Every Class	0.147	0.133	0.128	0.145

(B)

	2004 (n=740)	2009 (n=1017)	2012 (n=809)	2013 (n=809)
Never	10.5%	12.3%	12.2%	11.0%
Once or Twice	19.3%	21.7%	21.0%	16.6%
Several Times	30.4%	30.7%	34.9%	31.9%
Weekly	25.5%	22.8%	19.3%	25.2%
Nearly Every Class	14.2%	12.5%	12.6%	15.3%

Figure 4.3. Frequency of use of lecture with demonstration in (A) introductory courses and (B) courses for majors.

Overall, lecture with demonstration is used less frequently than traditional lecture, but at similar frequencies in both introductory courses and courses for majors. The use of demonstrations has changed little over the four administrations (Figure 4.3).

Lecture with questions answered by individual students

Lecture in which questions posed by the instructor are answered by individual students is another variant of traditional lecture. Instructors may pause in the middle of a lecture and ask a question to the entire class, and students may raise their hands and be called upon to answer. The frequency with which respondents use lecture with questions is shown in Figure 4.4.

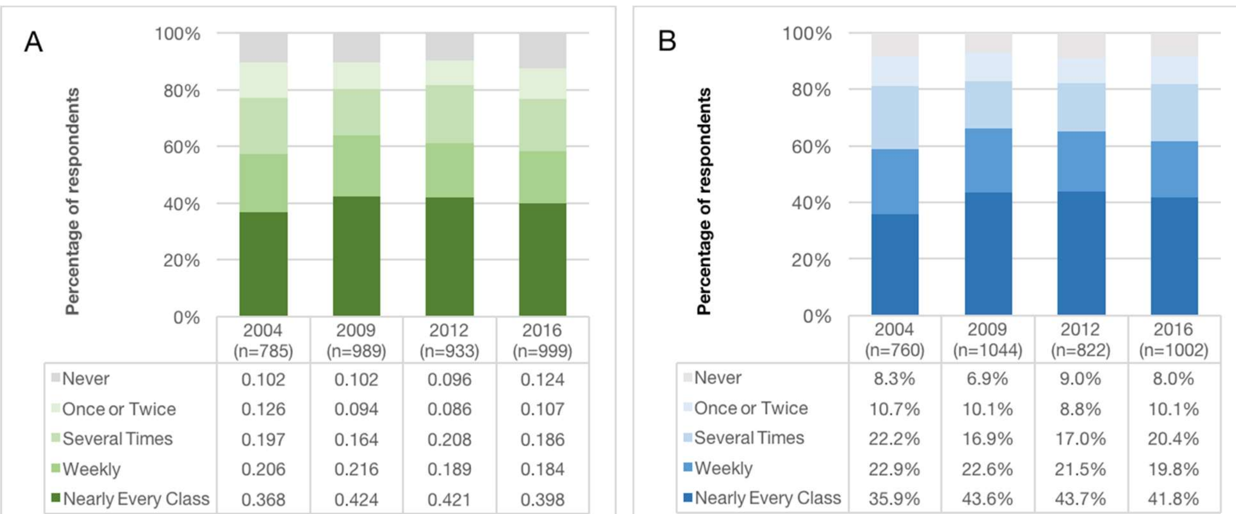
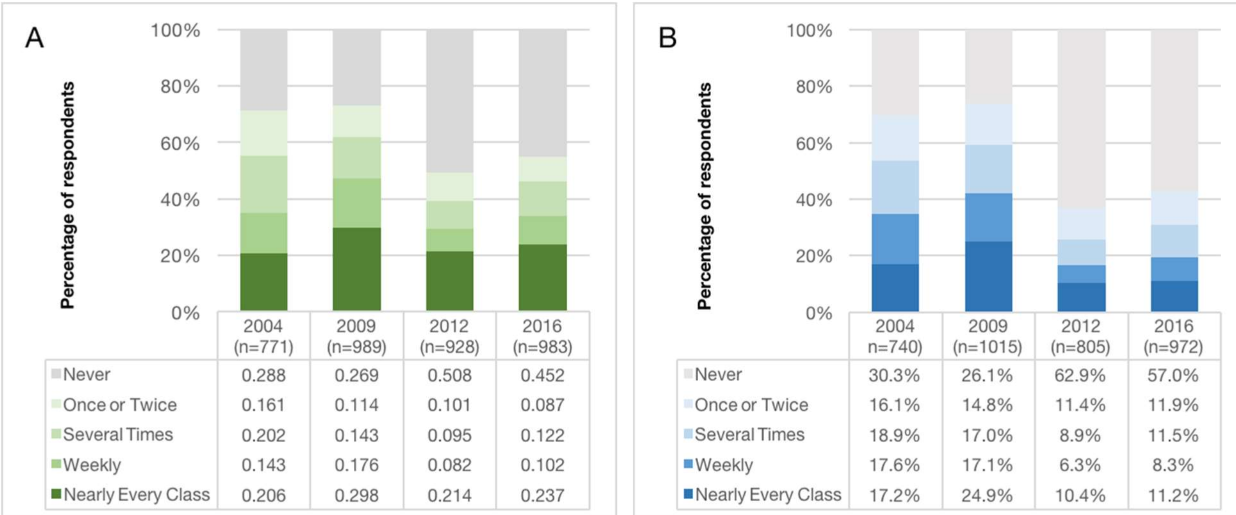


Figure 4.4. Frequency of use of lecture with questions answered by individual students in (A) introductory courses and (B) courses for majors.

Posing questions to the class for one student to answer is a commonly used teaching strategy, with greater than 30% of respondents in both introductory and majors courses reporting use in nearly every class (Figure 4.4). Use of this strategy in "nearly every class" increased slightly between the 2004 and later survey administrations, and has since remained fairly constant in both introductory courses and courses for majors.

Lecture with questions answered simultaneously by all students

A teaching strategy that makes use of the principle of active learning and can still be accommodated in a large lecture hall is that of lecture in which questions posed by an instructor are answered simultaneously by the entire class. This strategy may make use of classroom response systems (e.g., "clickers"), but also can be employed by using colored cards or other means that do not require the use of technology. The frequency with which respondents use lecture with questions answered simultaneously by all students is shown in Figure 4.5.



A	2004 (n=771)	2009 (n=989)	2012 (n=928)	2016 (n=983)
Never	0.288	0.269	0.508	0.452
Once or Twice	0.161	0.114	0.101	0.087
Several Times	0.202	0.143	0.095	0.122
Weekly	0.143	0.176	0.082	0.102
Nearly Every Class	0.206	0.298	0.214	0.237

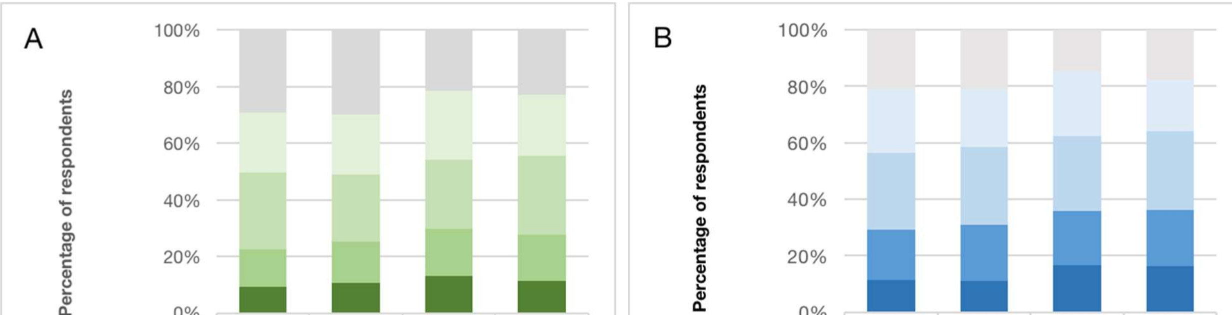
B	2004 n=740)	2009 (n=1015)	2012 (n=805)	2016 (n=972)
Never	30.3%	26.1%	62.9%	57.0%
Once or Twice	16.1%	14.8%	11.4%	11.9%
Several Times	18.9%	17.0%	8.9%	11.5%
Weekly	17.6%	17.1%	6.3%	8.3%
Nearly Every Class	17.2%	24.9%	10.4%	11.2%

Figure 4.5. Use of lecture in which questions are answered simultaneously by the entire class in (A) introductory courses and (B) courses for majors.

Lecture in which questions posed by the instructor are answered simultaneously by the entire class (Figure 4.5) is used less frequently than questions to individual students (Figure 4.4), and is used more frequently in introductory courses than in courses for majors. There was a sharp increase in the percentage of respondents reporting "never" using this strategy between the 2004/2009 surveys and the 2012/2016 surveys for both introductory and majors courses. Unlike other differences between the 2004/2009 and 2012/2016 frequencies, the higher proportion of "never" responses cannot be attributed solely to an increase in the respondents from Associate's institutions. Instead, the change may reflect growth in the widespread use of clickers and respondents' awareness of classroom response systems in general: respondents in 2012 and 2016 may have been more likely to interpret the question to be about clicker use (the 2016 version of the question specifically mentions electronic voting systems as an example) rather than posing questions that *could* be answered by all students simultaneously.

Whole-class discussion

In whole-class discussion, the instructor serves as the leader or facilitator of a discussion in which all students can participate. The frequency with which respondents use whole-class discussion is shown in Figure 4.6.



A

	2004 (n=789)	2009 (n=989)	2012 (n=926)	2016 (n=990)
Never	0.29	0.298	0.215	0.227
Once or Twice	0.215	0.213	0.244	0.218
Several Times	0.269	0.235	0.243	0.277
Weekly	0.132	0.148	0.167	0.166
Nearly Every Class	0.094	0.106	0.131	0.112

B

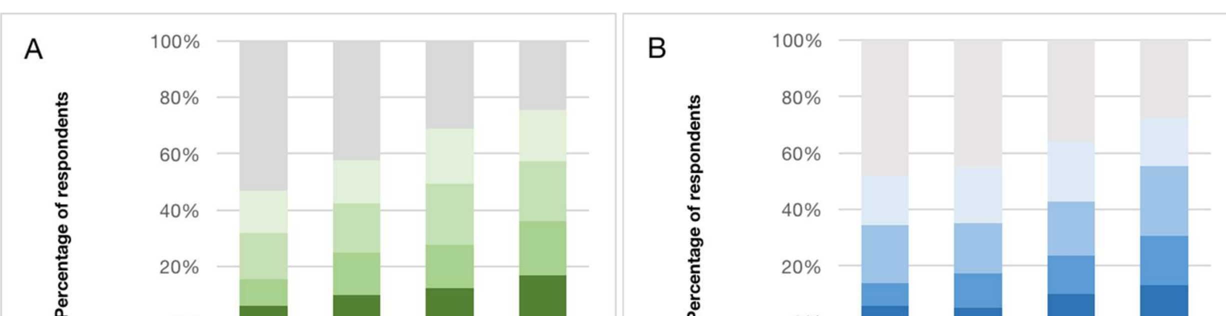
	2004 (n=773)	2009 (n=1059)	2012 (n=805)	2016 (n=1003)
Never	21.0%	20.8%	14.7%	17.8%
Once or Twice	22.5%	20.6%	23.1%	18.2%
Several Times	27.4%	27.9%	26.5%	27.6%
Weekly	17.7%	19.8%	19.0%	19.9%
Nearly Every Class	11.4%	11.0%	16.8%	16.4%

Figure 4.6. Use of whole-class discussion in (A) introductory courses and (B) courses for majors.

The use of whole class discussions remained fairly constant across all four survey administrations for both introductory and majors courses; the biggest changes are a 5% increase in the use of whole-class discussion in "nearly every class" in courses for majors and decreases in "never" and "once or twice responses" in both groups (Figure 4.6).

Small-group discussion or think-pair-share

In small-group discussions, instructors pose questions or give prompts and ask students to talk to each other in small groups, usually 2-5 students. Think-pair-share is a more structured format in which instructors post a question or prompt and ask students to think about it on their own first, then pair with a partner or small group to discuss, and then share out with a larger group. Both are considered strong active learning strategies. The frequency with which respondents use small-group discussion or think-pair-share is shown in Figure 4.7.



A

	2004 (n=783)	2009 (n=989)	2012 (n=923)	2016 (n=992)
Never	0.533	0.425	0.312	0.245
Once or Twice	0.148	0.153	0.195	0.183
Several Times	0.165	0.175	0.215	0.21
Weekly	0.093	0.149	0.156	0.194
Nearly Every Class	0.061	0.099	0.122	0.168

B

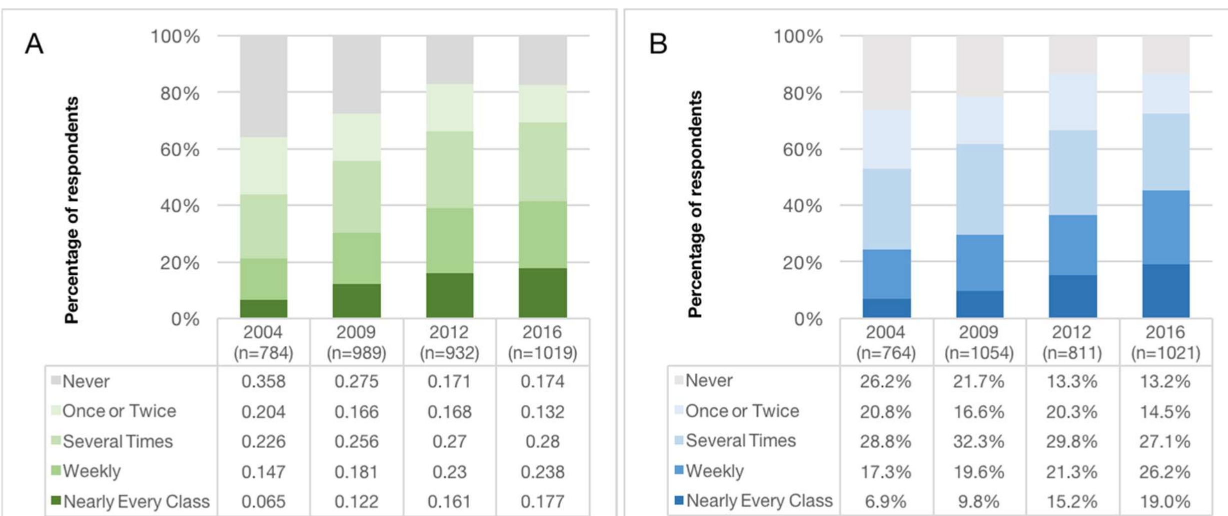
	2004 (n=757)	2009 n=1041)	2012 (n=807)	2016 (n=992)
Never	48.0%	45.1%	35.8%	27.7%
Once or Twice	17.7%	19.7%	21.3%	17.1%
Several Times	20.5%	17.8%	19.3%	24.4%
Weekly	7.9%	12.4%	13.5%	17.7%
Nearly Every Class	5.9%	5.1%	10.0%	13.0%

Figure 4.7. Use of small group discussion or think-pair-share in (A) introductory courses and (B) courses for majors.

The reported use of small-group discussion or think-pair-share increased in each survey year in both introductory and majors courses (Figure 4.7). The largest differences are seen in the decrease of respondents who reported "never" using small-group discussion, which dropped by almost 30% in introductory courses and 20% in courses for majors. Increases were seen primarily in the use of small-group discussions "weekly" and in "nearly every class" (Figure 4.7).

In-class exercises

In-class exercises might be activities like jigsaws, gallery walks, lecture tutorials, or problem-solving—anything in which students are actively engaged working on their own or in small groups, though the survey question did not provide a more detailed explanation of what would be included as an "in-class exercise." The frequency with which respondents use in-class exercises as a teaching strategy is shown in Figure 4.8.



A

	2004 (n=784)	2009 (n=989)	2012 (n=932)	2016 (n=1019)
Never	0.358	0.275	0.171	0.174
Once or Twice	0.204	0.166	0.168	0.132
Several Times	0.226	0.256	0.27	0.28
Weekly	0.147	0.181	0.23	0.238
Nearly Every Class	0.065	0.122	0.161	0.177

B

	2004 (n=764)	2009 (n=1054)	2012 (n=811)	2016 (n=1021)
Never	26.2%	21.7%	13.3%	13.2%
Once or Twice	20.8%	16.6%	20.3%	14.5%
Several Times	28.8%	32.3%	29.8%	27.1%
Weekly	17.3%	19.6%	21.3%	26.2%
Nearly Every Class	6.9%	9.8%	15.2%	19.0%

Figure 4.8. Use of in-class exercises in (A) introductory courses and (B) courses for majors.

The use of in-class exercises shows trends similar to those seen in the use of small-group discussion, with even more dramatic increases. The largest differences are seen in the decrease of respondents who "never" use in-class exercises (–18.4% over the four survey years in introductory courses, –13.0% in majors courses), and the increases are primarily in the use of in-class exercises "weekly" or in 'nearly every class" (Figure 4.8).

Summary of nature of teaching

Overall, the proportion of class time spent in student activities, questions, and discussion in both introductory and majors courses has increased from 2004 to 2016. The use of active learning strategies like small-group discussion/think-pair-share and in-class exercises has increased from 2004 to 2016 while the use of traditional lecture has decreased—it should be noted, however, traditional lecture is still the most commonly used teaching strategy in both introductory courses and courses for majors. The use of other strategies that have potential to facilitate active learning, such as demonstrations and whole-class discussions, have not changed systematically over time.

Further research

Manduca et al. (2017) conducted an exploratory factor analysis on responses to the questions described in this chapter and used the analysis to define three general teaching categories of strategies: active learning (frequent use of small-group discussion, whole-class discussion, and in-class activities), active lecture (frequent use of in-class demonstrations and posing questions), and traditional lecture (infrequent use of any strategies other than lecture).

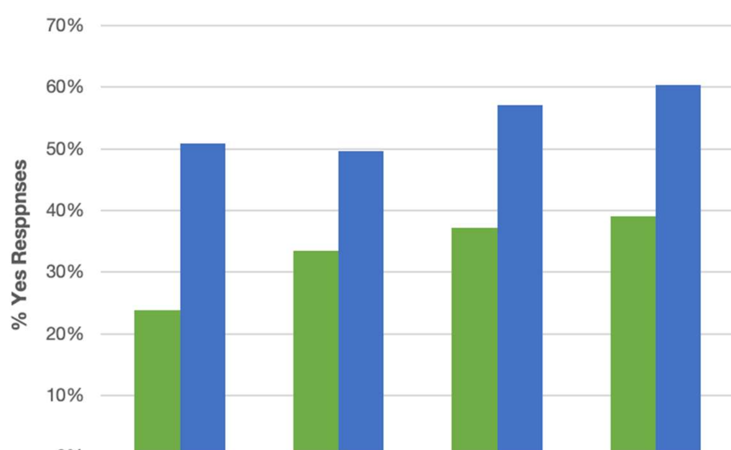
Chapter 5: Instructional activities

Over the four survey administrations, a number of questions have addressed specific instructional activities of interest to the geoscience community. These questions have changed the most of all of the survey questions over the four administrations, as new ideas and interests have emerged. Some of the questions about instructional activities address the extent to which instructors ask students to use general scientific skills, such as data analysis and interpretation, quantitative reasoning, and scientific communication. Others address skills that are more prominent in the geosciences than in other disciplines, such as three-dimensional spatial thinking and systems thinking. In addition, the most recent survey (2016) included questions that probed instructors' use of activities to support all students, including metacognitive strategies, making connections to the workforce, and addressing societal relevance.

Working with data

Working with data can help students address real-world problems scientifically, evaluate the robustness of their own and others' data, and prepare them for research (Manduca & Mogk, 2002), and there are many ways to engage students in working with data (see [How to Teach with Data](), from Pedagogy in Action). Respondents to both the introductory and majors survey sections were asked several questions about the extent to which they engaged students in the collection, evaluation, and interpretation of data in their courses.

In all four survey administrations, respondents were asked whether or not students collected their own data and analyzed them to solve a problem (Figure 5.1).

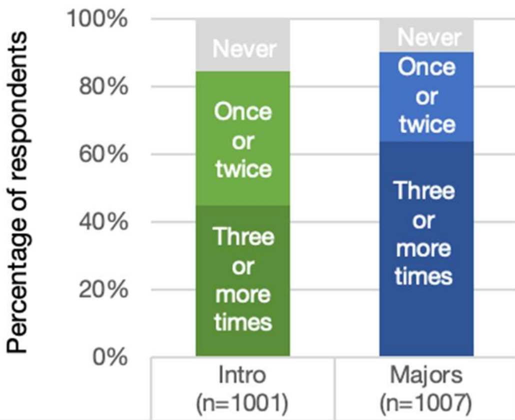


	2004 (n=851 Intro; n=839 Majors)	2009 (n=1041 Intro; n=1156 Majors)	2012 (n=927 Intro; n=813 Majors)	2016 (n=1032 Intro; n=1024 Majors)
Intro	23.8%	33.5%	37.2%	39.0%
Majors	50.9%	49.7%	57.1%	60.4%

Figure 5.1. Yes responses to "Did your students collect their own data and analyze them to solve a problem?"

Respondents describing their instructional activities in courses for majors more often report that their students collect and analyze their own data in comparison to introductory courses. In both groups, however, the percentage of “yes” responses increased across the four survey administrations, with a greater total increase in introductory courses (+16.2%) than in courses for majors (+9.5%) (Figure 5.1).

In 2016, respondents were asked to report how often their students distinguished observations from interpretations, with response options of “never,” “once or twice,” or “three or more times” (Figure 5.2).



	Intro (n=1001)	Majors (n=1007)
Never	15.4%	9.8%
Once or Twice	39.8%	26.3%
Three or More Times	44.9%	63.9%

Figure 5.2. How often students distinguished observations from interpretations (2016)

Students in majors courses are reported to distinguish observations from interpretations more frequently than students in introductory courses, with the biggest difference seen between the “three or more times” responses (Figure 5.2).

Also in 2016 only, both introductory and majors respondents were asked whether or not their students did a variety of other activities associated with working with data (Table 5.1).

Table 5.1. Ways in which students worked with data in introductory and majors courses (2016)

Did your students.... *(yes responses)*	**Introductory** (n = 1032)	**Majors** (n = 1024)
Describe quantitative evidence in support of an argument	60.4%	76.4%
Access and integrate information from different sources	62.4%	72.8%
Address uncertainty, non-uniqueness, and ambiguity when interpreting data	52.2%	72.5%
Evaluate important assumptions in estimation, modeling, or data analysis	41.8%	65.2%
Recognize distinctions among data sources (e.g. direct, indirect, and proxy)	40.7%	45.4%

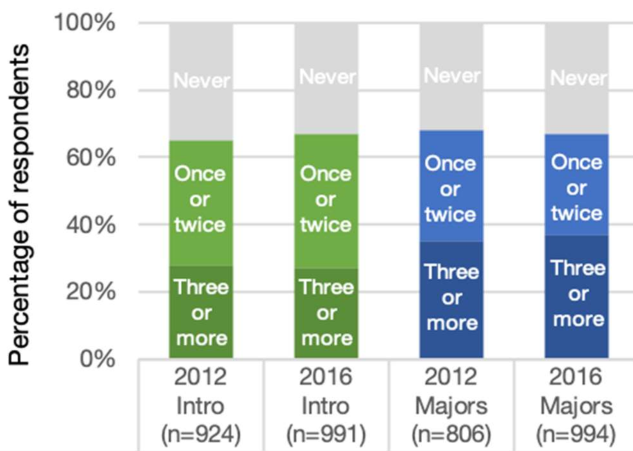
Overall, there are big differences between the reported use of these data skills in introductory and majors courses, with 5-24% higher “yes” responses from instructors in courses for majors (Table

5.1). Three-quarters of respondents report that their students describe quantitative evidence in support of an argument in majors courses, whereas less than two-thirds do so in introductory courses. Larger differences are seen in the responses to addressing uncertainty and evaluating assumptions. Both groups had the lowest frequencies reported for recognizing distinctions among data sources (Table 5.1).

Working with geoscience data

Geoscience data often has a spatial context, is collected in the field, or combines the two: putting field data in the context of a map and making interpretations on the basis of the spatial distribution. In 2012 and 2016, respondents were asked about how often students used some of these data skills prominent in the geosciences.

Working with geospatial data could encompass anything from interpreting a geologic or weather map to plotting GPS coordinates to describing the spatial distribution of earthquakes. The survey question was not specific, and asked "How often do your students work with geospatial data?" with response options of "never," "once or twice," or "three or more times" (Figure 5.3).

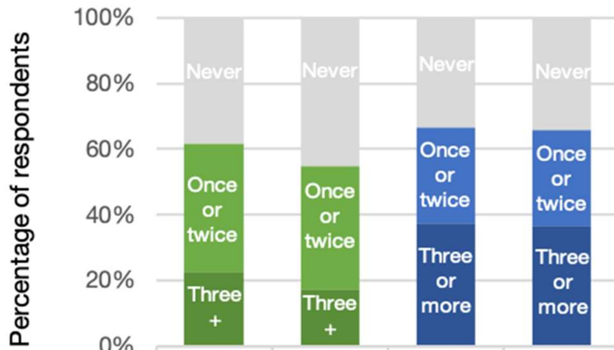


	2012 Intro (n=924)	2016 Intro (n=991)	2012 Majors (n=806)	2016 Majors (n=994)
Never	34.8%	33.2%	32.0%	32.9%
Once or Twice	37.3%	39.5%	32.9%	29.9%
Three or More Times	27.8%	27.3%	35.1%	37.2%

Figure 5.3. How often students worked with geospatial data (2012, 2016)

There is little difference in responses between 2012 and 2016, but 10% more respondents describing majors courses ask students to work with geospatial data "three or more times" than respondents describing introductory courses (Figure 5.3).

Making observations in the field is a critical component of geoscience, and experience working in the field is a hallmark of geoscience programs. Respondents were asked, "How often did your students make observations in the field?" (Figure 5.4).



	2012 Intro (n=930)	2016 Intro (n=966)	2012 Majors (n=804)	2016 Majors (n=1007)
Never	38.4%	45.0%	33.3%	34.2%
Once or Twice	39.0%	37.8%	29.1%	29.1%
Three or More Times	22.6%	17.3%	37.6%	36.7%

Figure 5.4. How often students made field observations (2012, 2016)

Overall, majors course respondents report that their students make field observations more often than introductory course respondents, with a noTable difference in the “three or more times” response (Figure 5.4). There is little difference between 2012 and 2016 responses.

Making a geologic map is a more specialized form of working with geoscience data, and typically happens in only a few undergraduate geoscience courses. Respondents were asked, “How often did your students make a geologic map?” (Figure 5.5).

	2012 Intro (n=922)	2016 Intro (n=996)	2012 Majors (n=806)	2016 Majors (n=991)
Never	62.3%	69.5%	66.8%	63.8%
Once or Twice	30.7%	25.0%	21.7%	23.6%
Three or More Times	7.0%	5.5%	11.5%	12.6%

Figure 5.5. How often students made a geologic map (2012, 2016)

About a third of both introductory and majors course respondents indicate that students make a geologic map at least once; again, there is little difference between the 2012 and 2016 responses (Figure 5.5). A small proportion of majors course respondents indicate that their students make geologic maps "three or more times" (Figure 5.5)—these are likely from courses where making maps is a critical learning outcome of the course, such as a field camp or structural geology.

Scientific communication

Scientific communication involves using data as evidence to make arguments in both written and oral forms, reading and gathering evidence from the primary literature, and communicating with colleagues to make progress. Several questions on the surveys probed respondents' use of scientific communication in their instruction.

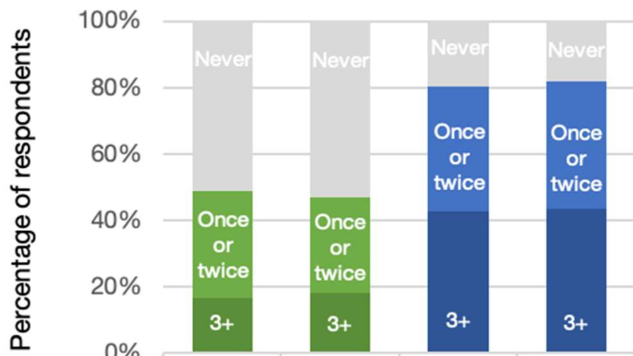
Respondents to the 2016 survey were asked how frequently students complete formal writing assignments (e.g. papers and abstracts), formally present project results in a talk or poster, and work as part of a team (Table 5.2). Response options for all questions were "never," "once or twice," or "three or more times."

Table 5.2. Use of scientific communication in instructional activities (2016)

	Introductory			Majors		
How often did your students….	**Never**	**Once or twice**	**Three or more times**	**Never**	**Once or twice**	**Three or more times**
Complete formal writing assignments *(Intro n=1002; Majors n=1004)*	42.8%	36.1%	21.1%	23.2%	39.2%	37.5%
Formally present project results in a talk or poster *(Intro n=994; Majors n=999)*	66.9%	26.5%	6.6%	46.6%	39.3%	14.0%
Work as part of a team *(Intro n=994; Majors n=999)*	16.5%	25.7%	57.7%	11.9%	27.0%	61.0%

Respondents describing their courses for majors indicate that they ask their students to complete formal writing assignments and present project results in a talk or poster more often than respondents describing introductory courses (Table 5.2). Respondents indicate that students in both introductory and majors courses frequently work as part of a team, with approximately 83% of respondents for introductory courses and 88% of respondents for majors-level courses reporting that students work as part of a team at least once in their course, and the majority report that students work as part of a team three or more times (Table 5.2).

In 2012 and 2016, the survey asked how often students read the primary literature (Figure 5.6).



	2012 Intro (n=928)	2016 Intro (n=1002)	2012 Majors (n=810)	2016 Majors (n=1006)
Never	51.4%	53.2%	19.6%	18.3%
Once or Twice	32.1%	28.9%	37.8%	38.5%
Three or More Times	16.5%	17.9%	42.6%	43.2%

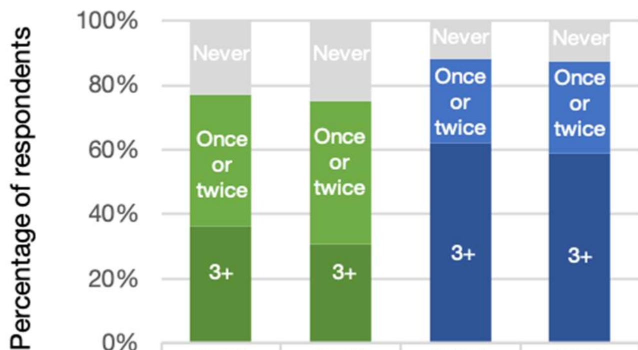
Figure 5.6. How often students read the primary literature (2012, 2016)

Respondents describing courses for majors report that their students read the primary literature much more frequently than respondents describing introductory courses in both the 2012 and 2016 survey (Figure 5.6). Little difference is seen between the 2012 and 2016 response frequencies.

Quantitative skills

Quantitative skills for students in geoscience courses can include everything from comfort describing relationships between variables to working with numerical data to computer modeling. In the 2012 and 2016 surveys, questions focused on the use of skills from particular areas of mathematics: algebra, statistics, and calculus.

Algebra is used throughout the geosciences in calculating rates, recurrence intervals, gradients, and in describing many other processes. Respondents to both the introductory and majors survey sections were asked how often students in their course use algebraic equations (Figure 5.7) with response options of “never,” “once or twice,” or “three or more times.”

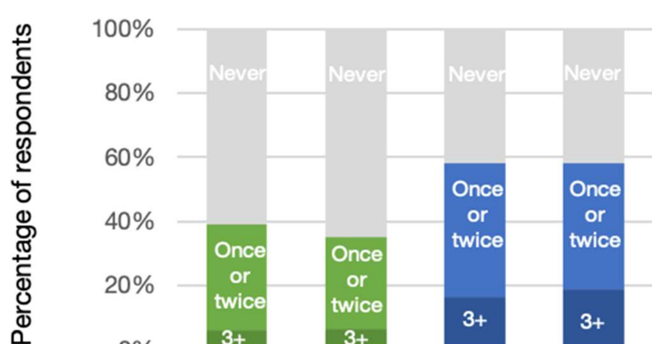


	2012 Intro (n=928)	2016 Intro (n=1004)	2012 Majors (n=812)	2016 Majors (n=1009)
Never	23.1%	25.0%	11.9%	12.7%
Once or Twice	40.7%	44.4%	26.0%	28.5%
Three or More Times	36.2%	30.6%	62.1%	58.8%

Figure 5.7. How often students used algebraic equations (2012, 2016)

Respondents indicate that students use algebraic equations more frequently in majors courses than in introductory courses, and there is very little difference in the response frequencies between 2012 and 2016. A large majority of respondents indicate that their students use algebraic equations at least once (Figure 5.7).

Statistical analysis in the geosciences includes calculations of means and standard deviation, uncertainty in data, and other analyses. Respondents to both the introductory and majors survey sections were asked how often students in their course conduct statistical analyses (Figure 5.8) with response options of "never," "once or twice," or "three or more times."

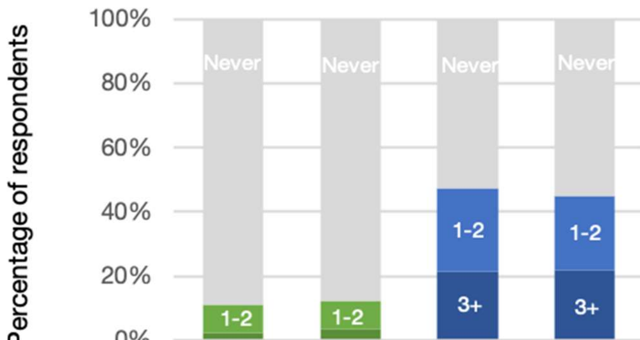


	2012 Intro (n=924)	2016 Intro (n=987)	2012 Majors (n=804)	2016 Majors (n=1002)
Never	60.8%	64.7%	41.7%	41.8%
Once or Twice	32.9%	28.7%	41.7%	39.2%
Three or More Times	6.3%	6.6%	16.7%	19.0%

Figure 5.8. How often students conducted statistical analyses (2012, 2016)

Statistical analyses are used less frequently than algebra. More respondents describing courses for majors ask students to conduct statistical analyses at least once compared to introductory course respondents (Figure 5.8).

Calculus is used frequently in specific sub-disciplines of the geosciences, including geophysics. Respondents to both the introductory and majors survey sections were asked how often students in their course use skills learned in a calculus course (Figure 5.9) with response options of "never," "once or twice," or "three or more times."



	2012 Intro (n=818)	2016 Intro (n=990)	2012 Majors (n=803)	2016 Majors (n=1004)
Never	88.8%	87.9%	52.7%	55.0%
Once or Twice	9.0%	8.7%	25.9%	23.3%
Three or More Times	2.2%	3.4%	21.4%	21.7%

Figure 5.9. How often students used skills learned in a calculus course (2012, 2016)

Not surprisingly, few introductory course respondents ask students to use calculus. Slightly less than half of majors course respondents do so (Figure 5.9).

Geoscientific and systems thinking

"Geoscientific thinking" encompasses the ways of thinking that make the geosciences unique as a group of disciplines within the sciences (see Geoscience Habits of Mind from InTeGrate). These ways of thinking include habits of mind in which spatial thinking, temporal reasoning, and systems thinking play prominent roles (Kastens & Manduca, 2012). In the 2016 survey, several questions were added to assess the extent to which instructors are incorporating geoscientific thinking into their courses.

Respondents to the 2016 survey were asked how frequently students in their most recent introductory or majors-level course practice 3D spatial thinking, and practice temporal reasoning, with response options of "never," "once or twice," or "three or more times" (Table 5.3).

Table 5.3. How often students practiced 3D thinking and temporal reasoning (2016)

	Introductory			Majors		
How often did your students....	**Never**	**Once or twice**	**Three or more times**	**Never**	**Once or twice**	**Three or more times**
Practice 3D spatial thinking *(Intro n=922; Majors n=1002)*	27.2%	39.4%	33.4%	20.5%	26.8%	52.7%
Practice temporal reasoning *(Intro n=989; Majors n=981)*	21.8%	44.3%	33.9%	18.6%	36.6%	44.9%

The majority of respondents for both introductory and majors courses indicate that students practice 3D spatial thinking and temporal reasoning at least once (Table 5.3). Students in majors courses are more likely to have the opportunity to practice these skills three or more times, however, while a greater proportion of students in introductory courses practice them once or twice.

Several questions in the 2016 survey probed the use of systems thinking (see What is Systems Thinking? from InTeGrate). Respondents were asked whether there are elements in their introductory or majors course that enable students to practice nine different components of systems thinking (Table 5.4).

Table 5.4. Presence of systems thinking elements in courses (2016)

Are there elements in your course that enable students to...	Introductory (n = 1032)	Majors (n = 1024)
Describe a system in terms of its parts and relationships	64.2%	64.5%
Discuss a change that has multiple effects throughout a system	54.9%	52.1%
Discuss complexity of scale and interactions	52.8%	64.2%
Distinguish outcomes of current processes from results of prior history	45.3%	38.3%
Discuss relationships between implications and predictions	40.0%	43.8%
Analyze feedback loops	38.4%	29.2%
Make systems visible through causal maps	26.6%	25.0%
Build predictive models	15.1%	29.8%
Explore systems behavior using computer models	12.0%	27.1%

Unlike many other skills-related questions, there is no consistent difference between introductory and majors courses in the incorporation of elements of systems thinking (Table 5.4). The most commonly reported element in both introductory and majors courses—by about two-thirds of respondents—is describing a system in terms of its parts and relationships. Over half also report discussing a change that has multiple effects throughout a system and discussing complexity of scale and interactions. Some strategies such as exploring systems behavior using computer models and building predictive models are more frequently used in majors courses than in introductory courses, though the proportions are still low for both groups. Other strategies like analyzing feedback loops and distinguishing the outcomes of current processes from the results of prior history are reported more frequently in introductory courses.

Further research

McFadden, Viskupic, and Egger (in review) explore the use of quantitative and data analysis skills in both introductory and majors courses. Gamage, McFadden, and Macdonald (in review) compare the use of quantitative and other skills in introductory courses at 2-year and 4-year institutions. Viskupic et al. (in review) investigate the use of desired workforce skills in majors courses by topic. Lally, Forbes, McNeal, and Soltis (2019) further explore the prevalence of systems thinking and other variables that are correlated with instructors' use of these elements. Soltis, McNeal, Forbes, and Lally (in press) use structural equation modeling to address the relationship between active learning and teaching Earth systems thinking.

Interdisciplinary thinking

Interdisciplinary thinking involves integrating the techniques and approaches from more than one discipline in addressing a topic or problem (see Interdisciplinary Approaches to Teaching from Pedagogy in Action), and is a hallmark of many complex socioscientific issues. In the 2012 and 2016 administrations, one question probed respondents' use of interdisciplinary thinking in their courses (Table 5.5).

Table 5.5. Integration of geoscience and other disciplinary knowledge (2012, 2016)

	Introductory		Majors	
Did your students….	**2012** (n = 927)	**2016** (n = 1032)	**2012** (n = 813)	**2016** (n = 1024)
Address a problem that required bringing together geoscience knowledge with knowledge from another discipline	51.1%	57.0%	59.7%	64.6%

The majority of respondents describing both introductory and majors courses indicate that their students addressed a problem that required bringing together geoscience knowledge with knowledge from another discipline, though the proportion is higher in majors courses (Table 5.5). The proportion of "yes" responses increased by about 8% in both groups from 2012 to 2016.

Making connections to societal issues

Connecting geoscience content to societal issues promotes relevance to students and can increase their interest and motivation (see Connect to the World We Live in from InTeGrate). In all four survey administrations, respondents were asked if their students addressed a problem of national or global interest (Figure 5.10), and if their students worked on a problem of interest to the local community (Figure 5.11).

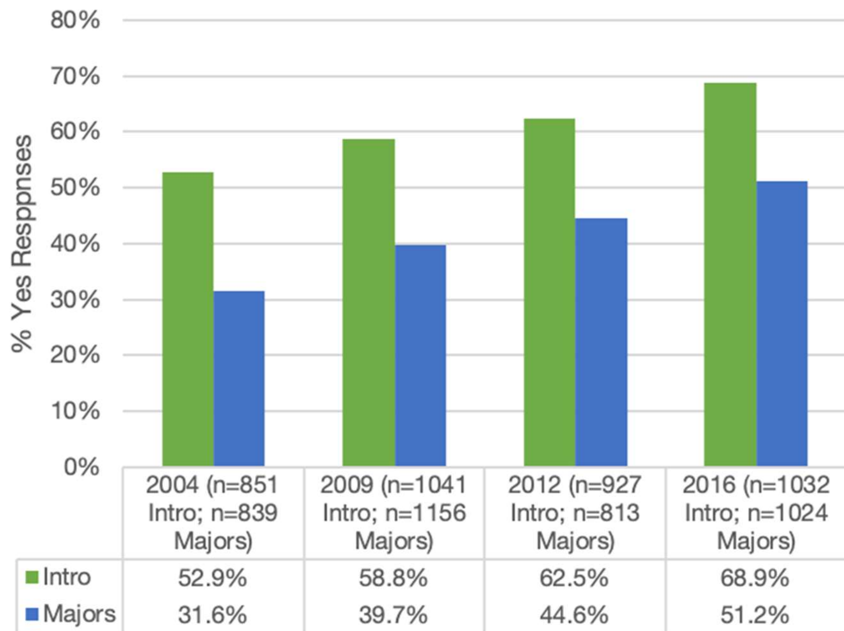


Figure 5.10. Yes responses to "Did your students address a problem of national or global interest?"

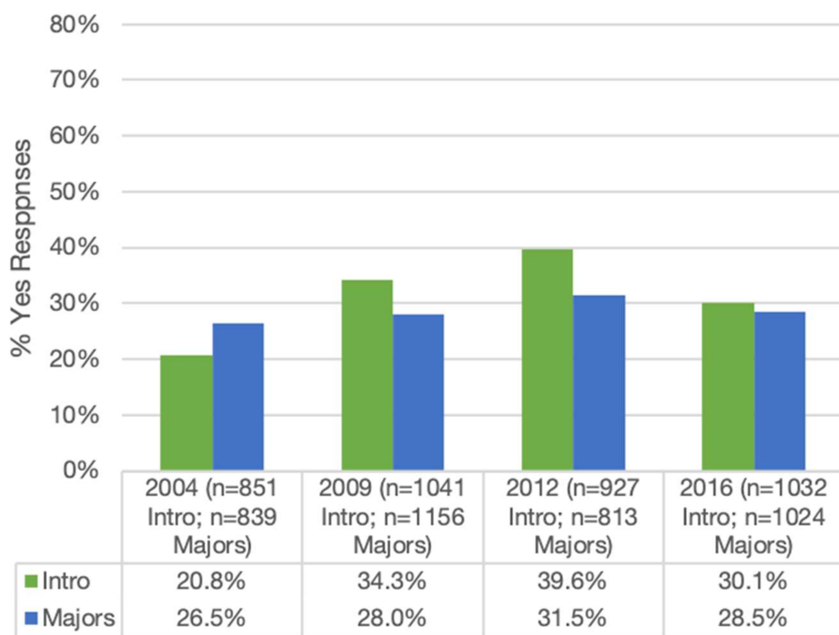


Figure 5.11. Yes responses to "Did your students work on a problem of interest to the local community?"

The percentage of respondents indicating that their students addressed a problem of national or global interest increased across all four survey administrations for both introductory and majors courses, with positive responses more common in introductory courses (Figure 5.10). The percentage of introductory respondents indicating that their students worked on a problem of interest to the local community increased from 2004 to 2012, then decreased in 2016, while responses for majors courses did not change appreciably (Figure 5.11). Overall, a much higher percentage of students in both introductory and majors courses are reported to address global and national problems than work on a problem of interest to the local community.

In 2016, respondents were also asked if their students worked on a community-inspired research or service project, and if their students addressed environmental justice issues (Table 5.6).

Table 5.6. Community-inspired projects and environmental justice (2016)

Did your students....	Introductory (n=1032)	Majors (n=1024)
Work on a community-inspired research or service project	7.8%	8.5%
Address environmental justice issues	32.8%	16.2%

Few respondents for either introductory or majors courses indicate that their students work on a community-inspired research or service project (Table 5.6). Addressing environmental justice issues is more common, and twice as common in introductory courses than in courses for majors.

Use of metacognitive strategies

Helping students make use of metacognitive strategies such as developing an awareness of their own learning processes, monitoring and reflecting on their learning, and managing their motivations and attitudes can lead to improved learning (see The Role of Metacognition in Learning from Teach the Earth). In the 2012 and 2016 surveys, respondents indicated if they asked their students to use a variety of metacognitive strategies (Table 5.7).

Table 5.7. Use of metacognitive strategies (2012, 2016)

	Introductory		Majors	
Did you ask students in your class to...	2012 (n=935)	2016 (n=1032)	2012 (n=817)	2016 (n=1024)
Use knowledge or skills developed in previous courses or learning experience	52.5%	49.0%	88.5%	82.4%
Reflect on strategies used to solve a problem as part of the course	39.0%	33.9%	47.0%	46.5%
Reflect on their success in learning a concept or skill during course	44.7%	42.3%	41.2%	46.0%
Reflect on effectiveness of study skills or time management	39.9%	44.0%	28.5%	33.6%
Make explicit connections from course content to their lives	--	77.7%	--	56.6%
Form student study groups	--	44.1%	--	42.1%
Reflect on effective study strategies	--	48.8%	--	31.7%

Each metacognitive strategy is used by at least approximately 30% of respondents in both introductory and majors courses. The large majority of majors respondents report asking students to use knowledge or skills developed in previous courses or learning experiences—while this is also a commonly used strategy for introductory courses, only about half of introductory respondents indicate that they make use of it (Table 5.7). About three-quarters of introductory respondents ask students explicitly to make connections between course content and their lives, while just above half do so in majors courses. Both groups showed an increase of about 5% in asking students to reflect on the effectiveness of their study skills or time management from 2012 to 2016 (Table 5.7).

Making connections to the workforce

Integrating workforce preparation into courses can help students learn about the diversity of careers available in the geosciences and show all students potential pathways and role models (see Strengthen Workforce Preparation in your Program from InTeGrate). In the 2016 survey, several questions addressed course activities related to workforce preparation (Table 5.8).

Table 5.8. Use of strategies to connect students to the workforce (2016)

In your most recent course, did you....	Introductory (n =1032)	Majors (n = 1024)
Include information about geoscience and STEM careers and career pathways	59.7%	57.0%
Make explicit connections between skills needed in the geoscience workforce and course assignments and outcomes	38.1%	64.4%
Highlight alumni from your program who are working in geoscience	36.4%	52.4%
Promote internship and research opportunities to all students	33.1%	47.9%
Help students with applications for internships, research experiences and/or jobs	29.2%	45.5%
Publicize job search and career resources available on your campus	19.2%	29.9%
Develop strategies to support less successful groups of students based on data from the course	22.7%	19.0%
Inform your class that many populations are under-represented in STEM disciplines, and especially in the geosciences	21.1%	16.3%
Give an assignment in which students explore geoscience careers	8.3%	9.1%

Overall, most strategies for workforce preparation are used more frequently in majors courses than introductory courses (Table 5.8). Although nearly equal proportions of respondents in both groups include information about geoscience and STEM careers and career pathways, much larger proportions of majors course respondents make explicit connections been course assignments and workforce skills, highlight alumni from their programs, and help students with applications. Few in either group report giving assignments in which students explore careers or highlight that some populations are under-represented in the workforce (Table 5.8).

One component of workforce preparation is giving students the opportunity to see role models, particularly of geoscientists with whom they can identify. Survey respondents were asked how frequently they include photos and stories of individual geoscientists and their work during their most recent course (Table 5.9), what percent of the geoscientists included were female (Table 5.10), and what percent of the geoscientists included were people of color (Table 5.11).

Table 5.9. Frequency of including photos and stories of individual geoscientists and their work (2016)

	Introductory (n = 1065)	Majors (n = 1041)
Never	11.8%	20.5%
Once or Twice	23.3%	22.7%
Several Times	42.6%	35.2%
Weekly	11.3%	11.0%
Nearly Every Class	11.0%	10.8%

Table 5.10. Percent of geoscientists included that are female (2016)

	Introductory (n = 933)	Majors (n = 816)
Less than 30%	51.9%	51.3%
Between 30 and 70%	44.7%	45.6%
More than 70%	3.4%	3.1%

Table 5.11. Percent of geoscientists included that are people of color (2016)

	Introductory (n = 933)	Majors (n = 813)
Less than 10%	79.6%	85.2%
Between 10 and 25%	16.9%	12.5%
More than 25%	3.4%	2.2%

The largest proportion of both introductory and majors course respondents include photos and stories several times in their courses, but most report that the proportions of geoscientists included in those photos and stories are less than 30% female and less than 10% people of color.

Summary of instructional activities

There are significant differences between introductory and majors courses in the extent to which respondents ask students to work with data, practice different forms of scientific communication, make use of quantitative skills, and use geoscientific and interdisciplinary ways of thinking—in all of these cases, majors course respondents ask their students to do these things more frequently than introductory course respondents.

In contrast, introductory course respondents ask students to make connections to societal issues more frequently than majors course respondents.

The use of most aspects of systems thinking is not widespread, and there is no consistent distinction between introductory and majors courses. Similarly, both introductory and majors course respondents make use of some metacognitive strategies with little distinction among them.

Respondents describing majors courses make more connections to the workforce, as might be expected, but introductory course respondents are more likely to alert students to issues of diversity in the geosciences.

Further research

Egger (2019) explored a variety of instructional activities in introductory courses to assess the extent to which they were preparing future K–12 teachers. Beane, McNeal, and Macdonald (2019) used factor analysis and linear modeling of several instructional activities and other variables to better understand the use of inclusive teaching practices. Viskupic et al. (in review) explored some aspects of interdisciplinary thinking and understanding societal relevance as they relate to the preparation of undergraduate students for the geoscience workforce.

Chapter 6: Influences on teaching

A number of factors influence instructors' willingness and ability to change their teaching and use evidence-based practices (Henderson & Dancy, 2007). In the introductory and majors sections of the surveys, respondents answered questions about if, why, and how they made changes to their courses and the kinds of changes that they made. All respondents answered questions about what kind of professional development activities they engage in and their interactions with a community that supports improving teaching practice.

Why instructors do or do not make changes to their courses

In the introductory and majors sections of the survey, respondents were asked to reflect on the last time they made a substantive revision to their course, and select *one* of the provided statements that most closely approximated their motivation for making changes (Table 6.1). Respondents could also select "none of the above" and/or use an open-response box to fill in their reason for making changes.

Table 6.1. Reasons instructors make changes in their courses (2016)

Reasons for making course changes	**Introductory** (n = 944)	**Majors** (n = 956)
To better meet the needs of all students	26.1%	32.5%
I attended a workshop or other professional development opportunity	18.3%	11.3%
The content needed to be updated	14.1%	15.0%
The previous time I taught the course, I was not happy with the results	13.2%	13.5%
I found a dataset or software tool	4.7%	5.0%
I adopted a new philosophy for my teaching	6.9%	6.8%
I received a great new idea from a colleague, a publication, or the web	6.8%	5.5%
Part of a department-wide effort	3.1%	2.9%
New facilities	2.6%	4.9%
Credit towards tenure and promotion	0.4%	0.2%
None of the above *(see text)*	3.8%	2.3%

The overall distribution of reasons for making course changes is generally similar for respondents for both introductory and majors courses, with some important differences. Although the largest proportion in both groups indicated that "to better meet the needs of all students" was a reason they made changes to their course, 6% more majors respondents selected this option. The second-most common response for introductory course respondents was "I attended a workshop or other professional development opportunity," while the second-most common response for majors respondents was "the content needed to be updated." The least common response for both groups was "credit towards tenure and promotion" (Table 6.1).

The most common open-response reasons entered included an indication that updating courses was a habit or regular practice, some combination of the listed factors, a commitment to updating courses every time they are taught, a new textbook, adding distance education or online components, and changing university requirements.

Respondents were also asked to reflect on the last time they wanted to make a substantive revision to a course, but decided not to. They could select as many provided statements as applied to their reasons for deciding against making changes; in addition, they could select "none of the above" and/or fill in an open-response box (Table 6.2).

Table 6.2. Reasons why instructors decided against making changes in their course (2016)

Reasons for deciding against making course changes	**Introductory** (n = 1006)	**Majors** (n = 1020)
Time constraints	67.1%	66.7%
The physical infrastructure would not allow changes	16.5%	12.1%
Lack of financial resources	12.5%	12.9%
Institution wouldn't value efforts	11.5%	11.0%
Lack of support from department chair/dean	5.9%	4.6%
Lack of support from colleagues	4.0%	2.5%
Don't have the authority to make changes	3.2%	0.9%
Didn't feel qualified	2.1%	1.4%
None of the above *(see text)*	18.3%	20.1%

The overall distribution of reasons was very similar between introductory and majors respondents. In both groups, about two-thirds indicated that time constraints are a factor in why they did not make changes in their courses. Only a small proportion responded that they "didn't feel qualified" or "don't have the authority to make changes" (Table 6.2). Open-response reasons entered included class size (too large to make changes), challenges of change when co-teaching or team teaching, lack of interest/motivation in changing, and fear of poor teaching evaluations.

In the 2012 and 2016 administrations, one question focused on changes at the level of an instructional activity, and asked respondents in both the introductory and majors sections of the survey what actions they took when designing a new activity. Respondents could select as many of the provided options as applied (Table 6.3).

Table 6.3. Strategies used when designing a new activity (2012, 2016)

	2012		2016	
	Intro (n = 913)	Majors (n = 802)	Intro (n = 1018)	Majors (n = 1023)
Look on the web to see what others have developed on this topic	79.0%	74.2%	79.6%	78.1%
Look for activities in texts, lab manuals, or instructor guide	63.6%	57.9%	66.9%	59.5%
Talk with my colleagues about how they teach this topic	61.8%	47.0%	61.5%	55.5%
Brainstorm ideas before looking to see what is available	43.9%	43.6%	54.1%	53.6%
Look first to see what data are available	36.3%	42.9%	41.4%	46.2%
Discuss new ideas with students	37.0%	40.0%	34.3%	41.5%
Read education research papers about the methods I am considering	28.7%	23.7%	29.5%	27.9%
Look for ideas from campus Learning and Teaching Center	10.8%	6.9%	11.3%	12.0%
None of the above	2.5%	6.1%	1.6%	3.8%

The most common strategy reported in both years and for both introductory and majors course instructors was looking on the web to see what activities others have developed (Table 6.3). In both years, more introductory course respondents reported looking on the web, looking in texts and lab manuals, talking with their colleagues, and reading education research papers than majors course respondents, whereas fewer reported that they looked to see what data are available or discussed ideas with students (Table 6.3). A relatively small proportion in both groups reported that they looked for ideas from campus teaching and learning centers.

Types of changes that instructors make

A set of questions in the 2012 and 2016 surveys asked respondents to both the introductory and majors sections if they had made any changes in the content and/or teaching methods in their course. Those who answered "yes" to these questions were presented with lists of possible changes and could select as many as applied and/or fill in an open-response box.

Changes in content

In all four administrations, respondents were asked if they had made any changes in the content of their course in the past two years and could respond "yes" or "no" (Table 6.4).

Table 6.4. Reported changes in course content

	2004		2009		2012		2016	
	Intro (n = 792)	Majors (n = 786)	Intro (n = 973)	Majors (n = 1069)	Intro (n = 912)	Majors (n = 800)	Intro (n = 1001)	Majors (n = 1016)
Yes	70.6%	58.1%	83.1%	65.1%	80.9%	81.1%	78.8%	78.3%
No	29.4%	41.9%	16.9%	34.9%	19.1%	18.9%	21.2%	21.7%

In all four administrations, a majority of respondents indicated that yes, they had made changes in content in the past two years. The proportions differed substantially between introductory and majors courses in 2004 and 2009, but there was little difference in 2012 or 2016 (Table 6.4). In 2012 and 2016, 78–81% of both introductory and majors course respondents had made changes to the content of their course within the previous two years.

In the 2012 and 2016 administrations, respondents who had replied "yes" were asked a set of follow-up questions in which they could select options for types of content changes they had made (Table 6.5). Three prompts were added in 2016 to parallel questions about instructional activities in quantitative skills, systems thinking, and communication skills.

Table 6.5. Types of content changes instructors made (2012, 2016)

	2012		2016	
Type of change (yes responses)	**Intro** (n = 738)	**Majors** (n = 649)	**Intro** (n = 790)	**Majors** (n = 798)
Included recent geological events covered in the general media	80.8%	51.2%	71.6%	45.9%
Updated content with latest research findings	73.4%	71.0%	63.0%	68.2%
Reorganized the topics covered	68.4%	71.3%	56.8%	61.5%
Added content linking geoscience to societal issues	49.6%	26.8%	47.7%	31.0%
Added new content area	37.5%	48.5%	40.9%	49.7%
Increased emphasis on environmental issues	41.7%	23.4%	40.8%	29.6%
Changed textbook	37.7%	34.2%	25.1%	23.8%
Added content drawn from another discipline	20.3%	20.6%	24.9%	23.6%
Increased focus on quantitative skills	--	--	26.8%	37.5%
Increased emphasis on systems thinking	--	--	25.9%	21.6%
Increased focus on communication skills	--	--	25.1%	29.3%
None of the above	0.1%	0.2%	0.4%	0.6%

Respondents report making different kinds of changes in content in introductory and majors courses. For introductory courses, respondents report including recent geological events in introductory courses, adding content linking geoscience to societal issues, and increasing the emphasis on environmental issues more commonly than for majors courses (Table 6.5). For majors courses, respondents report updating content with the latest research findings, and adding content more commonly than for introductory courses. Changing the textbook is reported in similar proportions by type of course, but 12% less frequently in 2016 than in 2012.

Changes in teaching methods

In all four administrations, respondents were asked if they had made any changes in the teaching methods used in their course in the past two years and could respond "yes" or "no" (Table 6.6).

Table 6.6. Reported changes in teaching methods

	2004	2009	2012	2016

	Intro (n = 800)	Majors (n = 773)	Intro (n = 960)	Majors (n = 729)	Intro (n = 903)	Majors (n = 799)	Intro (n = 999)	Majors (n = 1014)
Yes	51.8%	48.3%	62.6%	66.1%	65.1%	55.3%	61.2%	51.0%
No	48.3%	51.7%	37.4%	33.9%	34.9%	44.7%	38.8%	49.0%

Overall, fewer respondents report having made changes to their teaching methods (Table 6.6) than to the content of their course (Table 6.4), though still a slight majority report doing so in all administrations except for 2004. In 2012 and 2016, about 10% more introductory respondents report having made changes in their teaching methods than majors course respondents.

In the 2012 and 2016 administrations, respondents who replied "yes" were asked a set of follow-up questions in which they could select options for ways in which they had changed their teaching methods (Table 6.7).

Table 6.7. Types of teaching methods changed

	2012		2016	
Type of change (yes responses)	**Intro** (n = 588)	**Majors** (n = 442)	**Intro** (n = 619)	**Majors** (n = 723)
Revised lab activities	53.2%	63.1%	52.8%	65.2%
Spent less time lecturing	54.6%	55.9%	49.9%	57.7%
Increased questioning of students during lectures	53.6%	52.7%	49.8%	46.5%
Changed assessment tools or strategies	43.7%	27.1%	41.8%	36.9%
Increased time students spent working or discussing with one another	51.2%	53.4%	41.4%	45.9%
Added group work or small group activities	39.3%	43.7%	39.7%	43.2%
Spent more time on class discussions or small group discussions	31.0%	31.0%	34.6%	39.6%
Increased out-of-class work preparing for class	25.3%	18.6%	29.7%	29.3%
Employed more demonstrations during lectures	37.1%	34.4%	29.4%	32.3%
Increased time spent by students reflecting and synthesizing	21.3%	22.9%	22.5%	27.2%
Increased time spent on field trips	14.5%	24.0%	12.9%	20.8%
Integrated lab and lecture activities	--	--	30.5%	42.4%
Changed class to hybrid format	--	--	7.9%	9.8%
Changed class to entirely online format	--	--	5.8%	1.0%
None of the above	0.2%	0.5%	0.2%	0.0%

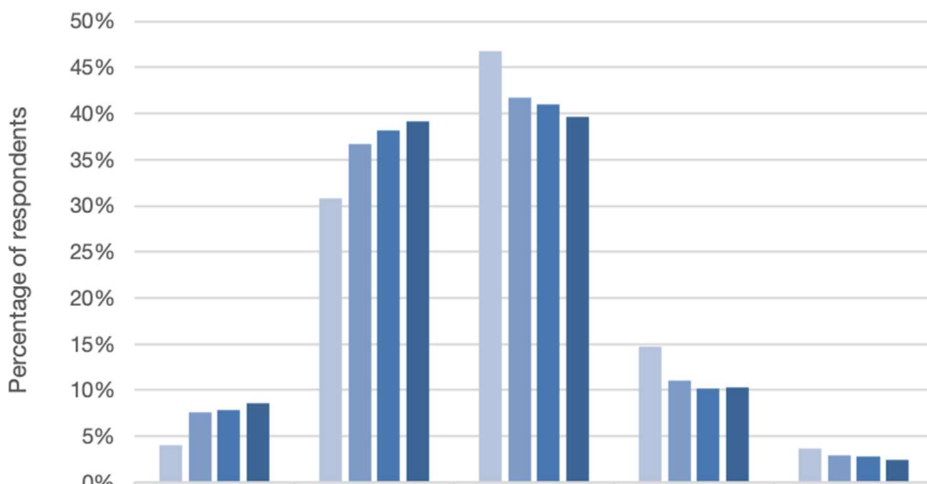
Both introductory and majors course respondents report revising lab activities, but more commonly in courses for majors. Introductory course respondents more commonly report having changed assessment tools or strategies, while majors course respondents more commonly report having increased the time spent on field trips (Table 6.7).

Interactions with the community about teaching

Interactions with colleagues are important in both science and teaching, and the ways in which instructors interact with colleagues can influence the transfer of ideas about teaching and learning. All survey respondents answered a set of questions about their interactions around teaching in general, not tied to a specific course.

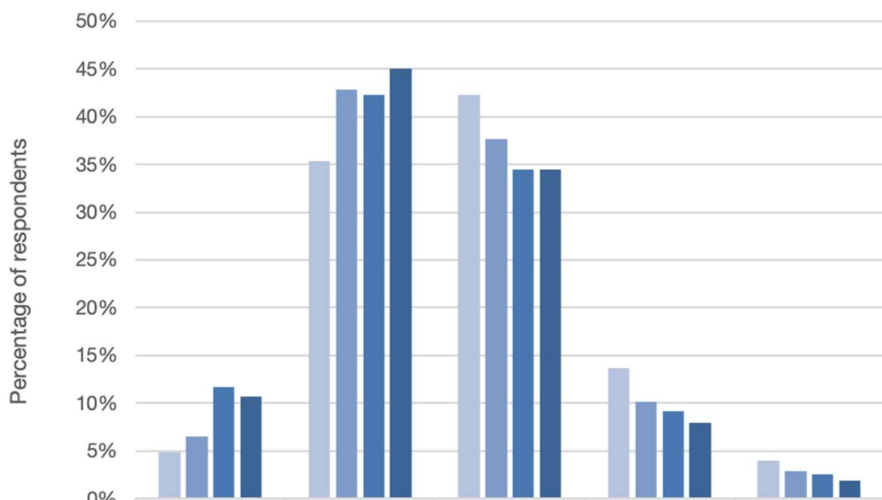
Learning from colleagues

In all four survey administrations, respondents were asked how often they talked or corresponded with colleagues about course content (Figure 6.1) and their teaching (Figure 6.2) in the previous two years. The concept of "colleagues" was not further constrained to colleagues in the respondent's department or beyond, and thus should be interpreted broadly.



	Never	Once or twice per term	Several times per term	Weekly	Nearly every day
2004 (n = 1574)	4.1%	30.8%	46.8%	14.7%	3.6%
2009 (n - 2429)	7.6%	36.7%	41.7%	11.1%	2.9%
2012 (n = 2141)	7.8%	38.1%	41.0%	10.2%	2.8%
2016 (n = 2419)	8.6%	39.1%	39.6%	10.3%	2.4%

Figure 6.1. Frequency of talking or corresponding with colleagues about course content.



	Never	Once or twice per term	Several times per term	Weekly	Nearly every day
2004 (n = 1567)	4.9%	35.3%	42.2%	13.7%	4.0%
2009 (n = 2403)	6.5%	42.8%	37.6%	10.1%	2.9%
2012 (n = 2120)	11.7%	42.3%	34.4%	9.1%	2.5%
2016 (n = 2412)	10.7%	45.0%	34.5%	8.0%	1.9%

Figure 6.2. Frequency of talking or corresponding with colleagues about their teaching.

About 80% of respondents reported that they talked or corresponded with colleagues at least once per term about course content, and a little over half of those did so several times per term (Figure 6.1). Similarly, about 80% of respondents talked or corresponded with colleagues at least once per term about their teaching, and slightly less than half of those did so several times per term (Figure 6.2).

In 2012 and 2016, respondents were asked if they frequently communicate with colleagues about several specific topics (Table 6.8). Two additional prompts were added in 2016 to parallel questions about instructional activities and making course changes. Possible responses were "yes" or "no," and "frequently" was not further defined within the question.

Table 6.8. Communication with colleagues about teaching (2012, 2016)

Do you frequently communicate with your colleagues about... (yes responses)	**2012** (n = 2121)	**2016** (n = 2445)
How well we are preparing students for careers	66.3%	65.1%
How to assess student learning	61.6%	58.0%
New ideas in pedagogy	43.2%	40.2%
How well we are preparing students for life on a finite planet	35.1%	34.4%
How the courses you teach relate to others' courses	--	55.2%
How to meet the needs of groups that traditionally have been underserved and/or underrepresented	--	35.7%
None of the above	12.7%	8.9%

In both years, a majority of respondents report that they frequently communicate with colleagues about how well they are preparing students for careers and how to assess student learning; fewer (but still a substantial portion) report discussing new ideas in pedagogy and preparing students for life on a finite planet. In 2016, over half reported that they discuss how their courses relate to others' courses, and about a third discuss meeting the needs of underrepresented groups.

Learning new teaching methods

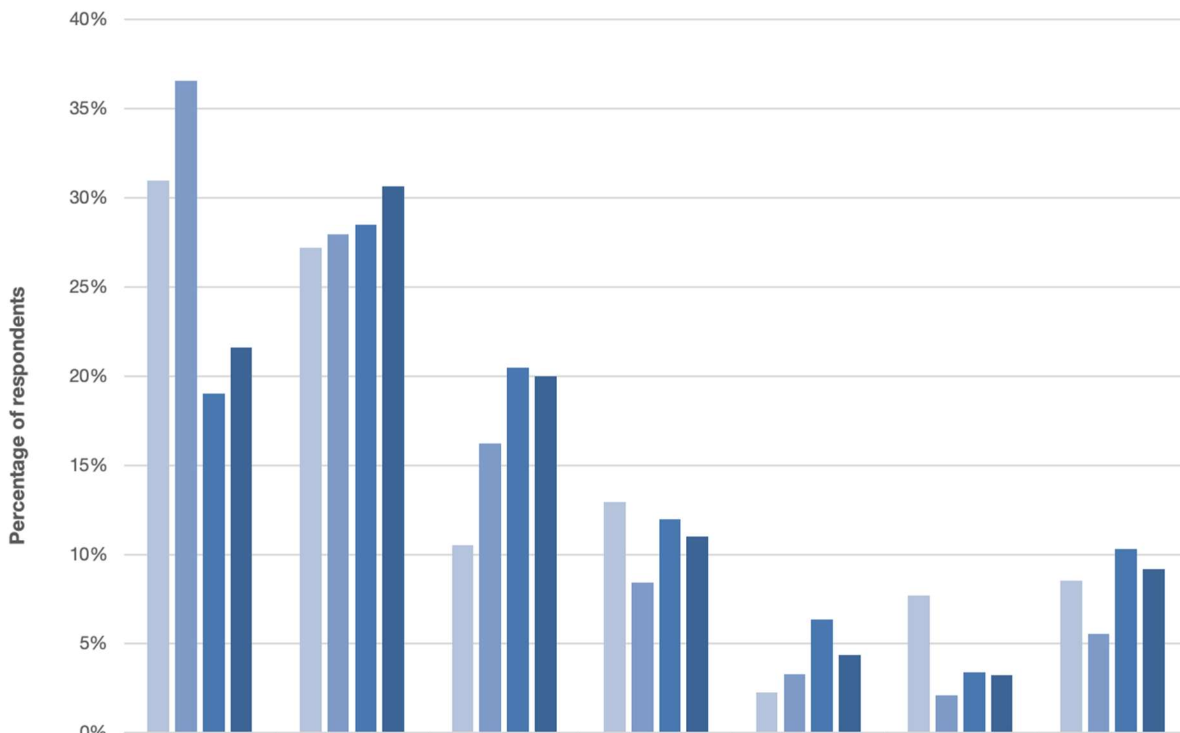
In 2012 and 2016, respondents were asked how they learn about new teaching methods; they could check all that applied from a list of options (Table 6.9).

Table 6.9. Ways in which instructors learn about new teaching methods (2012, 2016)

How do you learn about new teaching methods?	2012 (n = 2137)	2016 (n = 2445)
Professional meetings or workshops	58.3%	59.1%
Discussions with other faculty members in my department	62.3%	58.9%
Online resources	56.7%	57.9%
Discussions with colleagues in other institutions	49.2%	51.9%
Discussions with other colleagues on campus	44.7%	48.5%
Publications	39.1%	35.8%
My own research	27.6%	33.4%
Learning and Teaching Center	21.9%	24.6%
None of the above	4.5%	3.9%

Respondents report learning about new teaching methods in multiple ways. The majority in both years report learning about new teaching methods at professional meetings or workshops, discussions within their departments, and through online resources. Nearly half of respondents report learning about new teaching methods through discussions with colleagues not in their department.

In all four administrations, respondents were asked, "Approximately how many talks on teaching methods, other topics related to science education, or geoscience education have you attended in the past two years at professional meetings, on campus, or at other venues?" In the 2004 survey, respondents could enter a one- or two-digit number; subsequent surveys provided options from "none" to "11 or more." The 2004 data were recoded to be compatible with these forced responses (Figure 6.3).

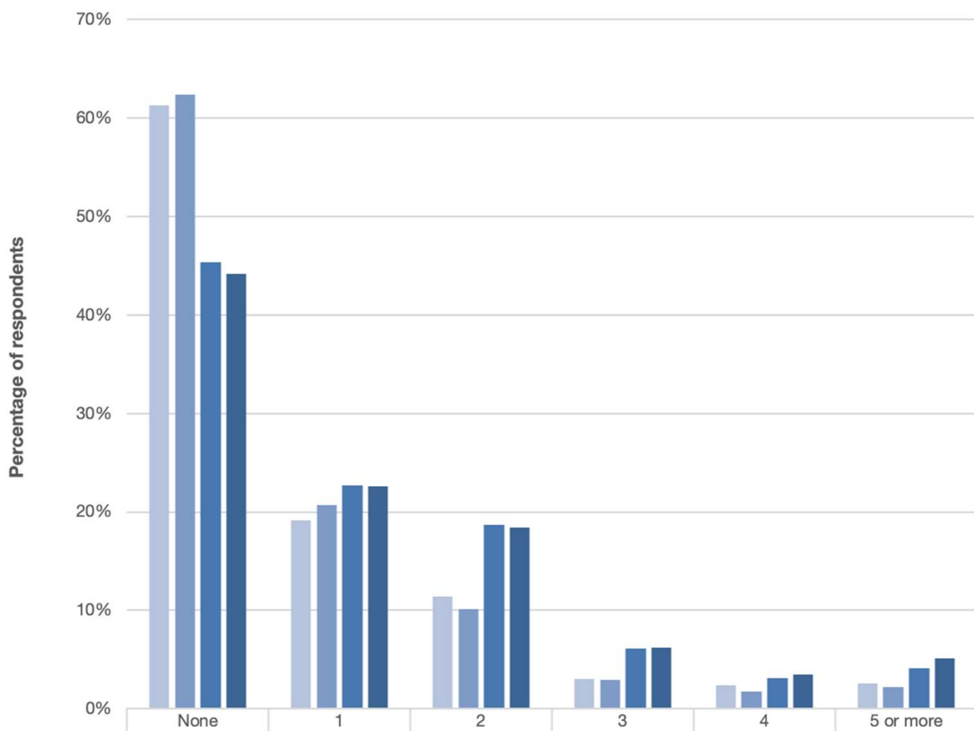


	None	1 or 2	3 or 4	5 or 6	7 or 8	9 or 10	11 or more
2004 (n = 1562)	30.9%	27.2%	10.5%	12.9%	2.2%	7.7%	8.5%
2009 (n = 2475)	36.5%	28.0%	16.2%	8.4%	3.3%	2.1%	5.5%
2012 (n = 2134)	19.0%	28.5%	20.5%	12.0%	6.3%	3.4%	10.3%
2016 (n = 2415)	21.6%	30.6%	20.0%	11.0%	4.3%	3.2%	9.2%

Figure 6.3. Number of talks about teaching respondents report attending in the previous two years.

The proportion of respondents who reported not going to any talks about teaching methods dropped significantly from 2009 to 2012. In 2016, about 50% of respondents reported attending one to four talks on teaching methods (Figure 6.3).

In all four administrations, respondents were also asked, “How many workshops related to improving your teaching did you attend in the past two years?” In the 2004 survey, respondents could enter a one- or two-digit number; subsequent surveys provided options from “none” to “5 or more.” The 2004 data were recoded to be compatible with these forced responses (Figure 6.4).



	None	1	2	3	4	5 or more
2004 (n = 1565)	61.3%	19.2%	11.4%	3.1%	2.4%	2.6%
2009 (n = 2475)	62.3%	20.7%	10.1%	2.9%	1.7%	2.2%
2012)n = 2130)	45.4%	22.7%	18.7%	6.1%	3.1%	4.1%
2016 (n - 2412)	44.2%	22.6%	18.4%	6.3%	3.5%	5.1%

Figure 6.4. Number of workshops related to teaching respondents report attending in the previous two years.

The proportion of respondents who reported attending no workshops dropped 12-15% from 2004/2009 to 2012/2016, with gains of 7-8% in those reporting having attended two workshops and 2-3% in those reporting having attended one or three workshops (Figure 6.4).

Engagement in the community of geoscience educators

In the 2016 survey, a set of questions was designed to assess the existence of a geoscience education "community of practice," though this phrase was purposefully not used in the questions. Questions addressed the extent to which respondents felt they were a part of a community of geoscience educators and felt that they benefited from it (Table 6.10).

Table 6.10. Extent of respondents' sense of connection to community (2016)

To what extent….	To a great extent	To some extent	To little extent	Not at all
Do you consider yourself part of a community of geoscience educators that shares your goals, philosophy, and values for geoscience education? *(n = 2408)*	18.1%	38.8%	26.0%	9.1%
Do interactions with this community help you become a better educator? *(n = 2162)*	14.9%	37.9%	26.6%	3.4%

The largest proportion of respondents reported that they consider themselves part of a community of geoscience educators to some extent, and that this community helps them become better educators (Table 6.10).

In addition, respondents were asked to indicate the ways in which they interacted with the community of geoscience educators, and could check all of the options that applied (Table 6.11).

Table 6.11. Ways of interacting with the community (2016)

In which of the following ways do you interact with the community? (n = 2175)	**Selected**
Seeking people to talk to who have experience relevant to my situation	53.2%
Discussing developments in geoscience education	43.3%
Providing assets or resources to other community members	37.8%
Finding collaborators for a new project	24.9%
Engaging in deep two-way conversation in support of our educational work	23.7%
Coordinating or strategizing to achieve a shared goal	20.1%

Over half of respondents indicated that they seek out others who have relevant experiences. Deeper involvement in community-level goals was less common.

Respondents also had the option to fill in an open response "other" box to describe ways in which they interact with the community, and 90 respondents chose to do so. These responses were highly varied, ranging from "I don't" to specific communities of interaction. The most common responses related to attending meetings.

Finally, respondents were asked how these interactions have influenced them, and could again check all of the options that applied (Table 6.12) and fill in an open-ended "other" response box.

Table 6.12. Influence of interactions with community (2016)

How have your interactions with this community influenced you? (n = 2175)	**Selected**
Renewed my enthusiasm	55.3%
Introduced me to new professional opportunities	34.9%
Built my confidence	27.8%

For this question, 416 people opted to enter open-ended responses. Again, these responses were highly varied. Many responses indicated that interactions had not had an influence, or very little, and others suggested less positive interactions ("left me unimpressed" or "made me more cynical"). A larger proportion mentioned specific, positive interactions, ideas, and ways in which the community helped them solve a problem.

Summary of influences on teaching

A majority of both introductory and majors course respondents report making changes in their teaching; more report making changes in content than in teaching methods. While they have a variety of reasons for making those changes, by far the most common reason for *not* making changes is time constraints.

More than 90% of all survey respondents indicate that they talk regularly with their colleagues about teaching, and learn about new teaching techniques and ideas in a variety of ways. Many feel that they are part of a community of practice that extends beyond their department and shares values and skills around teaching.

Further research

Riihimaki and Viskupic (2019) further explored motivators and inhibitors to faculty making changes in their teaching.

References

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The On the Cutting Edge, InTeGrate, and SAGE 2YC Professional Development programs are multi-year NSF-funded projects with comprehensive websites, a workshop and webinar program, and research activities that support high-quality undergraduate geoscience education. Serving thousands of educators, including graduate students, post-docs, and faculty, these programs continue to support engaging geoscience educators in utilizing effective pedagogies, engaging students, and strengthening geoscience and allied programs in the US and beyond.

The On the Cutting Edge Professional Development Program for Geoscience Faculty (https://serc.carleton.edu/NAGTWorkshops/about/index.html) was established in 2002, with funding from NSF. It carried out workshops and research activities, and developed a website of more than 9,000 pages of teaching and career resources.

The Interdisciplinary Teaching about Earth for a Sustainable Future (InTeGrate) project (https://serc.carleton.edu/integrate/about/index.html) is an NSF-funded STEP Center that created professional development, curriculum, and implementation programs connecting learning about the Earth to societal challenges. As of February 2019, there were more than 4,600 InTeGrate community members involved in various capacities, including the initial 1,678 materials authors, implementation program participants, and workshop and webinar participants.

The Supporting and Advancing Geoscience Education in Two-Year Colleges (SAGE 2YC) project (https://serc.carleton.edu/sage2yc/about/index.html) is an NSF-funded professional development program that was established in 2011. Beginning in 2015, the program has focused on building a national network of self-sustaining local communities of two-year college geoscience faculty Change Agents and administrators. The Change Agents focus on use of evidence-based strategies to improve all students' academic success, broaden participation, and facilitate students' professional pathways into the STEM workforce.

Appendix B. 2016 Survey Response Rates and Bias Analyses

The following Appendix was written by Lija Greenseid of Greenseid Consulting Group, LLC.

Background

The National Survey of Geoscience Teaching Practices has been administered four times, in 2004, 2009, 2012, and 2016. The 2016 survey preserved core questions from previous surveys, while adding, deleting, and revising questions to collect information to address new areas of interest. The methodologies of the 2004, 2009, and 2012 surveys are described elsewhere in technical reports and publications. This document provides an overview of the 2016 survey methodology for members of the research team and to provide language that can be excerpted and used in publications and presentations.

Sample

The 2016 survey sampling frame was comprised of seven lists of geosciences faculty: the American Geological Institute membership list (obtained with permission from AGI), the SERC Cutting Edge participant list, the Geosciences Two-year College list, the Texas Two-Year College list[1], the SAGE Two-Year College List, the SERC Cutting Edge Early Career List, and a list of meteorology faculty[2]. After removing 2,116 duplicates and removing 81 names without email addresses, the total number of eligible individuals was 10,910, see Table B1.

Table B1. Survey sample

Original list among all sampled	N	%
American Geological Institute	7,332	67.2%
Cutting Edge - participants	2,175	19.9%
Meteorology faculty list	491	4.5%
Geoscience 2 Year College	427	3.9%
Texas 2 Year College	260	2.4%
SAGE 2 Year College	193	1.8%
Cutting Edge Early Career List	32	0.3%
Total	**10,910**	**100.0**

Pilot

The survey was piloted in September 2016 with a sample of 200 individuals who were randomly selected from the survey sampling frame of 10,910 eligible individuals (Table B2). A total of 33

[1] The Texas 2YC list was generated by Bob Blodgett looking at the website of each of the 2YCs in Texas a few years prior to 2016 and for which he attempted to include as many adjunct faculty as possible.

[2] The meteorology list was generated by a SERC student worker in the summer of 2016. The student started from a list of meteorology faculty that Heather Macdonald had a staff member compile for the 2012 survey. The student was instructed to go to the American Meteorological Society Website and navigate to the list of U.S. institutions that offer undergraduate degrees in meteorology and to check for American faculty members' email addresses, minding email address and faculty rank changes.

individuals completed at least one question of the pilot survey. Based on the pilot results, a few minor changes were made to the final survey. None were sufficient enough to alter the meaning or order of any questions; therefore, the pilot data from the 33 completed surveys were included in the analysis dataset.

To address face validity of question items, interviews of faculty in 2007-2008 informed survey design for the 2009 survey, specifically related to the question items used for faculty type. Think-aloud interviews were conducted with the 2012 survey instrument prior to the survey administration. In 2016, the pilot included feedback questions but no common themes emerged.

Table B2. Sample description	
Sampled for pilot	200
Sampled for full launch	10,710
Total Sampled	**10,910**

Response Rates

The pilot study was conducted with 200 individuals between September 8-18, 2016. The survey was conducted with remaining sample of 10,710 individuals between October 19 and November 6, 2016. Individuals were contacted up to four times or until they took the survey. A total of 1,296 emails were returned as bad or invalid. A total of 2,615 individuals completed one or more questions to the survey. The median time to complete the survey was 14.4 minutes. 92% of respondents completed the survey on a desktop computer, while the remaining completed it on a smartphone, Tablet, or unknown device.

Response rates are calculated two ways as publications may require different response rate calculations. Eighteen individuals responded to the survey request stating they were retired and not eligible for the survey. Excluding the 18 retirees, the survey response rate is 24.0% (2,615 out of 10,892 eligible contacts), see Table B3. Excluding retirees and also survey contacts that had invalid or bad email addresses (1,296), the survey response rate is 27.3% (2,615 out of 9,596), see Table B4.

Table B3. Response rate 1: Among everyone sampled, exclude retirees that are known	
Sampled	10,910
Number determined to be retired(a)	18
Total assumed eligible for survey	10,892
Responded	2,615
Response rate 1	**24.0%**

Table B4. Response rate 2: Among all sampled with a valid email address	
Sampled	10,910
Number determined to be retired(a)	18
Number with invalid/bad email addresses(b)	1,296
Total eligible for survey with valid email address	9,596
Responded	2,615
Response rate 2	**27.3%**

Response Bias Analyses

Two response-bias analyses were conducted to determine the representativeness of survey respondents. The first response bias analysis compared 2016 survey responders to the full 2016 sample on two variables which were available for the majority of the sample: faculty rank and institution type. The second response bias analysis compared attributes of survey responders across the four survey administrations.

2016 response biases. Faculty rank was recorded for 72% of the 2016 sample. We found that survey respondents were more likely than the full sample to be full professors, associate professors, or assistant professors and less likely than the full sample to be instructors, lecturers, adjunct faculty or other faculty types (Chi-square=33.338, df=1, p<0.001). In other words, while 28% of the contacted professors, associate professors, and assistant professors responded to the survey, 21% of contacted instructors, lecturers, adjuncts, and others responded to the survey, see Table B5.

Table B5. Response rates for faculty types

	Respondents	Non-respondents	Total sampled	Response rate
Professor/Associate Professor/Assistant Professor	1,637	4,271	5,908	27.7%
Instructor/Lecturers/Adjuncts/Other	398	1,496	1,894	21.0%

Chi-square=33.338, df=1, p<0.001
Missing: n=3,108

Institution type was recorded for 93% of the 2016 sample. We found that survey respondents were less likely to teach at research and/or doctoral institutions and more likely to teach at master's, baccalaureate, two-year colleges, or other institution types (Chi-square=36.64, df=1, p<.001). While 23% of the contacted faculty from Research and/or Doctoral Institutions responded to the survey, 28% of contacted faculty from the other types of institutions responded, see Table B6.

Table B6. Response rates for institution types (collapsed Carnegie Classification)

	Respondents	Non-respondents	Total sampled	Response rate
Research and/or Doctoral	1,466	5,046	6,512	22.5%
Master's, Baccalaureate, Associate's, or other institution types	996	2,570	3,566	27.9%

Chi-square=36.64, df=1, p<0.001
Missing: n=832

Appendix C: Bibliography

This bibliography lists the peer-reviewed papers (as of September 1, 2019) that involve analyses of National Geoscience Faculty Survey in reverse chronological order.

Macdonald, R. H., Manduca, C. A., Mogk, D. W., & Tewksbury, B. J. (2005). Teaching Methods in Undergraduate Geoscience Courses: Results of the 2004 On the Cutting Edge Survey of U.S. Faculty. *Journal of Geoscience Education, 53*(3), 237-252.

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