2-12-2020

Design and Impact of the National Workshop for Early Career Geoscience Faculty

Rachel J. Beane
Bowdoin College

Ellen R. Altermatt

Ellen R. Iverson

R. Heather Macdonald

Journal of Geoscience Education

ISSN: 1089-9995 (Print) 2158-1428 (Online) Journal homepage: https://www.tandfonline.com/loi/ujge20

Design and impact of the national workshop for early career geoscience faculty

Rachel J. Beane, Ellen R. Altermatt, Ellen R. Iverson & R. Heather Macdonald

To cite this article: Rachel J. Beane, Ellen R. Altermatt, Ellen R. Iverson & R. Heather Macdonald (2020) Design and impact of the national workshop for early career geoscience faculty, Journal of Geoscience Education, 68:4, 345-359, DOI: 10.1080/10899995.2020.1722787

To link to this article: https://doi.org/10.1080/10899995.2020.1722787

JOURNAL OF GEOSCIENCE EDUCATION
2020, VOL. 68, NO. 4, 345–359
https://doi.org/10.1080/10899995.2020.1722787

Design and impact of the national workshop for early career geoscience faculty

Rachel J. Beane[a], Ellen R. Altermatt[b], Ellen R. Iverson[b], and R. Heather Macdonald[c]

[a]Department of Earth and Oceanographic Science, Bowdoin College, Brunswick, Maine 04011; [b]Science Education Resource Center, Carleton College, Northfield, Minnesota 55057; [c]Department of Geology, William & Mary, Williamsburg, Virginia 23187

ABSTRACT

The National Association of Geoscience Teachers' *Workshop for Early Career Geoscience Faculty: Teaching, Research, and Managing One's Career* has been offered annually since 1999. The five-day workshop with accompanying web resources employs a "whole faculty" approach to support geoscience faculty members during their transition into academic careers. More than 1,000 faculty members (53% female, 47% male) have attended the national workshop; 52% from doctoral-granting institutions, 15% master's, 28% bachelor's, and 5% associates. Evidence-based instructional practices are shared and modeled during workshop sessions. Situated learning theory grounds the workshop design and promotes the development of a community of practice. Examination of the 2016 National Geoscience Faculty Survey data using univariate analyses of covariance (ANCOVAs) showed that workshop alumni report spending more class time on student activities, questions, and discussion than faculty members who did not participate in the workshop, particularly on small group discussions or think-pair-share and in-class exercises (for introductory courses $p < .05$; for majors courses $p < .001$). Workshop alumni also were more likely than faculty who did not participate to report feeling part of a geoscience community that shares their goals, philosophy, and values for geoscience education ($p < .01$), more likely to report that interactions with this community help them to become better educators ($p < .001$), and more likely to attend talks on teaching methods or science education ($p < .001$). Although causality cannot be established without random assignment, these findings are consistent with the hypothesis that this discipline-based workshop with its holistic approach is effective at promoting evidence-based teaching strategies and a community of practice.

ARTICLE HISTORY
Received 22 July 2019
Revised 12 January 2020
Accepted 23 January 2020
Published online 12 February 2020

KEYWORDS
active learning; community of practice; early-career faculty; faculty development; situated learning

Introduction

An influential strategy to encourage the adoption of teaching practices that enhance student learning is to support faculty at the beginning of their careers, thus catalyzing a career-long impact on the early-career faculty members and on their future students. With this in mind, the *Workshop for Early Career Geoscience Faculty: Teaching, Research, and Managing One's Career* has been offered continuously since 1999, and since 2002 as part of the On the Cutting Edge professional development program for geoscience faculty. This long-running annual five-day workshop employs a "whole faculty" approach to prepare faculty to teach, to conduct research, to make strategic plans, and to manage professional responsibilities in balance with personal lives. More than 1,000 geoscience faculty have attended the workshop since their inception. And, after twenty years, strong demand remains for this annual workshop that is offered through the National Association of Geoscience Teachers (NAGT) On the Cutting Edge professional development program. The purpose of this paper is to detail this workshop, to situate it within the context of other STEM faculty development workshops, and to assess the impact of the workshop. We describe the workshop and its implementation, as well as its impact on the teaching practices of participants and their belonging to a community of practice. The impact of the workshop is evaluated through participant demographics, end-of-workshop survey data, and comparisons of the self-reported practices of workshop alumni to nonparticipating faculty at similar institutions and career stages.

Purpose and learning goals

New faculty members are at a pivotal stage in their careers as they step from being research-focused graduate students and post-doctoral associates toward launching independent careers as professors who teach, conduct research, advise students, and have a myriad of new responsibilities. They commonly, and not unexpectedly, feel overwhelmed as they face challenges to establish themselves in a new environment, prepare new courses, expand their research, and develop a network of support (e.g., Boice, 1991b; Columbia

CONTACT Rachel J. Beane rbeane@bowdoin.edu Bowdoin College, 6800 College Station, Brunswick, ME 04011, USA

University, 2016; Foote, 2010). The *Workshop for Early Career Geoscience Faculty* provides support for these faculty members during the critical transition that happens at the beginning of their careers. The purpose of the workshop is to offer specific implementable suggestions about "what works" to better prepare faculty for their teaching and research responsibilities, and for managing their academic careers (e.g., Boice, 2000). The workshop also connects faculty who are at a similar stage in their careers across institutions and types of institutions to promote peer mentoring and the development of a community of practice within the discipline. The discipline-specific approach of the workshop is complementary to multi-disciplinary programs offered by institutions for new faculty and by STEM professional development programs for graduate students (Austin et al., 2009; Hill, Savoy, Austin, & Bantawa, 2019).

The specific workshop goals are for participants to:

1. Learn about setting course goals, strategies for active learning, and methods for assessment.
2. Share ideas and approaches for teaching one or more courses.
3. Consider successful strategies for maintaining an active research program and advising/supervising undergraduate and/or graduate research students.
4. Discuss life as an early-career faculty member and explore ways to balance teaching, research, and service responsibilities.
5. Leave with examples of assignments and activities for various courses, strategies for balancing competing demands, a support network of other early-career faculty, and a plan for managing their early career as an academic.

From these listed goals, the first and second align closely with the President's Council of Advisors on Science and Technology (PCAST; 2012) "Engage to Excel" report that urged STEM fields in the United States to "Establish discipline-focused programs … to train current and future faculty in evidence-based teaching practices" (p.19). The workshop is an example of such a discipline-focused program that shares evidence-based practices from the scholarship of teaching and learning. In particular, active learning approaches are emphasized in the examples shared with participants and modeled through what participants themselves are asked to do in workshop sessions.

The degree to which all of the goals are met in a given workshop is assessed in part through an end-of-workshop survey that participants complete. The extent to which faculty participants incorporate active learning practices in their teaching after the workshop is evaluated in part by comparing former participants' responses to the National Geoscience Faculty Survey (Macdonald, Manduca, Mogk, & Tewksbury, 2005; Manduca et al., 2017) to the responses of non-participants at similar career stages. We further use faculty participant responses to the National Geoscience Faculty Survey to evaluate the extent to which former participants respond in ways that are consistent with being part of a community of practice (Lave & Wenger, 1991; Wenger, McDermott, & Snyder, 2002; Wenger-Trayner & Wenger-Trayner, 2015). Developing a community of practice substantially underpins the workshop design and particularly corresponds with a part of the fifth goal, to 'leave with … a support network of other early-career faculty.'

Literature context

Active learning

A component of the first goal of the workshop is for participants to "learn about … strategies for active learning." This goal is an important step toward enhancing the effectiveness of geoscience instruction and propagating more widespread use of evidence-based teaching practices. Instructional approaches designed to engage students as active participants have been shown to improve students' learning and class performance compared to traditional non-interactive lecture-based instruction (e.g., Derting & Ebert-May, 2010; Freeman et al., 2014; Hake, 1998; National Research Council, 2012; Prince, 2004). This type of instruction is often referred to as interactive learning or active learning. For their study on the effect of active learning on student performance, Freeman et al. (2014) coded and summarized multiple individuals' definitions of active learning to achieve this definition: "Active learning engages students in the process of learning activities and/or discussion in class, as opposed to passively listening to an expert. It emphasizes higher-order thinking and often involves group work" (p. 8413-8414). In their review of active learning strategies for the geosciences, McConnell et al. (2017) built on Freeman's definition and others, to emphasize the "student participation," "student reflection," and "peer-to-peer interaction" components of active learning (p. 605). Their review examined eleven strategies: case studies/problems, concept maps, concept sketches, gallery walks, lecture tutorials, minute papers, jigsaw, peer instruction, role-playing, and teaching with models (p. 620). During the workshop, many of these active learning methods are shared with participants, and participants themselves actively engage with case studies, gallery walks, minute papers, jigsaw, and peer instruction during workshop sessions.

Situated learning theory and community of practice

The design of the workshop is grounded in Situated Learning Theory which presupposes that knowledge is constructed as a function of participation in organized social activities (Adler, 2000; Lave & Wenger, 1991). As with active learning, knowledge is conceptualized as more than a commodity that encapsulates what can be put "in" an individual's head at a particular time (Schön, 1983). Instead, individuals learn through experiences (Dall'Alba & Sandberg, 2006; Webster-Wright, 2009) shaped by discourse with colleagues and practice (Lave & Wenger, 1991; Putnam & Borko, 2000). Through situated learning, participants learn over an extended period of time and are influenced by

the context of their learning (Borko, 2004; Cobb & Bowers, 1999). Connecting learning to the context of practice is viewed by some as essential in developing competence in specific practices (Dall'Alba & Sandberg, 1996), and interactions with peers strengthen and situate this learning (Boud & Walker, 1998). For the workshop, the participants share a context of beginning academic careers in the geosciences and encountering a similar array of new responsibilities with regards to teaching, research, and service; their discussions with each other are critical to situate their learning and allow it to continue once they return to their own institutions.

In relation to learning through peer dialogue, situated learning conceptualizes learning as distributed, where colleagues act as change agents as they promote others' learning through both structured and routine interactions (Condon, Iverson, Manduca, Rutz, & Willett, 2016; Eddy, Hao, Markiewicz, & Iverson, 2019). Effective faculty professional development draws upon how faculty learn through peer interactions using structured approaches to foster dialogue such as through faculty learning circles (Beach & Cox, 2009; Cox, 2013; Richlin & Essington, 2004), campus or departmental programs (Beyer, Taylor, & Gillmore, 2013; Owens et al., 2018) or discipline-specific workshops such as the Workshop for Early Career Geoscience Faculty. Classroom observation studies of geoscience teaching substantiate the role that discipline-specific workshops can play in faculty adoption of active learning teaching strategies (Manduca et al., 2017; Viskupic et al., 2019). Viskupic et al. (2019) identified facilitation of peer learning where participants "work collectively [and] where discourse is supported by participants' commonalities such as discipline" as a critical feature of professional development to support changes in instruction (p. 4).

Central to the workshop is the promotion of a community of learning through structured conversations between colleagues on topics common to their situation as early-career geoscience faculty. Thus, the workshop design aligns with what Wenger-Trayner and Wenger-Trayner (2015) define as communities of practice or "groups of people who share a concern or a passion for something they do and learn how to do it better as they interact regularly" (p. 1). In the case of the workshop, the participants in the community learn through social interactions and the learning is specific to their work as geoscience faculty members. The communities-of-practice framework has been used for sustaining faculty professional development (Stark & Smith, 2016) in STEM (Kezar, Gehrke, & Bernstein-Sierra, 2018) and with early-career faculty (McDonald & Star, 2006; Remmik, Karm, Haamer, & Lepp, 2011). The workshop gives space for participants to develop behaviors related to a community of practice through the sharing of experiences, resources, and tools (Duguid, 2005, Wenger-Trayner & Wenger-Trayner, 2015) and is facilitated by developing trust across individual members (Duguid, 2005; Stark & Smith, 2016). In the Implementation section, we share how this aspect of trust within a developing community of practice is built into the arc of the workshop.

Whole faculty approach

Within the context of situated learning and a discipline-based community of practice, the workshop design incorporates a holistic approach wherein sessions are offered on a range of topics related to teaching, research, and career management. This approach is aligned with studies on the attributes of early-career faculty who are "quick starters" (Boice, 1991a, 2000). These "quick starters" received higher teaching evaluations, were more productive in their research, and were happier (less stressed) in their work than other faculty at the same career stage (Boice, 2000). As opposed to approaching teaching in a way that emphasizes efficiency, content, and student ratings, "quick starters" are open to incorporating more active learning strategies, seek teaching advice from others, integrate their research into their undergraduate courses, and operate with a more balanced approach to time management (Boice, 1991b). Cultivating "quick starters" through early career professional development has been shown to be effective with campus-centered models (Cox, 2002, 2013); the workshop applies this model to a discipline-centered context.

The theory of change for the workshop addresses a "whole faculty" approach by situating the participants' learning within the multiple facets of faculty members' professional lives and in ways that are immediately applicable for early-career geoscience faculty. For example, participants have opportunities to apply their learning during reflective session activities such as developing a teaching activity for a specific course or working on a research plan to discuss with a National Science Foundation program officer. Furthermore, disciplinary-rich examples situate and promote the application of learning such as when participants are engaged in an active learning activity on seismic waves or when the research proposal session identifies geoscience funding sources. The breadth of workshop sessions that are offered reflect the multitude of responsibilities faculty members have at their institutions. By doing so, faculty participants are thought to be more likely to employ the knowledge and skills they gain through the workshop, as well as to be able to strategically plan and balance their many professional responsibilities.

Workshops for early career mathematics and science faculty

Similar to the *Workshop for Early Career Geoscience Faculty* offered through the National Association of Geoscience Teachers, other disciplines provide professional development workshops designed specifically for early-career faculty in their discipline (Table 1). These workshops include Project NExT (New Experiences in Teaching) offered through the Mathematical Association of America; Project ACCCESS (Advancing Community College Careers: Education, Scholarship, and Service) offered by the American Mathematical Association of Two-Year Colleges; the New Physics and Astronomy Faculty Workshop offered through the American Association of Physics Teachers; the Geography Faculty Development Alliance: Early Career

Table 1. Comparison of discipline-based early career faculty workshops, arranged in chronological sequence from year of first workshop.

Discipline	Mathematical Sciences	Physics and Astronomy	Geoscience	Geography	Mathematical Sciences	Chemistry	Computer Science
Workshop name	Project NExT (New Experiences in Teaching)	New Physics and Astronomy Faculty Workshop	Early Career Geoscience Faculty Workshop	Geography Faculty Development Alliance: Early Career Workshop	Project ACCCESS	New Faculty Workshop	New Computer Science Faculty Workshop
First offered	1994	1996	1999	2002	2004	2012	2015
Length	3 workshops; 2 at annual MAA conferences	4 days	5 days	1 week	3 workshops; 2 at annual AMATYC conferences	1.5-2.5 days	2 days
Frequency	annual	2 times/year	annual	annual	annual	3 times/year	annual
Focus	holistic	teaching emphasis	holistic	holistic	holistic	teaching emphasis	teaching emphasis
Participants per year	∼90-120	∼70/wkshop, *2/year=∼140	∼60-70	∼20	∼30	∼40-75/wkshop, *3/year	∼40
Participants	faculty in their first few years of post-doctoral teaching, including post-docs and 2-year college faculty	tenure-track faculty at a 4-year college or university, typically in their 2nd or 3rd year	Faculty at 2-year and 4-year institutions in their first 3 years of teaching	grad students, instructors, lecturers, assistant professors, & other untenured faculty	faculty in 1st-4th year of first full-time renewable position at any community college	faculty from 2-year college or 4-year institution in first 3 years of appointment, or starting in the fall	new faculty in the 1st 3 years of their position, focus on research-focused faculty
Selection	application: cv, teaching & research statement, letter of support from chair/dean	application; nomination by department chair	application	application; first-come, first-served	application: cover sheet, personal statement, vita, letter of support from chair/dean	application; biosketch, letter of support from department chair	application
Website	projectnext.maa.org	aapt.org/Conferences/newfaculty/nfw.cfm	serc.carleton.edu/NAGTWorkshops/earlycareer/index.html	aag.org/GFDA	amatyc.site-ym.com/page/ACCCESS	acs.org/content/acs/en/education/educators/coursesworkshops/csc-new-faculty-workshop.html	eventbrite.com/e/new-computer-science-faculty-teaching-workshop-tickets-62634327961

Information from websites and publications related to the workshops (Baker et al., 2014; Foote, 2010; Henderson, 2008, 2013; Higgins, 2013; Hilborn, 2013; Krane, 2013; Macdonald et al., 2013; Porter et al., 2017; Stains et al., 2015; Waterman & Feig, 2017) and reviewed by workshop program leaders (David Kung, Project NEXT; Robert Hilborn; AAPT; Ken Foote & Michael Solem, AAG; Christy Hediger & Laura Watkins, Project ACCCESS; Ashley Donovan, ACS; Leo Porter; New Computer Science Faculty Workshop).

The workshop is noted as having a teaching emphasis or holistic; this focus is a continuum and all workshops include sessions beyond those with a teaching emphasis.

Workshop offered through the American Association of Geographers; the New Faculty Workshop, initially offered as the Cottrell Scholars Collaborative New Faculty Workshop and now through the American Chemical Society; and the New Computer Science Teaching Faculty workshop. To illustrate the similarities and differences in workshops for early-career faculty in different disciplines, Table 1 lists aspects of seven early-career faculty workshop programs, with information drawn from workshop websites and publications (Baker et al., 2014; Foote, 2010; Henderson, 2008; Henderson, 2013; Higgins, 2013; Hilborn, 2013; Krane, 2013; Macdonald et al., 2013; Porter, Lee, Simon, & Guzdial, 2017; Stains, Pilarz, & Chakraverty, 2015; Waterman & Feig, 2017).

In a broad sense, these workshops aim to support early-career faculty in their teaching and to catalyze increased use of evidence-based teaching practices. More specifically, Hilborn (2013) noted that professional development workshops offered by STEM disciplinary societies share the following goals: "to develop expert competence in teaching, to enhance faculty views of teaching as a scholarly activity, and to promote the use of evidence in evaluating the effectiveness of teaching practices" with an underlying goal of "enhancing student learning in STEM fields" (p. 6). These early-career workshops range from those with a primary focus on teaching (Porter et al., 2017), to those with a "whole faculty" approach that includes teaching, research, service, outreach, and the interconnectedness of personal and professional lives (e.g., Foote, 2010; Solem, Foote, & Monk, 2009). In addition, other workshops support early-career faculty in complementary ways, e.g., the "Professional Development Workshop: Leadership Skills for Success in the Scientific Workforce" offered by the Earth Science Women's Network <https://eswnonline.org/applyworkshop2019/> and the American Society for Microbiology's online Science Teaching Fellows Program (Brancaccio-Taras, Gull, & Ratti, 2016).

These discipline-based workshops for early-career faculty garner high ratings in terms of satisfaction by participants and many note that participants report making changes in their teaching practices (e.g., Baker et al., 2014; Gallian et al., 2000; Henderson, 2008; Hilborn, 2013; Macdonald et al., 2013; Porter et al., 2017; Waterman & Feig, 2017). The workshops may also foster lasting networks (http://www.aag.org/gfda), develop a sense of community (Higgins, 2013), and be recommended by participants to other early-career faculty (e.g., Baker et al., 2014; Gallian et al., 2000; Henderson, 2008). Henderson (2013) noted that while the New Physics and Astronomy Faculty Workshop succeeds in "motivating participants to try using [evidence-based instructional] strategies," some participants later "discontinue use or modify strategies in ways that likely diminish their effectiveness" (p. 79) and participants "have room for additional growth in skill, self-efficacy and social support in their use of active learning (Chasteen, Chattergoon, Prather, and Hilborn (2016, p. 72). Similarly, Stains et al. (2015) noted that the Cottrell Scholars Collaborative New Faculty Workshop initially shifts participants' "teaching beliefs toward student-centered teaching, and increas[es] their use of interactive teaching" although "further pedagogical support is required in order for these impacts to be sustained" (p. 1466). Various workshops offer ongoing support such as post-workshop online mentoring (e.g., Hilborn, 2017), websites with related resources (Macdonald et al., 2013; Manduca et al., 2010), and programing at two consecutive annual disciplinary meetings for each cohort (Higgins, 2013; American Mathematical Association of Two-Year Colleges (AMATYC),), 2019). Still, how to effectively introduce research-based approaches to teaching in ways that lead to their sustained implementation remains an outstanding question.

Implementation

The workshop is designed for faculty who have a full-time position at a two-year or four-year college or a university, and are in their first three years of full-time teaching. In recent years, 60-70 faculty members have attended each workshop along with seven to ten faculty leaders who facilitate sessions and table discussions and have one-on-one mentoring conversations with participants. Many of the leaders are alumni of the workshop. Except for two workshops held at Montana State University, the workshops have been held at William & Mary and the University of Maryland, in part to facilitate the optional visit to the National Science Foundation on the final day of the workshop. Funding from the National Science Foundation has provided for most of the operational costs of the workshop, with nominal fees charged to participants. In cases where the cost of attending the workshop would cause financial hardship, participants may apply for a stipend to help defray registration and travel costs.

Workshop preparation

Prior to the workshop, participants complete a registration form on which they share their scholarly interests and the courses they teach (which are then distributed to all participants to foster connections), indicate their concurrent session preferences, and respond to the question "In general, what are the features that you look for in a strong teaching activity?" Participants also are invited to submit a two-page research proposal summary or a teaching activity for peer- and leader-review and feedback during the workshop. The proposals and teaching activities are reviewed by leaders prior to the workshop, and participants receive both leader- and peer-feedback through roundtable discussion sessions during the workshop.

To prepare for the workshop, two or three conveners take the lead, with staff support, to refine the program, publish the web pages, and print the workshop notebook; set a budget and arrange for session rooms, catering, and participant housing; solicit and review participant applications; recruit and prepare leaders; arrange for the visit to the National Science Foundation - including meetings with

Table 2. Typical schedule for the Workshop for Early Career Geoscience Faculty.

Opening evening	**Discussion** of Workshop Goals, Icebreaker, Introductions, Logistics **Strategic Decisions**: Elements of a Successful Career and a Satisfying Life (includes gallery walk activity)
Day 1 *teaching*	**Course Design**: a Goals-Activities-Assessment approach (includes a jigsaw activity on interactive activities; Beane, 2019) **Teaching Strategies Concurrent Sessions**: Engaging Students in Large Classes, Interdisciplinary and Team Taught Courses, Teaching Self Regulation for Improved Learning, Student Writing and Learning **Lesson Design**: Preparing for a Class Period (includes small group activity) **Teaching Fair**: posters and tips from workshop leaders **Sharing Ideas about Specific Courses**: informal evening session
Day 2 *scholarship*	**Working Effectively with Research Students**: small and large group discussions of example research expectations and guidelines **Strategies for Research and Scholarship Concurrent Sessions**: Research with Undergraduates , Setting the Scope for M.S. Research , Starting New Research Projects and Building Collaborations, Scholarship of Teaching and Learning, Recruiting and Working with Graduate Students **Lunch Discussions** (optional): dual academic careers, large classes, two-stage exams, teaching with mobile devices, working with industry, underrepresented faculty … **Connections, Extensions, Opportunities Concurrent Sessions**: Time Management, Bringing Data/Research into the Classroom, Diversity and Inclusion in the Classroom, Managing Service Expectations **Individual Consultations with Leaders** (1:1 mentoring)
Day 3 *planning, proposals and feedback*	**Creating a Strategic Plan for Research/Scholarly Activity Writing Proposals and Getting Funded Concurrent Sessions**: Getting Funded at Primarily Undergraduate Institutions, Getting Funded at Institutions with Graduate Students, Writing your First Proposal **Lunch Discussions** (optional): kids, online courses, international faculty, clickers, interdisciplinary research/ collaborations, effective use of startup funds, student mental health, … **Getting Feedback Concurrent Sessions**: Improving Research Proposals Through Review Proposal Summaries (peer review of participants' research proposal summaries, submitted before workshop), Improving Class Activities and Assignments through Review of Your Assignment (peer review of participants' activities and assignments, submitted before workshop) **Individual Consultations Time to Work on Posters**
Day 4 *sharing ideas and receiving feedback*	**Poster Session**: Participants share one poster related to teaching, and one related to research, and provide peer feedback to each other **Poster Follow-up and Reflection** **Building a Network of Support Strategic Action Planning**: goal-setting and action-planning session **Lessons Learned** and **Concluding Remarks Workshop Evaluation**
Day 5 *NSF visit*	**National Science Foundation** (NSF) optional visit includes group sessions and individual meetings with program officers and directors

program officers; and, communicate with participants prior to the workshop. Leaders adjust the program each year and discuss the implications of any changes. Nearly all sessions are co-led with leaders exchanging multiple drafts of slides before the workshop. The session notes and slides are shared with the conveners for review and inclusion in the workshop notebook. To assist with developing sessions, conveners share with leaders effective approaches for facilitating sessions following from principles for leading workshops developed by On the Cutting Edge (<https://serc.carleton.edu/NAGTWorkshops/workshops/convene/design.html>). The suggestions provided to session leaders are to:

> *Model effective pedagogy.* Participant evaluations tell us that our most successful workshop sessions are those taught with good pedagogy in mind and that our least successful sessions are those where a presenter simply stands up and talks. As you plan your sessions, please consider incorporating active learning techniques. These will help the session to be interactive and will model effective teaching for participants.
>
> *Engage participants actively during the workshop:* Nothing is less effective than a workshop where participants do not participate. Ways of engaging participants include small and large group discussions, short problem-solving tasks, reviewing and/or trying out activities, scheduled thinking and writing time, and so forth.
>
> *Plan your sessions thoroughly.—maybe even minute-by-minute:* Good sessions that appear to flow spontaneously reflect extensive planning by leaders, a clear understanding of the session and its objectives, and realistic planning for how long activities will really take. Please take care to plan time for questions at the end, and to fit into the specified time for the session.

Workshop leaders arrive prior to the start of the workshop to participate in a five-hour pre-workshop meeting during which they review the schedule, preview sessions, and talk through questions and suggestions. Daily breakfast meetings serve to listen to summaries of the previous day's participant feedback survey, review the day's program, highlight roles of table facilitators, and discuss any concerns.

Workshop program

The workshop program follows from the goals and incorporates advances from the scholarship of teaching and learning (e.g., Wiggins & McTighe, 1998; National Research Council, 2000; Pintrich & Zusho, 2007; Ambrose, Bridges, DiPietro, Lovett, & Norman, 2010) and from best practices of professional development (e.g., Loucks-Horsley, Stiles, Mundry, Love, & Hewson, 2009; Manduca et al., 2017). The workshop is designed to be interactive, to emphasize participant learning, and to model effective teaching practices. The workshop design includes ample opportunities for faculty participants to interact through plenary sessions, table discussions, concurrent sessions, informal discussions, individual consultations with workshop leaders, and a poster session. Participant discussions with each other are important to situate their learning. Their individual learning is shaped by discourse with colleagues and by practice as when they participate in sessions that model the teaching strategies they might then use in their classrooms (Lave & Wenger, 1991; Putnam & Borko, 2000).

The workshop program is updated every year to reflect research on learning and teaching, and to meet the evolving

interests and needs of early-career faculty. The arc of the program as outlined in Table 2 has been consistent for the past fifteen years. However, the specific sessions, particularly the concurrent sessions, have varied based on leader interests, new insights, and feedback from the previous year's participants. Day 1 begins with a session on strategic decisions, then focuses primarily on teaching. Day 2 focuses primarily on research. The session on working with research students includes examples of written guidelines; after this session participants uniformly state that they will be more explicit in sharing expectations and guidelines with their research students, either verbally or in writing. During day 3, participants develop and discuss a plan for their scholarship—including funding sources, receive feedback on a research proposal summary or teaching activity, and prepare two posters—one that focuses on one aspect of their teaching, and the other on their scholarship. On day 4, participants receive feedback on their teaching and scholarship posters in the morning and reflect on what they have learned; then, in the afternoon they develop an action plan for after the workshop and discuss specific issues they face (Macdonald et al., 2013). The programs for workshops held from 2002 to present are available through https://serc.carleton.edu/NAGTWorkshops/earlycareer/pastworkshops/index.html. These web pages also include presentation slides and other materials relevant to each session.

Within the arc of the workshop, sessions are scaffolded to allow overarching themes to develop related to community building and strategic planning. Community building starts the first evening with kinesthetic ice-breakers such as those that ask participants to arrange themselves in the room by the number of faculty in one's department, one's research focus from the Earth's core through distant planets, or the geographic location of one's institution. These types of questions allow participants to meet each other and begin to make connections. Participants are grouped in these and other ways throughout the workshop to help build connections; for example, when faculty discuss their scholarship with peers or sit at tables by region to discuss how they might continue to support each other after the workshop. The community building continues that first evening with a gallery walk exercise for which participants respond to prompts relevant to starting a faculty position, such as 'tenure expectations at my institution are clear,' and often come to realize they are not alone in their feelings and experiences. This purposeful development of community resumes the next morning with low-stakes peer feedback on course goals, through higher-stakes feedback on research proposals or assignments mid-workshop, and then seeking advice on specific action plans or sometimes-sensitive situations on the final day of the workshop. The scaffolding of these activities combined with ground rules of limited confidentiality (sharing good ideas while keeping confidential specific experiences) and careful facilitation by leaders contributes to increasing trust and the development of community.

Similar to the scaffolding of community building through the workshop activities, strategic planning also is built into the arc of the workshop. The opening evening session on 'Strategic Decisions: Elements of a Successful Career and a Satisfying Life' draws from Boice's (1991b, 2000) work on the characteristics of quick starters and emphasizes practical steps such as taking advantage of short time periods, talking with others, managing distractions, setting realistic goals, and taking breaks. Over the next two days, participants discuss teaching strategies, strategies for working with research students, and time and task management strategies. On day three, they develop a strategic plan for their research/scholarly activity and discuss it with others who share a similar research focus, and provide and receive feedback. That afternoon they meet in leader-facilitated small groups to peer-review the proposal summary or teaching activity they submitted before the workshop. The final afternoon involves writing a strategic action plan for the coming year involving components of teaching, scholarly activity, and other priorities.

The workshop uses a variety of mentoring models. Group mentoring takes place during small group discussions (e.g., discussions about supervising research students, table discussions following action planning) and discussions around posters in the final day poster session. One-to-one mentoring takes place during individual consultations (via an informal sign up schedule with individual leaders). Peer mentoring takes place throughout the workshop—at lunch discussions, through the poster discussion, at meals, and during unstructured gatherings in the evenings.

Website

The "Early Career Geoscience Faculty: Teaching, Research, and Managing Your Career" website https://serc.carleton.edu/NAGTWorkshops/earlycareer/index.html is a collection of resources that were developed as an outgrowth of the annual workshop (Ormand, Macdonald, & Manduca, 2006). The topical resources function as continued support for participants in their learning following the workshop, and also are publicly available for others who may be interested in topics such as balancing the demands of a career in academia with a healthy personal life, effective teaching, managing a research program, and the tenure process. For example, *The Making Choices/Finding Your Balance* module presents case studies of geoscience faculty members at a variety of academic institutions as well as resources on task (time) management and balancing career and family. The *Efficient, Effective Teaching* module provides resources for course design, teaching efficiently, effective teaching techniques, teaching large classes, keeping research seminars lively and engaging, assessment, and building one's teaching case for tenure. The *Developing a Thriving Research Program* module focuses on planning a research program, funding it, working with undergraduate and graduate research students, and making time for research. It features an online collection of successful geoscience grant proposals and case studies of successful researchers and their collaborations with students. The *Getting Tenure* module includes preparing yourself for the tenure process (St. John & Leckie, 2019), the tenure package (Leckie & St. John, 2019), and other

resources. Overall, the resources on the website offer multiple perspectives, examples, and suggestions from successful faculty members at a variety of colleges and universities.

Evaluation

Analyses of the end-of-workshop survey data focused on examining whether faculty participants reported that the five goals of the workshop were met. Analyses of the National Geoscience Faculty Survey data focused on examining whether faculty who participated in the workshop prior to completing the survey differed from respondents with similar years of experience teaching who did not participate in the workshop prior to completing the survey; this analysis focused on two outcomes: 1) self-reported use of active-learning teaching strategies, and 2) beliefs and behaviors that are indicative of belonging to a community of practice.

Data sources and collection

Demographic data from the workshop application

Workshop participants have completed a demographic survey as part of their application since 2002. Questions that they self-report include the type of institution at which they work, the location of the institution, and their gender, disabilities, race, and ethnicity.

End-of-workshop survey

Following the last session of the workshop, participants complete an end-of-workshop survey that includes questions with Likert-scale responses and open-ended responses. As part of the survey, participants are asked to rate their level of agreement that each of the five workshop goals are met on scales that range from 1 (disagree) to 4 (agree).

National Geoscience Faculty Survey

The National Geoscience Faculty Survey has been administered four times, in 2004, 2009, 2012, and 2016. The survey methodology is described in Macdonald et al. (2005) and Manduca et al. (2017). For this paper, we used responses only from the 2016 administration of the survey. Development and administration of the 2016 survey were supported by the On the Cutting Edge, InTeGrate, and SAGE 2YC programs, with financial support from their grants from the National Science Foundation (awards 1022844, 1125331, and 1525593) and with expertise from Greenseid Consulting Group, LLC and Professional Data Analysts, Inc. The full administration of the 2016 survey was sent by email to 10,910 individual geoscience faculty members in the United States. The survey asked faculty to report on teaching practices they use, on how they learn about the content and methods used in their teaching, and on how they share with colleagues what they learn about teaching.

The degree to which faculty report incorporating active learning strategies in their teaching was assessed in two ways on the National Geoscience Faculty Survey. First, faculty members were asked to estimate the percentage of class time spent on student activities, questions, and discussion. Responses could range from 0 to 100. Second, faculty members were asked to indicate the frequency with which they used seven specific teaching strategies: traditional lecture, lecture with demonstration, lecture in which questions posed by the instructor are answered by individual students, lecture in which questions posed by the instructor are answered simultaneously by the entire class (e.g., using electronic response systems), small group discussion or think-pair-share, whole-class discussion, and in-class exercises. Responses could range from 1 (never) to 5 (nearly every class). Faculty members who taught only introductory courses were asked to report on their teaching strategies in their most recent introductory course taught in the past two years. Faculty members who taught only courses for majors were asked to report on their teaching strategies in their most recent majors' course taught in the past two years. All other faculty members were randomly assigned to report on their teaching strategies in either their most recent introductory or majors course. In all cases, faculty members were asked to report on their teaching strategies in the "lecture" portion of the course.

Faculty members' community of practice beliefs were assessed by asking them to respond to two questions on the National Geoscience Faculty Survey: 1) to what extent do you consider yourself part of a community of geoscience educators that shares your goals, philosophy, and values for geoscience education? and 2) to what extent do interactions with this community make you a better educator? Responses could range from 1 (not at all) to 4 (to a great extent). Faculty members' community of practice behaviors were assessed by asking them to self-report the numbers of talks "related to teaching or science education" and "number of workshops related to improving teaching" they had attended in the last two years. For workshop participants who attended a workshop in 2014 and 2015, the self-reported workshop count was reduced by 1 as some (and perhaps many or all) of these participants may have included the early career workshop in their count of workshops attended in the last two years.

Data analysis, validity, and reliability

The end-of-workshop survey was developed for the purposes of gathering formative and summative evaluation data. All survey items were reviewed for face validity by experts in evaluation at the Science Education Resource Center (SERC) at Carleton College and by the conveners of the Workshop for Early Career Geoscience Faculty. The predictive validity of the items tapping participants' ratings of the degree to which workshop goals were met was assessed by correlating these ratings with participants' workshop satisfaction ratings. All correlations were statistically significant (all p values $<$ .001). The content and face validity of National Geoscience Faculty Survey items were established through consultation with a team of experts and thorough pilot testing with a

random sample of potential survey respondents. Pilot participants ($n = 33$) were asked to comment specifically on the length, format, and content of the survey and on the clarity of individual items. Analyses of pilot survey data and participant comments informed minor revisions prior to full survey administration. All data were analyzed using SPSS (version 25).

Study population

Demographics of workshop participants

A total of 1,025 faculty have participated in the workshop since its inception in 1999. Workshop participants come from a variety of institutions across the United States. Participants have come from institutions in all 50 states, Washington D.C. and Puerto Rico. With regards to the types of institutions at which the participants teach, 53% teach at doctoral institutions, 15% master's, 27% bachelor's, and 5% associate's ($n = 804$) based on the highest degree offered in the department. Geology/geophysics is the most commonly reported subdiscipline (74%), followed by marine geology/oceanography (9%), atmospheric/meteorology (9%), and 8% other disciplines ($n = 901$). Fifty-three percent of participants identify as female and 47% as male ($n = 887$). One percent of participants shared that they had a disability. With regards to race and ethnicity, 77% of participants identified as white, non-Hispanic; 16% Asian or Asian American; 4% African American or Black; 4% Hispanic; 1% Native American and 1% Pacific Islander ($n = 878$, multiple responses possible).

End-of-workshop survey

The sample for analyses of end-of-workshop survey data was limited to the 502 faculty who participated in the workshop from 2011 to 2018 as there was a shift made from seven workshop goals to five workshop goals in 2011. A total of 473 of these participants responded to the end-of-workshop survey from 2011 to 2018 (a 94% response rate).

National geoscience faculty survey participants

A total of 2,615 faculty participated in the National Geoscience Faculty Survey. Excluding retirees ($n = 18$) and survey contacts who had invalid email addresses ($n = 1,296$), the survey response rate was 27.3%, representing a significant portion of the nation's geoscience faculty. For analyses of the National Geoscience Faculty Survey data, two groups of respondents were created 1) those who participated in the *Workshop for Early Career Geoscience Faculty*, and 2) a comparison group of respondents who did not participate in the workshop. The sample for workshop participants was limited to faculty who attended the workshop prior to completing the survey (i.e., in 2015 or earlier). Then, to create a reasonable comparison group, the sample of respondents who did not participate in the workshop was limited to faculty who reported earning their highest degree in 1994 or later (i.e., 5 years before the annual workshop began). This approach resulted in a sample of 277 survey respondents who participated in the workshop and 1,218 survey respondents who did not participate. The two groups did not differ in the number of unique courses taught in the past academic term, the number of hours taught in the past academic term, or the number of students enrolled in their most recent introductory or majors course, all p values $>$ .05. Statistically significant differences did emerge between workshop participants and non-participants in degree type, length of time teaching, and institution type, however. Specifically, compared to faculty members who did not participate in the workshop, workshop participants were more likely to have earned a Ph.D. (96.4% vs. 87.2%), $\chi^2(1482) = 18.94$, $p < .001$, and to have taught for fewer years at the college or university level (9.65 years vs. 10.91 years), $t(1488) = 2.83$, $p < .01$. The two groups also differed by institution type, $\chi^2(1411) = 18.32$, $p < .001$, such that workshop participants were less likely to teach at associate's colleges (7.8% vs. 15.7%), more likely to teach at baccalaureate colleges (13.4% vs. 8.9%), and more likely to teach at master's institutions (25.7% vs. 19.5%), all p values $< .05$. There were no differences between the two groups in the percent teaching at research and/or doctoral institutions (both ~50%). All subsequent analyses controlled for these three variables to ensure that any effects that we attribute to early career workshop participation are not, instead, effects that should be attributed to degree type, length of time teaching, or institution type.

Results

End-of-workshop survey

End-of-workshop survey responses from 2011 to 2018 indicated that workshop participants reported that all five workshop goals were met, with mean ratings that ranged from 3.79 to 3.89 (on a 1 to 4 scale). The highest means emerged for Goal 1 ("learn about setting course goals, strategies for active learning, and methods for assessment"; mean = 3.89) and Goal 2 ("share ideas and strategies for teaching one or more courses"; mean = 3.87) which, together, focused on faculty learning how to improve their teaching to better foster student learning through workshop sessions and interactions with workshop leaders and one another. The other three goals also had high means: Goal 3 ("consider successful strategies for maintaining an active research program … "; mean = 3.82), Goal 4 ("discuss life as an early-career faculty member … "; mean = 3.79), and Goal 5 ("leave with examples of assignments and activities for various courses, strategies for balancing competing demands, a support network of other early-career faculty, and a plan for managing their early career as an academic"; mean = 3.85). Participant responses to an open-ended question that probed how the workshop impacted their teaching supported the numerical ratings. For example:

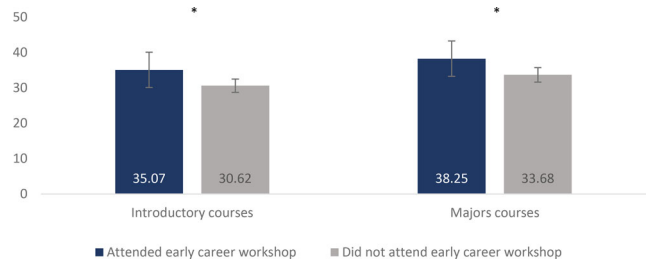

Figure 1. Faculty members' self-reported percentage of class time spent on student activities, questions, and discussion. Error bars represent 95% confidence intervals. *p <.05.

> *"I realize I need to incorporate more interactive teaching approaches. I learned some great ideas during the presentations, but especially during the poster session. I don't know if I would have ever been exposed to these ideas if I didn't attend this workshop." (2012)*

> *"I could tell my lectures were too long/monochromatic, and I will immediately begin incorporating in-class activities for both intro and upper-level/grad classes. I needed to see concrete examples (and hear success stories) about how to implement these." (2013)*

> *"I plan to be more diligent about thoroughly considering all facets of an assignment [that] I design and implement. What's the hook? What's the motivation? How much time will it take? What are the learning goals? How will students be assessed? Such a simple framework to build from, but one that I too often neglect. There were so many valuable teaching practices and anecdotes shared. I am eager to get to work applying the lessons learned as I prep[are] for my Fall courses!" (2015)*

> *"I am excited to try out these tools. Innovation and active learning don't have to be hard or time-consuming. I also have connections for others who are teaching similar classes and I am excited to combine forces with them. Teaching can be a tool for seeding new scientific collaborations." (2017)*

National geoscience faculty survey

Impact of workshop participation on use of active learning strategies

Univariate analyses of covariance (ANCOVAs) were used to examine the hypothesis that faculty members who participated in the workshop would more frequently incorporate active learning strategies in their teaching than faculty members who did not participate. Analyses controlled for degree type, length of time teaching, and institution type by including these variables as continuous covariates (in the case of length of time teaching) or as dummy-coded categorical covariates (in the case of degree type and institution type). Figures include estimated marginal means and 95% confidence intervals.

Consistent with the hypothesis, workshop participants estimated that they spent a greater percentage of class time on student activities, questions, and discussion than faculty members who did not participate in the workshop. The difference was statistically significant in both introductory, $F(1, 648) = 4.19$, $p < .05$, and majors courses, $F(1, 577) = 3.81$, $p < .05$ (Figure 1). Workshop participants also differed from faculty who did not attend the workshop in their use of specific teaching strategies. Specifically, in introductory courses (Figure 2), workshop participants reported more frequent use of small group discussion or think-pair-share, $F(1, 625) = 15.29$, $p < .001$, and more frequent use of in-class exercises, $F(1, 636) = 5.30$, $p < .05$. A marginally significant difference also emerged between the two groups in whole-class discussion, with workshop participants reporting more frequent use of this strategy, $F(1, 620) = 2.96$, $p < .10$. In majors' courses (Figure 3), workshop participants reported less frequent use of traditional lecture, $F(1, 561) = 12.72$, $p < .001$, more frequent use of small group discussion or think-pair-share, $F(1, 569) = 21.01$, $p < .001$, more frequent use of whole-class discussion, $F(1, 571) = 4.42$, $p < .05$, and more frequent use of in-class exercises, $F(1, 575) = 18.13$, $p < .001$.

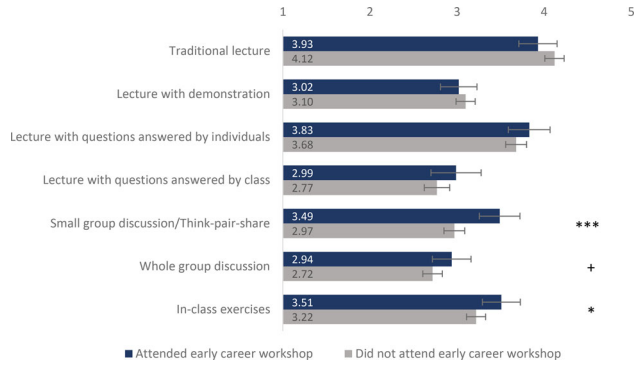

Figure 2. Faculty members' self-reported frequency of use of specific teaching strategies in introductory courses (1 = never; 5 = nearly every class). Error bars represent 95% confidence intervals. + p <.10. *p <.05. ***p <.001.

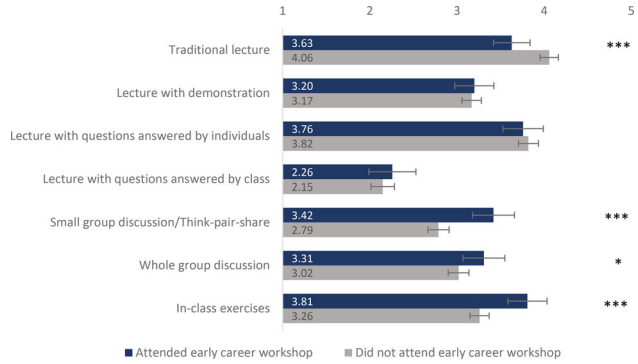

Figure 3. Faculty members' self-reported frequency of use of specific teaching strategies in majors courses (1 = never; 5 = nearly every class). Error bars represent 95% confidence intervals. *p <.05. ***p <.001.

Impact of workshop participation on community of practice beliefs and behaviors

Univariate analyses of covariance (ANCOVAs) were used to examine the hypothesis that faculty members who participated in the workshop would be more likely to report beliefs and behaviors that are indicative of belonging to a community of practice than faculty members who did not participate in an early career workshop. Analyses again controlled for degree type, length of time teaching, and institution type by including these variables as continuous covariates (in the case of length of time teaching) or dummy-coded categorical covariates (in the case of degree type and institution type).

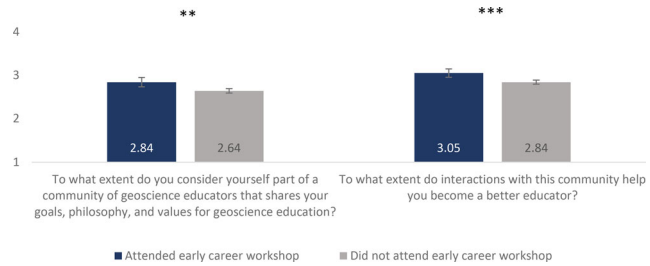

Figure 4. Faculty members' self-reported perceptions of being part of a community of practice (1 = not at all; 4 = to a great extent). Error bars represent 95% confidence intervals. $^{**}p < .01$. $^{***}p < .001$.

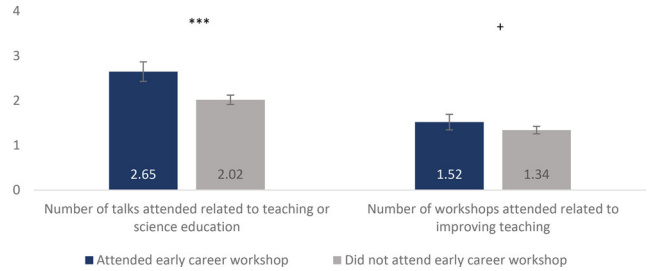

Figure 5. Faculty members' self-reported number of talks or workshops attended related to teaching in the past two years. Error bars represent 95% confidence intervals. $+ p < .10$. $^{***}p < .001$.

Figures include estimated marginal means and 95% confidence intervals.

Consistent with the hypothesis, workshop participants were more likely than those who did not participate to report feeling they were a part of a geoscience community that shares their goals, philosophy, and values for geoscience education, $F(1, 1345) = 10.05$, $p < .01$, and more likely to report that interactions with this community help them to become better educators, $F(1, 1205) = 15.03$, $p < .001$ (Figure 4). Workshop participants were also more likely than those who did not participate to have attended talks related to teaching or science education, $F(1, 1349) = 25.77$, $p < .001$, and, at marginally significant levels, more likely to have attended workshops related to improving teaching, $F(1, 1341) = 3.11$, $p < .10$, in the past two years (Figure 5).

Discussion

Workshop demographics

The workshop has had a broad reach into the community with more than 1,000 participants from across the country. Faculty from across institutional types are represented in the participants and the leaders. The workshop continues to have a large number of applicants every year, including many referrals from workshop alumni and department chairs, including those who suggest it as part of startup packages. Workshop participation by two-year college faculty may be low for multiple reasons including that two-year college faculty often teach summer courses, they may lack funding, and there are additional faculty development programs available for two-year college faculty (e.g., programs offered by SAGE: Supporting and Advancing Geoscience Education at Two-Year Colleges). The participation in the workshop by faculty from groups that have been historically marginalized is slightly higher than the percentage of those who earned geoscience doctorates (Bernard & Cooperdock, 2018) or who are in geoscience faculty positions (Dahl, 2016).

The participation of female participants (53%) is much higher than the percentage of women in faculty positions. The overall percentage of women in geoscience faculty positions at four-year institutions increased from 17% in 2015 to 20% in 2017 (Wilson, 2019). Holmes, O'Connell, Frey, and Ongley (2008) (based on data from 2004) wrote that 26% of assistant professors in the geosciences were women, with higher ranks having lower percentages, and that 34% of PhDs were received by women. Adams, Steiner, and Wiedinmyer (2016, p. 345) wrote about "the percentage of women in tenure-track faculty positions in atmospheric science departments decreasing significantly with rank, from 30% of assistant professors to 12% of full professors (MacPhee & Canetto, 2015). Proportionally higher participation by females also has been noted in other studies of faculty development (e.g., Chism & Szabo, 1996), and documenting the reasons why may be an interesting avenue for further study.

Active learning

Participants reported learning about teaching from workshop sessions and from each other. Their open-ended responses to the end-of-workshop survey expressed that they changed in their attitudes with a desire to include more active learning, learned new approaches, and planned changes in their courses. Workshop alumni self-reports for the National Survey of Geoscience Faculty indicate they incorporate more active learning in their courses than faculty who did not attend the workshop. Participants' incorporation of active learning strategies may result from the specific discussion of active learning strategies on the first day of the workshop as well as opportunities later in the workshop to receive feedback on a teaching activity/assignment. In addition, they participate in a variety of active learning strategies throughout the workshop which impacts their receptiveness to incorporate active learning in their courses. For the poster session, they construct posters about new ideas for their teaching and scholarly work that they plan to implement, get new ideas from viewing others' posters, give and receive peer feedback, and finally write reflections on their posters and the feedback they received.

Viskupic et al. (2019) noted that faculty who participate in geoscience professional development are more frequently observed teaching student-centered active-learning classes. Amongst the opportunities for geoscience faculty development, the *Workshop for Early Career Geoscience Faculty* has additional features that might help participants to be more likely to adopt evidence-based active-learning approaches. In particular, it is an intensive week-long program that offers multiple opportunities to practice active learning in sessions relevant to the geosciences and to their career during which participants benefit from these situated learning contexts. Furthermore, participants are supported post-workshop

through specific early-career website modules (Ormand et al., 2006), and more generally through the Teach the Earth site (https://serc.carleton.edu/teachearth) and the On the Cutting Edge geoscience activity collection (Manduca et al., 2010).

Community of practice

The workshop incorporates aspects central to situated learning and the development of a community of practice. Participants have shared domains of interest insofar as they are early-career geoscience faculty teaching some of their first courses. They seek each other and leaders to talk with as they have experiences relevant to their situations as geoscience faculty members. The holistic approach to the workshop design provides many opportunities to focus on multiple aspects of the participants' work and life as early-career faculty members. Talking with each other helps the faculty participants recognize that some of the issues they face and how they feel about these issues are not unique to them but are shared, which helps to develop a sense of belonging to the community. Having a community that engages in discussion and shares relevant information, as well as having a focus on the practice of teaching and scholarship, further builds the community (Wenger-Trayner & Wenger-Trayner, 2015). The workshop provides many structured activities that facilitate sharing and participants also have many informal discussions.

Throughout the workshop, participants learn from each other and from the leaders. This community-based learning is especially poignant during the poster session where participants share an aspect of their teaching and their scholarly work that they plan to implement, a good example of situated learning. The feedback they receive as part of the community of practice helps the participants to recognize that they are not alone in planning their work and resonates with Boice (2000) principles. During the action planning session, they also share something on which they would appreciate advice, and hear various perspectives from the other participants and workshop leader at their table. Opportunities for feedback and reflection are incorporated into the workshop around their action plans for teaching, scholarship, and their careers in a way that makes the implementation of such practices more likely.

Limitations

The current study has several limitations. First, because participants were not randomly assigned to attend the workshop, we cannot conclude that workshop attendance is causally related to differences between workshop participants and non-participants in their responses to the National Geoscience Faculty Survey. By controlling for factors that are associated with workshop attendance (i.e., degree type, length of time teaching, and institution type), however, we have eliminated some alternative explanations for the differences in teaching strategies and community of practice beliefs and behaviors reported here. Future work might employ matching as an alternative to the regression-based approach employed here. Future work might also examine other ways in which the two groups might differ (e.g., in their participation in professional societies or other networks that might impact their feelings of belonging to a community of practice). Second, respondents to the National Geoscience Faculty Survey represent only a sample of all identifiable geoscience faculty (Manduca et al., 2017). It is likely that survey respondents may be more likely than non-respondents to be interested in the adoption of active learning strategies in their teaching and/or in being part of a community of practice. We acknowledge that caution should be exercised in generalizing findings beyond this sample of geoscience faculty. Third, although the current study found statistically significant differences between workshop participants and non-participants in both active learning strategies and community of practice behaviors and beliefs, the effect sizes were small, with eta squared values ranging from .01 to .04. Small effect sizes are consistent with the notion that teaching and networking outcomes among faculty are multiply determined. Moreover, small effect sizes are not unexpected given that nearly one-third of the workshop participants included in the current sample had attended the workshop between 1999 and 2005 – more than a decade prior to reporting on their teaching practices and community of practice behaviors and beliefs in the 2016 National Geoscience Faculty Survey. Finally, the current study relied on faculty members' self-reports of their teaching strategies and community of practice beliefs and behaviors from end-of-workshop surveys and the National Geoscience Faculty Survey. Demonstrating the efficacy of the workshop will be strengthened by using multiple methodological approaches (e.g., by conducting classroom observations and by examining teaching artifacts including syllabi and exams) and by examining additional outcomes including those more closely tied to research and professional-balance goals. Toward this end, a mixed-method retrospective assessment is currently underway and includes interviews with a purposive sample of workshop participants who vary in participating year, appointment, and institutional context and a census survey of workshop attendees from 1999 to 2019.

Conclusions and implications

Participants in the Workshop for Early Career Geoscience Faculty reported more frequent use of active-learning strategies compared to faculty members who did not participate. Workshop participants also were more likely to report that they felt part of a community that shares their goals, philosophy, and values for geoscience education and that their interactions with this community help them to become better educators. These findings are important given that the most effective strategies for catalyzing widespread and sustained change from instructor-centered to student-centered teaching practices are still not well understood.

A holistic approach to faculty development, such as is offered through the workshop, aligns well with typical goals of early-career faculty, institutions, and disciplinary

communities. When starting out, faculty seek and look forward to a successful and satisfying academic career. Their goals, sometimes unarticulated, may be to achieve tenure or an ongoing position; to be successful in teaching, research, service, and life; to be respected; and to feel included in departmental, institutional, and disciplinary communities (e.g., Boice, 2000; Columbia University, 2016; Foote, 2010). Academic institutions seek to retain and promote faculty who contribute to their missions which may include cultivating faculty who are effective teachers, productive scholars, and contributors to the institution, as well as building the institution's organizational strength (Columbia University, 2016; Zellers et al., 2008). Disciplinary communities value faculty who advance the field, excite and educate the next generation, are effective research mentors, are thoughtful reviewers, and contribute to the community. A holistic workshop design thus appeals to multiple stakeholders which works to enhance support for faculty development and for these faculty members during the critical transition that happens at the beginning of their careers.

Acknowledgments

We thank the many leaders and participants of the Early Career Geoscience Faculty Workshop for their commitment, willingness to share openly, and their constructive input. In particular, we thank the leaders of the original workshop series (Heather Macdonald, Barb Tewksbury, David Mogk, Bob Newton, Randy Richardson, and Steve Semken), past and present conveners (Richelle Allen-King, Rachel Beane, Josh Galster, Tessa Hill, Heather Macdonald, Sarah Penniston-Dorland, Michael Wysession, and Richard Yuretich), and the developer of the associated website (Carol Ormand). The 2016 National Geoscience Faculty Survey was developed and administered by a team involving leadership from the National Association of Geoscience Teachers (NAGT), On the Cutting Edge, InTeGrate, and SAGE 2YC with assistance from Greenseid Consulting Group, LLC. and Professional Data Analysts, Inc. We appreciate discussions with and feedback from members of the survey research team. We thank the reviewers and editors for comments that improved this article.

Funding

The Workshop for Early Career Geoscience Faculty has been supported through National Science Foundation (NSF) grants 9752809, 9752801, 9752819, 0127310, 0127141, 0618725, 0618482, 1022910, 1022844, 1711022, 1821138, and 1821317. The National Geoscience Faculty Survey was supported by NSF grants 1022844, 1125331, and 1525593. Any opinions, findings, conclusions or recommendations expressed in this work are those of the authors and do not necessarily reflect the views of the NSF.

ORCID

Rachel J. Beane http://orcid.org/0000-0002-0507-4944
Ellen R. Altermatt http://orcid.org/0000-0002-8245-5126
Ellen R. Iverson http://orcid.org/0000-0001-9312-2258
R. Heather Macdonald http://orcid.org/0000-0002-0014-8991

References

Adams, A. S., Steiner, A. L., & Wiedinmyer, C. (2016). The Earth Science Women's Network (ESWN): Community-driven mentoring for women in the atmospheric sciences. *Bulletin of the American Meteorological Society*, *97*(3), 345–354.

Adler, J. (2000). Social practice theory and mathematics teacher education: A conversation between theory and practice. *Nordic Studies in Mathematic Education*, *8*, 31–53.

Ambrose, S., Bridges, M., DiPietro, M., Lovett, M., & Norman, M. (2010). *How learning works: Seven research-based principles for smart teaching*. San Francisco, CA: Jossey-Bass.

American Mathematical Association of Two-Year Colleges (AMATYC). (2019). AMATYC Project ACCCESS. Retrieved from https://amatyc.site-ym.com/general/custom.asp?page=acccess.

Austin, A. E., Campa, H., III, Pfund, C., Gillian-Daniel, D. L., Mathieu, R., & Stoddart, J. (2009). Preparing STEM doctoral students for future faculty careers. *New Directions for Teaching and Learning*, *117*, 83–95. doi:10.1002/tl.346

Baker, L. A., Chakraverty, D., Columbus, L., Feig, A. L., Jenks, W. S., Pilarz, M., … Wesemann, J. L. (2014). Cottrell scholars collaborative new faculty workshop: Professional development for new chemistry faculty and initial assessment of its efficacy. *Journal of Chemical Education*, *91*(11), 1874–1881. doi:10.1021/ed500547n

Beach, A. L., & Cox, M. D. (2009). The impact of faculty learning communities on teaching and learning. *Learning Communities Journal*, *1*(1), 7–27.

Beane, R. (2019). Active learning via earth science posters. *In the Trenches: The News Magazine of the National Association of Geoscience Teachers*, *9*, 10–12.

Bernard, R. E., & Cooperdock, E. H. G. (2018). No progress on diversity in 40 years. *Nature Geoscience*, *11*(5), 292–295. doi:10.1038/s41561-018-0116-6

Beyer, C. H., Taylor, E., & Gillmore, G. M. (2013). *Inside the undergraduate teaching experience: The University of Washington's growth in faculty teaching study*. Albany, NY: SUNY Press.

Boice, R. (1991a). New faculty as teachers. *The Journal of Higher Education*, *62*(2), 150–173. doi:10.2307/1982143

Boice, R. (1991b). Quick starters: New faculty who succeed. *New Directions for Teaching and Learning*, *48*, 111–121. doi:10.1002/tl.37219914810

Boice, R. (2000). *Advice for New Faculty Members: Nihil Nimus*. Needham Heights, MA: Allyn & Bacon.

Borko, H. (2004). Professional development and teacher learning: Mapping the terrain. *Educational Researcher*, *33*(8), 3–15. doi:10.3102/0013189X033008003

Boud, D., & Walker, D. (1998). Promoting reflection in professional courses: The challenge of context. *Studies in Higher Education*, *23*(2), 191–206. doi:10.1080/03075079812331380384

Brancaccio-Taras, L., Gull, K. A., & Ratti, C. (2016). The Science Teaching Fellows Program: A model for online faculty development of early career scientists interested in teaching. *Journal of Microbiology & Biology Education*, *17*(3), 333–338. doi:10.1128/jmbe.v17i3.1243

Chasteen, S., Chattergoon, R., Prather, E., & Hilborn, R. (2016). *Evaluation methodology and results for the New Faculty Workshops*. 2016 Physics Education Research Conference *Proceedings*, 72–75. https://www.compadre.org/per/items/detail.cfm?ID=14196. doi:10.1119/perc.2016.pr.013

Chism, N. V. N., & Szabo, B. (1996). Who uses faculty development services? In L. Richlin (Ed.), *To improve the academy*, Vol 15 (pp. 115–128). Stillwater, OK: New Forums Press and the Professional and Organizational Development Network in Higher Education.

Cobb, P., & Bowers, J. (1999). Cognitive and situated learning perspectives in theory and practice. *Educational Researcher*, *28*(2), 4–15. doi:10.3102/0013189X028002004

Columbia University. (2016). Guide to best practices in faculty mentoring https://provost.columbia.edu/sites/default/files/content/MentoringBestPractices.pdf.

Condon, W., Iverson, E. R., Manduca, C. A., Rutz, C., & Willett, G. (2016). *Faculty development and student learning: assessing the connections*. Bloomington, IN: Indiana University Press.

Cox, M. D. (2002). Achieving teaching and learning excellence through faculty learning communities. *Essays on Teaching Excellence*, *14*(4), 1–6.

Cox, M. D. (2013). The impact of communities of practice in support of early-career academics. *International Journal for Academic Development*, *18*(1), 18–30. doi:10.1080/1360144X.2011.599600

Dahl, R. M. (2016). How many profs of color are there in the geosciences? Retrieved from http://www.robynmdahl.com/blog/2016/11/3/how-many-profs-of-color-are-there-in-the-geosciences.

Dall'Alba, G., & Sandberg, J. (1996). Educating for competence in professional practice. *Instructional Science*, *24*(6), 411–437. doi:10.1007/BF00125578

Dall'Alba, G., & Sandberg, J. (2006). Unveiling professional development: A critical review of stage models. *Review of Educational Research*, *76*(3), 338–412. doi:10.3102/00346543076003383

Derting, T. L., & Ebert-May, D. (2010). Learner-centered inquiry in undergraduate biology: Positive relationships with long-term student achievement. *CBE—Life Sciences Education*, *9*(4), 462–472. doi:10.1187/cbe.10-02-0011

Duguid, P. (2005). The Art of Knowing": Social and tacit dimensions of knowledge and the limits of the community of practice. *The Information Society*, *21*(2), 109–118. doi:10.1080/01972240590925311

Eddy, P. L., Hao, Y., Markiewicz, C., & Iverson, E. (2019). Faculty change agents as adult learners: The power of situated learning. *Community College Journal of Research and Practice*, *43*(8), 539–555. doi:10.1080/10668926.2018.1507848

Foote, K. E. (2010). Creating a community of support for graduate students and early career academics. *Journal of Geography in Higher Education*, *34*(1), 7–19. doi:10.1080/03098260902954087

Freeman, S., Eddy, S. L., McDonough, M., Smith, M. K., Okoroafor, N., Jordt, H., & Wenderoth, M. P. (2014). Active learning increases student performance in science, engineering, and mathematics. *Proceedings of the National Academy of Sciences*, *111*(23), 8410–8415. doi:10.1073/pnas.1319030111

Gallian, J. A., Higgins, A., Hudelson, M., Jacobsen, J., Lefcourt, T., & Stevens, T. C. (2000). Project NExT. *Notices of the American Mathematical Society*, *47*(2), 218–220.

Hake, R. (1998). Interactive-engagement vs. traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses. *American Journal of Physics*, *66*, 64–74.

Henderson, C. (2008). Promoting instructional change in new faculty: An evaluation of the physics and astronomy new faculty workshop. *American Journal of Physics*, *76*(2), 179–187. doi:10.1119/1.2820393

Henderson, C. (2013). Evaluation of the physics and astronomy new faculty workshops. In *The Role of Scientific Societies in STEM Faculty Workshops: A Report of the May 3, 2012 Meeting of the Council of Scientific Society Presidents* (pp. 79–82). College Park, MD: American Association of Physics Teachers. https://www.aapt.org/Conferences/newfaculty/upload/STEM_REPORT-2.pdf.

Higgins, A. (2013). Project NExT: A Program of the Mathematical Association of America. In *The Role of Scientific Societies in STEM Faculty Workshops: A Report of the May 3, 2012 Meeting of the Council of Scientific Society Presidents* (pp. 56–62). College Park, MD: American Association of Physics Teachers. https://www.aapt.org/Conferences/newfaculty/upload/STEM_REPORT-2.pdf.

Hilborn, R. C. (2013). Meeting overview. In *The Role of Scientific Societies in STEM Faculty Workshops: A Report of the May 3, 2012 Meeting of the Council of Scientific Society Presidents* (pp. 4–17). College Park, MD: American Association of Physics Teachers. https://www.aapt.org/Conferences/newfaculty/upload/STEM_REPORT-2.pdf.

Hilborn, R. C. (2017). *Physics and Astronomy New Faculty Workshops: 20 years of workshops and 2000 faculty*. American Physical Society Abstracts for March Meeting 2017, abstract id. H53.001. http://meetings.aps.org/link/BAPS.2017.MAR.H53.1

Hill, L. B., Savoy, J. N., Austin, A. E., & Bantawa, B. (2019). The impact of multi-institutional STEM reform networks on member institutions: A case study of CIRTL. *Innovative Higher Education*, *44*(3), 187–202. doi:10.1007/s10755-019-9461-7

Holmes, M. A., O'Connell, S., Frey, C., & Ongley, L. (2008). Gender imbalance in US geoscience. *Nature Geoscience*, *1*(2), 79–82. https://www.nature.com/articles/ngeo113. doi:10.1038/ngeo113

Kezar, A., Gehrke, S., & Bernstein-Sierra, S. (2018). Communities of transformation: Creating changes to deeply entrenched issues. *The Journal of Higher Education*, *89*(6), 832–864. doi:10.1080/00221546.2018.1441108

Krane, K. S. (2013). Workshops for New Faculty in Physics and Astronomy. In *The Role of Scientific Societies in STEM Faculty Workshops: A Report of the May 3, 2012 Meeting of the Council of Scientific Society Presidents* (pp. 70–77). College Park, MD: American Association of Physics Teachers. https://www.aapt.org/Conferences/newfaculty/upload/STEM_REPORT-2.pdf.

Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge, UK: Cambridge University Press.

Leckie, R. M., & St. John, K. (2019). Your tenure package. Retreived from https://serc.carleton.edu/NAGTWorkshops/earlycareer/tenure/package.html.

Loucks-Horsley, S., Stiles, K.E., Mundry, S., Love, N., & Hewson, P. W. (2009). *Professional development for teachers of science and mathematics*. Thousand Oaks, CA: Corwin Press.

Macdonald, R. H., Beane, R. J., Allen-King, R. M., Iverson, E. R., Manduca, C. A., Mogk, D. W., … , Yuretich, R. F. (2013). *On the Cutting Edge* workshops and web resources for early career geoscience faculty. In *The Role of Scientific Societies in STEM Faculty Workshops: A Report of the May 3, 2012 Meeting of the Council of Scientific Society Presidents* (p. 46–55). College Park, MD: American Association of Physics Teachers.

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. doi:10.5408/1089-9995-53.3.237

MacPhee, D., & Canetto, S. S. (2015). Women in academic atmospheric sciences. *Bulletin of the American Meteorological Society*, *96*, 59–67. https://doi.org/10.1175/BAMS-D-12-00215.1

Manduca, C. A., Iverson, E. R., Luxenberg, M., Macdonald, R. H., McConnell, D. A., Mogk, D. M., & Tewksbury, B. J. (2017). Improving undergraduate STEM education: The efficacy of discipline-based professional development. *Science Advances*, *3*(2), e1600193. doi:10.1126/sciadv.1600193

Manduca, C. A., Mogk, D. W., Tewksbury, B., Macdonald, R. H., Fox, S. P., Iverson, E. R., … Bruckner, M. (2010). SPORE: Science prize for online resources in education: On the Cutting Edge: Teaching help for geoscience faculty. *Science*, *327*(5969), 1095–1096. doi:10.1126/science.1183028

Manduca, C.A. (2017). Surveying the landscape of professional development research: Suggestions for new perspectives in design and research. *Journal of Geoscience Education*, *65*(4), 416–422. doi:10.5408/17-281.1

McConnell, D. A., Chapman, L., Czajka, C. D., Jones, J. P., Ryker, K. D., & Wiggen, J. (2017). Instructional utility and learning efficacy of common active learning strategies. *Journal of Geoscience Education*, *65*(4), 604–625. doi:10.5408/17-249.1

McDonald, J., & Star, C. (2006). *Designing the future of learning through a community of practice of teachers of first year courses at an Australian university*. Paper presented at the Proceedings of The First International LAMS Conference 2006: Designing the Future of Learning, Sydney, Australia.

National Research Council. (2000). *How* people learn*: Brain,* mind, experience, and school*: Expanded edition*. Washington, DC: The National Academies Press. doi:10.17226/9853

National Research Council. (2012). *Discipline-based education research: Understanding and improving learning in undergraduate science and engineering*. Washington, DC: The National Academies Press.

Ormand, C., Macdonald, H., & Manduca, C. (2006). Managing your career: New "On the Cutting Edge" resources for graduate students, post-doctoral fellows, and early career faculty. *Geological Society of America Abstracts with Programs*, *38*(7), 141.

Owens, M. T., Trujillo, G., Seidel, S. B., Harrison, C. D., Farrar, K. M., Benton, H. P., … Tanner, K. D. (2018). Collectively improving our teaching: Attempting biology department-wide professional development in scientific teaching. *CBE-Life Science Education*, *18*(1), ar2.

Pintrich, P., & Zusho, A. (2007). Student motivation and self-regulated learning in the college classroom. In R. P. Perry & J. C. Smart (Eds.), *The scholarship of teaching and learning in higher education: An evidence-based perspective* (pp. 731–810). Dordrecht: Springer.

Porter, L., Lee, C., Simon, B., & Guzdial, M. (2017). Preparing tomorrow's faculty to address challenges in teaching computer science. *Communications of the ACM*, *60*(5), 25–27. doi:10.1145/3068791

President's Council of Advisors on Science and Technology. (2012). *Engage to excel: Producing one million additional college graduates with degrees in science, technology, engineering, and mathematics*. Washington, DC: Executive Office of the President.

Prince, M. (2004). Does active learning work? A review of the research. *Journal of Engineering Education*, *93*(3), 223–231. doi:10.1002/j.2168-9830.2004.tb00809.x

Putnam, R. T., & Borko, H. (2000). What do new views of knowledge and thinking have to say about research on teacher learning? *Educational Researcher*, *29*(1), 4–109. doi:10.3102/0013189X029001004

Remmik, M., Karm, M., Haamer, A., & Lepp, L. (2011). Early-career academics' learning in academic communities. *International Journal for Academic Development*, *16*(3), 187–199. doi:10.1080/1360144X.2011.596702

Richlin, L., & Essington, A. (2004). Overview of faculty learning communities. *New Directions for Teaching and Learning*, *97*, 25–39. doi:10.1002/tl.130

Schön, D. A. (1983). *The reflective practitioner: How professionals think in action*. New York, NY: Basic Books, Inc.

Solem, M. N., Foote, K. E., & Monk, J. J. (2009). *Aspiring academics*. Upper Saddle River, NJ: Prentice-Hall.

St. John, K., & Leckie, R. M. (2019). Preparing yourself for the tenure process. Retrieved from https://serc.carleton.edu/NAGTWorkshops/earlycareer/tenure/preparing.html.

Stains, M., Pilarz, M., & Chakraverty, D. (2015). Short and long-term impacts of the Cottrell Scholars Collaborative New Faculty Workshop. *Journal of Chemical Education*, *92*(9), 1466–1476. doi:10.1021/acs.jchemed.5b00324

Stark, A. M., & Smith, G. A. (2016). Communities of practice as agents of future faculty development. *New Forums Press*, *30*(2), 59–67.

Viskupic, K., Ryker, K., Teasdale, R., Manduca, C. A., Iverson, E., Farthing, D., … McFadden, R. (2019). Classroom observations indicate the positive impacts of discipline-based professional development. *Journal for STEM Education Research*, *2*(2), 201–228. doi:. doi:10.1007/s41979-019-00015-w

Waterman, R., & Feig, A. L. (2017). The Cottrell Scholars Collaborative New Faculty Workshop: Early lessons for change in teaching. In R. Waterman & A. Feig (Eds.) Educational and Outreach Projects from the Cottrell Scholars Collaborative Professional Development and Outreach Volume 2, ACS Symposium Series 1259 (pp. 23–34). Washington, DC: American Chemical Society.

Webster-Wright, A. (2009). Reframing professional development through understanding authentic professional learning. *Review of Educational Research*, *79*(2), 702–739. doi:10.3102/0034654308330970

Wenger, E., McDermott, R., & Snyder, W. (2002). *Cultivating communities of practice: A guide to managing knowledge*. Cambridge, MA: Harvard Business School Press.

Wenger-Trayner, E., & Wenger-Trayner, B. (2015). Introduction to communities of practice: A brief overview of the concept and its uses. Retrieved from https://wenger-trayner.com/introduction-to-communities-of-practice/.

Wiggins, G., & McTighe, J. (1998). Backward Design. In *Understanding by design* (pp. 13–34). Alexandria, VA: Association for Supervision and Curriculum Development.

Wilson, C. E. (2019). Percentage of female faculty working within geoscience research fields. American Geosciences Institute Data Brief 2019-001. Retrieved from https://www.americangeosciences.org/geoscience-currents/percentage-female-faculty-working-within-geoscience-research-fields.

Zellers, D. F., Howard, V. M., & Barcic, M. A. (2008). Faculty mentoring programs: Reenvisioning rather than reinventing the wheel. *Review of Educational Research*, *78*(3), 552–588. doi:10.3102/0034654308320966