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The Science Teaching Fellows Program: A Model for Online Faculty Development of Early Career Scientists Interested in Teaching †

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The American Society for Microbiology (ASM) has a history of providing a wide range of faculty development opportunities. Recently, ASM developed the Science Teaching Fellows Program (STF) for early career biologists and postdoctoral students to explore student-centered teaching and develop the skills needed to succeed in positions that have a significant teaching component. Participants were selected to STF through a competitive application process. The STF program consisted of a series of six webinars. In preparation for each webinar, participants completed a pre-webinar assignment. After each webinar, fellows practiced what they learned by completing a post-webinar assignment. In a survey used to assess the impact of STF, participants reported greater knowledge of the webinar-based instructional topics and a sense of being part of an educational community and were more confident about varied teaching methods.

INTRODUCTION

In recent years, higher education has become more outcome-based. Faculty teaching classes are expected to know what their students should be learning and be able to identify evidence that students are successful learners. However, many faculty are trained as scientific experts but are not experts in classroom assessment techniques, identifying measures that demonstrate students' mastery of knowledge, or education research. The 2012 national report by the President's Council of Advisors on Science and Technology, *Engage to Excel* (5), states one million science, technology, engineering, and mathematics (STEM) workers will be needed to meet the nation's demand for STEM jobs. In addition, the report also mentioned the need to "catalyze widespread adoption of empirically validated teaching practices including the establishment of discipline-focused programs funded by disciplinary societies to train current and future faculty in evidence-based teaching practices."

The American Society for Microbiology (ASM) has been actively engaged in meeting the demands for the development of future educators in the microbial sciences as well as other life sciences. One of the recent initiatives has been the Science Teaching Fellows (STF) Program. The overall goal of the STF Program is to explore student-centered teaching and develop the skills needed to succeed in positions that have a significant teaching component.

BACKGROUND

The STF Program began in 2012 through support from the Burroughs Wellcome Fund. STF is a five-month program aimed at preparing postdoctoral students and early career biologists for science teaching positions. Interested program participants completed an online application that was reviewed by the STF committee. The STF committee represented faculty from different institutional types, and the committee members served as STF facilitators. The committee members evaluated the applications using a scoring rubric (see Appendix 1). Four committee members reviewed each application and scores were averaged. Applications with average scores of six to nine were accepted. For those applicants who obtained a score of five, the following criteria were taken into consideration: 1) academic achievement of the candidate in the microbial and related sciences; 2) the fact that individuals were curious about or pursuing a science teaching career; 3) limited access to resources and mentors with information about undergraduate science teaching positions; and 4) whether applicants were positioned to immediately use the skills presented in the program. Once accepted, Fellows participated in a series of six webinars on topics such as metacognition, course design, developing learning outcomes, assessment methods, active learning approaches, and writing a teaching philosophy statement.

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Prior to each webinar, Fellows were required to complete an assignment to prepare them for the webinar's content. During the one-hour Adobe Connect webinar, Fellows were given practical examples of classroom approaches, invited to participate in polling questions, and asked to respond to open-ended questions. Webinars included two to three opportunities for questions to be answered. Following each webinar, any questions that were not answered during the webinar were gathered, and answers were sent to the Fellows as a frequently asked questions (FAQs) document. Also, immediately following each webinar, an optional one-hour online learning lab was conducted. The learning labs were led by STF committee members who were STF Program alumni; Fellows were able to practice items described in the webinar, such as writing learning outcomes, and were able to interact with one another as well as with the webinar facilitators in a more informal way. The learning labs were a way to build community and allow Fellows to network with the facilitators, ASM staff, and one another. The last component of each of the webinars was a mandatory post-webinar assignment that was an extension of the ideas of the webinar.

STF program assessment

At the completion of the 2015–2016 program, Fellows completed a summative evaluation survey. The survey focused on assessing the following:

- gains as a result of STF participation
- pre- and post-activity knowledge about topics included in STF Program
- actions as a result of STF participation

RESULTS

STF program participant data

From 2012 to 2016, four cohorts have participated in the STF Program. Over this time period, a total of 425 applicants were reviewed. Of these, 278 Fellows were accepted to the program, an acceptance rate of 65.41%. The Fellows represented early graduate students, advanced graduate students, temporary placed faculty (adjuncts or visiting professors), early postdoctoral scientists, and early career, non-tenured faculty. Most of the applicants were advanced graduate students, followed by early postdoctoral students. Of the Fellows accepted to the program, 85.25% successfully completed it. Table 1A displays a breakdown of STF cohorts, including total number of applicants, applicant type, and number who completed the program. Table 1B displays the number of applicants by type, accepted Fellows, and graduates for all cohorts of the program.

Summative survey results

Summative survey results are reported here for the 2015–2016 cohort. The first portion of the summative survey asked Fellows to report how much they gained in 14 different areas as a result of their participation in the STF Program (Table 2). For all areas, the majority of respondents self-reported their gains as either large or very large. The largest gains were reported on confidence to develop active learning instruction for small classes (82.35%) followed by ability to write questions that align with learning goals (71.43%) and ability to write learning goals that measure higher-order thinking (74.29%). The lowest level of confidence was reported in the Fellows' confidence to design feasible projects for undergraduates (16 out of 35 respondents; 45.71%).

The summative survey also included questions that required Fellows to report their agreement with a series of statements, on a Likert scale of one to seven, before and after their participation in the STF Program (Table 3). The difference between the "before" Likert score and the "now" Likert score represents the gain. Results were statistically compared using a Mann-Whitney U Test (significance level 0.05, two-tailed). The greatest change (1.97) was reported in the use of backward design to develop course learning modules. Notable changes were also reported by Fellows in their alignment of test questions with course or learning goals (1.77) and use of active learning teaching approaches (1.74) after the STF program. These gains were statically significant ($p = 0.05$). Gains were not statistically significant for Fellows' interest in conducting research with undergraduates (0.87), and the lowest gains were observed in Fellows' interest in a teaching career at a non-doctoral institution (0.74).

Beyond examining familiarity with the specific topics covered during the webinars and in the assignments, Fellows were also asked to report on their career goals as well as their sense of belonging and being part of an educational community (Table 4). A majority of the Fellows (67.65%) either strongly agreed or very strongly agreed that they would like to continue to learn about course design and effective pedagogy for undergraduate science education. In addition, a majority of the Fellows either agreed or strongly agreed that they felt more confident about identifying and evaluating resources to improve teaching (55.82%), applying for positions in undergraduate science education (55.88%), and drawing from the expertise of others (55.88%).

Fellows reported large gains or very large gains in confidence in the following areas (Table 5): talking to others about teaching approaches (70.59%); talking to others about their needs to become a better teacher (67.65%); and talking to others about career goals to pursue undergraduate science education (64.71%).

DISCUSSION AND FUTURE DIRECTIONS

The overall goal of the STF Program was for Fellows to explore student-centered teaching and develop the skills needed to succeed in positions that have a significant teaching component. The content of the webinars was selected based on the experiences of undergraduate educators as

TABLE 1A.
Breakdown of Fellows.

	Applicants	Accepted	Graduated
2012–2013 Cohort			
Early graduate student	2	0	0
Advanced graduate student	30	16	16
Temporary placed faculty	7	5	5
Early postdoctoral scientist	18	15	15
Advanced postdoctoral scientist	16	10	9
Early career, non-tenured faculty	13	9	9
Other	1	1	1
Total	87	56	55
2013–2014 Cohort			
Early graduate student	4	0	0
Advanced graduate student	29	19	19
Temporary placed faculty	8	6	6
Early postdoctoral scientist	19	15	15
Advanced postdoctoral scientist	14	7	7
Early career, non-tenured faculty	13	6	6
Other	0	0	0
Total	87	53	53
2014–2015 Cohort			
Early graduate student	6	5	5
Advanced graduate student	42	28	28
Temporary placed faculty	9	4	3
Early postdoctoral scientist	35	23	4
Advanced postdoctoral scientist	33	26	23
Early career, non-tenured faculty	14	11	11
Other	0	0	0
Total	139	97	74
2015–2016 Cohort			
Early graduate student	8	5	3
Advanced graduate student	37	23	23
Temporary placed faculty	12	8	2
Early postdoctoral scientist	24	15	15
Advanced postdoctoral scientist	22	16	6
Early career, non-tenured faculty	9	5	6
Other	0	0	0
Total	112	72	55

TABLE 1B.
Compiled numbers for all cohorts (2012–2016).

	Applied	Accepted	Graduated
Early graduate student	20	10	8
Advanced graduate student	138	86	86
Temporary placed faculty	36	23	16
Early postdoctoral scientist	96	68	49
Advanced postdoctoral scientist	85	59	45
Early career, non-tenured faculty	49	31	32
Other	1	1	1
Total	425	278	237

TABLE 2.
Gains in content areas as a result of participation in STF[a].

How much did you *gain* in each of the following areas as a result of your participation in the ASM STF Program?		
Statement	**Average Score (out of 7)**	**Number of Respondents Who Agreed or Strongly Agreed/Total Number of Respondents[b] (%)**
Ability to align my desire to balance teaching, research, and service with a potential position	4.91	16/35 (45.71)
Ability to align my personal goals with the mission, purpose, and student body of a potential employer	5.25	18/35 (51.43)
Confidence to use backwards design to develop a lesson or course	5.71	24/35 (68.57)
Confidence to use the ASM Curriculum Guidelines to develop a lesson or course	4.88	18/35 (51.43)
Ability to identify characteristics of effective learning	5.74	26/35 (74.29)
Confidence to develop active learning instruction for small classes	5.91	28/34 (82.35)
Confidence to develop active learning instruction for large classes	5.40	19/35 (54.29)
Ability to write learning goals that measure lower-order thinking (e.g., recall and recite)	5.54	23/35 (65.71)
Ability to write learning goals that measure higher-order thinking (e.g., analyze and evaluate)	5.77	26/35 (74.29)
Ability to use feedback (e.g., formative assessments) to inform my instructional practices and conceptual understanding as it relates to student learning	5.54	24/35 (68.57)
Ability to write questions that align with learning goals	5.80	25/35 (71.43)
Ability to assess student learning	5.48	25/35 (71.43)
Confidence to design feasible projects for undergraduates	4.80	15/35 (42.86)
Ability to identify steps to apply my research to projects for undergraduates	4.77	16/35 (45.71)

[a] Data for 2015–2016 cohort only.
[b] Some fellows did not answer all survey questions.
ASM = American Society for Microbiology; STF = science teaching fellows.

TABLE 3.
Pre-post survey results[a].

Indicate your level of agreement with each of the following statements before your STF participation and now.			
Statement	**Average Score (out of 7)**	**Number of Respondents Who Agreed or Strongly Agreed/Total Number of Respondents[b] (%)**	**Gain (Average Before - Average After)**
I apply backward design methods to develop new learning modules or courses-BEFORE	3.00	3/35 (8.57)	**1.97**
I regularly experiment with backward design to develop new learning modules or courses-NOW	4.97	14/35 (40.00)	
I often use active learning teaching approaches-BEFORE	3.74	5/35 (14.29)	**1.74**
I regularly experiment with active learning teaching approaches-NOW	5.48	22/35 (62.86)	
I align my test questions with the learning or course goals-BEFORE	3.63	3/35 (8.57)	**1.77**
I regularly consider aligning my test questions with the learning or course goals-NOW	5.40	19/35 (54.29)	
I am interested in doing research with undergraduate students-BEFORE	4.56	12/34 (34.29)	0.87
I am interested in doing research with undergraduate students-NOW	5.43	21/35 (60.00)	
I am interested in a teaching career at a non-doctoral institution-BEFORE	4.83	17/35 (48.57)	0.74
I am interested in a teaching career at a non-doctoral institution-NOW	5.57	26/35 (74.29)	

[a] Data for 2015–2016 cohort only.
[b] Some fellows did not answer all survey questions.
Numbers in bold represent statistically significant differences at $p = 0.05$.
STF = science teaching fellows.

TABLE 4.
STF experience[a].

Indicate your level of agreement with each of the following statements after your STF experience.		
Statement	**Average Score (out of 7)**	**Number of Respondents Who Agreed or Strongly Agreed/ Total Number of Respondents (%)**
I am more clear about my career goal to pursue undergraduate science education	5.23	14/34 (41.18)
I am more confident about applying for employment opportunities in undergraduate science education	5.52	19/34 (55.88)
I am more confident about applying for professional opportunities (e.g., travel grants, fellowships) in undergraduate science education	5.06	13/34 (38.24)
I wish to continue learning about course design and effective pedagogy for undergraduate science education	5.62	23/34 (67.65)
I am more confident about asking for help and drawing upon others' expertise	5.50	19/34 (55.88)
I am more confident about identifying and evaluating resources to improve teaching	5.70	20/34 (58.82)
I feel part of a community of teachers and educators	5.20	18/34 (52.94)
I have ideas about teaching to share with peers	5.03	17/34 (50.00)

[a] Data for 2015–2016 cohort only.
STF = science teaching fellows.

TABLE 5.
Gains in confidence as a result of STF participation[a].

How much did you gain in each of the following areas as a result of your participation in the STF program?		
Statement	**Average Score (out of 7)**	**Number of Respondents Who Agreed or Strongly Agreed/Total Number of Respondents (%)**
Confidence to succeed in the discipline that I am teaching	5.18	18/34 (52.94)
A sense of belonging in the academic culture	5.00	19/34 (55.88)
My expectations for my own academic success	5.23	17/34 (50.00)
Seeing myself as a faculty member working with undergraduates	5.26	19/34 (55.88)
Confidence in talking with others about my teaching approaches	5.56	24/34 (70.59)
Confidence in talking with others about my career goals to pursue undergraduate science education	5.59	22/34 (64.71)
Confidence in talking with others about my needs to become a better teacher	5.73	23/34 (67.65)

[a] Data for 2015–2016 cohort only.
STF = science teaching fellows.

well as the current body of knowledge about education research. Several studies have shown that active learning (3, 6) and high-impact practices (4) enhance student learning when incorporated into undergraduate STEM classes. STF provided Fellows, who represent scientists who are fairly new to teaching, the opportunity to explore pedagogies of engagement, learn how to successfully implement these pedagogies, as well as gather evidence about teaching approaches in order to determine their effectiveness.

Prospective new faculty face a number of challenges. The culture of science education for many graduate students and postdoctoral scientists reflects that of research institutions where the greatest emphasis is on the acquisition of grant funding and research productivity. New scientists receive excellent scientific training at research universities. However, they are not generally made aware of other potential career options, such as a position that only involves teaching, a combination of teaching and a research program involving primarily undergraduates, or a science education researcher. These trends stimulated ASM to include webinar content that directly addresses these instructional issues. Many STF Fellows were unaware of these options and that more institutions are now offering positions for education research specialists within science departments. Bush *et al.* (2) report that the hiring of faculty with expertise in science education will facilitate change in the way STEM classes are taught so that faculty can learn how to include more evidence-based teaching practices that are known to foster student learning.

Expanding the number of STEM majors and accurately measuring what students are learning in STEM will require multiple faculty development efforts. These efforts need to focus on instructors who are currently teaching in STEM classrooms as well future STEM educators. Currently, many faculty are still relying on delivering content in a traditional lecture format (1), and many students report they are leaving science majors at four-year institutions as a result of classes that are not engaging and a lack of student-faculty interactions in these classes (7). The STF program creates a pool of new faculty who take a scientific and scholarly approach to teaching and connects these faculty into a working network of practitioners with the potential to positively affect many STEM students.

Based on the results presented, more work needs to be done in the area of getting Fellows to think about teaching careers at non-doctoral institutions and conducting research with undergraduates. Undergraduate research and teaching at non-doctoral institutions were not webinar topics and were discussed tangentially with the Fellows during the introductions of the webinar presenters. Possibly a more formal presentation on these topics could stimulate interest in these two important areas of science education. In addition, providing Fellows with information about opportunities, such as the Council for Undergraduate Research, might make the significance of such work more apparent. In addition to presenting these supplementary webinar topics, the STF program is looking to increase the number of Fellows participating in and completing the program and to provide workshops about applying for faculty positions and career fair information. Also, with the expansion of distance education and technology in the classroom, information about these topics would benefit prospective new faculty.

Comparable to ASM's Biology Scholars Program, STF is building a network of trained educators who can continue to reform and explore the best teaching practices in STEM in order to improve student learning and retention in these disciplines. Many Fellows have stated that, based on their undergraduate experiences, they had no idea there were ways to teach content other than lecture. The STF Program organizers believe the program's experiences, particularly in the area of effective teaching practices, will make candidates better prospects in the job market.

STF has connected cohorts of new educators who can network with one another and meet ASM members who are experienced educators. These cohorts were able to share their ideas and talk about teaching, effective practices, as well as teaching career options in a "safe space." Since several STF alumni volunteer to participate as mentors to new Fellows, future leaders are emerging who can participate in STF and other ASM education programs, as well as add to the body of knowledge about student learning in STEM by conducting education research.

SUPPLEMENTAL MATERIALS

Appendix 1: STF applicant scoring rubric

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