

Origins of Science Faculty with Education Specialties: Hiring Motivations and Prior Connections Explain Institutional Differences in the SFES Phenomenon

SETH D. BUSH, MICHAEL T. STEVENS, KIMBERLY D. TANNER, AND KATHY S. WILLIAMS

Situated in university science departments as potential science-education change agents, science faculty with education specialties (SFES) reported differences in the origin of their positions depending on the nature of their institution. For instance, SFES at PhD-granting institutions most commonly reported being hired to relieve other faculty from teaching and service burdens. At MS-granting institutions, SFES reported being hired primarily to prepare future K–12 science teachers. At primarily undergraduate institutions, SFES reported transitioning to these specialized roles after their initial hire. In our random, stratified sample of 50 interviewed SFES, all were tenured or tenure track, excepting 45% of SFES at PhD-granting institutions. Those non-tenure-track SFES were more likely to have prior institutional connections—as alumni of, through previous employment at, or with a spouse also employed at their institution—than were other SFES. These findings provide new insights into the evolving SFES phenomenon and clarify previously reported differences among SFES.

Keywords: science education, higher education, faculty career development, undergraduate teaching, science workforce

Attention to improving science education at the college and university level is widespread and growing in the United States (NAS et al. 2007, NSB 2007, Singer et al. 2012) and across the globe (OECD 2007, Hénard 2010). One approach to improving science education has been the inclusion of education specialists within the faculty of science, technology, engineering, and mathematics (STEM) departments. Known as *science faculty with education specialties* (SFES; Bush et al. 2006, 2008), these education specialists advance science education by affecting undergraduate science education, influencing K–12 science education, and/or conducting discipline-based research in science education (Sunal et al. 2001, Walczyk et al. 2007, Bush et al. 2008, 2011, 2016). Although all SFES focus on science education, there is a great deal of variety in the goals, structure, and even tenure status of individual SFES positions.

Previous research on SFES has shown that they most commonly perceive that SFES in general are hired to help with the preparation of future science teachers, to fulfill a particular teaching role, or to participate in course or curriculum

development and reform (Bush et al. 2015). Surprisingly, those reasons for hiring did not align well with SFES perceptions of their own potential and actual contributions (Bush et al. 2015). However, those prior results emerged from brief online responses to survey questions offered to SFES who were asked about SFES hiring in general and not about their perceptions of the origins of their own positions. Given the continued and increasing interest in hiring SFES (Bush et al. 2008, Addy et al. 2015) and the impacts they can have on multiple science-education arenas (Bush et al. 2008, 2011, 2016), more research is needed to investigate the origins of individual SFES positions.

To more deeply investigate the SFES phenomenon across the United States, we conducted an interview study of SFES who occupied positions at PhD-granting institutions, MS-granting institutions, and primarily undergraduate institutions (PUIs), who had acknowledged their willingness to be interviewed via a national online survey, and who had self-identified as SFES (Bush et al. 2013, 2015). In the interview study, we probed a random, stratified sample of SFES

about many aspects of their professional efforts, including their perception of their professional impacts on science education, their identity as SFES, their training in science education, and their job satisfaction. For this current study, we took the opportunity to examine how SFES perceived the origins of their current positions. The interview questions were specifically designed to promote in-depth responses about SFES perceptions of the origins of their own positions, allowing us to determine whether results from the previous SFES survey (Bush et al. 2015) were supported and to possibly uncover unanticipated findings about SFES origins. In addition, investigations into the perceived origins of SFES positions could yield insights into why nearly one-third of SFES previously reported intentions to leave their current position (Bush et al. 2013).

We were particularly interested in exploring how SFES perceptions of their position origins might differ at different institution types (i.e., PhD-granting institutions, MS-granting institutions, and PUIs). Although SFES across institution types have reported having similar impacts on undergraduate science education (Bush et al. 2016), one might hypothesize that SFES at PUIs and MS-granting institutions would be more likely to report that their SFES positions were created on the basis of the desire to improve undergraduate science education, whereas SFES at more research-focused PhD-granting institutions might report jobs created to promote discipline-based science-education research.

These SFES interviews provided complex insights into SFES perceptions about the origins of their positions, and in this article, we present findings that relate specifically to SFES perceptions about the origins of their particular position. Although future studies are needed to triangulate these findings, SFES perceptions about the origins of their positions provide previously undiscovered insights about how SFES differ across institution types and across different tenure-status positions. Throughout this report, we will use the term *origins* as an umbrella term that includes both (a) SFES perceptions about the motivations for the hiring of their position and (b) any prior connections that an individual SFES had to their employing institution.

An interview study of science faculty with education specialties

We used an interview-based approach to explore the professional experiences of SFES across the United States, and we have reported previously on the roles and perceived impacts of SFES (Bush et al. 2016). Our interviews produced rich and broad descriptions of the professional experiences of 50 individual SFES, and here, we present evidence and new insights on the perceived origins of these positions, including SFES perceptions of hiring motivations and prior institutional connections, among SFES working at PhD-granting, MS-granting, and primarily undergraduate institutions.

Sample. Our interview sample of 50 individuals was selected from a population of 166 SFES who had previously completed an online survey and indicated their willingness to participate in future research involving interviews (Bush et al. 2013). Those 50 individuals were selected using a stratified random sampling method to represent (a) membership across institution types (PhD-granting, MS-granting, or primarily undergraduate institutions) and disciplinary fields (biology, chemistry, geoscience, and physics) and (b) strong considerations of leaving their current position (i.e., staying or leaving). These criteria were selected because earlier studies had shown differences in the SFES phenomenon across institution types (Bush et al. 2013) and because substantial numbers of SFES across the United States reported that they were seriously considering leaving their current positions (Bush et al. 2008, 2011). This study was approved by Utah Valley University's Institutional Review Board (IRB). The subjects provided written informed consent prior to participation following a procedure approved by the aforementioned IRB.

Data collection. The subjects each completed a 60-minute, semistructured telephone interview between July and September 2013. Interviews were audio-recorded, conducted by two interviewers (with one taking a more active questioner role), and fully transcribed using pseudonyms to replace actual names. In reporting quotations, institution names were redacted to protect the identities of our participants. The interviews of SFES included an informational preamble followed by seven main questions centered on (1) the description of their current position and how they obtained it, (2) perceptions of their identity as an SFES, (3) the motivations for the creation of their current position, (4) their perceptions of their professional impact and influence, (5) the effectiveness of their training, (6) their job satisfaction, and (7) their viewpoints regarding the SFES phenomenon in general.

Data analyses. The transcripts were analyzed using a grounded-theory approach to detect emergent themes across the SFES interviewed and through a constant comparative method (Merriam 1998, Bryant and Charmaz 2007, Stake 2010, Trainor 2013). At least two researchers examined all of the interview responses, independently determined emergent themes, and then discussed coding schemes together. Through iterative discussion and language revisions, common themes were identified. Once independent coding of all the evidence by multiple researchers resulted in high levels of agreement, the categories were finalized.

The results from the interviews are reported primarily as emergent themes and quotations represented in figures and tables. Sample quotations from the SFES have been edited to remove identifying information, and pseudonyms are used, excepting in those situations in which anonymity across quotations could be compromised. Descriptive statistics are used to compare the responses of SFES from different

I. Undergraduate Science Ed.	
A	Teach lower division and large enrollment courses
B	Teach upper division courses
C	Facilitate course reform or curriculum development
D	Coordinate lab courses, teaching assistants, or other course support
II. K-12 Science Education	
E	Prepare future K-12 science teachers
III. Research in Science Ed.	
F	Conduct educational research or obtain grant money
IV. Cross Science Ed. Arenas	
G	Broaden departmental expertise
H	Respond to administrator desires related to education
I	Respond to departmental faculty desires related to education
V. Not Related to Sci. Ed. Arena	
J	Replace retiring or departing faculty member
K	Transitioned, not hired, into this role
L	Relieve other faculty from teaching and service burdens
M	Need only limited resources, such as space and start-up funds
N	Emerged from an individual's prior connection(s) to the institution
O	Other

Figure 1. Hiring motivation categories. Categories are labeled A-O and clustered into groups aligned with the three arenas of science education (A-I) or related to issues beyond the three arenas (J-O).

institution types or with different tenure statuses. Finally, although these semistructured interviews of a randomized, stratified SFES sample produced rich, varied, and detailed findings, we urge readers to recognize that the data reported here reflect SFES perceptions of their own professional positions.

Science-faculty-with-education-specialties perspectives on the origins of their positions

Although evidence suggests that science departments have been increasingly hiring SFES over the last decade (Bush et al. 2011, 2013), SFES have not been systematically queried regarding their perspectives on the origins of their positions. Why are SFES positions being created? First, we present reported motivations for hiring SFES disaggregated by institution type and by tenure-track status. Next, we explore the SFES hiring pathway, examining the role of prior institutional connections, again disaggregated by institution type and by tenure-track status. Finally, we examine origin patterns, with respect to both hiring motivations and prior connections, across individual SFES. Consistent with Bush and colleagues (2016), we found no disciplinary differences among SFES in our sample.

Hiring motivations. Our interview protocol systematically probed the perceived motivations behind hiring the SFES in our pool. Through systematic coding of the interview transcripts, 15 categories emerged that characterized the reported motivations for hiring SFES across institution types (figure 1; interrater reliability more than 99%). Some SFES reported multiple motivations, which were each coded into a category. Nine of these categories, A–I, align well with the three arenas of science education: undergraduate science education, K–12 science education, and research in science education. The remaining six categories, J–O, including an “other,” relate to issues beyond the three arenas.

The top hiring-motivation categories that reflect 25% or more of the respondents for PhD SFES, MS SFES, and PUI SFES are highlighted in figure 2. A set of sample quotations for each top category reported by the SFES from each institution type is included in tables 1–3. Two of the top three reported categories for the PhD SFES, *Relieve other faculty from teaching and service burdens* (L) and *Teach lower division and large enrollment courses* (A), were unique to the PhD SFES. Phil, a tenure-track PhD SFES, expressed both of these motivations for his hiring: “[I was hired] because nobody in our department wanted to be saddled with this massive course... So, they knew they needed to get a new faculty member to take it over ... and then take it on as a primary responsibility as a teaching load, every semester, forever.”

Similarly, the top-reported category for the MS SFES, *Prepare future K–12 science teachers* (E), and the top category for the PUI SFES, *Transitioned, not hired, into this role* (K), were unique top categories for the MS and PUI SFES, respectively. Betty, a tenure-track MS SFES, described the

PhD (n=20)	MS (n=15)	PUI (n=15)
L Relieve other faculty from teaching and service burdens (50%)	E Prepare future K-12 science teachers (60%)	K Transitioned, not hired, into this role (53%)
A Teach lower division and large enrollment courses (45%)	F Conduct educational research or obtain grant money (40%)	B Teach upper division courses (47%)
H Respond to administrator desires related to education (45%)	B Teach upper division courses (33%)	C Facilitate course reform or curriculum development (40%)
C Facilitate course reform or curriculum development (40%)	H Respond to administrator desires related to education (33%)	J Replace retiring or departing faculty member (27%)
F Conduct educational research or obtain grant money (40%)	G Broaden departmental expertise (27%)	
D Coordinate lab courses, teaching assistants, other course support (35%)	I Respond to departmental faculty desires related to education (27%)	
G Broaden departmental expertise (35%)		
I Respond to departmental faculty desires related to education (25%)		
J Replace retiring or departing faculty member (25%)		
N Emerged from an individual's prior connection(s) to the institution (25%)		

Non-Tenure-Track PhD (n=9)	Tenure-Track PhD (n=11)
D Coordinate lab courses, teaching assistants, other course support (78%)	H Respond to administrator desires related to education (82%)
L Relieve other faculty from teaching and service burdens (78%)	C Facilitate course reform or curriculum development (55%)
A Teach lower division and large enrollment courses (44%)	F Conduct educational research or obtain grant money (55%)
N Emerged from an individual's prior connection(s) to the institution (44%)	A Teach lower division and large enrollment courses (45%)
G Broaden departmental expertise (33%)	G Broaden departmental expertise (36%)
	J Replace retiring or departing faculty member (36%)
	I Respond to departmental faculty desires related to education (27%)
	L Relieve other faculty from teaching and service burdens (27%)

Figure 2. Top hiring motivations categories disaggregated by institution type and by tenure-track status. Values represent the percentages (25% or more) of SFES from a given institution type and tenure-track status who reported each hiring motivation. Shading is used to highlight categories that were reported at 25% or above in only one institution type.

motivations for her hire as the following: “they started the biology education degree program in the biology department, rather than the education [department], because they felt that teacher preparation program should focus more on the science.” And Thedora, a tenure-track PUI SFES, described the motivations for her hire as the following: “I started out doing really lab bench kind of research and sort of halfway along my trajectory, I really started to become much more interested in questions around teaching and learning than I was about molecules on surfaces.”

The top motivational categories for the PhD SFES were further disaggregated by tenure-track status. The top two categories for the non-tenure-track SFES, *Coordinate lab courses, teaching assistants, or other course support (D)* and

Relieve other faculty from teaching and service burdens (L) were reported by more than three-fourths of the non-tenure-track SFES and were unique to this group. As an example, Teresa, a non-tenure-track PhD SFES, described these motivations driving her hire: “It was created so there would be some way of having somebody in charge of the labs because the position was created before I took it... So, the job involves coordinating the teachers, designing the materials, and teaching three or four of the labs per semester.”

In contrast, the top category for the tenure-track PhD SFES, *Respond to administrator desires related to education (H)*, was reported by more than 80% of the tenure-track PhD SFES and was also a top category for the MS SFES. Lee, a tenure-track PhD SFES, described the motivations for her

Table 1. Hiring motivations mentioned by 25% or more of SFES employed at PhD-granting institutions (n=20).

Category	Sample Quotes	%
Relieve other faculty from teaching and service burdens L	<p>“They needed to do something to try to address the administrative tasks that were some of the burdens on the faculty for because the university did not value that in promotion and tenure.” – Emmett TT PhD</p> <p>“So, the class that I usually teach for students who have no other (science) background, I think I teach that because no one else wants to. No one else has got an interest in that class; no one else is lining up to teach it. So, as long as that class is offered here, it’s going to be available for me to teach... And, I think that’s why I have my job. By doing things no one else wanted to do...” – Tuan, TT PhD</p>	50
Teach lower division and large enrollment courses A	<p>“So, the science departments want to hire an education specialist, a discipline-based education research person, but, really what they wanted was somebody who will come in and teach one of the level 600-seat classes.” – Willa, nTT PhD</p> <p>“I think they would say that they needed someone to look after the chemistry majors, someone who had an interest in teaching the large courses, because often times these positions end up teaching your large general chemistry or preparatory chemistry courses, and you need someone who is willing to do that and who is good at doing that.” – Nugent, TT PhD</p>	45
Respond to administrator desires related to education H	<p>“The position was created by a dean, and the dean essentially said, <i>you’ll take this position or you won’t have a position</i>. And so the faculty against it hesitantly agreed to open the position.” – Francine, TT PhD</p> <p>“There was a provost who felt this was an important thing and was willing to put some money into this so that departments wouldn’t have to take on the full burden of hiring these positions themselves. The challenge is...if you say, <i>we have a position, who should we hire?</i> nobody who is not already in some kind of discipline-based education research (DBER) position is ever going to say, <i>Oh, let’s hire a DBER person...</i> So, without somebody saying, <i>we’ll give you quite a lot of money on this side if you put in a little bit on your side</i>, I don’t think the program would have taken off the way it did.” – Duggler, TT PhD</p>	45
Facilitate course reform or curriculum development C	<p>“This position opened up because the semester before I was hired, the students took out a half-page ad in the local student newspaper warning people not to take the course.” – Dina, nTT PhD</p> <p>“They had this search that was primarily oriented toward getting someone who would completely revamp introductory biology...” – Teresa, nTT PhD</p>	40
Conduct educational research or obtain grant money F	<p>“I was hired to do Physics Education Research.” – Francine TT PhD</p> <p>“And, so if they’re going to be spending a tenure-track position on it, then it needs to be someone who is, in all honesty, generating indirect costs.” – Phil, TT PhD</p>	40
Coordinate laboratory courses, teaching assistants, or other course support D	<p>“I oversee the lab, and I think to a certain extent my position was created because the tenure-track faculty were looking to minimize their involvement in the labs.” – Tuan, nTT PhD</p> <p>“It was pretty clear that they were having some issues with tenure-track faculty not having enough time and problems cropping up because of (them) not having enough time to do the course coordination.” – Emmett, nTT PhD</p>	35
Broaden departmental expertise G	<p>“...at that point, they were applying to create a PhD in chemical education. And, so it was really important to replace the first person...my line was created to support that program...” – Colton, TT PhD</p> <p>“The former chair of the department thought that they should have someone in the area of Chemistry Education. I think he was very forward thinking.” Nugent, TT PhD</p>	35
Respond to departmental faculty desires related to education I	<p>“Well, I would say that the prime mover was a distinguished professor... He’s a bulldog. He gets his teeth into something, and he won’t let go, and he shakes and shakes and shakes until people fall into line.” – Willie, nTT PhD</p> <p>“they [the faculty] had a problem, and they wanted it fixed. Okay. And, their problem was that the students were incredibly dissatisfied with the course the way it had been taught. Okay? And, they – they wanted to fix it, basically.” – Dina nTT PhD</p>	25
Replace retiring or departing faculty member J	<p>“The education research group was losing one tenure-track faculty to a different university. So, they would be really short on people who can service GTAs and grants and be advisors to graduate students. They did not have the political status within the university...to renew the tenure track position.” – Paul, nTT PhD</p> <p>“I think the first position was a replacement for one of the researchers who wasn’t tenured. But at that point, they were applying to create a (graduate program in discipline-based education research). And so it was really important to replace the first person, but then my line was created to support that program.” – Colton, TT PhD</p>	25
Emerged from an individual’s prior connection(s) to the institution N	<p>“Well...they knew me. They knew what I could do. They called me when the position opened up, okay? And, you know, it was sort of a tailor-made position.” – Dina, nTT PhD</p> <p>“My position was created for multiple reasons. One is that I wanted to stay here, and (the people here) wanted me to stay here and not take a tenure-track position elsewhere. But they didn’t have the political status at the university to argue for a tenure-track position, and so this was a compromise.” – Paul, nTT PhD</p>	25

Table 2. Hiring motivations mentioned by 25% or more of SFES employed at MS-granting institutions (n=15).

Category	Sample Quotes	%
Prepare future K-12 science teachers E	"They needed someone to teach the methods course. In short, that's what it was." – Betty, MS	60
	"It's historical precedent. So, our university was started as a teaching college back in the late 1800's, and so there has always been a strong education component. For as far back as I know, this model had been the way it went. There were a few people from each department who were the science education specialists." – Wilma, MS	
Conduct educational research or obtain grant money F	"I don't think most people outside of science education research know what it is that they may be asking, and probably their stereotype was that a physics education person could come up with better techniques for a lab or a better way to present something." – Carter, MS	40
	"...with some of the things that had come out of NSF, in terms of really saying there's a need for better (science) education...I think that was part of their motivation." – Rita, MS	
Teach upper division courses B	"Positions in our department are almost exclusively determined by teaching need. So when I was hired, there was a real need for someone to contribute to undergraduate offerings in marine biology and graduate offerings in biological oceanography." – Terrance, MS	33
Respond to administrator desires related to education H	"(An SFES position) was offered at the provost and the president's level. Physics took them up on it, and chemistry and biology did not." – Roger, MS	33
	"The dean of the college and the chair of the natural sciences department (were) the people that were pushing the degree. So, that was basically where it went. They just wanted to see more focus on the biology coursework." – Betty, MS	
Broaden departmental expertise G	"Their motivation was that they wanted to expand chemistry education as a disciplinary area in the department, to create that as niche area, to have more impact, as a growing area in chemistry and a place where they could have more identity in the field." – Rita, MS	27
	"...they thought an education-focused person could help both with their teaching and then possibly help form an identity that we didn't have previously. So, I think that's how my position came about." – C.K., MS	
Respond to departmental faculty desires related to education I	"Our department goes through a very thoughtful assessment and planning cycle...we look at what are our key initiatives, what are our strengths, what are our weaknesses, and the department collectively decided that one of our strengths was the ability to do a scholarship of teaching and learning. That then informed the hiring committee as one of the areas we are interested in (hiring), because it was one of our main initiatives." – Pete, MS	27
	"My impression (was) that they had a tenure line that they needed to hire, and they were having a heated argument about what kind of person to (hire) for that position. It sounded like (one person) was arguing very strongly that we needed somebody with a physics education research focus because our undergraduate program was suffering..." – Tara, MS	

hire as the following: "I think they saw a need within our college, within our department, of restructuring the learning that was taking place in the classroom. The 'they' would be the administration: deans, associate deans, vice presidents... I think they saw a lot of opportunity in education. I will not deny that they see a lot of dollar signs with financial grant money there."

Prior institutional connections. Many (42%) of the SFES in this study reported that they had previous connections to their current employing institution prior to being hired. Through systematic coding of the interview transcripts (interrater reliability more than 99%), three categories emerged that described prior institutional connections that the SFES in our study had to their employing institution. These categories were being *Alumni (X)* of, having a *Previous job, different in kind (Y)*, and/or having a *Spouse or partner (Z)* who is or was also employed at their institution (figure 3). Some SFES reported multiple prior connections, which were each coded into a category. Each prior connection category is disaggregated by institution type and then by tenure-track status in figure 3. A comprehensive set of sample quotations for each category is included in table 4. Overall, a greater

proportion of the PhD SFES (65%) had prior connections to their employing institution than either the MS SFES (20%) or the PUI SFES (33%). By looking at the PhD SFES group disaggregated by tenure-track status, one can see that this trend appears to be driven by the non-tenure-track PhD SFES. Nearly all (89%) of the non-tenure-track SFES held previous positions at their institutions that were different in kind from their current positions, and two-thirds of the non-tenure-track PhD SFES were alumni of their employing institution. In comparison, just over one-third of the tenure-track PhD SFES (36%) held previous positions at their employing institution, and no other groups—that is, the tenure-track PhD SFES, MS SFES, or PUI SFES—reported that they were alumni of their employing institution. These prior institutional connections of SFES, which had not appeared in data from previous survey studies, emerged during interviews when the SFES described the perceived origins of their positions.

Patterns across individual science faculty with education specialties. When one examines hiring motivations and prior connections for individual SFES (figure 4), telling patterns emerge with respect to institution type, tenure-track

Table 3. Hiring motivations mentioned by 25% or more of SFES employed at primarily undergraduate institutions (n=15).

Category	Sample Quotes	%
Transitioned, not hired, into this role	"I don't think it was a position that was created as much as it was a position that I kind of carved out for myself." – Patty, PUI	53
	K "I think that it was largely evolutionary, rather than created. I transitioned my interest, and many people do evolve their research interest, their scholarly activity. I was finding that I could do some novel things... When I started to do this, I was extremely supported, and I was getting to be creative on a number of avenues." – Quentin, PUI	
Teach upper division courses	"...they just needed someone to teach certain courses. The person who was teaching analytical chemistry was going to be on leave, and they needed somebody else." – Thedora, PUI	47
	B "(I was hired) as a biologist and as a person who could cover both genetics and molecular biology and have a lot of knowledge about those things." –Annie, PUI	
Facilitate course reform or curriculum development	"I think the department as a whole recognized a need to develop their courses in a particular way that they did not have the expertise to do, and so they deliberately sought out that expertise." – Ron, PUI	40
	C "The whole department is really deeply, deeply invested and interested in how to teach well and how to use the results of research to help them teach well...but they needed to know how to do that in their upper-level classes. So, they searched for a physics education research person to do lots and lots of things... But among them were faculty development to help them learn how to teach upper-level classes in a research-based way, in a research inspired way, reform their upper-level classes, investigate the coherence of their four-year curriculum, and make both within-course adjustments and four-year structural adjustments." – Allison, PUI	
Replace retiring or departing faculty member	"There was a person who was teaching analytical chemistry who was going to be on leave. And they needed somebody else (to teach)." – Thedora, PUI	27
	J "My specific position was created (long ago), and I think it's because, back then, the person that had my position before me did teach the elementary science methods class." – Cerra, PUI	

status, and staying or leaving status. Some orientation to this complex figure will help elucidate these patterns. In figure 4, each rectangle represents an individual SFES, with individual SFES grouped by institution type (top to bottom) and tenure-track status (left to right). The black dots toward the top of each rectangle are used to indicate the number of different hiring motivations reported by each individual. The gray dots near the center of each rectangle indicate the number of prior connections reported by each individual. Those marked *nTT* are individuals who reported occupying a non-tenure-track position at their institution, whereas all others reported that they were in tenure-track positions. The shading of each rectangle differentiates the SFES who were strongly considering leaving their positions (gray) from those who were not strongly considering leaving their positions (white). As an example, the top, left-most individual was an SFES at a PhD-granting institution who was in a tenure-track position and was not strongly considering leaving their position. This particular individual reported five or more different hiring motivations for their position and reported one prior connection to their institution.

In this graphical depiction, one clearly sees the striking institutional differences between reported prior connections. Prior connections are generally concentrated among the PhD SFES and in the non-tenure-track PhD SFES, in particular. Not only do almost all the non-tenure-track PhD SFES have prior connections to their hiring institution, but the majority also had multiple prior connections. In contrast, only one other individual (a PUI SFES strongly considering leaving) had multiple prior connections to their hiring institution. In this graphical depiction, it is

also clear that most of the SFES report multiple motivations for their hire. However, the PhD SFES tended to report more hiring motivations than their MS SFES or PUI SFES peers, with most of the PhD SFES reporting four or more different hiring motivations and most of the MS SFES and PUI SFES reporting three or fewer. It is noteworthy that there are no apparent patterns in these origins data specific to the SFES who expressed desires to leave their positions.

Conclusions

In the current study, we investigated SFES perceptions about the origins of their current faculty positions, including motivations for their hire and their prior institutional connections. Findings from interviews with a sample of 50 SFES revealed that the motivations for hiring SFES were different among SFES at different institution types, with the greatest divergence of reported hiring motivations among SFES at PhD-granting institutions. In addition, striking differences emerged in the motivations for hiring tenure-track versus non-tenure-track SFES, who were only represented at PhD-granting institutions. These data also revealed that non-tenure-track SFES were more likely to have prior connections to their current institution—as an alumnus, employee, or spouse—compared with tenure-track SFES. Taken together, these findings provide new insights into previously reported differences among SFES at different institution types with respect to their time spent on teaching, the tenure status of their positions, and the extent of their formal training in science education (Bush et al. 2013). Below, we consider these new findings about the perceived origins of

PhD (n=20)	MS (n=15)	PUI (n=15)
Y Previous job, different in kind (60%)	Z Spouse or partner (13%)	Y Previous job, different in kind (27%)
X Alumni (30%)	Y Previous job, different in kind (7%)	Z Spouse or partner (13%)
Z Spouse or partner (25%)		

Non-Tenure-Track PhD (n=9)	Tenure-Track PhD (n=11)
Y Previous job, different in kind (89%)	Y Previous job, different in kind (36%)
X Alumni (67%)	Z Spouse or partner (9%)
Z Spouse or partner (33%)	

Figure 3. Prior connection categories (Alumni; Previous job, different in kind; Spouse or partner) disaggregated by institution type and by tenure-track status. Values represent the percentages of SFES from a given institution type and tenure-track status who reported each prior connection.

SFES positions in the context of previous research reports about the SFES phenomenon generally and SFES differences across institution types more specifically.

Reconsidering apparent misalignments between perceived motivations for hiring science faculty with education specialties and their professional activities. Previous research on the SFES phenomenon has suggested that there may be misalignments between likely motivations for hiring SFES and their potential efforts and impacts (Bush et al. 2015). These misalignments have been hypothesized to be one potential driver of 30.4% of SFES in the United States considering leaving their current positions (Bush et al. 2013). The initial description of these potential misalignments between why SFES were hired and their professional efforts emerged from written responses collected as part of a large national survey of SFES. However, in that study, SFES were probed about the SFES phenomenon generally, not necessarily their own particular situation, and as a result, those data were not analyzed for differences among SFES at different institution types. Examination of the in-depth interview data from the present study suggests that those previously described misalignments between hiring motivations and professional activities may be explained partly by differences among SFES at different institution types. For example, the most prevalent reasons for hiring SFES offered in the previous study were to prepare future science teachers or to fulfill a particular teaching role in the department (Bush et al. 2015). In the present analyses, these two hiring motivations were the most prevalent ones reported by SFES at MS-granting and SFES at PhD-granting institutions, respectively. However, each motivation was predominantly reported by SFES from that

particular institution type and not by others. In addition, SFES at PUIs most often reported in the present interview study that they were not really hired but rather transitioned into an SFES role, which supports previous findings (Bush et al. 2013). Although the professional activities of SFES were not reported here, previous research has shown that these, too, are different among SFES at different institutions types (Bush et al. 2013). As such, attending to the institution type of a particular SFES may resolve some of the apparent misalignments between why SFES are generally being hired and what they may accomplish; however, there are no doubt examples of misalignment for individual SFES within a given institutional context. For example, assuming their role would be in educational research and later understanding that motivation for their hire was to prepare future teachers may play a role in considerations of SFES leaving their current position. Given that the motivations for hiring and the reported professional activities of SFES are consistently different depending on institution type, it may be most appropriate to consider SFES as a collection of different types of faculty positions in the service of science-education efforts rather than as a singular type of position.

The differences in time spent on research and teaching among PhD science faculty with education specialties may be driven by perceptions of origins. Another finding from previous research on the US SFES phenomenon was that SFES employed at PhD-granting institutions perceived that they spent more time on teaching and less time on research than do their non-SFES peers (Bush et al. 2013). But why might this be the case, given that PhD-granting institutions have at the core of their missions faculty research? Deeper explorations of SFES

Table 4. Prior institutional connections reported by SFES employed at PhD-granting, MS-granting, and primarily undergraduate institutions. Pseudonyms are redacted to protect anonymity.

Category	Sample Quotes	%
PhD SFES (n=20)		
Previous job, different in kind Y	<p>"I got an opportunity to do some additional TA'ing while I was a graduate student, and then this opportunity came up to be the ... lab manager and I was able to negotiate with the chair that I would have a teaching responsibility associated with that,"</p> <p>"they asked if I would come in ... and teach for a semester and I worked things out to do that, still maintaining kind of my post-doctoral position I was in ... And, one thing led to another, to another, and I remained temporary ... for quite some time before going into the tenure track position. ..."</p> <p>"I started as non-tenure track faculty ... they officially called it "Visiting Scientist," who was a combination post doc and teaching ... and then this was changed to the [course] coordinator position"</p>	60
Alumni X	<p>"I started full time ... Before that, I was hired as an adjunct and also as a TA, as a graduate teaching assistant."</p> <p>"As a graduate student, I had rewritten one of the lab manuals that was used in the – in the general intro course. ... they knew me, they knew what I could do. They called me when the position opened up"</p>	30
Spouse or partner Z	<p>"So I finished my PhD here. And, I was married to somebody who works here, too. So it was more – this – this was where I was likely to stay."</p> <p>"... my wife got a permanent tenure track position in another department, so I was doing a post-doc in the chemistry department for a couple of years and then got the teaching position after that."</p>	25
MS SFES (n=15)		
Spouse or partner Z	<p>"...my wife and I are both academics. ... we left and when we left, we were looking around, the classic two-body problem. We received a couple of offers to go to different places.... So we came to here."</p> <p>"so my current position is senior lecturer in the department. It is not tenure track. ... We moved here two years ago ... – because, my husband applied for and got a tenure track position, here ... So, my position specifically was created because they wanted to hire my [spouse]."</p>	33
Previous job, different in kind Y	<p>"So, one thing led to another and I started in that temporary position while I was still in graduate school and a couple years later, they opened a tenure track position that – in ... education that more or less was specifically – they had specifically me in mind when they opened that."</p>	27
PUI SFES (n=15)		
Previous job, different in kind Y	<p>"So after my post doc, I was hired at my institution on a one-year appointment, followed by another one-year appointment, followed by a tenure track position. And, I've moved from Assistant to Associate, to Full Professor..."</p> <p>"I originally came as a lecturer. ... I actually applied for a tenure track position ... in [another department] ... and they said, "we'd like you to consider this other position," ... "we want you to do your research in [discipline]. We just have this education stuff that's kind of on the side that somebody needs to deal with. And, you'd be great for it." ... And, so they brought me here as a lecturer the first year, and then after the first year - I started as a two-year lecturer position. But after the first year, they converted it over into an Assistant Professor."</p>	27
Spouse or partner Z	<p>"My [spouse] has a tenure track position here. I have a stuck captive spouse."</p> <p>"... My [spouse's] on the faculty here. ... I was working at a ... company, ... I started looking for a faculty position. I looked in a number of different places. It just ended up that this position opened up here."</p>	13

work situations in the current interview study provided insights into why this institution-specific finding might be the case. Among the PhD SFES in our sample, the most prevalent category for hiring motivations was to *Relieve other faculty from teaching and service burdens*. As such, greater teaching responsibilities at the expense of time available for research could stem from the initial reason some of these SFES were hired. This finding is further corroborated by the next two most prevalent reported hiring motivations for the PhD SFES in our study, which were to *Teach lower-division and large-enrollment courses* and *Respond to administrator desires related to education*. Lower-division and large-enrollment courses can take additional time for grading, office hours, student emails, and course logistics

and as a result can be viewed as particularly burdensome by some faculty members. As such, it appears that some PhD-granting institutions may be hiring SFES as specialized science instructors who espouse and potentially have skills in student-centered pedagogies, as was explored in previous research (Addy et al. 2015).

Differences in tenure status may be explained by the perceived origins of science-faculty-with-education-specialties positions. In the United States, previous national survey data have shown that SFES employed at PhD-granting institutions were less likely to occupy tenure-track positions than SFES employed at MS-granting institutions and PUIs (Bush et al. 2013). Similarly, in our interview sample, only 55% of the PhD

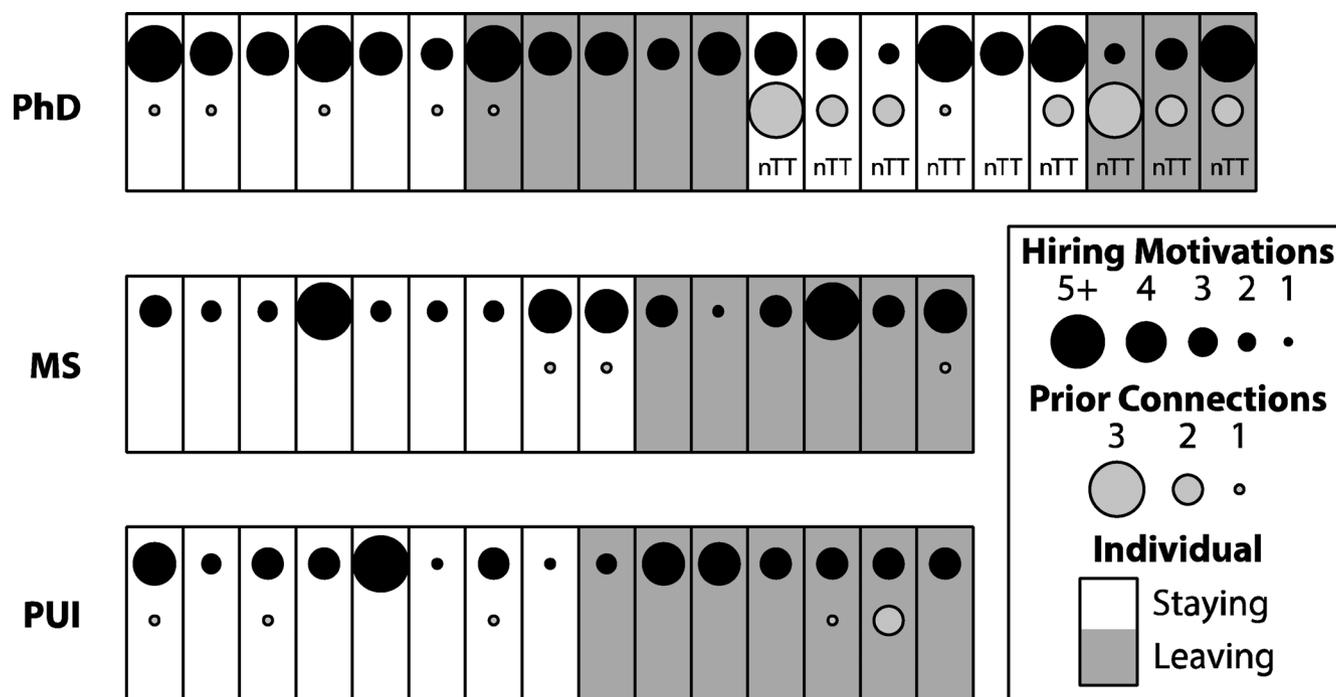


Figure 4. Visual summary of individual SFES representing hiring motivations, prior institutional connections, considerations of staying or leaving current position, and tenure-track status (nTT = non-tenure-track).

SFES were tenure track, whereas 100% of the MS SFES and the PUI SFES were tenure track. Tenure status can clearly affect a faculty member's ability to influence their department and discipline (NEA 1996), and the overall percentage of faculty with tenure has been described as being generally similar across institution types (NCES 2015). However, a different pattern has emerged for SFES. So what might be driving the differences in SFES tenure status at different institution types? The present interview study results clarify why this might be the case. Specifically, differences in tenure status may emerge as a result of the different perceived origins of SFES positions across the three institution types. In particular, the PhD SFES were more likely to have prior connections to their employing institution than were the MS SFES or the PUI SFES. The prior connections that we discovered included being an alumnus or alumna of the institution, holding a previous position at the institution, or having a spouse or partner employed at the institution. In some cases, the SFES position may not have been traditionally advertised. The interviewees described situations in which "one thing led to another, to another, to another..." and resulted in some cases in tenure-track and in other cases in non-tenure-track positions. In terms of hiring motivations, our current interview data also highlight that the tenure-track and non-tenure-track PhD SFES were hired for very different reasons. The tenure-track PhD SFES reported most commonly being hired in response to administrator desires related to improving education, facilitating course reform, and/or obtaining grant money to conduct education research, whereas the non-tenure-track PhD SFES most

commonly reported being hired to coordinate laboratory courses, to supervise teaching assistants, or to relieve other faculty from teaching and service responsibilities. In total, these data are consistent with the hypothesis that some non-tenure-track SFES at PhD-granting institutions are being hired into positions that may have been crafted for them specifically.

Differences in formal training in science education may be driven by differences in perceived position origins. Whether SFES arrive in their faculty positions with formal science-education training has been a subject of persistent interest and perplexing evidence. Although the vast majority of the participants in a national survey study of SFES reported formal training in basic science, only a minority reported formal training in science education (Bush et al. 2013). Intriguingly, SFES working at MS-granting institutions were previously shown to be statistically more likely to have formal science-education training compared with their SFES counterparts at PhD-granting institutions and PUIs (Bush et al. 2103). So what could be driving the differential training profiles among SFES at different institution types? One hypothesis previously offered was that MS-granting institutions may be constructing SFES positions to be typical tenure-track science faculty positions and explicitly envisioning SFES as providing expertise in an area of specialization (education) analogous to specialization in other areas (e.g., ecology or organic chemistry). The present interview data support this hypothesis, because the SFES at MS-granting institutions reported dramatically different hiring motivations from

those of the SFES at other institution types. In addition, these new data suggest an alternative hypothesis about lower rates of formal science education training among PhD SFES and PUI SFES. Because high proportions of the PhD SFES reported prior connections to their current institutions, with most apparently being directly hired into their current SFES position from a previous role, these individuals simply may not have had an opportunity to acquire training prior to transitioning to an SFES role from within their current institutions. Similarly, over half of the PUI SFES in the present study could not report on motivations for their hiring, because they transitioned into the SFES role as an existing departmental faculty member. This finding is consistent with the PUI SFES in the national survey being more likely to have transitioned into their role, as opposed to being hired into their role (Bush et al. 2008, 2013). Perhaps PUI science faculty generally view science-education activities, as have been defined for SFES, as integral to their occupation, so little distinction exists between SFES and non-SFES at PUIs. In summary, these new findings on the perceived origins of SFES positions—motivations for hiring and prior institutional connections—may explain the previously perplexing differences in formal science-education training among SFES across MS-granting versus PhD-granting and primarily undergraduate institutions. As such, the lack of formal training among SFES at PhD-granting institutions and PUIs may have resulted from transitioning directly into an SFES role with no time for pursuing formal training opportunities.

Evidence supports a role for administrators in driving the hiring of science faculty with education specialties. These in-depth interviews with SFES about the perceived origins of their positions revealed that input from administrators, including deans and chairs, is typically key in driving the hiring of SFES at PhD-granting and MS-granting institutions but not at PUIs. In both PhD-granting and MS-granting institutions, the SFES more commonly reported their hirings being motivated by administrators rather than by departmental faculty (figure 2, tables 1–3). Interestingly, when our interview findings were disaggregated by non-tenure-track and tenure-track PhD SFES, it became clear that the motivation stories for these hirings differed greatly. The non-tenure-track SFES were hired primarily to *Coordinate lab courses, teaching assistants, or other course support*, and neither administrator-driven nor faculty-driven hiring motivations were reported as prevalent reasons for hiring. In contrast, the tenure-track PhD SFES were hired primarily to *Respond to administrator desires related to education*. Administrators at PhD-granting institutions may be interested in tenure-track SFES as course reformers, curriculum developers, and education researchers, which were also reported by multiple tenure-track PhD SFES as hiring motivations for their positions. These data describing the role of administrators in motivating SFES hires is consistent with conceptualizing SFES as potential change agents who can foster educational change from

within science departments (Addy et al. 2015, Bush et al. 2016). Given the high proportions of non-tenure-track SFES with prior connections to their PhD-granting institutions, it may be that these individuals were hired under the assumption that they might have greater success in fostering change given their existing familiarity with the institution, its culture, and their science department colleagues.

Future directions. In conclusion, we have discovered that the motivations for hiring SFES appear to be different among SFES at different institution types, with particularly striking differences between motivations for hiring tenure-track versus non-tenure-track SFES. In addition, the non-tenure-track SFES were more likely to have prior connections to their current institution—as an alumnus, employee, or spouse—compared with the tenure-track SFES. Future studies should investigate whether the findings presented here for non-tenure-track SFES, who all happened to be from PhD-granting institutions, would be predictive for non-tenure-track SFES at MS-granting institutions and PUIs. In future research and discussions, it may be appropriate to consider SFES as a collection of different types of faculty positions focused on science education rather than a singular type of position, given that SFES positions differ in multiple ways depending on institution type. Furthermore, although the present study's findings offer in-depth perspectives from individual SFES about their situations, future investigations are needed to probe the perceptions of deans, chairs, and non-SFES colleagues about SFES position origins. Finally, the SFES phenomenon—initially described in 2006—is evolving rapidly. One wonders how the profile of SFES—their training, their professional activities, and the structure of their positions—is changing over time and at particular types of institutions.

Acknowledgments

We thank the 50 SFES who were willing to share their professional experiences through interviews with us, as well as James Rudd and Nancy Pelaez for their involvement in earlier research on SFES that set the stage for the current work. In addition, we thank our advisory board members (Mark Connolly, Erin Dolan, Noah Finkelstein, Barbara Gonzales, and Arlene Russell) and our families for their support. Funding was provided by the National Science Foundation's Division of Undergraduate Education grant no. (DUE)-1228657 and by the Scholarly Activities Committee of the College of Science and Health at Utah Valley University to MTS.

References cited

- Addy TM, Simmons P, Gardner GE, Albert J. 2015. A new “class” of undergraduate professors: Examining teaching beliefs and practices of science faculty with education specialties. *Journal of College Science Teaching*: 91–99.
- Bryant A, Charmaz K. 2007. Grounded theory in historical perspective: An epistemological account. Pages 31–57 in Bryant A, Charmaz K, eds. *The SAGE Handbook of Grounded Theory*. Sage.

- Bush SD, Pelaez NJ, Rudd JA, Stevens MT, Williams KS, Allen DE, Tanner KD. 2006. On hiring science faculty with education specialties for your science (not education) department. *CBE—Life Sciences Education* 5: 297–305.
- Bush SD, Pelaez NJ, Rudd JA, Stevens MT, Tanner KD, Williams KS. 2008. Science faculty with education specialties. *Science* 322: 1795–1796.
- . 2011. Investigation of science faculty with education specialties within the largest university system in the United States. *CBE—Life Sciences Education* 10: 25–42.
- . 2013. Widespread distribution and unexpected variation among science faculty with education specialties (SFES) across the United States. *Proceedings of the National Academies of Science* 110: 7170–7175.
- . 2015. Misalignments: Challenges in cultivating science faculty with education specialties in your department. *BioScience* 65: 81–89.
- Bush SD, Rudd JA II, Stevens MT, Tanner KD, Williams KS. 2016. Fostering change from within: Influencing teaching practices of departmental colleagues by science faculty with education specialties. *PLOS ONE* 11 (art. e0150914).
- Hénard F. 2010. Learning Our Lesson: Review of Quality Teaching in Higher Education. Organisation for Economic Co-operation and Development.
- Merriman SB. 1998. *Qualitative Research and Case Study Applications in Education*. Jossey-Bass.
- [NAS] National Academy of Sciences, National Academy of Engineering, and Institute of Medicine. 2007. *Rising above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future*. National Academies Press.
- [NCES] National Center for Education Statistics. 2015. Digest of Education Statistics for 2015. Table 315.50. Full-Time and Part-Time Faculty and Instructional Staff in Degree-Granting Postsecondary Institutions, by Level and Control of Institution and Selected Characteristics: Fall 1992, Fall 1998, and Fall 2003. NCES. (23 September 2016; www.nces.ed.gov/programs/digest/d15/tables/dt15_315.50.asp)
- [NEA] National Education Association. 1996. The Truth about Tenure in Higher Education. NEA. (23 September 2016; www.nea.org/home/33067.htm)
- [NSB] National Science Board. 2007. National Action Plan for Addressing the Critical Needs of the US Science Technology, Engineering, and Mathematics Education System. National Science Foundation.
- [OECD] Organisation for Economic Co-operation and Development. 2007. PISA 2006: Science Competencies for Tomorrow's World. OECD. Publication no. 39725224.
- Singer SR, Nielsen NR, Schweingruber HA. 2012. *Discipline-Based Education Research: Understanding and Improving Learning in Undergraduate Science and Engineering*. National Academies Press.
- Stake RE. 2010. *Qualitative Research: Studying How Things Work*. Guilford Press.
- Sunal DW, Hodges J, Sunal CS, Whitaker KW, Freeman LM, Edwards L, Johnston RA, Odell M. 2001. Teaching science in higher education: Faculty professional development and barriers to change. *School Science and Mathematics* 101: 246–257.
- Trainor AA. 2013. Interview research. Pages 125–138 in Trainor AA, Graue E, eds. *Reviewing Qualitative Research in the Social Sciences*. Routledge.
- Walczyk JJ, Ramsey LL, Zha P. 2007. Obstacles to instructional innovation according to college science and mathematics faculty. *Journal of Research in Science Teaching* 44: 85–106.

All authors contributed equally to the research and writing of this article and are listed alphabetically. Seth D. Bush is a professor of chemistry and biochemistry at California Polytechnic State University, San Luis Obispo. Michael T. Stevens (michael.stevens@uvu.edu) is an associate professor of biology at Utah Valley University, in Orem. Kimberly D. Tanner is a professor of biology at San Francisco State University, in California. Kathy S. Williams is a professor of biology at San Diego State University, in California.