Science Education Faculty Academy (SEFA): A Unique and Effective Learning Community for Professional Development

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Abstract

This study explored a learning community approach for professional development specifically catering to science education faculty. The Science Education Faculty Academy (SEFA) was a five-day experience with the objectives to help faculty collaborate, learn about new research relevant to teacher development, share effective teaching strategies, and network to build infrastructure to support science education faculty across the state. Data was gathered from 13 participants across the first two years of SEFA. Quantitative survey response data and qualitative data that included field notes, surveys, artifacts, and interviews were analyzed with regard to these objectives and to gain insight into participants perceptions about strengths of SEFA and areas for improvement. Likert scale questions measured participants' perceived understandings of key aspects of the professional development including inquiry, nature of science (NOS), problem-based learning (PBL), proficiency in incorporating research-based science instruction into their courses, ability to seek out funding, and ability to collaborate with colleagues. Paired sample t-tests indicated statistically significant gains across all measured constructs for participants' pre- and post-SEFA scores. Participants' perceived understandings of inquiry were significant one year following SEFA attendance, but perceived understandings of the other constructs were not. Qualitative data indicated SEFA was an important experience that affected participants' ability to be effective as science educators. Further, participants reported the ability to collaborate with colleagues was an especially valuable part of their experience. SEFA engaged participants as active learners, promoted collaboration, and aligned with broader state science education initiatives.

Keywords: science education faculty, professional development

Introduction

Science education faculty have an important role in teaching and mentoring new teachers into the teaching profession. Methods courses offer preservice teachers an opportunity to develop their skills integrating science content with research-based pedagogical strategies (Lederman, Gess-- Newsome & Latz, 1994) and implementing standards into their instruction. Important research-based pedagogical strategies for science teachers include inquiry, problem-based learning (PBL), the nature of science (NOS), and the appropriate integration of technology into instruction. If science education faculty are not aware of research-based teaching practices, this will have a negative impact on preservice teacher learning and ultimately PK-12 student learning. Thus professional development for science education faculty is of great importance.

University faculty are important to students' personal and academic success (Endo & Harpel, 1982; Komarraju, Musulkin & Bhattacharya, 2010). Even a high-quality close relationship with a single faculty member can have a great impact upon students' university life and future careers (Rosenthal, et. al., 2000). Faculty confront a variety of barriers that influence their teaching and interacting with students. Jacobs & Winslow (2004) indicate faculty take on a variety of roles and must be successful at teaching, developing courses, serving on committees and producing research. These multiple expectations and roles can be quite challenging for faculty to balance. Other difficulties faced by faculty include access to needed resources, not having enough time for all aspects of their job, promotion and tenure issues, and inadequate training (Sunal et al., 2001). Barriers to faculty collaboration in higher education also exist due to the nature of the tenure system. Bohen and Stiles (1998) point out that the tenure system rewards individual achievement, that many faculty have not had sufficient experience with collaboration, and that administrative structure in higher education does not adequately support collaborative work.

Professional development is needed to help faculty navigate these challenges, and helping university faculty in supporting students should be an important component of faculty professional development. Multiple approaches to faculty professional development in the past have included workshops, mentorship programs, peer coaching, or distribution of literature to attempt to aid faculty in their research and teaching responsibilities (Caffarella & Zinn, 1999; Huston & Weaver, 2007). However, most faculty professional development initiatives focus on only one aspect of their professional responsibilities, most often teaching (Young, 1987). Eleser and Chauvin (1998) surveyed more than a hundred faculty members across multiple departments in a university about their professional goals, and found that perceived professional needs included a desire to improve their teaching, but were not limited to it. Responses indicated a desire to maintain and broaden in-depth content knowledge of their field, increase productivity in research, and improve skills in research methods and techniques.

Despite professional development initiatives provided by universities, science education faculty, in particular, face some additional specific challenges in their positions in higher education institutions. Almost all higher education institutions expect new science education faculty to teach science methods classes and supervise preservice teachers in their field placements; however, not all new faculty have had this experience as part of their graduate programs. Thus, they find themselves unprepared for this aspect of their job (Jablon, 2002). Also complicating the issue, most new science education faculty generally find themselves in the isolated position as one of the only or even the sole science education faculty at their institution (Johnston & Settlage, 2008). This isolation makes it difficult for science education faculty to stay current with research in their field and makes collaborating with peers a significant challenge. In a review of the literature, Harwood (2004) describes the benefits of collaboration between science and education faculty within the same institution, but few studies have focused on professional development specifically emphasizing collaboration internally within the community of science education faculty. The only example of professional development related to collaboration catering specifically to science education faculty in the literature is a model called Vexation and Ventures developed by Johnston and Settlage (2008). The Vexation and Venture format requires participants to write and share with other participants an aspect of their work causing them difficulty and then offers an opportunity for colleagues to listen and discuss these difficulties in a group format in order to come up with actionable solutions.

Another approach that may help foster collaboration among science education faculty is using a professional development format of professional learning communities. Professional learning communities are a growing focus of research in recent years. These communities value members as a resource and rely on the members' knowledge and experience, often using a form of collaborative inquiry to facilitate discussions (Vescio, Ross & Adams, 2008). In a review of the literature, Stoll et al. (2006) characterizes a learning community as a group of people with shared vision who collaborate, possess collective responsibility, and engage in reflective professional inquiry. Further, Stoll and colleagues (2006) describes them as valuing both individual and group learning. A learning community format for science education faculty professional development that offers extended and meaningful contact with colleagues would be a logical choice for meeting their needs for staying current with pedagogical research and to foster collaboration with other science education faculty.

Science Education Faculty Academy (SEFA)

One such professional development program that focuses on supporting science education faculty is the Science Education Faculty Academy (SEFA). SEFA began in 2011 as an annual week-long professional development experience for science education faculty situated in the larger Virginia Initiative for Science Teacher Achievement (VISTA) statewide program. The VISTA program is funded as a 5-year Investing and Innovation (i3) validation grant by the U.S. Department of Education and also includes PD for elementary teachers, secondary science teachers, and science coordinators (Sterling & Frazier, 2010; Sterling, Matkins, Frazier, & Logerwell, 2007).

As recommended by Birman et al. (2000), the SEFA engaged participants in active learning around the content, which included hands-on activities and discussions about inquiry, PBL, NOS, effective discourse, and grant writing. The SEFA also intentionally aligned this content with the broader state-wide VISTA initiative and provided participants with consistent definitions of its constructs. There is no clear and consistently used definition of the term "inquiry instruction" in the science education literature leading to confusion when attempting to generalize or compare studies investigating this topic (Anderson, 2002). VISTA's operationalized definition of inquiry was specified as asking questions, collecting and analyzing data, and using evidence to solve problems (Bell & Maeng, 2012). Similar ambiguity exists with the term problem-based learning (Savin-Baden, 2000). Within VISTA, PBL is defined as students solving a problem with multiple solutions over time like a scientist in real-world context; both the context and the problem must be meaningful to students (Bell & Maeng, 2012). VISTA also places emphasis on the nature of science. There are many ways to describe the nature of science. Often it is presented in the form of key tenets deemed appropriate for K-12 teachers and students of science (Lederman, Abd-El-Khalick, Bell, & Schwartz, 2002). VISTA focused on the following key features of nature of science: 1) scientific knowledge is empirical, reliable and tentative, based on observation and inference; 2) scientific theories and laws are different kinds of knowledge; and 3) many methods are used by scientists to develop scientific knowledge. Without proper guidance, teachers do not often teach the nature of science, and when they do, such instruction is often implicit (Capps & Crawford, 2013). VISTA emphasizes that the nature of science must be taught by explicitly drawing students' attention to it, because students do not learn the nature of science when it taught implicitly (Abd-El-Khalick & Lederman, 2000).

Another aspect of SEFA is that it reserved blocks of time for faculty to collaborate, addressing the problem of isolation of faculty members within the science education community and helped foster a learning community among participants. The first opportunity used a model developed by Johnston & Settlage (2008) called Vexations and Ventures (V&V). During one SEFA session, participants shared their pre-prepared vexation with the group, their thoughts about potential solutions, and then listened to input from their peers. Another opportunity was provided on the last day of each SEFA experience to collaborate regarding future Virginia Association of Science Teachers (VAST) conferences and meetings at the Virginia Science

Education Leadership Association (VSELA). Finally, unstructured time in the evening was provided for participants to interact in a less formal way.

Theoretical Framework

This study examined the first two years of the SEFA through a social constructivist framework. Social constructivism views learning as co-constructed through participation with others in a social setting, but acknowledges that learning ultimately occurs within the individual (Duit & Treagust, 1998; Hodson & Hodson, 1998). Social constructivism also recognizes that individual learning is inextricably rooted in the meanings, dominant metaphors, and implicit understandings of one's social environment (Mitchell & Sackney, 2011). SEFA is a learning community comprised of science educators from across the state of Virginia and one of the primary research questions focused on the effectiveness of SEFA at promoting communication, networking and collaboration across the state. Also, the rich discussion format of the SEFA sessions focuses heavily on sharing and collaboration, both between implementers and participants, and among participants, which provided many opportunities for learning through social interactions.

Models for evaluating faculty PD programs are lacking in the literature; however, one area with extensive literature on the evaluation of effective PD is in-service K-12 teachers. Birman, Desimone, Porter, and Garet (2000) mention three key features for successful PD. These are a focus on content, active learning on the part of participants, and coherence. Coherence is defined as fostering continued collaboration or being aligned with desired goals. Expanding on these central features, Guskey (2000) mentions five domains in which PD programs may be analyzed for their effectiveness. These include:

1. Participants' reactions to and level of satisfaction with the PD
2. Participants' learning and demonstration of new knowledge or skills
3. Participants' implementation of new knowledge and skills
4. The eventual effect on student learning outcomes
5. The PD's effect on larger organizations in which the individual is situated.

These five domains encompass both the immediate and long-term effects at the level of the individual, but also take into account impacts at the institutional level. Guskey's model is compatible with a social constructivist framework, taking into account individual perceptions as well as one's social environment. It was therefore selected as a conceptual framework to gauge the effectiveness of SEFA.

Purpose

The present study addresses the need to explore professional development specifically designed to meet the needs of science education faculty. By critically examining SEFA, we provide insight into what constitutes successful PD for science education faculty. The following research questions guided the investigation:

1. How were participants' understandings of and confidence in implementing inquiry, PBL, and NOS instruction shaped by their participation in SEFA?
2. To what extent and in what ways did participants' experience with SEFA enhance their collaboration within the science education community?
3. To what extent and in what ways did SEFA have broader impacts across the state science education community?
4. What were participant-identified strengths and areas for improvement of SEFA following their experience?

Methods

Participants

Participants were recruited by the implementation team to take part in the SEFA professional development program. Across the two cohorts of the SEFA explored in the present investigation, 13 science educators participated; 8 in cohort 1 and 9 in cohort 2. Of the 9 cohort 2 participants, four attended in year 1. Therefore, there were 5 new participants in cohort 2. Participants can attend SEFA a maximum of two times. The purpose of allowing participants to attend multiple years of SEFA was to allow for continuity across cohorts and to strengthen the professional learning community of science educators across the state. Demographic data (gender, ethnicity and position) was self-reported by participants and can be found in Table 1. Pseudonyms are used throughout this paper to protect participant identities.

Table 1. *SEFA Participant Demographic Data*

Year	Total	Gender		Position					Ethnicity		
		Female	Male	Assistant Professor Education	Associate or Professor, Education	Assistant Professor, Science Area	Associate or Professor, Science Area	Other (Adjunct, Education and Continuing Studies)	Caucasian	African American	Asian American
1	8	4 (50%)	4 (50%)	2 (25%)	2 (25%)	1 (12.5%)	1 (12.5%)	2 (25%)	6 (75%)	2 (25%)	0 (0%)
2	5[1]	5 (100%)	0 (100%)	3 (60%)	1 (20%)	0 (0%)	1 (20%)	0 (0%)	2 (40%)	2 (40%)	1 (20%)

Note: [1]Participants are only included for the first year in which they participated.

Context

The SEFA is a faculty professional development experience with the primary purpose to build state-wide infrastructure to support effective science teaching and learning through a professional learning community model. The 5-day (27 contact hours) SEFA was implemented by a team of 5 facilitators at a mid-Atlantic university in late May. These facilitators were experts in science education and worked collaboratively to develop SEFA. Participants engaged in presentations, activities, and discussions related to the following SEFA objectives (McDonnough, Sterling, Matkins, & Frazier, 2012):

1. Collaborate to identify challenges and develop solutions in science teacher education at the licensure level and within institutions of higher education,
2. Learn about new research related to effective science teacher development and science teaching,
3. Share effective teaching strategies for how to best meet the needs of elementary and secondary science teachers at the licensure and advanced levels through collaborative grant proposals, as well as collaborative syllabi and experiences for implementation in methods courses and teacher professional development seminars, and
4. Network to establish an infrastructure of support among science education faculty across the state (Virginia Science Education Professors - VSEP) that augments and supports existing infrastructure for science teachers and coordinators in the state.

Additionally, participants submitted an initial reflection (vexation/venture) on problem-based learning (PBL) prior to SEFA. These served as the foundation for discussions on Day 3 of SEFA.

Each day began with an overview of the topics and concluded with an exit slip designed to help the participant identify what they learned, how they could apply it in their own setting, and to provide the implementation team with feedback. Integrated throughout each day were opportunities for collaboration and discussion. The SEFA professional development focused on PBL, NOS, inquiry, grant writing, and collaboration. Table 2 provides an overview of the topics and activities each day and the corresponding objectives.

Table 2. *Overview of the SEFA and Relevant Objectives (in parentheses)*

Day 1	Day 2	Day 3	Day 4	Day 5
Constructing a professional learning community through problem-solving (4)	Exploring NOS (2, 3)	Continuous Improvement (Vexation/Venture) (1)	Grant-writing and Funding (3)	Planning for VAST and VSELA (4)
PBL as a vehicle for inquiry (2, 3)	PBL in methods courses - syllabi sharing (1, 2, 3)	Collaborative planning (4)	Creativity and Reflection (3)	
	PBL scenario development – question mapping (3)	Syllabi sharing – general (1, 3)		
	Effective discourse (3)			

Data Collection

Data consisted of pre-/post-/delayed-post surveys, follow-up interviews of a subset of participants, researcher field notes, and artifacts from SEFA. Participants completed the pre- and post-SEFA surveys on the first and last days of the PD. Interviews were conducted via phone within the month immediately following SEFA. Delayed post-surveys were administered a full year after participation. Full-day observations were made of SEFA during the fifth day of the first year and the first and second days of the second year. The variety of data collected allowed for triangulation, which increased the internal validity of the findings.

Surveys. Surveys contained 15 Likert-scale items that ranged from 1 (not very proficient) to 5 (highly proficient) and was administered prior to and following SEFA. These items focused around the first research question of this study, eliciting participants' understanding of and proficiency incorporating instruction associated with problem-based learning, NOS, and inquiry science instruction into their science methods courses. Other Likert-scale questions assessed participants' incorporation of research-based science instruction into their courses, perceived ability to seek out funding, and perceived ability to collaborate with colleagues, which addressed the second research question. The post-survey contained 5 additional Likert-scale questions and 4 open-ended questions related to participants' perceptions of the strengths and weaknesses of SEFA and the quality of SEFA relative to other professional development experiences in which they have previously participated (research question 3).

Approximately one year after participation in SEFA, participants completed a delayed-post survey. In addition to the questions on the pre-/post- survey, the delayed-post survey asked participants to indicate the extent to which they implemented what they learned in SEFA over the year. Additional open-ended questions elicited participants' estimate of how many PK-12 students, preservice and in-service teachers they impacted. A panel of three experts in science education, evaluation, and measurement provided support for face and content validity of these surveys.

Interviews. Following analysis of the pre- and post- SEFA survey, five participants, (38%) (2 from Year 1 and 3 from Year 2) were purposefully selected for follow-up semi-structured interview about their experience (Appendix A). These participants were selected because their pre- and post- survey responses indicated little, moderate, or great changes in their proficiency of the key SEFA objectives following their experience. Questions focused on participants' perspectives on the most and least valuable aspects of SEFA, components of the SEFA they planned to implement, and suggestions for improvement. These interviews also served as a member-check of these participants' survey responses, providing information about their understandings of the SEFA constructs as well as their perceptions about perceived strengths and weaknesses.

SEFA Observations. Observations were conducted the fifth day of Year 1 and the first and second days of Year 2. Different days were chosen for observation each year so that as many different aspects of the week-long SEFA could be observed as possible, with the ultimate aim to observe all aspects of SEFA by Year 3. Qualitative field notes captured the format and organization of SEFA sessions and provide detailed information about the specific schedule of events on observed days.

Artifacts. Collected artifacts included the daily schedule of SEFA given to participants, and copies of PowerPoint presentations used by implementers.

Data Analysis

Quantitative and qualitative data was gathered across the two years of SEFA. Participants' responses to the pre-, post-, and delayed-post survey were analyzed using descriptive and inferential statistics. For each participant, mean scores and standard deviations were calculated pre-, post-, and delayed-post along with an aggregate mean score for those survey items assessing inquiry, NOS, and problem-based learning, collaboration, and broader impacts across years. For each of these constructs, a paired sample t-test determined if differences in pre/post- Likert scores were statistically significant. To determine if achieved gains remained stable over time. Paired sample t-test also ascertained if there was a statistically significant difference between the pre- and delayed-post responses. Significance was measured at an α level of 0.05.

Analytic induction, as described by Bogdan and Biklen (1992), was used to analyze open-ended survey responses and interview transcripts. These data sources were examined for patterns with the goal of characterizing the experiences of participants of SEFA. From these patterns, preliminary categories were developed and refined through comparison with the original data set. Patterns consisted of themes that were common to at least two participants. For example, positive comments about SEFA were examined for similarities among participants leading to the creation of categories related to positive perception of collaboration and the perceived ability that SEFA specifically addressed needs of science education faculty. The goal of this inductive analysis was to better understand participant understandings of inquiry, NOS, and PBL after their participation in SEFA, and also to gain more descriptive information about participants' experiences with collaboration and perceived strengths and weaknesses of SEFA. Qualitative field notes and artifacts provided further insight into describing the format and context of participants' experiences at SEFA. Three researchers read the body of data and came to consensus on emergent themes and patterns that resulted in the final categories presented.

Results

Both quantitative measures and qualitative analysis of the survey and interview responses suggested that participants perceived positive outcomes with respect to the program's key objectives. Follow-up survey responses indicated that participants varied as to their levels of understanding of inquiry, PBL and NOS constructs. After one year, SEFA participants reported continued collaboration with other science education colleagues they met at SEFA and also reported substantial impact on K-12 students, preservice and in-service teachers. Participants recognized the value of SEFA in addressing the needs of science education faculty and offered suggestions for improvement for future years.

Understandings of Inquiry, PBL, and NOS

Overall, participants' perceived themselves to be proficient or highly proficient in their knowledge of and ability to enhance preservice science teachers' inquiry, NOS, and PBL instruction following SEFA. Participants' inquiry, PBL, and NOS means and standard deviations increased pre- to post- and pre- to delayed-post SEFA (Table 3). A paired sample t-test comparing pre-/post- Likert measures indicated statistically significant gains across all three of these constructs. A paired sample t-test compared means of pre- and delayed-post Likert measures. Delayed-post inquiry scores still showed a significant difference over pre- inquiry scores, however PBL and NOS did not. Thus, significant gains in inquiry were maintained a year after SEFA, while PBL and NOS gains were not.

Table 3. *Overall Likert Responses of Participants Relating to Inquiry, NOS and PBL*

	Inquiry M (SD)	NOS M (SD)	PBL M (SD)
Pre (n=13, 100%)	4.0 (.8)$^{*+}$	3.5 (1.1)*	3.9 (.7)*
Post (n=13, 100%)	4.6 (.5)	4.5 (.5)	4.6 (.5)
Delayed-Post (n=10, 77%)	4.4 (.7)	4.0 (.8)	4.1 (.6)

Note: Analysis performed on data from participants in their first year of participation (1=not very proficient, 5=highly proficient)

* = significantly different than post mean ($p<.05$)

$^+$ = significantly different than delayed-post mean

Participants' in depth responses in follow-up interviews conducted within the month following SEFA provided further insight with regard to how participants understood inquiry, NOS, and PBL. Interviewees were purposely selected to represent low, medium, and high pre- to post- changes in an attempt to see a full range of responses. Participants showed much variation in their understandings of inquiry, NOS, and PBL.

Understanding of Inquiry. While the majority of participants entered SEFA with high self-perceptions about inquiry (M=4.0), participants significantly improved their perceived knowledge and ability to implement inquiry following SEFA (M= 4.6, t= -2.4, p=.03). Here, one participant with high positive Likert score changes described her understanding of inquiry instruction following SEFA.

> *Inquiry? Okay, well that's definitely got to be students performing scientific-based experiments in the way a scientist actually does it. So they have the materials they are manipulating, and they are essentially conducting research in a way that a scientist would do so* (Beverly, Interview, Year 2).

Beverly's response highlights hands-on aspects of inquiry and that it be tied to authentic science practice. When asked to define inquiry instruction, George, a participant with medium Likert score changes, stated:

> *It's basically just seeking information by questioning. The level of metacognition involved where students question their thinking and not accepting typical answers but to lead to a broader understanding of something* (George, interview, Year 2).

George's response includes that students should be asking questions, but does not include any aspects of inquiry related to hands-on activity, or authentic science practice.

Understanding of PBL. Participants also entered with high self-perceptions about PBL (M=3.9), and also showed significant gains following SEFA (M= 4.6, t= -3.0, p=.01). Here a participant with low overall Likert score changes describes how she understood PBL based on her own instructional practice.

> *And so what they ultimately did, is they designed their own buoy and, actually it's interesting that you ask this, cause now that I walk through it I'm thinking well that really was problem based learning. They designed their own buoy and they chose what sensors to put on it and so they got answers to questions, that were, very specific questions, which is what scientists would do. Absolutely. And I think in camp there's more focus for that but I think just some of the examples that [were] shared in class that you know, I can't think right off the top of my head, but certain things they would do in the classroom, calling it problem based, but it really wasn't how a scientist would do it. But I think, but yeah, but under the circumstance that's kind of, I guess it's a lesser version of what I was thinking of, in a perfect world with lots of time, camp and money, we do it like scientists* (Melissa, interview, Year 1).

This response indicates that Melissa views PBL as students asking questions and designing open-ended solutions in an authentic science context. Catherine, who showed high overall Likert changes, described PBL in the following way:

> *It's made me realize what exactly it is, because I wasn't quite, I just kind of thought of it as it being very, as almost being separate from inquiry. You used an inquiry approach where you start with a question and a problem-based approach when you start with a problem, but the two really can be intermixed a little bit more. You can do problem-based learning starting with questions, which to me is very much a hallmark of inquiry* (Catherine, interview, Year 1).

Catherine seems to be working out the relationship between inquiry and PBL, and recognizes that PBL begins with a problem. She did not mention anything further about PBL; however, such as solving problems or multiple solutions over an extended period of time.

Understanding of NOS. Finally, with regard to NOS, participants started out slightly less confident in their self-perceptions about this construct (M= 3.5) but showed significant gains following SEFA (M= 4.5, t= -3.8, p<.01). One participant, who had low overall Likert changes, mentions some of the tenets that she remembered from SEFA.

> *I think about the nature of science as revolving around the tenets of the nature of science such as science is based on observation – we use our five senses to help us learn more about science. With the nature of science it involves using more than one…there's not one best method, if you will, to discover and generate knowledge about science. It's tentative, it's subject to change, based on new ideas. And also one thing I like about nature of science, which is important, it does involve creativity and innovation* (Harriet, interview, Year 2).

This response mentions that science is empirical, tentative, is based on observation and inference and is based on many methods. No information was included in her definition about teaching the nature of science explicitly.

Only one of the five interviewees mentioned that the nature of science should be taught explicitly, with that participant saying "We need to explicitly say nature of science because the students aren't making that connection" (Beverly). Another participant, showing medium overall Likert score changes, defined the nature of science in the following way:

> *Nature of science instruction*…[long pause] *I probably have to say that is*…[long pause] *trying to see if I can summarize what I want to say*…[long pause] *looking at science from many different perspectives*…[long pause] *probably looking at science probably from a human perspective; approaching science with a diverse perspective; understanding that science is interchangeable; that it is dynamic; it raises curiosity; and it aims to answer things in a comprehensive and simplistic way at the same time. The nature of science does involve a level of scientific inquiry, but at the same time understanding that there's a knowledge base – a knowledge acquisition involved* (George, interview, Year 2).

George seems uncertain about NOS in his response and makes statements about this construct in only vague or general ways. Together, the subset of participants who were surveyed as to their understandings of inquiry, PBL, and NOS showed a large variation in their views of these constructs.

Enhancing State-Wide Infrastructure of Science Education and Broader Impacts

Overall, participants significantly improved their perceptions about their proficiency to incorporate research-based science instruction into their courses, perceived ability to seek out funding, and their perceived ability to collaborate with colleagues following SEFA (Table 4). A year later; however, there was no longer any significant difference with pre- SEFA mean scores for all three constructs. This may suggest that participants' felt initially confident about their understandings immediately after the week-long SEFA experience, but that over time, with less exposure to these constructs, familiarity and confidence with them declined. These constructs all relate to success in their roles as science education specialists and participation in the larger community of science educators across the state.

Table 4. *Overall Likert Responses of Participants on Selected Outcomes*

	Research-based strategies M (SD)	Seeking funding M (SD)	Collaborative Interactions M (SD)
Pre (n=13, 100%)	3.6* (1.0)	3.2* (.8)	3.6* (.8)
Post (n=13, 100%)	4.5 (.5)	4.5 (.5)	4.8 (.4)
Delayed-Post (n=10, 77%)	4.4 (.5)	3.8 (1.2)	4.4 (.7)

Note: Analysis performed on data from new participants only
* = significantly different than post mean ($p<.05$)
+ = significantly different than delayed-post mean

Science Education Faculty Collaboration. Qualitative responses yield a more descriptive picture of faculty collaboration and networking. In post-surveys immediately following the SEFA and in interviews shortly after participation in the SEFA, some participants indicated they had plans to work on presentations, journal articles, and grant with colleagues they connected with at the SEFA. Other participants noted that SEFA established a network for communication among science educators at different universities. One participant said:

> *In addition, the connections I made with other faculty allowed me access to many different ideas. I could call a colleague or email and get immediate feedback. I was introduced to other professional development opportunities (children's engineering conference) which expanded my own knowledge and teaching.* (Beth, delayed-post perception survey, Year 2).

Multiple participants indicated that they now had lines of communication open with other science educators who took part in SEFA. Like Beth, many participants described presentations and papers that had resulted from this ongoing communication or that were in the works. One first year participant noted the impact of being given the opportunity to collaborate with colleagues specifically during the Vexation and Venture component of the SEFA. "It was really interesting to me to hear people with all these vast experiences sit there and basically kind of vent things that I thought and felt" (Melissa, interview, Year 1). The V&V component provided a chance for new science education faculty to interact with more established faculty members. This quote shows how this experience was a good chance for faculty across all experience levels to share common concerns and collaborate to help each other address them.

Another participant mentioned that the V&V component was an important piece in building lasting and ongoing relationships with other science education faculty, as indicated by Lorie's response.

> *The Vexations & Ventures exercise was an excellent kick-off to the week. It allowed me to get to know each of the participants and their primary concerns, identify individuals who share concerns and interests of mine, and work with them later in the week to collaborate and form long-term professional contacts* (Lorie, delayed-post perception survey, Year 1).

Though many participants listed collaboration as one of the most important features of SEFA on their post- and delayed-post surveys, when asked for feedback about SEFA, some said they would like to see even more. One participant requested "More time for rich conversations with colleagues" (Beth, post- survey, Year 2).

Another aspect of collaborating with the science education community was participants' choice in attending meetings of state science education organizations. On delayed-post surveys a year following SEFA, five participants had positive comments about attending VAST and one had positive comments about attending VSELA, while others did not provide evidence of having participated in either organization. Interview data collected immediately following SEFA suggested participants did not yet have the opportunity to attend any of these meetings of other science educators. When asked about VAST and VSELA, one participant stated, "To be quite honest, the first time I had ever been to VAST was last year. So if VAST and VSELA have collaborations or whatever available, I haven't really had an opportunity to make use of them" (Beverly, interview, Year 2). Because the interviews were conducted in the month following SEFA, participants likely did not yet have time to attend these organizations' meetings. However, a year following SEFA, one participant described her experience with VAST.

> *Students in the Fall 2011 semester had to present their projects at the Nov. VAST conference. (They did a great job and noted on their evals that they felt much more confident about teaching science after the experience* (Melissa, delayed-post perception survey, Year 2).

It appears that given enough time, participants began to report products stemming from participation in state science education organizations.

Broader Impacts of SEFA. On the delayed-post surveys, participants described the products that resulted from their participation in VISTA a year after their attendance. These included presentations at VAST, journal articles, professional development programs related to PBL for in-service teachers, and summer camps for students that incorporated PBL. One participant shared the following:

> *I wrote an article for [my university's journal] on the VISTA experience. It is the featured article in the recently published journal. I co-authored an article on our group PBL research. I revised my course syllabi to revolve around PBL for the methods class. I presented three sessions at VAST based on my group research. My students presented a session featuring their PBL units. I implemented PBL into the Shining Stars Camp (last summer for at-risk middle schoolers)… And, much to my surprise, this past week I was named Outstanding Faculty of the Year. My work in science education was cited during the award ceremony* (Melissa, delayed-post perception survey, Year 2).

Combined, the 9 respondents (69%) reported an estimate of the number of pre-service and in-service teachers and PK-12 students directly and indirectly impacted as a result of these products (Table 5). However, this may be an underestimate as some participants did not respond to one or more of these questions, or reported impacting "many" without quantifying the value. Examples provided by participants in open-ended survey questions and interviews support the self-report number of teachers and students potentially impacted by SEFA.

Table 5. *Year 1 and 2 Estimated Impact on In-service Teachers and PK-12 Students (n=9).*

Direct Impact			Indirect Impact		
Pre-service Teachers	In-service Teachers	PK-12 Students	Pre-service Teachers	In-service Teachers	PK-12 Students
163	220	3525	600	2605	4180

Note: Analysis performed on self-report data from all participants in their first year of SEFA.

Qualitative responses highlighted the particulars of how participants applied many aspects of their experience at SEFA to their classes of preservice teachers. One participant said, "I learned how to coach preservice teachers in problem-based learning, and nature of science, something I was not very strong in previously" (Lorie, delayed post-perception survey, Year 1). Like Lorie, many participants mentioned that they had incorporated the key research-based methods taught during SEFA, including inquiry, NOS and PBL. When asked to describe any products produced as a result of SEFA, Evelyn shared the following example of her effect on both students and in-service teachers

> *I have developed four STREAM projects focusing on life sciences relevant for grades Pre-K to 2. I have collaborated with physical and earth science teachers in a school division to develop curriculum for after school science clubs focusing on increasing interest in STEM among low-income, military, and female populations. One of the courses focuses on the chemistry of food preparation while another focuses on using natural products to create skin care products and cosmetics* (Evelyn, delayed-post perception survey, Year 2).

These responses provide examples of how SEFA participants were able to put into practice what they learned from SEFA to create lessons for in-service and preservice teachers as well as PK-12 students.

Perceived Strengths and Weaknesses of the SEFA

Analysis of qualitative survey and interview data suggested participants valued many aspects of the SEFA experience and that it was highly relevant to their work in the field of science education. For example one participant indicated, “I have felt more confident in my abilities as a science educator. I always knew the science, but felt lacking on the education component. I now consider myself a science educator - not a scientist in education” (Catherine, Delayed-post survey, Year 2). This participant’s response suggests that the SEFA functioned well as a professional learning community comprised of participants sharing a similar vision and goals for themselves as members of a science education faculty community.

Another participant said, “VISTA SEFA is the only professional development workshop that I have attended that specifically addresses my science methods course” (Beverly, post-perception survey, Year 2). This indicates that some SEFA participants perceived that this professional development addressed issues related to their work in the field of science education, and that it filled a unique role not found elsewhere.

Various other themes emerged about specific strengths and weaknesses of SEFA as viewed by participants. These included opinions about the grant writing portion of SEFA, issues with pacing and timing, and the role of returning participants.

Grant Writing. In post- and delayed-post surveys several participants listed grant writing as one of the more helpful components of SEFA. Other participants indicated that their experience with SEFA had a positive impact on their grant writing. Within a long list of products coming out of her experience with SEFA, a first year participant wrote,

> *I wrote a grant for (and received funding) a PBL based camp for at-risk 4th graders this summer. As part of our dept.s technology grant, I was able to receive funding for a set of proscopes, labquest units, and 24 ipads to further support my implementation of PBL.* (Melissa, delayed-post survey, Year 2).

Not only did many participants find the grant writing sessions helpful, but some participants attributed funded grants they received to their SEFA experience. Other feelings about the grant writing piece emerged from the interview data. Two participants mentioned that perhaps too much time was focused on grant writing and that perhaps some of the participants did not need as much assistance in this area. One participant said:

> *The actual components of how to write a grant wasn’t as helpful as the scenario on where to find particular grants that might be meeting the needs of your school and having a chance afterwards to get together with folks and say ‘maybe we can partner and do a collaborative grant between our three smaller schools so we could have more of an impact.’ I think if we had surveyed the people in the room, I think most people had actually written grants, maybe not huge grants, but had received state and federal funding in some format or another* (Beverly, interview, Year 2).

It is unclear from the data collected in this study what prior experience participants had in writing grants. Likert scores did show a positive change in participants’ perceived ability to seek out funding, but as Beverly mentions, this involves both writing skills and knowledge of funding sources.

Pacing and Timing. Across both years, participants mentioned that the fast-paced nature of the SEFA schedule and long hours were taxing. When asked about suggestions for future SEFA programs, Sam indicated, "*The sessions were too long and intense without enough breaks. It's unhealthy for me to sit still for that long. I recommend that you integrate more varied activities or at least change environments"* (Sam, post-survey, Year 1). Another participant noted that the fast-paced nature of the schedule seemed to detract from the content presented, saying:

> *One of my complaints is that you all did not allow for much "down" time. Seemed rushed. Too concerned with getting to the next topic instead of delving into discussions that we might have been interested in. In this way, you did the opposite of what we think is best...rushing to get all the content in instead of going deeper into fewer topics*. (Jenna, post-survey, Year 2).

Suggestions such as these about changing the pacing and timing were by far the most common suggestion given by participants and suggest that this aspect of SEFA may be detracting from some of the content of the sessions. One participant suggested specific schedule changes for future years that would be more amenable.

> *We discussed as a group that the institute might be just as effective as a 3-4 day workshop. After about 3:00 each day we were all so saturated that our productivity waned:*
>
> *a. Either have a 5-day institute where we end at 3:00, or*
>
> *b. A 3-day institute where we go until 4:45* (Lorie, post-perception survey, Year 1).

The notion that the length of each day should be shorted or that SEFA should be less than a week was shared by other participants. Overall, these types of critiques were common, but almost always related to the scheduling of certain session components, the fast-paced nature of many sessions, and the lack of breaks. Participants generally made positive comments about the actual content of the sessions, directing their negative comments instead to the pacing and timing of those sessions.

Returning Participants. On the delayed-post surveys, nine of the ten respondents indicated they would be interested in attending a second time. When asked about attending SEFA again, one returning participant suggested a different experience for returning versus new participants:

> *I like the idea of reframing the experience for those of us who return next year. While it was great to come and brainstorm with old and new faces, it was hard to sit through much of the same stuff two years in a row. Much of what we discussed I had already put into practice so I felt I could have gotten more from the group if a different format was offered.* (Melissa, post- survey, Year 2).

This quote indicates that some of the material seemed redundant and not as valued the second time. A participant who chose not to return for a second year seemed to indicate he might still be interested in returning saying, "I would like to attend a follow up to find out what progress had occurred with others I attended with earlier." (Jacob, delayed-post survey, Year 1). This also suggests that simply repeating the content of SEFA would not be valuable without sharing experiences that old participants tried out based on what they had previously learned with new participants. Another participant offered specific suggestions on how to change the format of SEFA for returning participants.

> "*I would attend a SEFA follow-up session. I would like to see presentations by SEFA alumni on the implementation of VISTA products at their respective institutions. I would like more time to collaborate with SEFA alumni on research projects, papers and presentations*" (Beverly, delayed-post survey, Year 2).

The numbers of participants expressing interest in a second year of SEFA indicate first-time participants valued their experience, but survey responses suggest that specific steps should be taken to modify the experience for returning participants.

In summary, SEFA was designed to function as a learning community, specifically catering to the needs of science education faculty. Participants indicated having shared vision and goals around their identities as science education faculty and worked collaboratively with colleagues both during and after SEFA. Participants showed significant gains in their perceived understandings of and ability to implement inquiry, PBL and NOS instruction immediately following the SEFA. Gains in perceived understanding of inquiry remained significant after one year, while PBL and NOS did not. Interview responses revealed a wide range of views related to PBL, NOS and inquiry.

Participants overwhelmingly perceived opportunities for collaboration were among the most important features of SEFA. Many participants noted that they were still in communication with other participants they met at SEFA after one year, and some had worked on joint projects together or were planning joint projects. After one year, participants estimated they had substantial impact on a large number of PK-12 students, preservice, and in-service teachers. Some participants reported participation in state organizations connected to certain topics covered by SEFA. Overall, reviews of SEFA were very positive and participants were surprised by the impact it had on their views of teaching and other aspects of their jobs as science education faculty.

Discussion

Data indicate SEFA provided participants with an opportunity to learn about effective instructional approaches, provided opportunities for collaboration with other science education faculty across the state, and helped these faculty develop various skills related to succeeding in their careers. SEFA demonstrated the features that Birman et. al. (2000) deems necessary for successful professional development, including a focus on content (inquiry, PBL, NOS, and grant writing) and active learning of these constructs on the part of participants during SEFA daily sessions. There is also clear evidence of coherence through continued collaboration among participants over time around these constructs.

In examining SEFA through the lens of Guskey's (2000) model for evaluating professional development, substantive alignment appears. First, participants reacted positively to their experience, reporting that they benefited from the key features of SEFA, especially learning about inquiry, PBL, NOS, and having opportunities to collaborate. Participants' main critique of their experience related to timing and pacing of the daily sessions, but not the content. However, based on the almost unanimous desire on the part of participants to return to SEFA for a second year, this experience was valued.

Second, participants demonstrated new knowledge and skills. Likert measures indicated that SEFA helped improve participants' self-perceptions of PBL, NOS, inquiry, proficiency to incorporate research-based science instruction into their courses, ability to seek out funding, and ability to collaborate with colleagues. Further analysis will need to be done in future years of SEFA to systematically determine participants' actual understandings of these constructs as opposed to self-perceptions of their understanding. Approaches used at SEFA for teaching inquiry, PBL, and NOS were similar to those used with elementary and secondary teachers in the state-wide VISTA program. Results from the first year of implementation of VISTA showed positive changes in understandings of these constructs (Bell & Maeng, 2012). There is also substantial literature that supports the effectiveness of using an explicit reflective approach, as used at SEFA, for producing positive changes in understandings of the nature of science (Abd-El-Khalick & Lederman, 2000; Akerson, Abd-El-Khalick & Lederman, 2000). Gains related to self-perceptions of understanding inquiry remained after one year following SEFA, but not for any of the other constructs. This may simply be due to the fact that participants did not have as much exposure to these constructs after one year compared to their week at SEFA, leading to less familiarity and confidence with these constructs. Also, since these gains are self-reported from SEFA participants, they may be an overestimate of changes in practice, and may help explain the drop over time (Ebert-May et al., 2011).

Guskey's third category deals with the degree to which participants implement what they have learned, and there is evidence that participants implemented what they learned from SEFA. Many participants reported integrating features of inquiry, PBL and NOS into their preservice methods courses in delayed post- surveys and interviews. However, the extent and quality of implementation would be better ascertained via observations of participants' methods course instruction. Others reported that they had successfully received grants or produced other products relating to these constructs. Further evidence suggests rich and productive collaboration that continued even after a year had passed since SEFA. This may indicate that a need for collaboration existed due to the isolated nature of most science education faculty at their respective institutions as mentioned by Johnston and Settlage (2008). SEFA may have served to show participants that they are indeed members of a larger science education community and provided them with an opportunity to develop and maintain relationships across university lines.

Fourth in Guskey's model is the effect on student learning outcomes. There is evidence that participants directly impacted a large number of preservice and in-service teachers as well as PK-12 students'; however, direct effects on student learning were not assessed in the present study. Other studies indicate that the constructs and approaches used at SEFA have a positive effect on student outcomes. A synthesis of nearly two decades of research on inquiry instruction clearly links this approach with improved conceptual understandings of science content (Minner, Levy, & Century, 2010). Research on PBL links this instructional approach to improved problem solving skills and self-directed student learning (Hmelo-Silver, 2004). Nature of science instruction has been linked to both increased student interest in science (Lederman, 1999; Meyling, 1997; Tobias, 1990) and reinforced learning of science content (Cleminson, 1990; Songer & Linn, 1991).

Finally, Guskey mentions that professional development can be evaluated for its effect on larger organizations in which the individual is situated. SEFA participants had direct and indirect affects on PK-12 students, preservice teachers, and in-service teachers across the state through outreach in their communities. The present study did not explore the effects at the organizational level of the universities in which participants work. While it is unclear the full impact of SEFA on the statewide and university-wide infrastructure, evidence from the present study suggests already connections have been made among science education faculty across university lines who were previously more isolated. There is evidence to suggest that this networking has been productive, demonstrated by numerous published articles and presentation stemming from collaborations, and meets a need for collaboration felt by participants.

SEFA functioned as a professional learning community. Specifically, it functioned as a group of people with shared vision who collaborate, possess collective responsibility and engage in reflective professional inquiry. These features of a professional learning community, as outlined by Stoll et al. (2006) continued to some degree after the implementation of SEFA and may produce lasting effects among members of the science education community across the state of Virginia.

This study revealed SEFA to be a model for professional development that meets the important needs of science education faculty. Future research will explore student outcomes, details about the nature of participant collaborations beyond SEFA, and the effect of SEFA on facilitating a community among science education faculty across the state. Also, data from future years of SEFA will be analyzed to increase statistical power of Likert measures and provide more qualitative descriptions to gain a richer understanding of the various aspects of SEFA. Based on the results of the present study, this professional development model is viable in supporting science education faculty and has the potential to transform the practice of science education at the university level. Therefore, it should be considered as a model for professional development in other states.

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Appendix

VISTA College Science Educator Interview Protocol

This interview is designed to follow up on your responses from the VISTA College Science Educator Academy survey. It will be tape-recorded for transcription, then blinded.

1. What are your definitions of the following types of instruction:
   - Inquiry instruction
   - Nature of science instruction
   - Problem-based learning

2. How did your participation in VISTA affect your thinking about these instructional approaches?

3. Which components of the VISTA College Science Educator Academy (CSEA) did you find to be most valuable? Why?

4. How did you find the process of learning you engaged in at the VISTA Academy?

5. Which components of the VISTA Academy do you plan to implement in the coming year? In what ways? (give concrete examples)
Let interviewee respond to the above general question, then follow-up with prompts to explore his/her plans regarding the following CSEA components:
inquiry instruction support
nature of science instruction support
problem-based learning instruction support
systematic reflection on professional practice with peers

6. You mention ____ and ____ as suggestions for improvement (question 4 on the short-answer part of the post-Academy survey). Please elaborate on these suggestions.

7. How will your VISTA Academy participation influence your collaboration strategies going forward?

8. How, if at all, has VISTA supplemented the collaborative activities already offered through VAST and VSELA?

9. Describe any other VISTA-related products and/or projects that you've recently begun, or plan to implement in the near future.

10. Is there anything else we should know about your participation in VISTA?