An Exploration of Science Coordinator Practices following Professional Development

Brooke A. Whitworth, Northern Arizona University
Jennifer L. Maeng, University of Virginia
Randy L. Bell, Oregon State University

Abstract

This study explored science coordinators' practices supporting teachers' science instruction and how they designed and implemented professional development (PD) for teachers. Each of these science coordinators had participated in in PD designed for science coordinators that aligned with a situated learning model. This qualitative case study included 3 science coordinators from three different districts in a mid-Atlantic state and principals and teachers from those districts. Data included observations of science coordinators, surveys, artifacts, and interviews with science coordinators, principals, and teachers. A constant-comparative approach was utilized to analyze the data for each case and to develop case profiles, then cross-case analysis was used to look for similarities and differences across the cases. Results indicated coordinators supported their teachers through newsletters, emails, resources, websites, walk-throughs, and PD. The PD strategies varied across science coordinators and included in-service days, one-on-one PD, after-school opportunities, and integrating science with other subjects. District characteristics and science coordinator teaching backgrounds influenced their practices. Finally, all 3 coordinators' practices aligned with many of the goals of the PD, suggesting that the PD for science coordinators was effective in facilitating implementation of support strategies for reformed-based science instruction to new settings.

Introduction

The President's Council of Advisors on Science and Technology (PCAST, 2010) recently stated, "STEM education will determine whether the United States will remain a leader among nations and whether we will be able to solve immense challenges in such areas as energy, health, environmental protection, and national security" (p. vi). To enhance STEM education, the PCAST (2010) report emphasized the importance of providing professional development to educational leaders about the "unique issues and best practices in achieving excellent STEM education" (p.115). Furthermore, they recommended researchers work to understand how educational leadership plays a role in STEM education (PCAST, 2010). Similarly, Luft and Hewson (2013) identified a need to investigate those who provide professional development to science teachers and the ways in which they are educated and supported. This includes school district leadership, subject-area supervisors, and district science coordinators. However, very little research exists on the role of these important educational leaders (Luft & Hewson, 2013).

This study explores science coordinators' leadership practices in providing support to teachers and developing and delivering professional development. Science coordinators are individuals responsible for science curriculum and instruction within a district. Usually, a science coordinator is a district administrator who holds at least a Master's of Education and is experienced in the classroom (Edmondson, Sterling, & Reid, 2012). These individuals' responsibilities include conducting and overseeing professional development for science teachers and for the science curriculum. This study explores how science coordinators provide support for teachers' science instruction following participation in a professional development program specifically geared towards science coordinators. This study seeks to contribute insight into the role of science coordinators in supporting science teacher learning as well as how professional development can influence science coordinators' practices.

District Science Coordinators

Subject-area supervisors' job responsibilities include evaluating school curricula, developing educational materials, working with teachers, recommending changes to curriculum, and monitoring curriculum and material implementation (Dillon, 2001). They benefit school districts because they support teachers in ways principals cannot, are able to work across school, department and subject-area boundaries, and proactively respond to teachers' needs due to their separation from formal teacher evaluation (Tracy & MacNaughton, 1993; Tracy, 1996). Teachers, principals, and other supervisors perceive subject-area supervisors as having a high impact on the improvement of instruction (Tracy, 1993, Tracy 1996). Thus, subject-area supervisors may have a significant role to play in supporting and improving teachers' instruction.

Over the years, the science coordinator role has been identified as essential in helping to strengthen science programs (Reinisch, 1966). A science coordinator provides leadership to help increase scientific literacy for students and implements change within a district (Beinsenherz & Yager, 1991). In a review of the literature, McComas (1993) proposed a taxonomy for classifying positions related to the supervision of science (Figure 1). Clearly, a diversity of roles exists for those involved with science education leadership and each encompasses a different amount of responsibility and takes on different foci of evaluation.

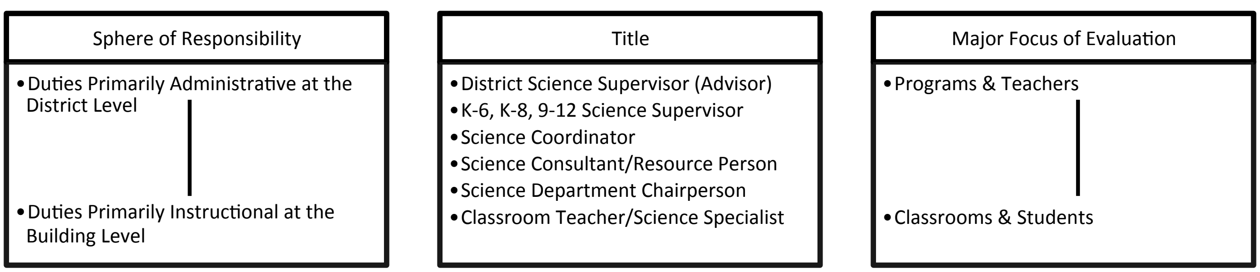

Figure 1. Taxonomy of positions related to supervision of school science (Adapted from McComas, 1993).

Research suggests that these various roles need to be more clearly defined so all district stakeholders (e.g. principals, teachers, district administrators) hold the same expectations of district science leaders (Perrine, 1984). Science coordinators and teachers often hold different idealized expectations for each other than what happens in actual practice (Madrazo & Hounshell, 1987). Although teachers and science coordinators may not agree on leadership practices, both groups agree that critical components of science leadership involves providing teachers with content and pedagogical supports and effective communication with teachers (Perrine, 1984). Research describing current practices of science coordinators needs to be investigated in order to understand the different perceptions of this role (Madrazo & Hounshell, 1987). Doing so has the ability to illuminate common job responsibilities and perhaps move towards common standards for individuals serving in this role. Understanding these relationships may provide more insight into the training and support supervisors need themselves.

Research also suggests that science coordinators may have an incomplete view of what constitutes effective professional development (Rogers et al., 2007). If this is the case, then the professional development they offer teachers may be ineffective and an area where science coordinators need of further support. For instance, in one study math and science coordinators identified effective professional development as having classroom application, including opportunities for teachers to be learners, developing collegial relationships with teachers, and improving teacher knowledge (Rogers et al., 2007). Coordinators identified only some of the aspects of effective professional development cited elsewhere in the literature (e.g. Desimone, 2009; Loucks-Horsley, Stiles, Mundry, Love & Hewson, 2010). Therefore, coordinators may have an incomplete view of what constitutes effective professional development. If this is the case, then the professional development they offer teachers may be ineffective and an area where science coordinators need of further support. Rogers et al. (2007) did not address the content knowledge of the coordinators' themselves. We assume coordinators' possess this knowledge, but this may not be the case, and may be another area where coordinators need support.

Providing professional development specifically tailored to science coordinators may help change coordinators' practices and understandings. For example, Whitworth, Bell, Maeng, & Gonczi (2013) found coordinators' understandings about pedagogy and their job responsibilities improved significantly after participating in science coordinator professional development. Furthermore, many important practices including writing and implementing a strategic plan, using data to support their practice, and implementing professional development around inquiry were incorporated into their practices after attending the professional development. However, coordinators' understandings about nature of science (NOS) and problem-based learning (PBL) were not transferred into their practices. Results also indicated coordinators encountered barriers that hindered their ability to effect change within a district and that other stakeholders (i.e. principals, superintendents) may need to be included to effect sustained changes. Although this study provided evidence that professional development designed specifically for science coordinators can change understanding, results also suggest that coordinators may need more support in transferring understandings into practice. The study points to the need to examine what factors may influence coordinators' ability to transfer their understandings into practice.

District science coordinators play an important role in supporting high-quality teacher instruction (Perrine, 1984; Tracy, 1993; Tracy, 1996; Whitworth et al., 2013) and thus potentially influences student achievement (Beinsenherz & Yager, 1991; PCAST 2010; Reinisch, 1966). In addition, the relationship between a subject-area supervisor and other stakeholders, teachers, students, principals, in a district needs further investigation (Tracy, 1996; Whitworth et al., 2013). Coordinators may need more support in facilitating professional development (Rogers et al., 2007) and in transferring their understandings into practice (Whitworth et al., 2013). Because of the paucity of research in this area and the importance of the science coordinator role, there is a need for more research to understand the role of subject-area supervisors in providing effective support for teachers' instructional practices.

High Quality Science Instruction

In order to support teachers' instructional practices, it is critical for science coordinators to understand what encompasses high quality science instruction. Over the last few decades in science education there has been a shift away from didactic, lecture-based, teacher-centered pedagogy for the purpose of recalling facts to a greater emphasis on active, hands-on, student-centered pedagogy focused on allowing students to construct their own knowledge (Duschl, Schweingruber, & Shouse, 2007; National Research Council [NRC], 1996). Many reforms-based practices have been suggested as appropriate for helping teachers achieve this type of classroom learning environment (Duschl, et al., 2007; Hmelo-Silver, 2004; NRC, 1996).

Problem-Based Learning

In problem-based learning (PBL), students are presented with a real-world science problem, work collaboratively to research and solve the problem, and make recommendations based on their findings (Sterling, 2007). In this teaching approach, it is critical that the PBL instruction activates the interests and addresses student needs (Sterling & Frazier, 2006; Sterling, 2007). Incorporating PBL in the classroom has the ability to engage students in active, inquiry-based learning opportunities, increase student achievement and understandings, and present opportunities for engaging communities in student learning (Sterling, 2006; Sterling, Matkins, Frazier, & Logerwell, 2007).

Inquiry

Inquiry is an important aspect of science instruction that helps students develop scientific literacy and allows them to practice scientific process skills (NRC, 1996). Engaging students in scientific inquiry can also lead to improvements in student understandings and achievement (Bransford, Brown, & Cocking, 2000). At its simplest, inquiry is defined as "an active learning process in which students answer a research question through data analysis" (Bell, Smetana, & Binns, 2005). Teachers should scaffold inquiry so students are able to develop the skills needed to design and conduct investigations from start to finish (Peters, 2009). Inquiry instruction should also incorporate instructional objectives and the inquiry approach taken should be appropriate for meeting these objectives (Luft, Bell, & Gess-Newsome, 2008). Utilizing an inquiry-based approach in the classroom aids students in developing scientific process skills and increases in student achievement; thus, inquiry is a critical component of high quality science instruction.

Nature of Science

The nature of science (NOS) concerns the characteristics of scientific knowledge and refers to science as a way of knowing. NOS is a key component of scientific literacy (Bybee, 1997) and includes tenets for exploration at all grade levels (NRC, 1996). There are many opinions on what comprises NOS, but the tenets described below are recognized as appropriate for K-12 teaching (Driver, Leach, Millar, & Scott, 1996; Lederman, 2007; McComas & Olson, 1998):

1. Scientific knowledge is based on evidence.
2. Scientific knowledge is both reliable and tentative.
3. Scientific knowledge is based on both observations and inferences.
4. Creativity is involved in the creation of scientific knowledge.
5. Scientific laws and theories are different kinds of knowledge.
6. Many methods are involved in the development of scientific knowledge.

7. Scientific knowledge is subjective.

In teaching NOS, research indicates explicit instruction in conjunction with reflective discussions may be effective in developing an accurate understandings of NOS (e.g. Abd-El-Khalick & Akerson, 2004; Akerson & Hanuscin, 2007; Bell, Abd-El-Khalikc, & Lederman, 1998). Teaching NOS supports students in understanding the big picture of what science is and how it works; thus, it supports broader reforms in science education and the goal of high-quality science instruction.

VISTA Professional Development

The Virginia Initiative for Science Teaching and Achievement (VISTA) program, which served as the context for the present investigation, was designed to support teachers' high-quality, reforms-based science practices. Another primary goal of VISTA is to build infrastructure to support sustained, intensive science teacher professional development to increase student performance. To support these goals, VISTA provides four professional development opportunities for different groups of educators: an Elementary Summer Institute (ESI) for in-service teachers, a Secondary Teaching Program (STP) for uncertified, provisionally licensed, and licensed first- and second-year secondary (grades 6-12) science teachers, a New Science Coordinator Academy (NSCA), and a College Science Educator Faculty Academy (SEFA). This study focuses on the New Science Coordinator Academy.

VISTA provides professional development for K-12 science teachers to include "inquiry-based and explicit nature of science instruction in the context of problem-based learning" (Maeng & Bell, 2012, p. 3). VISTA professional development focuses specifically on these reforms-based practices because they effect teacher change, increase student achievement, and constitute high quality science instruction (Akerson & Abd-El-Khalick, 2003; Delisle, 1997; Hmelo-Silver, 2004; Krynock & Krynock, 1999; NCMSTTC, 2000; NRC, 1996; NRC, 2007; Shack, 1993; Stepien & Gallagher, 1993). Specifically, the present study focuses on the VISTA NSCA, which is described in detail in the methods section.

Situated Learning

VISTA draws from a situated learning framework, which proposes knowledge is created as individuals interact to attain an objective (McLellan, 1996). Learning is a situated and contextualized process that is continuously occurring; every experience an individual encounters influences the knowledge an individual has of a concept. The individual and the context influence and change (or construct) one another, and are not separate (McLellan, 1996).

McLellan (1996) identified six key components of a situated learning model. These key components are: reflection, cognitive apprenticeship, collaboration, coaching, opportunities for multiple practice, and the articulation of learning skills. *Reflection* provides students the opportunity to stop and consider what they have learned and assimilate it with their prior experiences. This can be integrated into professional development by allowing participants the opportunity think before sharing or asking participants to write reflections at the end of each day. *Cognitive apprenticeship* emphasizes the importance of students engaging in authentic practices in authentic contexts. This may include the opportunity for participants to practice what they are learning in professional development with the support and feedback from others. *Collaboration* is tied closely to cognitive apprenticeship. This aspect stresses the social construction of knowledge. The following strategies are suggested for collaboration: collective problem solving, giving opportunities for multiple roles, confronting misconceptions and ineffective strategies and giving opportunities for students to develop collaborative skills. Another component of the situated learning model closely tied to cognitive apprenticeship is *coaching*. When coaching is effective, the instructor becomes the "guide on the side" (McLellan, 1996, p. 11), leading students to understand concepts without using direct instruction.

Opportunities for multiple practice relates to the importance of students having frequent opportunities to practice and develop skills in a reflective and collaborative context (McLellan, 1996). In a professional development setting for teachers, this may manifest itself as the opportunity to practice presentations or the opportunity to experience a type of new pedagogy as a student would and develop the same skills students are asked to develop. The *articulation of learning skills* asks teachers to express their thinking, knowledge, reasoning, and problem-solving processes. In articulating these skills, teachers come to a clear understanding of how they think and can explain concepts more effectively to themselves and peers. Providing teachers opportunities to reflect on their thinking process through discussion or journaling is one way this could be integrated into a professional development program. Ideally, by using a situated learning framework the VISTA program aims for science coordinators to transfer their learning into practice within their district.

Purpose

This study explored science coordinators' practices in supporting teachers as a result of their attendance at the VISTA NSCA through a case study of three district science coordinators. This study builds on previous research that found the VISTA NSCA to be an effective model for doing professional development with science coordinators (Whitworth et al., 2013). In the present study, we focus on how science coordinators work within their districts after completing the VISTA NSCA with the goal of illuminating if and how science coordinators' new knowledge was transferred into practice. The research questions that guided this study were:

1. In what ways do VISTA NSCA science coordinators provide support for teachers to develop high quality science instruction in their district?
2. How do VISTA NSCA science coordinators plan for and implement professional development to support high quality science instruction in their district?
3. How does the support and professional development provided by the district science coordinators to teachers in their district align with VISTA NSCA goals?

Methodology

This study explored how science coordinators support and provide professional development to teachers in their district. Interpretive research is used to "understand what a thing 'is' by learning what it does, how particular people use it, in particular contexts" (Schwartz-Shea & Yanow, 2012, p.23). Specifically, we investigated the types of professional development and support VISTA science coordinators provided teachers, how they did that within the context of their district, and the alignment of this support with the VISTA goals. Therefore, this study used a qualitative case study approach framed within an interpretive paradigm.

An interpretivist qualitative design (Erickson, 1986) was selected because its focus is on the perspectives of participants in a social context. Erickson's (1986) interpretive paradigm assumes reality is created through social interaction. Thus, there are multiple realities and these realities are constructed and inter-related. Reality is created through the eyes of each individual as he makes sense of the world and makes meaning of the actions and situations where he finds himself. Therefore, knowledge and meaning are constructed socially and are context dependent. Since individuals create their own meaning, an interpretivist researcher must understand that she is interpreting the meaning that occurs in a context while those being observed are also interpreting the meaning. Consequently, the findings of this study represent the meanings of the beliefs and practices of science coordinators as defined by the participants as well as the researchers' interpretations of both these beliefs and practices and their enacting of these in district and professional development settings.

Interpretive methods are concerned with making meaning and making sense of the meaning (Erickson, 1986). They seek to examine how objective realities are produced. However, interpretivism assumes all research methods are fallible and therefore, one method should not be trusted. In this study, surveys, interviews, observations, and artifacts were used to collect data about the participants. According to the interpretive paradigm, the researcher must focus on the participants within their context from a holistic perspective and not attempt to generalize beyond that context.

The methods also look at the relationship of the researcher to the participant and recognize that the researcher is the instrument for conducting the research. The tasks of the researcher include examining her own assumptions and the participant assumptions to gain an understanding of the social phenomena in terms of acts and meanings, to search out the organization of participant meanings and relate those to the larger social context, and to construct a credible, coherent account of the phenomena (Erickson, 1986).

Methods

In order to understand science coordinators' practices and the alignment of those practices with VISTA NSCA goals, a qualitative case-study approach (Yin, 2014) framed within an interpretive paradigm was employed to understand how science coordinators define and make meaning of reforms and to understand what they actually do in practice. Case-study designs are appropriate when there is a lack of in-depth understandings of a phenomena and a need to analyze unexplored details in order to inform practice (Creswell, 2009).

The unit of analysis for the study was the science coordinator within the school district. A variety of data were gathered during the VISTA NSCA and over a three-month period for each coordinator. The researcher took the role of unobtrusive observer and spent an extended period of time within the district to form relationships and gain access to insiders' perspectives. Descriptions of the context and participants are provided next, followed by the data collection and analysis methods.

Context & Participants

NSCA. The NSCA provided professional development for beginning science coordinators (i.e. those in their first five years in the position). The primary purpose of this component of the VISTA professional development was to support classroom teachers' instruction and foster a statewide infrastructure for science education. Specifically, the NSCA's goals for participants included:

1. Learning to make improvements in leadership, teacher learning, quality teaching, and student learning.

2. Developing a common understanding of inquiry, nature of science, and problem-based learning.
3. Identifying aspects of effective science teaching and learning.
4. Comparing district models of creating standards-based science curricula.
5. Investigating data sources available to use to provide a focus to improve district science programs.
6. Developing a science program strategic plan. (Bell, Konold, Maeng, & Heinecke, 2012, p.80)

During the NSCA, participants engaged in activities, presentations, and discussions that moved them toward accomplishing these goals. The incorporation of these goals throughout VISTA NSCA implementation is described thoroughly in Whitworth et al. (2013).

The first cohort of the NSCA began in the spring of 2011, the second cohort began in the fall of 2011, and the third cohort began in the fall of 2012. All of the science coordinator academies occurred over a five-day period and were facilitated by a team of six instructors.

Science Coordinators. Three district science coordinators who participated in the VISTA program's NSCA were purposefully selected to participate in the present study (Table 1). This selection was based on their district's participation in the VISTA program and the location, type, and size of the district. Science coordinators were selected from three separate locations in the state (western, central, and northern), from three types (rural, suburban, and city) and from three different sizes (small, mid-sized, and large). These different selection criteria ensured the districts were unique and representative of the different types of districts in the state. The state of Virginia designations of location, type, and size were used for each of these districts (Virginia Department of Education, 2013).

Other factors affecting selection were the intention of the science coordinator to implement professional development and the presence of VISTA ESI schools within the district. Not all science coordinators who attended the NSCA planned professional development in the coming year nor did every science coordinator who attended have VISTA schools within the district. All of the principals and teachers from VISTA ESI schools in the selected coordinators' district were also selected for interviews, as described below, to triangulate the data collected from their respective district coordinators. Pseudonyms are used for all districts, schools, and participants.

Table 1
Demographic Information about the Selected Districts

Science Coordinator	**District**	**District Location**	**District Type**	**District Size**
Alex	Yellow County	Northern	Suburban	Large
Ann	Brown County	Central	Rural	Mid-sized
James	Blue City	Western	City	Small

Alex's district. Alex was a member of the first NCSA cohort who holds a B.S. in Chemistry, an M.S. in Chemistry, and a Ph.D. in Science Education Leadership. Alex taught chemistry for 9 years at the secondary level. He is currently the Supervisor of Science and Family Life Education for Yellow County Schools and has been in the position for 3 years.

Yellow County Schools is a large, suburban school district in the northern part of the state serving 83,551 PK-12 students. There are 92 schools in the district – 11 high schools, 16 middle schools, 57 elementary schools, three special educations schools, two alternative schools, two specialty schools and a Governor's school. Yellow County Schools has an average student to teacher ratio of 15.5:1 and a 7.1% dropout rate.

Of the 92 schools in Yellow County, three of these schools were identified as VISTA ESI schools for inclusion in this study based on their participation in the VISTA ESI (Table 2).

Table 2
Yellow County VISTA Schools and Participants

School	**Treatment or Control**	**Teacher Names**	**Grade Level Teaching**	**Years' Experience**	**Principal Name**
Blue River	Treatment	Jeanie	5^{th}	2	Ruby
		Kara	5^{th}	1	
		Justin	5^{th}	4	
		Amy	4^{th}	3	
Longwood	Treatment	Casey	4^{th}	13	Janette
		Drew	4^{th} & 5^{th}	9	
North Fork	Control	Lee Anne	5^{th}	13	Rosa
		Linda	5^{th}	6	

Ann's district. Like Alex, Ann was purposefully selected from the first cohort of participants of the NSCA and holds a B.A. in Elementary Education and a M.S. in Curriculum and Instruction. Ann taught at the elementary level for 28 years and has been the Science Lead Teacher Specialist for 4 years in Brown County.

Brown County is a mid-sized, rural school district in a central part of the state serving 18,531 PK-12 students. There are 25 schools in the district – one alternative, one technical, four high, four middle, and 15 elementary schools. Brown County has a student to teacher ratio of 21.8:1 and has less than one percent of students drop out before graduation.

Table 3
Brown County VISTA Schools and Participants

School	**Treatment or Control**	**Teacher Names**	**Grade Level Teaching**	**Years' Experience**	**Principal Name**
James E. Lewis	Treatment	Abby	4^{th}	24	Sarah
		Tina	4^{th}	8	
Oak Ridge	Control	Lauren	4^{th}	16	Mary
Prairie Village	Control	Kelly	5^{th}	9	Hannah
		Megan	5^{th}	21	
South Creek	Treatment	Sue	4^{th}	7	Dan
		Pam	5^{th}	17	
		Matt	5^{th}	31	

Of the 25 schools in Brown County, four schools were identified as VISTA ESI schools for inclusion as they also had teachers participating in the VISTA ESI (Table 3). Data from interviews with teachers and principals from these schools were used to triangulate data collected from Ann about the district.

James' district. James was purposefully selected from the second cohort of NSCA participants. He holds a B.S. degree in Geology and a M.S. in Geosciences. James taught physical science for 21 years at the secondary level and has been the Science Coordinator for Blue City Public Schools for the last 3 years.

Blue City Public Schools is an urban school district in the west part of the state serving 13,094 PK-12 students. There are 29 schools in the district – one technical school, two academies, one Governor's school, two high schools, five middle schools, and 18 elementary schools. Blue City Public Schools has a student to teacher ratio of 16:1 and a 5.60% dropout rate.

Of the 29 schools in Blue City, three of these schools were purposefully selected for inclusion in this study based on their participation in the VISTA ESI (Table 4). Data from interviews with teachers and principals from these schools were used to triangulate the data collected from James about the district.

Table 4
Blue City VISTA Schools and Participants

School	Treatment or Control	Teacher Names	Grade Level Teaching	Years' Experience	Principal Name
Maplewood	Treatment	Bethany	4^{th} & 5^{th}	19	Patrick
Washington	Treatment	Abigail	5^{th}	2	Grace
		Rebekah	4^{th}	11	
Kennedy Middle	Treatment	Luke	6^{th}	29	Clayton
		Jordan	6^{th}	1	

Data Collection Methods

Various forms of data were collected to triangulate evidence (Patton, 1987; Yin, 2014). Data included NSCA pre-, post-, and delayed-post surveys from the science coordinators, semi-structured interviews with science coordinators, principals, and teachers, field notes from observations of science coordinators working in their districts, and artifacts. Face and content validity for all surveys and interview protocols was supported through review by a panel of experts in science education, evaluation, and measurement (Haynes, Richard & Kubany, 1995; Newman & McNeil, 1998). Two rounds of review occurred. Following each round of review, edits for clarity, addition and deletion of questions, and the addition of prompts were added. Each of the data collection methods is described in more detail below.

NSCA Perceptions Survey. Pre-, post-, and delayed-post Perceptions Surveys were administered as part of the NSCA. This survey elicited participants' beliefs about their ability to evaluate and implement professional development related to PBL, NOS, and inquiry science instruction. Participants received an email with a link to the pre-survey in SurveyMonkey™

prior to attending the NSCA. Completion of this survey was required for participants to begin the NSCA. The pre-survey included 14 Likert-scale items and three short answer questions designed to assess science coordinators' understanding of PBL, NOS, and inquiry science instruction. The three open-ended questions were the only items analyzed from the pre-survey for the present study (Appendix A).

Participants completed the post-survey during the last 45 minutes of the last day of the NSCA. The post-survey included the same three open-ended items as the pre-survey and four additional open-ended questions designed to elicit participants' perceptions of the NSCA professional development and the quality of the experience (Appendix B).

Participants responded to the delayed-post survey approximately one year after completing the NSCA. The delayed-post survey included the same items as the pre-survey and nine additional open-ended questions designed to elicit participants' perceptions of the effectiveness of the NSCA and how they have incorporated aspects of the NSCA into their practice (Appendix C).

Post-NSCA Science Coordinator Interview. After completing the NSCA, participants responded to a follow-up semi-structured interview about their experiences during and following the NSCA (Appendix D). The interview protocol provided insight into how or if participants utilized the training they received at the NSCA. Each interview lasted approximately 30 to 45 minutes.

Post-observation Science Coordinator Interview. After observing science coordinators in the field, a follow-up semi-structured interview about professional development coordinators offered, affordances and hindrances of their district, and their job description was conducted (Appendix E). This interview lasted approximately 30 to 45 minutes and provided understanding about coordinators' implementation of VISTA goals and the alignment between VISTA goals and their practices.

NSCA school-level principal follow-up interview. This interview was administered to principals whose science coordinator participated in the NSCA and whose schools participated in the VISTA ESI (Appendix F). This allowed for characterization of the interactions principals had with their science coordinator and about science teaching in their schools. Each interview lasted approximately 15 to 30 minutes.

NSCA school-level teacher follow-up interview. This interview was administered to teachers whose science coordinator participated in the NSCA and whose schools were participating in the VISTA ESI (Appendix G). It characterized the teachers' experiences with their science coordinator and provided data about teachers' participation in professional development outside of VISTA. The interviews lasted approximately 30 to 45 minutes. All science coordinator, principal, and teacher interviews were digitally recorded, transcribed, and initial inferences and interpretations were added.

Observations. Observations served two purposes: to describe the activities coordinators participated in during the NSCA and to determine how science coordinators plan for and implement professional development. Over the first three years of implementation, the NSCA was observed for six days (48 hours). Observations characterized the activities science coordinators participated in, their engagement level, the methods used by the implementation team to deliver instruction, and the presence of the components of the situated learning model.

In addition to observations of the NSCA, participants were purposefully observed whenever they were providing professional development over a 3-month period. Alex was observed for a total of 28 hours on five different days. Ann was observed on five separate occasions during this time frame for a total of 31 hours. James was observed on four occasions for a total of 28 hours. Field notes captured all of the observations and initial analysis was added within two days of the original observations.

Artifacts. Various artifacts were collected through the observations and in interaction with the science coordinators. These artifacts included materials used in the NSCA, materials used by science coordinators in professional development they delivered, and the science coordinators' job descriptions.

Data Analysis

A constant comparative (Strauss & Corbin, 1990) approach was used to analyze the data. Each district's set of documents (surveys, interview transcripts, field notes, and job description) were analyzed separately. First, each incident in a district was coded for a category. As the incidents were coded, we compared them with the previous incidents that coded in the same category to find common patterns as well as differences in the data (as in Glaser, 1965). NVivo qualitative research software facilitated the process of coding categories and looking for patterns and differences. Categories emerging from the data were exhaustive, mutually exclusive, sensitizing, and conceptually congruent and reflected the purpose of the study (Merriam, 1998). For example, the following categories were created for Ann and Brown County: alignment, collaboration, data, evaluating teachers, student achievement, inquiry, job responsibilities, district characteristics, professional development, planning professional development, principal interactions, science coordinator characteristics, strategic plan, teacher interactions, and teacher support.

In the second step, the categories were compared for each participating district and "memos" developed (Glaser & Strauss, 1967). At this point, case studies for each science coordinator and district were written based on the most striking and relevant categories as recommended in Yin (2014). These categories were: teacher support, professional development, and alignment with NSCA goals. Case studies were written as recommended in Yin (2014). After the individual case study narratives were written, cross-case analysis was utilized to look for similarities and differences across cases (Yin, 2014). In this last phase of analysis, the researcher team defined major themes derived from the data. Evidence to support these similarities and differences were searched for and included.

Validity. Erickson (1986) identifies possible threats to the validity of an interpretive study: an insufficient amount of evidence, a lack of variety in the type of evidence used, and/or a failure to account for disconfirming evidence. In order to address these threats, a total of 135 hours were spent in the field and several different types of data sources were collected. Furthermore, the reader is provided with evidence to support the developed cases and categories. Only those categories with an appropriate amount of data (i.e. more than two instances) and accounting for confirming and disconfirming evidence are presented in the final analysis.

Results

The purpose of the present study was to describe how science coordinators' transferred what they learned in the NSCA to support teachers' high quality science instruction in their own districts. Results indicate each of the three participants supported their teachers and implemented professional development in their districts differently. Below, the cases of these science coordinators describe the similarities and differences in the support they provided teachers in their districts, how they planned for and implemented professional development in their districts, and how these practices aligned with VISTA NSCA goals.

Alex's Case

Alex was a third-year science coordinator in a large, suburban school district in the northern part of the state. He taught high school chemistry for 9 years before obtaining his Ph.D. in Science Education Leadership (Pre-Survey). Alex supervised a staff of six who assisted him in supporting teachers in science and family life education (Observation). Alex was responsible for: developing, implementing, and monitoring the science and family life curriculums, designing professional development opportunities, communicating with administrators, staff members, parents, and community members about the science and family programs, staying current with the research on trends and effective practices related to curriculum and instruction, observing and evaluating teachers, facilitating textbook and curriculum adoption, overseeing the county's watershed education program, directing the regional science fair, managing the science and family life budget, preparing, analyzing and submitting reports, and other duties as assigned (Job Description).

Teacher support. Teachers described their day-to-day interaction with Alex as "limited" (Teacher Interviews). They indicated he was available when needed and provided support when they contacted him (Teacher Interviews). On average, Alex emailed teachers once a week and provided them with links to resources and reminded them of opportunities for professional development (Post-interview). His department also maintained a website which allowed access to a variety of resources (Observation). In the year of his participation in the NSCA, Alex worked with his district to provide every elementary school with the same set of science materials. In some cases, Alex helped to set up some of the more difficult materials (i.e. living garden), but in most cases teachers in the schools chose where to store and set up the materials (Observation). If teachers needed special materials for science, Alex was often contacted and delivered the materials needed as evidenced by Lee Anne's experience interacting with Alex:

> When I was working with the fifth-grade teacher, we were working on scientific investigation. And we wanted to have the students take a look at different cells under a microscope but we were missing slides. I asked Alex if he had any available and within the day, before school ended, he had dropped it off at my school. So, the way that I felt that he helped is that he responds. If you send him an e-mail, if you have an inquiry, he responds very promptly. (Lee Anne, Interview)

Alex made himself available to teachers, responded in a timely manner to teacher requests, and provided teachers with the resources they need to do their work (Teacher and Principal Interviews).

As part of his strategic plan, Alex worked toward developing two volumes of an Elementary Science Inquiry Handbook (Observation). Teachers had access to a hard copy of this handbook in their schools as well as an online version on the website. These handbooks included details on how to implement inquiry lessons on different topics designed specifically to meet the needs of students in different grade levels. For each lesson, the handbook provided teachers step-by-step directions, a list of necessary materials, and examples of editable student hand-outs.

Alex and his team also provided feedback to teachers on their practice by doing walk-throughs at schools (Post-observation Interview). Alex observed and provided feedback on how they can improve their practice to new secondary teachers in the district twice during the fall semester (Observation). He also observed elementary school teachers once a year or as needed for science (Post-observation Interview). Alex also led monthly meetings with the science lead teachers (Post Interview). Each school had a science lead or department chair who attended these monthly science committee meetings. Alex described the goal behind these meetings:

> I think the things I'm looking to do is really try to build capacity in our buildings for, my staff is very small and you know I have a very large division and so finding teacher leaders and sort of having them be comfortable and secure working with other teachers. You know that's something that's a priority for me. (Post-observation Interview)

Alex worked toward developing teacher leaders in his district and finding multiple ways to support his teachers in their day-to-day work. However, the majority of his teachers received this support indirectly from him through the website, school-level teacher leaders, or from others on his team (Teacher and Principal Interviews).

Professional development. When asked how Yellow County improves student achievement in science, Alex answered:

> It's doing professional development. It's having various content courses or we do courses with inquiry. We do content courses to develop background knowledge and foundational knowledge in different areas where the data says we have challenges. Working with other departments whether it's working with our ESL department or working with our Special Needs Department as part of our strategic plan or looking at ways to try to close that achievement gap, whether it's do some of these things or whether it's do sort of one-off professional development with individual schools to address if they have a different gap than someone else. We took time to work with each of our secondary schools looking at student performance by question data for individual schools versus the division versus the state and saying where their gaps may be different or more significant than what we're seeing at the division level and looking at what things we can do with our curriculum to support where there may be some needs. (Post-observation Interview)

In Yellow County, Alex viewed professional development as the primary way to impact student achievement scores. He utilized his analysis of the district data to direct and guide the content and type of professional development his team provided. Alex also collaborated with other departments to meet teacher needs and to be as effective as possible in providing professional development. Furthermore, he asked individuals who participated in his professional development to provide feedback on their experience and on what other topics they need assistance (Observation). This evaluation provided Alex more data as he continued to plan and determine what types of professional development to offer in the future.

Alex provided a variety of professional development to a wide array of audiences in his district (Observations). In the first observation of Alex at work in his district, he provided professional development sessions for a group of principals and district leaders. This professional development focused on defining inquiry, providing participants an inquiry experience, and helping these administrators think about what they should be seeing in teachers' classrooms when they are teaching an inquiry-oriented lesson (Observation). Alex also provided professional development to new secondary science teachers prior to school starting, to elementary teachers during in-service days and on pull-out days, and to all secondary teachers on an in-service day (Observations). Given the large size of Alex's district, the sessions on the in-service and pull-out days for elementary and secondary teachers were differentiated by grade-level and content areas. Beyond what was observed, Alex also supported teachers in implementing field trips for the Watershed program in the district, attended career days for schools when asked, and provided professional development at lead teacher and principal meetings (Post-interview).

When asked about what characterizes effective professional development, Alex responded:

> I think when you're planning the ultimate goal has to be what's sustainable and what's usable for your target audience, whether it's teachers and student strategies. Is it effective for them? Is it sustainable? Is it something they can take back and use or incorporate it into the classroom? If it's administrators, is it something they can use to help the folks in their building, the students and the teachers. It's got to be practical. You want them to be able to use something that makes sense and is intuitive and gives them enough background knowledge to be able to use it and understand the implications of why they're doing it. (Post-observation Interview)

Alex strongly believed professional development should provide sustainable and practical applications for his participants. This was evidenced in the differentiated professional development he provided. The following vignette exemplifies how every session presented applicable practices, lessons, or ideas participants could use in their respective positions:

> Alex leads a session for second grade teachers, while others in his department lead sessions for the other elementary grades. Alex models how to teach an inquiry lesson around weather, a specific content-area for the second-grade standards. Teachers take on the role of students and are actively engaged as they build weather vanes to collect data outside. Alex discusses how teachers might extend this lesson and what other subject areas could be incorporated to the lesson. He also describes how this content relates to other grade-level standards. He then provides the teachers with handouts of the lesson and reminds them that the lesson is also on the district website. (Observation)

After attending one such elementary teacher pull-out day, Linda said, "What I got out of it is one, seeing the vertical alignment and two, seeing the thinking behind selecting certain activities for students to do at different grades" (Teacher Interview). In general, teachers perceived positive take-aways and practical applications provided for them in Alex's professional development.

Practice alignment with VISTA NSCA goals. Alex's support and professional development aligned with VISTA NSCA goals in many areas. When asked how he decided what topics to address in professional development, Alex responded:

> Data. I mean in the simplest terms, data. It comes from lots of places. Obviously, you use whatever formative or state data you may have from various sources you're using. You're also pulling school data and you're getting the best student performance questions and those sorts of things from the state that are available. Part of also, what we try to do is, if it's a series that we're doing, we try to pull from the previous time. Okay, what is it that you think that you need assistance on for next time and use that as well. (Post-observation interview)

Alex used the formative data he collected from teachers after professional development to inform future professional development offerings (Post-observation Interview). Alex also used data from state student assessments to inform the professional development he provided and in the creation of his science program strategic plan (Post and Post-observation Interview). One of the major initiatives in Alex's strategic plan was to provide professional development for all elementary teachers on using inquiry in the classroom (Post-Interview). Two grades were chosen every year to attend pull-out days and receive professional development around the inquiry lessons created for their grades in the Elementary Inquiry Science Handbooks (Observations).

Alex was fortunate to have the support and buy-in of his superintendent:

> I'm very fortunate that [my superintendent] is a big science guy, and so, he's been supportive of the idea that we really need to start at the foundation of building the capacity in our elementary schools. Getting them to really enjoy science, because the time that they're allotted is very small, and that's sort of a different story. Working with teachers to understand how they can maximize the time that they do have effectively and get students to really enjoy science and look at ways to build contextual strength in their classrooms. (Post-Interview)

Alex's superintendent was very supportive of science and encouraged teachers to implement hands-on, inquiry-based science lessons in the classroom at least once a week (Observations). Teachers and principals also mentioned this mandate (Teacher and Principal Interviews).

Alex worked to develop a common understanding of inquiry and encouraged its' implementation by the teachers and principals in the district (Observations, Teacher and Principal Interviews). This aligned well with two of the goals of the NSCA: to make improvements in leadership and quality teaching and to understand inquiry. However, Alex did not implement professional development around NOS and PBL. In regards to NOS, Alex said:

> I think for focusing on elementary, well even K-12, I think nature of science is probably more abstract. It's one of the things that people maybe have an understanding of, but I don't know if it's as concrete as we want it to be, as meaningful and so that's something that's on my radar. (Post-Interview)

Alex viewed NOS as more "abstract" and as something more difficult to implement with his teachers; therefore, he had not yet thought about how he would integrate it into the professional development plan for his district. Alex's implementation of PBL was similar to that of NOS, he saw it as a more complicated pedagogy to incorporate into instruction; thus, he had not yet integrated it into his professional development plans (Delayed Post-Survey, Post-Interview). When asked about PBL, Alex stated:

> We didn't spend as much time on PBL. But at the elementary school, they do a couple of different summer programs, summer school things where we're talking about using

> problem-based learning for you know, whether it's 2 week or 3 week summer camp, something like that. And so I think, again my comfort level wasn't as high, but it becomes a matter of finding ways that we can realistically support our teachers trying to do that in the classroom. (Post-Interview

Alex planned to implement PBL into some of the summer programs their district offered, but was not clear how he would implement it for the day-to-day use by teachers. While Alex appeared to have a good understanding of NOS and PBL, his intention to implement these pedagogies in his district were limited.

Ann's Case

Ann was in her fourth-year as a science coordinator in a mid-sized, rural school district in the central part of the state. She taught elementary school for 28 years before entering her role as a coordinator in Brown County (Pre-Survey). As part of her job responsibilities, Ann was responsible for: planning, implementing, and evaluating professional development, developing and updating district-wide assessments, analyzing and using student achievement data to ensure student success, program effectiveness, and instructional improvement, assisting teachers and principals in content and pedagogy knowledge, ensuring appropriate articulation, alignment and assessment of the curriculum, planning, supervising, and assessing curriculum and instruction, observing classrooms to provide clinical supervision and assess teaching effectiveness, assisting in budget development, recommending and monitoring the use of resources, disseminating information about the program, participating in school level meetings, remaining abreast of current trends in curriculum and instruction, and other duties as assigned (Job Description). Ann, at the time of the study, was also serving as a regional director for her state science organization (Observation).

Teacher support. Teachers described Ann as "very supportive," "encouraging," and "available" (Teacher Interviews). They also indicated she was very accessible and willing to support them in their instruction (Teacher Interviews). Ann sent periodic "Science Matters" newsletters by email to teachers with information on different topics and professional development opportunities (Post-Interview, Principal Interviews). She also attended secondary science department meetings at least once a year and held elementary science curriculum committee meetings and secondary science curriculum meetings at least five times a year with each group of teacher leaders from her district (Post-Interview). Ann described these curriculum committee meetings:

> The curriculum committees are representatives from each school so I have an elementary curriculum committee and then I have a secondary. The elementary has 15 teachers on it from all the elementary schools and I make sure there's representation from gifted and special ed, and then the secondary has 10 on it....I model effective strategies for improving instruction and assessments. Typically, I'll have a little bit of information, but I usually send that out by email so I don't spend too long on that. I always give them a chance to share what's going on in their schools, try to keep the positives, how things are going well. And upcoming events and how we might participate. (Post-Interview)

She went on to explain the representatives on this committee are expected to go back to their departments and schools and share what they learned (Post-Interview). Through these meetings Ann provided direct support to a select group of teachers and indirect support to a larger group of teachers.

Ann frequently communicated to teachers that she was willing to come to their classroom and model or co-teach a lesson in an area where teachers might be struggling or have a desire to try something new (Observations, Teacher and Principal Interviews). Several of the teachers interviewed indicated they took advantage of this opportunity. For example, Abby a new teacher to the fourth grade described her experience with Ann:

> I was just very unfamiliar with the science curriculum and when I thought about teaching the electricity unit especially I wanted help because I just didn't feel like I knew enough about it to do it justice. And so Ann came in and she spent two to three mornings with us. I thought the way she taught it was incredible and it just was very hands-on. After I went through all of the training with VISTA I realized what she was doing, she was already teaching me a lot of what I was going to be learning this summer about just asking them questions, using inquiry-based learning, giving them a problem to solve. I was amazed and just wrote notes constantly while she was teaching so that I could use that this year not realizing that I'd be going through VISTA as well. (Teacher Interview)

Abby's experience with Ann is representative of how other teachers and principals described her willingness to spend one-on-one time with teachers and their experience with her. It also shows how Ann's professional development was well aligned with the goals of VISTA.

Ann also made kits available with materials and sample lessons for teachers to check out and use with their students (Observations, Post-Interview). Ann worked to develop a video library of different lessons to be posted on the district's website as a resource for teachers (Post-observation Interview). In these videos, teachers observed Ann's modeled instruction and how they might cover content with which they are unfamiliar or have difficulty understanding (Post-observation Interview). This was a resource teachers accessed easily to get ideas and see instruction modeled on their own time.

Finally, Ann also observed teachers and provided them feedback to improve their practice (Post-Interview). She utilized the inquiry rubric provided by the NSCA to help her identify and evaluate inquiry lessons in the classroom (Delayed-Post Survey). Ann performed school walk-throughs throughout the year to support teachers and would also observe teachers when requested by principals (Observations). This was another way she was able to encourage teachers and support them in their practice.

Professional development. In order to improve student achievement in science, Ann explained that in Brown County:

> I tag on to literacy and math skills in professional development because I think, and the way education is set up today, science and social studies real often are over looked or not as valued for as much as what I think they can offer. (Post-observation Interview)

Ann identified the integration of science with other subjects as the key method of increasing student achievement in her district. Due to the focus on testing in math and reading in Ann's district at the elementary level, Ann felt she had to find ways to tie science to these subject-areas in order to make science relevant (Post-observation Interview, Teacher Interviews). Ann continued her description of how she supported teachers in improving student achievement by saying, "In fact, I don't even say the word science by itself anymore to elementary or primary schools. I always say, here's how I'm helping you with your literature and reading or math skills through science" (Post-observation Interview). Thus, the professional development provided by Ann always had a literacy or math component and she emphasized this during those sessions.

The professional development Ann provided came in a variety of ways, but seemed to focus on the elementary level (Observations). Ann was more comfortable with elementary teachers as this was where the vast majority of her experience lies, but she also identified these teachers as in need of support for science (Post-Interview). For this reason, in her role as a regional director for a state science organization and in collaboration with other science coordinators in the area, Ann designed a professional development day specifically for elementary teachers (Observation). Throughout the day, a variety of professional development was provided and Ann herself presented workshops on inquiry, science and literacy, and using GoogleMaps with science in the classroom (Observation). Ann also provided professional development to high-school and elementary teachers during in-service days prior to school starting, to elementary teachers during the school year, and to a varied audience at a state-wide conference (Observations). Outside of these observations, Ann also did one-on-one coaching with teachers and provided professional development at department meetings and curriculum committee meetings (Teacher and Principal Interviews, Post-Interview). Ann also selected schools that were struggling significantly with their science scores and visited monthly with those teachers (Post-observation Interview). During those visits, Ann taught one of their classes, modeled different methods and then discussed it with the teachers afterward (Post-observation Interview). This approach also allowed her the opportunity to work with students and keep her classroom skills sharp. Finally, Ann also offered "Science Spots," one hour professional development opportunities teachers attended after school (Observation, Post-observation Interview).

When asked about the characteristics of effective professional development, Ann responded:

> I think teacher engagement. It's not sit and get, number one. It's something that they can use and take back, an application of a concept so they can apply what I'm saying. I have an application for what I'm showing them and the tools to pull it off. I would put those as my top three. I think too often we say, here's a philosophy, do you agree with it? Teachers are like, yes I'm there but then we don't show them how to use it and give them the resources to do it in the classroom. To me, the best professional development combines all three of those. (Post-observation Interview)

Ann indicated the importance of providing practical applications for her participants, contextualizing the professional development for the teachers. She also identified the importance of teachers being actively engaged in their learning and arming them with the tools they need to carry out the new methods.

Ann's beliefs about effective professional development were further substantiated by observations of her practice. In every observation, Ann provided resources, lessons, or ideas teachers could use in their classrooms. The following vignette provides an example of the type of professional development provided by Ann.

> Ann begins her session on Animal Web Cams as part of the regional PD day. Ann shares her background as a teacher and tells a story about one of her past students to

> introduce the use of web cams in the classroom. Ann shows an example of one of the online web cams and then shows a video of an Eagle egg hatching that is also on the website. She asks the teachers what kind of questions we could ask as we watch this video and begins to elicit responses from the teachers. Ann is allowing the teachers to come up with questions and then they answer the questions using the data in front of them – this is inquiry. Ann states that KWL is overdone, and what is better and more fruitful is: 1. What do I see? 2. What do I know? 3. What do I wonder? She says the third question is great because it moves students away from the test. She talks about letting students get their curiosity out. "Good instructional technique is to model the curiosity for your students." She says part of the Nature of Science is embedded in our standards now so we need to get students to be curious and to make good observations and inferences. Ann says "smack yourself if you ever say, this is on the test". The teachers laugh and seem to appreciate her humor. Ann goes on to explain how animal webcams could be used to do inquiry with students and how to get students engaged in understanding and doing science. Ann also asks the teachers to reflect on how they might incorporate reading and writing into the session. The teachers actively engage in a discussion about their ideas. As the session wraps-up Ann provides the teachers with a CD of resources to use with this type of material. (Observation)

This professional development session focused on how elementary teachers could implement inquiry in their classrooms and was well-aligned with VISTA goals and instruction. Ann mentions nature of science, but it is not the focus of her session. After attending a different session, Lauren said, "I got to get some extra supplies so that I could do some hands-on activities with electromagnets and working with the different kinds of circuits" (Teacher Interview). Overall, teachers indicated there were practical applications and resources provided in the professional development given by Ann.

Practice alignment with VISTA NSCA goals. The support and professional development Ann provided aligned with the VISTA NSCA goals in several areas. Ann used data to determine the schools she would work with one-on-one and support in improving teaching quality and student learning (Post and Post-observation Interview). Additionally, she used data to help teachers identify student needs and content areas to which the district needed to give more attention (Post-observation interview). Ann further utilized data to identify professional development topics teachers wanted and needed (Post Interview).

Also, Ann developed and implemented a strategic plan (Post-survey and Post Interview). In fact, one of the major needs Ann identified through examining district data became the main focus of her strategic plan: "To move teachers more toward inquiry learning" (Post Survey). She discussed how she went about achieving this goal:

> And the way to do that was through professional development, for us to clearly define what that looks like, what it's not and what it. And then when I do my walk-throughs I look for those things, you know how many students are manipulating the equipment versus the teachers and especially with questioning, how they question students to further it. So I planned five meetings with elementary and five with secondary and two of those were joint where everyone was together and then we looked at some vertical teaming, how does it look as it goes from elementary to middle and middle to high. (Post Interview)

Ann had a clear desire to improve teacher quality, impact teacher learning, and to ensure the teachers in her district had a common understanding and definition of inquiry. One of the goals of the NSCA was for science coordinators to be able to identify aspects of effective science teaching. When asked how she used the content and materials from the NSCA, Ann responded, "I've used the inquiry rubric to more clearly identify what is/isn't inquiry lessons. Teachers have been given these tools to use with their own colleagues" (Delayed-Post Survey). Furthermore, Ann identified the NSCA activities designed to help coordinators identify and evaluate inquiry lessons as one of the most important things she learned as part of the NSCA (Post Survey, Post Interview). Ann used a "Science Walk Through" list and the "Inquiry Rubric" provided at the NSCA when she visited classrooms and "served as a liaison with administrators on what the focus of the professional development [VISTA] included. I have supported and shared the key features through a "Science Walk Through" list of "look fors" when they visit their teachers" (Delayed-Post Survey).

Like Alex, Ann focused more on inquiry than on NOS and PBL. When asked about NOS instruction at the NCSA, Ann said:

> The nature of science I thought was really good and I think of the three, I think that was the one I went in with the least understanding of. I mean I was aware of it but I didn't know how to get that across to the students. So the workshops, the institute, actually gave me more confidence in being able to voice what the nature science was and how to pass that on to teachers. (Post Interview)

Observations indicated that Ann continued to struggle to understand NOS herself. In every observation of Ann, NOS was mentioned or peripherally discussed; however, the discussions were often perfunctory or failed to address misconceptions teachers brought up about NOS (Observations). For example, in one observation a teacher kept mentioning "THE scientific method" and Ann did not address this misconception as one of the tenets of NOS is that science uses multiple methods (Observation). While Ann's surveys indicated she was presenting professional development on PBL, there was no evidence of this in observation or in interviews with teachers and principals. Ann had a good understanding of PBL (Post-Interview) and supported the VISTA elementary teachers in the implementation of PBLs (Teacher and Principal Interviews). However, there was no evidence she provided professional development to other teachers in this pedagogy beyond providing the appropriate definition when asked (Observations).

Finally, Ann maintained the relationships she developed with other coordinators during the VISTA NSCA. Three of the coordinators who attended the NSCA collaborated with her and supported her in planning and implementing the regional elementary professional development day (Observation). The coordinators occasionally met for lunch, traveled to observe professional development in one another's districts, and emailed each other with questions and ideas (Observations, Post-observation Interview). Ann also indicated that she utilized the resources the NSCA provided her with and emailed NSCA implementers with questions or requests as needed after the NSCA ended (Post Interview, Delayed-post Survey). This suggests the situated nature of the NSCA was effective in allowing long-lasting, supportive relationships to develop between participants and implementers.

James' Case

James was in his third-year as a science coordinator for Blue City, a small, urban school district in the west part of the state. James taught high school physical science for 21 years before moving into the coordinator position (Pre-Survey). As a science coordinator James was responsible for: coordinating PK-12 science instruction, developing and updating benchmark tests, planning and implementing professional development, analyzing and using data to improve student learning and teacher effectiveness, observing teachers and providing feedback to teachers and principals, overseeing textbook adoption, participate in district and school meetings, and performing other duties as assigned (Job Description). As part of his "other duties as assigned", James also served as the K-12 Testing Coordinator and the Chess Club advisor for the district (Observation, Teacher Interviews).

Teacher support. Teachers described James as "supportive" yet "unavailable" (Teacher Interviews). They indicated he supports them with professional development and by providing them with materials and resources they need for the classroom (Teacher and Principal Interviews). Yet, teachers also suggested his responsibilities as a testing coordinator for the district hindered his ability to engage with and support teachers. Luke said, "He doesn't have much time to help us out" (Teacher Interview), which was also supported by Jordan's statement, "We don't see him very often. Not because he is unavailable, well yeah, because he is unavailable. He is usually doing something with testing" (Teacher Interview).

Despite these other responsibilities, James still worked hard to support his teachers in a variety of ways. He provided professional development for teachers on in-service days and suggested other optional opportunities during the school year and in the summer (Observations, Post Interview). He attended grade level meetings at schools, worked with principals to do observations and evaluations of teachers as requested, and worked with the other instructional coordinators to do "instructional rounds" (Post-Interview, Principal Interviews). James described these, "We go and visit, in the course of an hour, all of the classrooms and do a brief visit, looking for certain things that their principal has asked us to look for" (Post Interview).

James met periodically with teachers by subject-areas and in vertical teams. In these meetings, James provided a professional development component and then spent time obtaining feedback from the teachers (Observation, Post Interview). In these meetings, teachers analyzed test data, provided feedback about the curriculum and pacing guides for the district, or discussed opportunities and issues (Observations, Post Interview). James further supported his teachers by ordering supplies and materials and making these available to teachers (Observations, Teacher Interviews). He created a website of resources for teachers and frequently updated it with information (Observations). James also created email groups for teachers by subject area for secondary and grade level for elementary (Observations). The teachers then used these groups to communicate with one another, get ideas, and send requests for materials or supplies (Teacher Interviews).

Professional development. James perceived professional development as the key method for increasing student achievement in his district. For example, when asked how Blue City works to improve student achievement in science, James answered:

> We try to do PD on things that will be applicable to do in class that the teachers can repeat. I try very hard to provide needed materials. The expectation is not for the

> teachers to go out and get a bunch of stuff, but if there's hands-on things required, we try to provide that. (Post-observation Interview)

James provided a variety of forms of professional development (Observations). For example, during the summer James planned an optional professional development day on inquiry and NOS in collaboration with three science coordinators from other districts. The collaborating coordinators wrote a grant together to obtain the funds and then worked to plan and coordinate the day (Observation). In addition, James provided professional development to teachers on in-service days prior to school starting and then throughout the year as those days arrived (Observations). On the days prior to school starting, James focused on providing teachers the information they needed for the new school year, gave them the opportunity to participate in a 15-20 minute NOS activity, and then led the teachers in reviewing and analyzing test data for their schools and the district (Observations). He also brought in local agencies who shared about the programs they offered and how teachers could incorporate them in the classroom. During the school year, James used his analysis of testing data to determine content areas where teachers needed support (Post-observation Interview). James then developed and presented activities related to these content areas. Finally, he used some of his in-service professional development days to meet with teachers by subject-area and in vertical teams to look at the curriculum and pacing guides and make adjustments (Observations).

When asked about what characterizes effective professional development, James responded:

> It has to be aligned with the standards. Particularly as the standards have changed and as the curriculum framework has become more important, it needs to highlight the role of the curriculum framework in the planning. I think that it needs, in science particularly, to provide teachers with everything that they need to be able to implement whatever it is we're talking about in the classroom. That means modeling activities that the students might do, whether it means training with Probeware or supplies. I think as much as possible part of it needs to be how the supplies are going to be provided so the teachers can implement whatever they are learning in training. (Post-observation Interview)

James identified the importance of contextualizing the professional development so teachers could see how it related to the standards and the curriculum they were responsible for covering in their classroom. In addition, he indicated the importance of modeling and providing teachers the opportunity to practice with the tools and materials in the professional development. In every observation, James related the activities and material he was discussing to the standards and modeled how it could be implemented with students. He also provided resources or ideas teachers could use in their classroom (Observations). In describing the type of professional development James provided, Jordan said, "Every professional development I think I have ever attended with him has awesome hands-on activity and the SOL correlations for that activity. They are all very practical for all of our student body, which I think is hugely important" (Teacher Interview). This was representative of how teachers described James' professional development opportunities.

Practice alignment with VISTA NSCA goals. The support and professional development provided by James aligned with the VISTA NSCA goals in several areas. James used data to determine the areas where his teachers needed support and provided professional development in these areas (Observations, Post-observation interview). He worked with teachers to analyze their own test data and helped them make decisions about areas they needed to re-think or give more focus (Post Interview, Teacher Interviews).

In developing his strategic plan, James identified NOS as an area where all teachers needed support (Post-Survey). Thus, he provided professional development focused on NOS to all of the teachers in the district and emphasized how NOS related to their standards and curriculum (Delayed-Post Survey, Post Interview). This was aligned with the NSCA goals of developing a strategic plan, understanding NOS, and improving teacher learning and quality. James also used the resources the NSCA provided to deliver his professional development on NOS for teachers (Delayed-Post Survey, Observation).

James emphasized NOS based on what he was seeing in the data and because of the new focus on NOS in the standards (Post Interview). James' understanding of inquiry was evident in the professional development he delivered (Observations). However, it was rarely the focus of the professional development. James indicated inquiry had been a focus in previous years (Post Interview) but it is unclear how aligned this previous teaching was with VISTA NSCA goals. One principal, Patrick revealed, "He really challenged us at the beginning of this year. The Principal PD, it was about focusing on PBL strategies for students on a regular basis" (Principal Interview). James challenged principals to think about how to support teachers in implementing PBL strategies in the classroom. James stated the NSCA provided him with a definition and examples of PBL (Delayed-Post Survey). However, there is no other supporting evidence that James did professional development related to PBL.

Finally, James developed relationships with other coordinators and maintained these relationships through email and phone calls after the NSCA ended (Observations, Post Interview). In fact, some of the professional development James planned was in collaboration with other science coordinators (Observation). James indicated the opportunity to connect with other coordinators was one of the most beneficial aspects of attending the NSCA:

> Well there's a lot of things that were all dealing with. And we deal with it at different time frames. So it's very helpful to get input from other coordinators. There's nobody else in my district who's dealing with necessarily the same problems. Math coordinators not dealing with the same issues perhaps as science. And a lot of time has been spent by various coordinators across the state solving problems. So being able to talk about that, and what are you doing about this particular issue is very helpful. (Post Interview)

The opportunities to develop relationships at the NSCA allowed James to create a supportive network of coordinators. He had people in similar positions he could call on and consult when needed.

Cross-Case Similarities and Differences

The cases of these three coordinators provide insight into the role and practices of science coordinators in different types of districts. The stated job responsibilities of these coordinators were similar, but the scope and implementation of these responsibilities was quite different. The key similarities and differences are elaborated on in the sections that follow.

Teacher support. All three coordinators provided support to their teachers in multiple ways. They all sent some sort of newsletter or email on a regular basis and maintained a website of resources for teachers. They also supplied materials as needed or requested by teachers, did walk-throughs at school, and visited teachers as requested or needed by principals. The coordinators also held or attended committee meetings and department meetings on a regular basis.

The differences between the coordinators were in the form of how the coordinators provided teacher support. Alex's support was characterized as "limited" by the teachers. His role was more administrative and involved less day-to-day interactions with the teachers. Given the large size of Alex's district, this characterization of his support by teachers makes sense. Ann took a hands-on approach in supporting her teachers and was more involved in the day-to-day lives of her teachers, but her support was more focused on the elementary level. This may be a result of her elementary teaching background and comfort with working with teachers at these grade levels. Teachers in James' district described him as supportive yet unavailable due to his other responsibilities. The small size of James' district may contribute to the need for him to hold multiple positions; thus, limiting his ability and time to be available to his science teachers.

Professional development. The three coordinators perceived professional development as a means to improve student achievement and teacher understanding. While all three coordinators provided professional development to the teachers in their district, each coordinator implemented the professional development in different ways and focused on different topics. Alex felt effective professional development, similar to Ann and James, should be contextualized, practical, and provide immediate applications for teachers. Alex also perceived professional development should be sustainable and provide opportunities for teachers to give input into areas they would like to be addressed in the future. Ann believed teachers should be actively engaged in their learning, and James felt modeling was critical for professional development to be effective.

All three coordinators used formative data from professional development evaluations and state assessment data to determine areas in which teachers needed professional development. As a result of this analysis, Alex focused on inquiry, Ann focused on inquiry and selected certain schools in need of more targeted support, and James focused on NOS. Alex and James provided the majority of their professional development during the days prior to school starting or on in-service days during the school year. Ann provided professional development on these days, but also worked one-on-one with teachers in their classrooms when requested and provided after-school opportunities for teachers. Given the sheer number of teachers in Alex's district, he was also able to differentiate the professional development provided by grade level or content area. This was not always a possibility for Ann and James, because of a lack of staff and time to provide this type of professional development.

Practice alignment with VISTA NSCA goals. The science coordinators' practices aligned well with the goals of the VISTA NSCA (Table 5). All of them used data to inform their practice, whether to develop their strategic plans, to plan professional development, or to discover areas or schools where teachers needed more support. At the time of the study, the coordinators were also all in the process of writing and/or implementing a strategic plan, the components of which aligned with the VISTA NSCA goals.

Even though all three coordinators conveyed understandings about inquiry, NOS, and PBL that were well-aligned with the VISTA NSCA goals, they did not always transfer these understandings into their work with teachers. Alex and Ann focused on implementing professional development around inquiry for their teachers, while James focused on NOS. Alex felt NOS was abstract and that PBL was complicated to implement; thus, he did not have immediate plans to implement professional development around these two concepts. Ann frequently mentioned NOS in professional development she delivered but she often failed to address misconceptions or to indicate the importance of teaching NOS explicitly. James chose to focus on NOS as an area of professional development with his teachers because of his analysis of the data and the new emphasis on NOS in the Virginia standards. He indicated that he focused on inquiry in previous years' professional development, but had no plans to implement professional development around PBL. Thus, though they all held accurate understandings of the key VISTA constructs, they did not always transfer this knowledge into their practice.

Table 5
Alignment of Science Coordinator Practices with VISTA NSCA goals

VISTA NSCA Goals	**Alex**	**Ann**	**James**
1. Making improvements in leadership, teacher learning, quality teaching, and student learning.	X	X	X
2. Developing a common understanding of inquiry, nature of science, and problem-based learning.	X	X	X
3. Identifying aspects of effective science teaching and learning.	X	X	X
4. Comparing district models of creating standards-based science curricula.	X	X	X
5. Using data to improve district science programs.	X	X	X
6. Developing a science program strategic plan.	X	X	X
7. Developing relationships to build an infrastructure for science education in the state.		X	X

Finally, Ann and James valued the relationships they developed with other coordinators during the NSCA. They maintained these relationships after the NSCA and drew on them for planning professional development in their districts. Ann and James indicated the importance of the NSCA in helping them create a supportive network of coordinators which they had never had before. Alex did not seem to have the same experience in developing and maintaining relationships with other coordinators at the NSCA. The large size of Alex's district resulted in a staff of six assistant science coordinators. It is possible these relationships may have met Alex's need for support and networking and have been more convenient to maintain than relationships with coordinators from other districts.

Barriers. Alex, Ann, and James all encountered barriers in attempting to serve their teachers and districts. Not surprisingly, the coordinators, teachers, and principals from all of the districts indicated the focus on reading and mathematics testing limited the amount of time for science instruction at the elementary level (Surveys, Interviews). In fact, many of the principals and teachers indicated the science instruction time was limited to 20-30 minutes a day (Principal & Teacher Interviews). In one professional development observation in Ann's district, a teacher asked, "So how would I have the time to do this activity in my own classroom?" (Observation). The teacher was referring to the fact that the inquiry activity Ann had modeled for the teachers took 90 minutes. It was clear the teacher believed it was a worthwhile activity, but did not know how to translate it into her own classroom given the time constraints placed on her by her school. Ann responded by explaining how the teacher might break up the lesson into three parts that would allow the teacher to do it over three days (Observation). Observations of James and Alex revealed similar concerns among teachers in their districts.

Additionally, science coordinators mentioned the lack of time they have for professional development and to work with teachers in their district. For example, James said, "It's very challenging because we do have very little professional development time, particularly contracted time, like professional development days." (Post-observation Interview). Limited time for professional development in James' district constrained his ability to work with and motivate teachers. This was similar to the experiences of Ann and Alex. The coordinators also noted that they did not have the power to require teachers to attend the optional professional development (Interviews). Thus, they found it difficult to reach all teachers in meaningful, successful ways.

The content-focus of optional professional development offered was another issue across districts. For instance, one of Ann's teachers, Kelly said, "When she does professional development she has to make it K through 5 and that's more generic. Because of that it's harder to apply and adapt it immediately to my classroom." (Teacher Interview). Coordinators found contextualizing professional development and making it interesting and relevant to teachers to be critical, especially if the professional development is optional. James also indicated on professional development days he was "responsible for K through 12"; therefore, his ability to give his teachers the contextualized professional development they desired and wanted was limited (Post-observation Interview). These barriers severely limit the opportunities coordinators had to work with and support teachers in their practice.

Finally, different from Alex and James whose backgrounds were both secondary, Ann's background as an elementary teacher was a constraining factor in her work as a coordinator. Despite Ann's 28 years of elementary experience, she struggled to gain respect from and work effectively with the secondary teachers (Interviews, Observations). Ann had a wealth of knowledge in curriculum, instruction, and behavior management, but the secondary teachers had difficulty understanding how she could support them (Interviews, Observations). Thus, Ann focused on thinking about ways to develop these relationships and even sought out other presenters for professional development with her secondary teachers (Post-observation Interview).

Discussion

This study investigated how science coordinators supported teachers and planned for and implemented professional development after participating in the VISTA NSCA. Through these case studies, we sought to understand how their practices aligned with the goals of the VISTA NSCA. The results suggest the situated nature of the NSCA influenced participants' practices to better align with the goals of the NSCA. However, many factors influenced the coordinators ability to do so and these are discussed in more detail below.

Critical Factors Influencing Coordinator's Practices

The district context and coordinators' backgrounds had a noteworthy impact on the science coordinators' practices. The size of the district and the background of the coordinators influenced their ability to provide support and professional development to teachers.

District context. The size of the district appeared to play an important role in how the participants supported and provided professional development to their teachers. The large size of Alex's district allowed him to differentiate professional development for specific grades and content areas. This allowed the professional development to be highly contextualized and relevant to the teachers, making the likelihood of teacher change more probable (Birman, Desimone, Porter, & Garet, 2000; Desimone, 2009; Kennedy, 1999; Loucks-Horsley & Matsumoto, 1999). This supports Ingersoll's (2003) findings that large districts have a greater capacity for high-quality professional development. The smaller size of Ann and James' districts did not allow this type of differentiated professional development. This suggests a need for coordinators in smaller districts to be more creative in how they think about contextualizing professional development for their teachers.

The small size of James' district required him to take on more responsibilities. He worked as both a science coordinator and a testing coordinator, which limited the time he had to do the work of a science coordinator. Thus, the available time he had to support and work with science teachers outside of the regular professional development days was constrained. This indicates that science coordinators in small districts who have to take on other roles may not have the time or resources to support their teachers in improving instruction. This finding refines other studies suggesting that science coordinators have a positive impact on teacher instruction (Tracy, 1993). Rather, the impact of science coordinators may vary depending on district size due to other roles science coordinators are required to undertake.

One might expect a science coordinator in a small district to have the greatest one-on-one interaction with his or her teachers. Surprisingly, this was not the case in our study. Unlike James, who had to take on additional responsibilities beyond that of science coordinator, the medium size of Ann's district had sufficient infrastructure to allow her to be involved in working one on one with teachers in her district. These opportunities allowed her to attend to teachers' immediate classroom needs. This allowed Ann to incorporate more characteristics of effective professional development such as content-focus and coherence (Birman et al., 2000; Desimone, 2009). Ann was able to tailor the content of professional development specifically to the needs of the teachers she worked one-on-one with, and she was able to provide support for the specific goals of the teachers within the context of the individuals' schools giving it coherence. Teachers in the Rogers et al. (2007) investigations indicated classroom application and teacher as learner were professional development strategies that helped support them in their teaching. Similarly, our results seem to indicate the teachers in Ann's district perceived these strategies as effective as well.

Coordinator background. Each science coordinator's teaching background appeared to have considerable impact on how coordinators supported and provided professional development to teachers. Alex and James were both previously secondary science teachers and felt confident in supporting all K-12 teachers. Their experience with science content areas at the secondary level allowed them to have the necessary knowledge to support the elementary teachers as well. Ann's background in elementary, while extensive in curriculum and instruction, appeared to limit her capacity to support all of the secondary science content areas. Ann did not appear to have the content knowledge needed to support all of the secondary content areas. It is possible that over time she will develop a rapport with secondary teachers in her district that will allow her more access and opportunities to support them in the classroom. Research suggests teachers become more confident and effective in their roles over time (Berliner, 2001; Henry, Bastian, & Fortner, 2011), this would seem to confirm our hypothesis that Ann may be able to do the same. Regardless, the background of the science coordinators seems to be a critical factor in their ability and success in supporting all teachers.

The Influence of Situated Learning on Coordinator's Practices

McLellan's (1996) situated learning model served as a theoretical framework for VISTA NSCA. Results suggest the situated nature may have helped coordinators' transfer of inquiry and/or NOS professional development, using data to make decisions, writing and implementing a strategic plan, and the creation of relationships with other coordinators into their own practices. This is discussed in more detail below.

Coordinator practices. Although science coordinators' inquiry, NOS, and PBL understandings were aligned with the goals of the VISTA NSCA, not all of the science coordinators embedded some of these components into their own professional development and support for teachers. Alex focused on inquiry, Ann on inquiry with some NOS, and James focused on inquiry in previous years, but was currently emphasizing NOS in professional development. Inquiry was an area all three coordinators were implementing or had implemented in professional development. This may indicate inquiry is a practice science coordinators value and believe will help to increase student achievement. Research on the implementation of inquiry is extensive (Hmelo-Silver, Duncan, & Chin, 2007; Kirschner, Sweller, & Clark, 2006; Minner, Levy, & Century, 2010); it is a reform-based practice that stressed in many reforms-based documents (NRC, 1996; NRC 2000; NRC, 2007; NRC, 2012); and it is an area where teachers often encounter barriers (Anderson, 2002; Keys & Bryan, 2001). Consequently, it is not surprising that all three coordinators made an effort to focus on inquiry in the professional development they provided.

Research on NOS indicates that teachers often lack understanding of NOS (Akerson, Morrison, & McDuffie, 2006; Smith & Anderson, 1999; Tsai, 2002) and have difficulty in addressing NOS in classroom instruction (Abd-El-Khalick, Bell, & Lederman, 1998; Bell, Lederman, & Abd-El-Khalick, 2000). Likewise, Alex felt the concept was abstract and difficult to implement in professional development with teachers and Ann seemed to still be developing her confidence in teaching NOS herself. These results support the existing literature on NOS that teachers struggle with translating their understandings into instructional practice (e.g., Abd-El-Khalick et al., 1998; Akerson & Abd-El-Khalick, 2003; Trumbull, Scrano, & Bonney, 2006). However, the results of the present study extend this body of literature by exploring the understandings and practices of science coordinators charged with providing professional development to support science teachers' reforms-based practices. Therefore, the VISTA NSCA implementers may need to consider how to emphasize and provide more contextualized support around NOS.

The same may also be true of PBL as science coordinators did not have plans to implement professional development around this practice. Research indicates that teachers perceive PBL implementation to be difficult and encounter many barriers in their attempt to use PBL in their classroom instruction (Ertmer & Simons, 2006; Ertmer et al., 2009; Frykholm, 2004; Hmelo-Silver, 2004). Similarly, Alex viewed PBL as more complicated than inquiry or NOS instruction. Given that elementary teachers who participate in VISTA ESI spend 4-weeks learning to design and implement PBL in their own instruction, it may be that science coordinators viewed this practice as too difficult to implement in the amount of time they have allotted to work with teachers.

Similar to other areas of science teacher education research (e. g., Anderson, 2002; Jorgenson, MacDougall, & Llewellyn, 2003; Keys, 2001), the science coordinators in this study encountered barriers as a result of reduced time for science instruction at the elementary level due to state mandated testing. In fact, 27% of elementary schools feel there is insufficient time to teach science (Banilower et al., 2013). The effects of state mandated testing and the subsequent benchmark tests districts mandate to prepare for these tests appear to significantly reduce the amount of time teachers have for science instruction. Science coordinators attempted to incorporate science instruction with other subject areas and to provide teachers with creative ways to address their science standards despite their lack of time for instruction. Just as teachers lack time for science instruction, science coordinators lacked contracted professional development time with teachers. Research indicates professional development is more effective when it is sustained and on-going (Birman et al., 2000). Our findings indicate science coordinators may struggle with finding ways to make professional development of significant duration, possibly indicating that the professional development they are providing could be more effective.

Alignment with NSCA goals. Collaboration incorporated into the VISTA NSCA resulted in the science coordinators having the opportunity to work one another and cement relationships with other coordinators. All three coordinators indicated the NSCA was a unique opportunity to meet and network with other coordinators. These relationships provided a continued network of support for the coordinators. Our findings extend research on teacher professional growth that found working in isolation can be an inhibitor to teacher learning (Little, 1982) and that teacher learning can be suppressed without continual interactions (Gallagher & Ford, 2002). The collaborative nature of the NSCA provided a chance for coordinators to create relationships with peers and to maintain the support network they developed. It may be that science coordinators focused on this aspect of the NSCA because it was a unique opportunity to work with peers and a new experience for the coordinators who attended.

Articulation of learning skills also seemed to have an effect on the coordinators' transfer of learning. The integration of this component into the VISTA NSCA resulted in the science coordinators successfully using data to inform their practice, writing and implementing strategic plans, developing aligned understandings of inquiry, NOS, and PBL. During the NSCA, coordinators frequently engaged in discourse about their practice, shared their successes, failures, and questions, problem-solved, and discussed how what they were learning might aid them in their practice. These conversations were collaborative in nature and aided in the cementing of relationships as well. Research on teacher development found opportunities for teachers to discuss their successes and mistakes can allow them to learn from one another and grow professionally (Boyd, 1992). The findings of our study emphasize that these type of discussion opportunities are not only important for teacher professional growth, but for science coordinators as well.

Despite the clear effects of collaboration and articulation of learning skills on science coordinators' transfer of learning, the components of reflection, opportunities for multiple practice, coaching, and cognitive apprenticeship did not appear to have a similar impact. It may be the uniqueness of the collaboration and opportunity to articulate learning skills with peers were the most exciting aspect of the NSCA for coordinators. If so, it may be that these other aspects still had an impact but were not mentioned by the coordinators due to their enthusiasm around these other opportunities. The integration of collaboration and the articulation of learning skills were almost hourly in the NSCA; thus, this may be another reason coordinators mentioned these aspects. The failure of coordinators to fully transfer their understandings of NOS and PBL into their professional development practices may be influenced by the fewer opportunities for multiple practice around these constructs and a similar lack of cognitive apprenticeship.

These results indicate developing professional development that employs a situated learning instructional model may facilitate transfer. In particular, the components of McLellan's model that appears to be most important in facilitating transfer were collaboration and the articulation of learning skills.

Implications

The findings of this study suggest district size, science coordinator background, and embedding opportunities for collaboration into professional development influence the support and professional development science coordinators provide to teachers. Science coordinators in smaller districts may need more support in thinking about how to differentiate and contextualize professional development for their teachers because they lack the resources to have professional development by grade level or specific content areas. Districts should consider the importance of having science coordinators who are focused on particular age groups (i.e. elementary vs. secondary). This may allow for their support and professional development to have more coherence and be more content-focused. However, given the fiscal limitations of many small districts, this may not be feasible. Thus, professional development programs designed to support science coordinators in areas where they do not have background or experience may be helpful. For example, Ann may have benefited from professional development regarding secondary education and/or content areas at the secondary level to help her relate to and work with secondary science teachers.

Given the barriers science coordinators encountered in their practice, implementers may need to include discussion opportunities for coordinators to address the minimized time for science instruction at the elementary level due to state mandated testing. Doing so may allow coordinators the chance to discuss and brainstorm ways to support teachers despite this barrier. Additionally, the lack of contracted time for professional development with teachers may limit the effectiveness of professional development science coordinators can provide. Implementers may need to consider how they can support coordinators in finding resources to support additional professional development within their districts. It may help for coordinators to receive some training in searching for and writing grants to support work in their district.

The findings of this study also provide suggestions for the implementation of professional development programs designed for science coordinators. Well-designed programs utilizing a situated learning model in professional development, specifically integrating collaboration and the articulation of learning skills, may have positive impacts on the transfer of learning. Implementers may also need to consider the reality and ability of science coordinators to transfer their learning into practice. For example, the professional development around inquiry was easily transferred into the coordinators' practice. NOS professional development may need to be contextualized further and provide more opportunities for coordinators to practice. Doing so may provide those coordinators with less confidence the chance to further develop their understanding and desire to implement it with their teachers. Thus, the implementers may need to consider how they support and provide resources for coordinators around PBL. Despite coordinators' apparent increased understanding of PBL, they did not transfer this understanding into their practice. Science coordinators may need more time to process how they implement professional development for PBL or more support in thinking about how they might transfer what VISTA does for teachers into a setting designed for less time and more teachers. It may also help coordinators to be provided more opportunities for cognitive apprenticeship around NOS and PBL.

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Appendix A.

NSCA Pre-Perceptions Short-Answer Questions

1. Please define inquiry instruction. Describe what teachers and students are doing during a typical activity that emphasizes science inquiry.

2. Please define nature of science instruction. Describe what teachers and students are doing during a typical activity that emphasizes nature of science.

3. Please define problem-based learning. Describe what teachers and students are doing during a typical activity that emphasizes problem-based learning.

Appendix B.

Additional Open-ended Questions on the Post-NSCA Perceptions Survey

Please answer the following questions completely.

1. What previous professional development experiences (if any) have you had that addressed topics that were covered in the VISTA New Science Coordinators Training? If you have participated in such professional development experiences, how does the VISTA New Science Coordinators Academy compare to these previous professional development experiences (if any)?

2. What are the most important content and strategies that you have learned through this professional development experience? (Please describe as many as apply).

3. How will you (or have you) use(d) the content, materials, and/or strategies that you learned in this professional development experience? (Please describe as many as apply).

4. What suggestions do you have for the instructors as they plan for future delivery of the VISTA New Science Coordinators Academy?

Appendix C.

Additional Open-Ended Questions on the Delayed-Post NSCA Perceptions Survey

Please answer the following questions **in their entirety** in terms of VISTA NSCA's components (five days of professional development at GMU, a dropbox of resources, and attendance at the VSELA conference).

1. Which components of the VISTA NSCA did you find to be the most valuable? Why?

2. Describe any components of the VISTA NSCA that you did not find valuable. Why?

3. In the past year, how have you used the content, materials and/or strategies from the NSCA components (professional development at GMU, dropbox resources, VSELA attendance)?

4. Describe the relationship between the VISTA NSCA and your ability to perform your duties as a science coordinator.

5. Thinking about your responses to Question 3, estimate the numbers within each population **<u>directly</u>** impacted by your activities:
   Inservice teachers: ____
   PK-12 students: ____

6. Thinking about your responses to Question 3, estimate the numbers within each population **indirectly** impacted by your activities:
   Inservice teachers: ____
   PK-12 students: ____

7. A. What types of professional development have you offered/do you plan to offer to your teachers/districts this year? (Please provide dates for these professional development experiences if known.)
   B. What topics did this professional development address?
   C. If the VISTA NSCA impacted the offering, describe how (e.g. used materials from NSCA, provided the idea for the session, etc.)?

8. Describe any interactions you have had with teachers from your district who are participating in the VISTA program (either on treatment or control teams).

9. If VISTA were to offer a follow-up to the VISTA New Science Coordinator Academy, would you attend? Why or why not? What format would you suggest for a follow-up? What topics would you like to see addressed in a follow-up?

Appendix D.

Post-NSCA Science Coordinator Interview

1. What is your role in the district? Describe the leadership skills you feel are needed to be effective in this role.

2. Which components of the VISTA New Science Coordinator Academy did you find to be most valuable? Why?

3. Describe any components of the VISTA New Science Coordinator Academy that you did not find valuable. Why?Which components of the VISTA New Science Coordinator Academy have you implemented this year? In what ways?
   Let interviewee respond to the above general question, then follow-up with prompts to explore his/her plans regarding the following NSCA components:
   -inquiry instruction support
   - nature of science instruction support
   - problem-based learning instruction support
   -strategic planning strategies
   -indicators of high-quality science instruction
   - planning professional development
   - using data to support high-quality science instruction

4. How do you interact with principals in your district? With teachers? With VISTA coaches?

5. What types of professional development have you offered/are you planning to offer for the teachers in your district?
   PROBE: Describe any role the VISTA New Science Coordinator Academy played in your planning of this professional development.
   PROBE: Probe participants to address the following if not stated in description of professional development: coherence, duration, content-focus, active-learning, and collaboration.

6. Describe the strategic plan for science your district.
   PROBE: Is it possible to get a copy of this plan?

7. Can you describe the relationship, if any, between data and program decisions about science instruction?
   PROBE: Can you describe the relationship, if any, between data analysis and change in student achievement?

8. What, if any, is the relationship between VISTA and your practice as a Science Coordinator? PROBE: In what ways has it been effective? If not, why do you think so?

9. How would you characterize your interactions with other science coordinators from the Academy since the end of the VISTA NSCA?
   PROBE: To what extent have you continued to use the NSCA Resources for Science Coordinators DropBox?
   PROBE: Are there any other resources/ways you have interacted with other science coordinators? If so, what and in what ways?

10. If VISTA were to offer a follow-up to the VISTA New Science Coordinator Academy, would you attend? Why or why not?. What format would you suggest for a follow-up? What topics would you like to see addressed in a follow-up?

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

Appendix E.

Post-observation Science Coordinator Interview

1. What do you think are the characteristics of effective professional development?
    a. Can you give an example of professional development you've done or planned that aligns with these characteristics?
        i. Describe how you think this aligns with these characteristics.
    b. In what ways, if any, do these characteristics align with what you learned in the NSCA?
2. When planning professional development, how do you decide what topics to address? [Possible probes: student achievement data, teacher input, what you know from research, SOLs/standards, district curriculum goals]
    a. What is your approach for addressing the topics you identify as important in PD given the limited amount of time you have with teachers across the year?
3. Do you bring in outside presenters to do PD in your district?
    a. If so, what type of preparation do outside presenters have for professional development in your district?
    b. How do you pick who to ask to present?
    c. How do you communicate your goals of the PD with them?
    d. How consistent would you say they are in meeting your goals? Example?
4. How does the district approach improving student science achievement?
    a. How do you support teachers to increase student achievement in their classes?
    b. Is it through professional development for teachers? Example?
    c. Is it working directly with students? Example?
5. How do you get buy-in from teachers, principals, and central administration to support the science strategic plan in your district?
6. What, if anything, are the strengths about the size/location of your district as pertinent to science instruction?
7. What, if anything, are the weaknesses of the size/location of your district as pertinent to science instruction?
8. Any clarification questions about their job description.
9. Who do you work with on a regular basis?
    a. What are their roles?
    b. How many people, if any, do you directly supervise?
10. How is your job description aligned with what you actually do?
11. What do you think would make you more effective at your job?
    a. Is there a certain type of support you wish you had?
    b. From whom?
12. What prior knowledge and/or experiences do you think individuals who serve as science coordinators need to be effective in this position?
    a. Why do you think these qualifications are necessary?

Appendix F.

NSCA School-level Principal Follow-up Interview

This interview is designed to explore your experience with your science coordinator. It will be tape-recorded for transcription and then blinded.

1. Did you attend the VISTA ESI?
    a. If so, did you implement anything you learned at the VISTA ESI in your school? Describe this.

2. Describe your interactions with your science coordinator during the VISTA ESI.
    a. Did they attend?
    b. Were they engaged? Can you give examples?

3. Describe any professional development planned by your district/science coordinator this year with teachers at your school.
    a. Describe your relationship with the science coordinators in supporting this planned professional development.
    b. If you attended the VISTA Elementary science institute, did you see connections between this professional development and VISTA? If so, in what ways? If not, how was it different from VISTA?

4. How would you characterize your interactions in terms of support with the science coordinator this school year?
    a. Can you give examples?

5. How would you characterize any changes you might have seen in your science coordinator's practice this year?
    a. Can you give examples?

6. How would you characterize the outcomes of the VISTA program in your school this year? Have they been what you expected?

7. How would you define a professional learning community?

8. Can you describe the relationship between professional learning communities and the VISTA teachers who attended the ESI together?

9. Describe the confidence level of the VISTA teachers in teaching science.
    a. Describe any changes you have seen compared with last year.

10. Describe any changes in attitude toward science in your school or district this year compared to previous years.
    a. Has there been a shift? If so, why do you think?

b. Describe any changes you’ve seen in the amount of science curriculum integration with other subjects compared to previous years.

11. Describe any interactions you have had with VISTA coaches this year.
    a. In what ways have you seen the VISTA coaches support your teachers?
    b. Describe the effectiveness of the coaching relationship.

Appendix G.

NSCA School-level Teacher Follow-up Interview

This interview is designed to explore your experience with your science coordinator. It will be tape-recorded for transcription and then blinded.

1. Describe your interactions with your science coordinator and principal during the VISTA ESI.
    a. Did they attend?
    b. Were they engaged?
    c. Can you give examples?

2. How would you characterize your interactions with your principal and science coordinator this school year?
    a. Describe your interactions with your science coordinator this year.
    b. Describe your interactions with your principal this year.

3. Describe any changes you've seen in your science coordinator's practice this year.

4. Describe any changes you've seen in your principal's practice this year related to science instruction.
    a. Can you propose any reasons for any changes you've seen?

5. Describe any professional development planned by your district/science coordinator this year.
    a. What's the relationship of VISTA to this professional development?
    b. What's been the outcome of your participation in this professional development? Provide examples.

6. What outcomes of the VISTA program in your school have you seen this year? Have they been what you expected?

7. How do you define a professional learning community?

8. How do you characterize a professional learning community with regard to how you work with the other VISTA teachers at your school?

9. Can you describe the relationship between your confidence level in teaching science and your participation in VISTA this year?
    a. Has it changed since last year? If so, how? If not, why?
    b. If it has changed, what do you think caused it?

10. Describe any changes in climate toward science and science instruction in your school this year compared to previous years.

a. Has there been a shift? If so, why do you think?
b. Describe any changes you've seen in the amount of science curriculum integration with other subjects compared to previous years.
c. Can you characterize the role of VISTA in this change?

11. Describe any interactions you have had with your VISTA coach this year.
    a. In what ways has your VISTA coach supported your science instruction?
    b. Describe the effectiveness of the coaching relationship.