EXPLORING THE CRITICAL ROLE OF A DISTRICT SCIENCE COORDINATOR

A Dissertation

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By

Brooke A. Whitworth

B.A., William Jewell College

M.A.Ed., Wake Forest University

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ABSTRACT

This dissertation, a three-paper set, explored the critical role of a district science coordinator in supporting teacher learning. The first paper examined the literature on effective professional development, teacher change, and the factors influencing teacher change. The review identified the role of school and district leaders as a critical factor missing from the professional development models. School district leaders are not just a contextual factor influencing teacher change, but through professional development and ongoing leadership support they are an integral part of the process and should be included in professional development models.

The second and third papers assessed the outcomes of the Virginia Initiative for Science Teaching and Achievement (VISTA) New Science Coordinator Academy (NSCA) professional development. The second paper investigated the changes in science coordinators' understandings and practices following their participation in the NSCA. Pre-, post-, and delayed-post survey responses, follow-up interviews, and observations of the professional development and of science coordinators at work in their district were collected from 28 participants in the first and second year cohorts. Results suggested science coordinators' understandings changed and were aligned with the goals of the NSCA. However, their practices did not fully reflect their understandings about pedagogy. Participants also indicated they had little power within their districts which hindered their ability to affect change; therefore, professional development efforts may need to also include other district stakeholders.

The third paper, a qualitative case study of 3 purposefully selected VISTA science coordinators from 3 different districts, explored each coordinator's design and implementation of professional development and their practices supporting science teachers' instruction. Observations of science coordinators at work, surveys, artifacts, and interviews with science coordinators, principals, and teachers were collected and analyzed using a constant comparative approach. Results suggested coordinators supported teachers through a variety of methods and an array of professional development strategies. District characteristics and science coordinator teaching background were critical factors influencing their practice. Despite differences, all 3 coordinators' practices aligned with most of the goals of the NSCA.

Department of Curriculum, Instruction, and Special Education
Curry School of Education
University of Virginia
Charlottesville, Virginia

APPROVAL OF THE DISSERTATION

This dissertation, Exploring the Critical Role of a District Science Coordinator, has been approved by the Graduate Faculty of the Curry School of Education in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

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Randy L. Bell, Co-Chairperson

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Jennifer L. Chiu, Co-Chairperson

____
Carol A. Tomlinson, Committee Member

____
Jennifer L. Maeng, Committee Member

March 28, 2014

DEDICATION

To my amazing parents, Mark and Linda Whitworth.

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CHAPTER ONE

Introduction

The major focus of educational reform today is on student learning of standards set by each state. The ultimate goal of No Child Left Behind is for all districts to be held accountable for student achievement by measuring progress against state standards. In recent years, STEM education at the elementary and secondary levels has been identified as an area where the United States is falling behind other nations (President's Council of Advisors on Science and Technology [PCAST], 2010). In order to remain a leader among nations, the United States must find a way to improve not only student achievement, but also student interest in STEM education (PCAST, 2010).

A vital component of national efforts to increase student learning is the professional development of science teachers (Desimone, Porter, Birman, Garet, & Yoon, 2002; Hewson, 2007; PCAST, 2010). Professional development programs have the ability to make powerful and sustaining changes in teacher practice (Desimone et al., 2002; Kennedy, 2005; Luft, 2001; Supovitz & Turner, 2000) resulting in an increase in student achievement (Buczynski & Hansen, 2010; Desimone, 2009; Johnson, Khale, & Fargo, 2007; Wallace, 2009; Yoon, Duncan, Lee, Scarloss, & Shapley, 2007). School districts play a key role in providing professional development to teachers and are often the principal providers of professional development (Birman et al., 2007; Pianta, 2011). District administrators experience pressure from states, school boards, teachers, parents, and their communities to show improvement in student achievement. Thus, curriculum and instruction administrators are constantly searching for reform efforts that will improve student learning and satisfy these multiple stakeholders. The individuals often responsible for implementing professional development and supporting these reform efforts for science curriculum are science coordinators.

Many large school districts employ a science curriculum administrator, such as a science coordinator, director of STEM education, or science supervisor, who is responsible for coordinating science curriculum at the district level. However, many small or rural school districts lack the financial resources to hire science curriculum administrators. In these districts, the task of coordinating curriculum may fall to a global curriculum and instruction director or a science lead teacher. These individuals, who work at the district level, can see the whole picture, whereas a principal focuses on building level issues. Regardless of who is responsible for the science curriculum within a district, the role these individuals play is critical to improving student achievement (Marzano, Waters, & McNulty, 2005).

While the characteristics of effective professional development are well-documented in the literature, (Desimone, 2009; Hewson, 2007; Luft & Hewson, 2013), little research explores the individuals who plan and conduct professional development and how they do it (Luft & Hewson, 2013). PCAST (2010) recommended research investigate the role of educational leadership in science to gain further knowledge about how educational leaders are supported through professional development programs. From past research, we know teachers and science coordinators perceive the coordinator role differently (Madrazo & Hounshell, 1987; Perrine, 1984). Teachers appear to have higher expectations for coordinators than the coordinators themselves, and teachers need and want support for their science instruction from science coordinators (Perrine, 1984). Science coordinators have an impact on how and whether teachers choose to use instructional resources (Lee, Leary, Sellers, & Recker, 2013) and they provide specific support with science curriculum (Knapp & Plecki, 2001). However, these studies did not investigate how science coordinators interact with other stakeholders in the district or how their science instructional support is implemented. Furthermore, these studies did not investigate the support science coordinators may themselves need in order to develop professionally.

Statement of the Problem

Despite initial evidence supporting the critical nature of the district science coordinator role, the research in this area is meager and outdated. Research needs to investigate the role of district science coordinators in supporting teacher change and student learning. Investigations also need to explore the professional development science coordinators receive and how these experiences may affect changes in science coordinator understandings and practices. Additionally, there is a need to examine how science coordinators provide ongoing support to teachers and plan for and provide professional development to teachers. The three studies that comprise this dissertation begin to address these deficits in the current literature base, as outlined below.

A review of the literature (Chapter Two) situates the critical role of a district science coordinator within the research on professional development, teacher change, and ongoing leadership for teacher change. The review synthesizes the findings of the literature on the characteristics of effective professional development and links to teacher change, as well as student achievement. It also considers the factors influencing teacher change, including the influence of ongoing leadership. This review suggests that professional development models should integrate district science coordinators as an essential component and not just another peripheral, contextual factor.

The study documented in chapter three examines the professional development science coordinators receive. This study investigates changes in 28 district science coordinators understandings and practices after attending a state-wide professional development designed specifically for science coordinators. The effectiveness of this professional development opportunity was evaluated based on the changes experienced by the coordinators. This study is significant as it is the only study, to our knowledge, investigating a professional development opportunity designed specifically for science coordinators. Understanding the role this type of professional development may play in supporting science coordinators is a first step in gaining insight into how they support teachers and the barriers they may encounter.

A more in-depth look at the role of a science coordinator within a district further explored how science coordinator support is enacted within a district (Chapter Four). A qualitative case-study of three different school districts in Virginia investigated how science coordinators support teachers, plan for and implement professional development, and whether their practices aligned with the goals of the professional development the coordinators attended. In this study, three district science coordinators as well as principals and teachers from the districts served as the cases.

These studies are important as they represent the few examples of research that investigate the role of a science coordinator and the impact science education leadership may have on teacher change and student learning.

Significance of the Studies

Together, the implications and results from the three studies reported in this dissertation address important shortcomings in the literature associated with science coordinators and to build a foundation for future research in this area. This paper set represents a systematic evaluation of the critical role of a district science coordinator and captures a detailed perspective of the science coordinator role within a district. It provides insight into how science coordinators support teachers' instruction and provide professional development, and the barriers they encounter in doing so. It also examines the critical factors influencing science coordinators' practice within a district. Additionally, it identifies professional development aligned with a situated learning model designed specifically for science coordinators as an effective method in facilitating transfer of knowledge to new settings. Overall, this work begins to explore and present an in depth view of the critical role of a district science coordinator.

References

Birman, B., Le Floch, K. C., Klekotka, A., Ludwig, M., Taylor, J., Walters, K., Wayne, A., Yoon, K. (2007). *State and local implementation of the No Child Left Behind Act: Vol. 2. Teacher quality under NCLB: Interim report.* Washington, DC: U.S. Department of Education; Office of Planning, Evaluation and Policy Development; Policy and Program Studies Service.

Buczynski, S. & Hansen, C. B. (2010). Impact of professional development on teacher practice: Uncovering connections. *Teaching and Teacher Education, 26,* 599-607.

Desimone, L. M., Porter, A. C., Birman, B. F., Garet, M. S., & Yoon, K. S. (2002). How do district management and implementation strategies relate to the quality of the professional development that districts provide to teachers? *Teachers College Record, 104*(7), 1265-1312.

Desimone, L. M. (2009). Improving impact studies of teachers' professional development: Toward better conceptualizations and measures. *Educational Researcher, 38*, 181-199.

Hewson, P. W. (2007). Teacher Professional Development in Science. In S.K. Abell & N.G. Lederman (Eds.), *Handbook of research on science education.* London: Lawrence Erlbaum & Associates, Publishers.

Johnson, C. C., Kahle, J. B., & Fargo, J. D. (2007). A study of the effect of sustained, whole-school professional development on student achievement in science. *Journal of Research in Science Teaching, 44*, 775-786. doi:10.1002/tea.20149

Kennedy, M. M. (2005). *Inside teaching: How classroom life undermines reform.* Cambridge, MA: Harvard University Press.

Knapp, M. S., & Plecki, M. L. (2001). Investing in the renewal of urban science teaching. *Journal of Research in Science Teaching*, *38*, 1089-1100.

Lee, V. R., Leary, H. M., Sellers, L., & Recker, M. (2013). The Role of School District Science Coordinators in the District-Wide Appropriation of an Online Resource Discovery and Sharing Tool for Teachers. *Journal of Science Education and Technology*, 1-15.

Luft, J. A. (2001). Changing inquiry practices and beliefs: The impact of an inquiry-based professional development programme on beginning and experienced secondary science teachers. *International Journal of Science Education, 23*, 517-534.

Luft, J. A. & Hewson, P. W. (2013, in press). Research on teacher professional development programs in science. In In S.K. Abell & N.G. Lederman (Eds.), *Handbook of research on science education (Second Edition).* London: Lawrence Erlbaum & Associates, Publishers.

Madrazo, G. M. & Hounshell, P. B. (1987). Science supervisor: Results of research in science supervision. *Science Education, 71*(1), 9-14.

Marzano, R. J., Waters, T., & McNulty, B. A. (2005). *School leadership that works: From research to results.* Denver, CO: Mid-continent Research for Education and Learning.

Perrine, W. G. (1984). Teacher and supervisory perceptions of elementary science supervisors. *Science Education, 68,* 3-9.

Pianta, R. C. (2011). Teaching children well: New evidence based approaches to teacher professional development and training. *Center for American Progress, 11,* 1-36.

President's Council of Advisors on Science and Technology (2010). Prepare and Inspire: K-12 Education in Science, Technology, Engineering, and Math (STEM) for America's Future. Retrieved from http://www.whitehouse.gov/sites/default/files/microsites/ostp/pcast-stem-ed-final.pdf

Supovitz, J. A., & Turner, H. M. (2000). The effects of professional development on science teaching practices and classroom culture. *Journal of Research in Science Teaching, 37*, 963–980.

Wallace, M. R. (2009). Making sense of the links: Professional development, teacher practices, and student achievement. *Teachers College Record, 111*, 573-596.

Yoon, K. S., Duncan, T., Lee, S. W.-Y., Scarloss, B., & Shapley, K. (2007). *Reviewing the evidence on how teacher professional development affects student achievement* (Issues & Answers Report, REL 2007–No. 033). Washington, DC: U.S. Department of Education, Institute of Education Sciences, National Center for Education Evaluation and Regional Assistance, Regional Educational Laboratory Southwest.

CHAPTER TWO

LITERATURE REVIEW

Professional Development and Teacher Change: The Missing Leadership Link

Brooke A. Whitworth

Abstract

Professional development is the main method used to support teacher learning with the ultimate goal of improving student achievement. A multitude of factors influence teacher change and the effectiveness of professional development. This review of the literature explores these factors and identifies school and district leaders as a critical factor missing from the professional development models. School and district leaders play a significant role in the planning and implementation of professional development, as well as providing ongoing leadership to support teacher change. Considering this role, school district leaders are not just a contextual factor, but rather an integral part of the process and should be integrated into and considered part of any professional development model.

Introduction

Professional development aims to improve teacher learning and practices, and ultimately students' learning, specifically in science (Loucks-Horsley, Love, Stiles, Mundry & Hewson, 2010; Fishman, Marx, Best, & Tal, 2003). Professional development in the United States is estimated to cost $1 billion to $4 billion per year (Wilson, 2013). Teachers in the United States have access to a multitude of professional development opportunities including mentoring, national, state, and local conferences, content specific courses, summer institutes, school-based opportunities provided by schools or districts, research experiences, and coaching (Pianta, 2011; Wilson, 2013). While teachers believe professional development can support them in becoming more effective teachers and that by attending professional development their students will benefit (Luft & Hewson, 2013; Whitehurst, 2002), not all professional development results in teacher change. What is the difference between those opportunities that result in teacher change and those that do not? Why do teachers change their practice in some cases? Why does some professional development result in increases in student achievement and not others? Given the amount of resources being spent on professional development in this country, it is critical we answer these questions and seek to align the research we have on professional development with the needs of teachers in the classroom.

To illustrate a conceptual framework for studying the effects of professional development on teachers and students, Desimone (2009) used a path model to reflect the links between professional development, teacher knowledge, practice, and student achievement. This model suggests effective professional development can result in teacher learning and teacher changes in attitudes and beliefs, which leads to subsequent changes in teacher practices. Ideally, these changes then lead to increased student achievement. Desimone's (2009) model sets this path within a context of teacher and student characteristics, curriculum, school leadership, and policy environment (Figure 1).

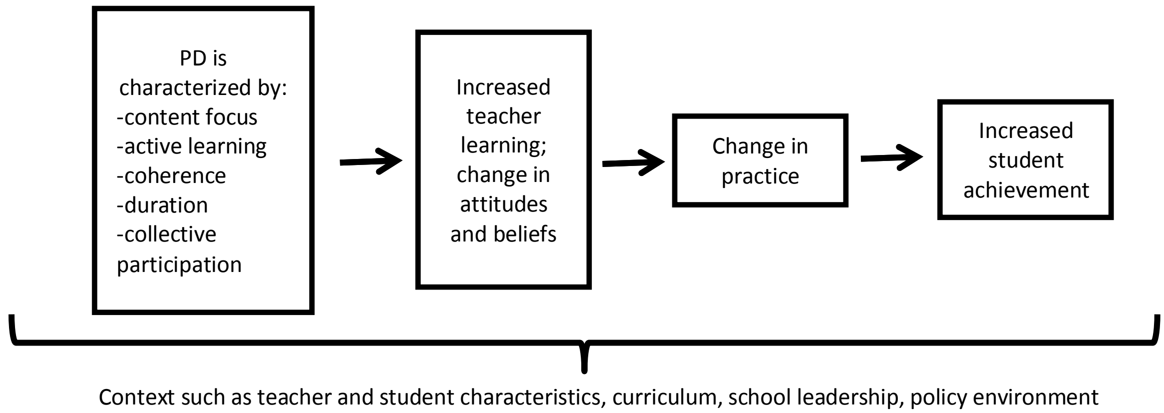

Figure 1. Model for studying the effects of professional development on science teachers and students (Modified from Desimone, 2009).

A vast amount of research exists on professional development and teacher change (Borko, 2004; Desimone, 2009). Several researchers have undertaken the process of completing meta-analyses and syntheses of the research (Hattie, 2008; Luft & Hewson, 2013; Stronge, 2010; Yoon, Duncan, Wen-Yu Lee, Scarloss, & Shapley, 2007). From these studies it is evident there is a relationship between professional development and teacher change, and between teachers and student achievement (Darling-Hammond, 1999; Guskey & Sparks, 1996; Stronge, 2010; Wallace, 2009). However, relatively few studies exist that address the role of the leaders who plan and implement professional development (Borko, 2004; Little & Wong, 2007; Luft & Hewson, 2013; Stein, Smith, & Silver, 1999). The present work utilizes Desimone's (2009) model as a framework for reviewing literature on the characteristics of effective professional development and links to teacher change, as well as professional development and student achievement. We then review the literature on the factors influencing teacher change and identify school and district leaders as a critical component in itself rather than a contextual factor of professional development.

Characteristics of Effective Professional Development and Teacher Change

Researchers generally agree that professional development should include active learning, a strong content focus, collective participation, be coherent and of a significant duration (Birman, Desimone, Porter, & Garet, 2000; Desimone, 2009; Garet, Porter, Desimone, Birman, & Yoon, 2001; Luft & Hewson, 2013). These characteristics are some of the design elements and conditions of professional development that are most successful in promoting teacher change and/or affecting student achievement (Borko, 2004; Garet et al., 2001; Knapp, 2003). Teacher change can be defined in a variety of ways. For the purposes of this review we define teacher change as change in teacher beliefs, understandings, and/or practices. This section synthesizes relevant literature around characteristics of effective professional development and discusses links to teacher change.

Active learning

To support teacher growth, teachers should be engaged actively in their own learning (Desimone, 2009; Guskey, 1997, 1999; Sparks, 1994, 1995) and reflect upon their own understanding and practice (Heller, Daehler, Wong, Shinohara, & Miratrix, 2012). Professional development can support active learning in a variety of ways, including: observing other teachers, practicing what has been learned and receiving feedback, reviewing and analyzing student work, leading and participating in discussions, applying their knew knowledge to lesson plans, or participating in activities as students (Birman et al., 2000). Professional development programs that incorporate active learning strategies such as practice teaching, planning, presenting, and reviewing student work can contribute to teacher learning (Garet et al., 2001). For instance, Heller et al. (2012) compared teachers engaged with activities of teaching cases, looking at students' work, and reflecting on teachers' own work during professional development to control teachers. The authors found that all treatment activities led to teacher learning as evidenced by gains on measures of teacher content knowledge.

Content-focused

The content knowledge of teachers plays a vital role in both the quality of instruction and student performance (e.g. Darling-Hammond, 1999; Shulman, 1986). Professional development characterized by a content focus not only leads to increased teacher knowledge but also can lead to changes in teacher practices (Birman et al., 2000; Desimone, 2009; Garet et al., 2001; Kennedy, 1999). For example, in examining the effects of professional development on science and mathematics teachers' instruction over a three-year period, Desimone, Porter, Garet, Yoon, and Birman (2002) determined professional development focused on a particular technology, instructional, or assessment practice resulted in an increased use of these learned practices in the classroom. Furthermore, professional development lacking a strong content component has been found to be ineffective in changing teacher practices (Cohen & Hill, 2000; Kennedy, 1998).

Coherence

Coherence refers to how professional development can be integrated into a program of teacher learning (Birman et al., 2000). Professional development should be well aligned with the national, state, district and school policies and standards (Desimone, 2009; Garet et al., 2001). Professional development activities should help teachers plan to implement changes in their classrooms (Ottman, 1997), and help teachers identify and strategize about barriers they will encounter once back in their schools (Ottoson, 1997) through mentoring and coaching (Luft et al., 2011). Mentoring and coaching also supports teachers as they try to implement new practices from PD programs (Grierson & Woloshyn, 2013; Luft et al., 2011; Smith & Ingersoll, 2004). For example, Grierson and Woloshyn (2013) conducted a 7-month reading professional development experience that included collaborative, small-group sessions and individualized classroom coaching. Results suggested that coaching provided teachers with the differentiated support they needed to change their practices in the classroom. Specifically, providing teachers with individualized feedback, tailored to their needs and classrooms, supported teachers to make substantial changes to their existing practices as the coaches and teachers identified those areas together (Grierson & Woloshyn, 2013).

Duration

Duration concerns the number of hours of professional development and the amount of time over which it occurs (Desimone, 2009). Longer professional development spread out over time, like a full year or semester, tends to be characterized by more active learning, content focus, and coherence than shorter activities (Birman et al., 2000). Short, single workshops common to teacher professional development days have little follow-up, and have little effect on teacher growth or understanding of content and/or pedagogy (Loucks-Horsley & Matsumoto, 1999; Pianta, 2011; Spillane, 2002). Research demonstrates that professional development of a longer duration is more effective in changing teacher practices related to the focus of the professional development (Banilower, Heck, & Weiss, 2007; Boyle, Lamprianou, & Boyle, 2005; Cohen & Hill, 2000). For example, Supovitz and Turner (2000) explored the relationship between aspects of professional development and teachers' reports of classroom practice through a national survey of over 3500 K-8 teachers. The authors found that only teachers who were engaged in over 80 hours of professional development reported using inquiry-based practices more frequently. Similarly, in a review of technology-enhanced science instruction, Gerard, Varma, Corliss, and Linn (2011) found that professional development of over one year resulted in significant improvements in inquiry-based instruction.

Collective participation

Collective participation occurs when teachers from the same school, department, subject, or grade attend professional development together (Desimone, 2009). When teachers from similar areas attend professional development together, it is more effective (Porter, Garet, Desimone, Yoon, & Birman, 2000), and enables conversations and discussions that increase teacher change in understandings and practices (Birman et al., 2000; Borko, 2004; Loucks-Horsley & Matsumoto, 1999). Other positive aspects of collective participation are the ability of teachers to discuss curricular changes as a group and to work toward developing their own professional learning community (Birman et al., 2000). However, most professional development does not use collective participation (Porter et al., 2000), which limits the potential impact of many programs.

In summary, the literature indicates teacher knowledge and understandings are increased when professional development is characterized by active learning, content focus, coherence, duration, and collective participation (Kennedy, 2005; Luft, 2001; Supovitz, Mayer, & Kahle, 2000). Furthermore, this type of professional development can also lead to changes in teacher practices (Desimone et al., 2002; Jeanpierre, Oberhauser, & Freeman, 2005; Kennedy, 2005; Luft, 2001; Supovitz & Turner, 2000). Future research should clarify exactly how these characteristics effect change in teacher understandings and instruction as a result of professional development.

Professional Development and Student Achievement

Teachers are the most important factor in student achievement (Carey, 2004; Haycock, 1998; Sanders & Rivers, 1996); therefore, effective professional development should result in increased student achievement (Guskey, 1986; Guskey, 2002; Loucks-Horsley & Matsumato, 1999). Although much research investigates the impact of professional development on teacher change, less research exists that explicitly links professional development to student outcomes (Desimone, 2009; Kennedy, 1998). Existent literature indicates that when characteristics of effective professional development are present, student achievement can be improved (Buczynski & Hansen, 2010; Desimone, 2009; Johnson, Khale, & Fargo, 2007; Wallace, 2009; Yoon et al., 2007).

For example, in a systematic review, Yoon et al. (2007) identified 1,300 studies as having the potential to address the effectiveness of teachers' in-service professional development on student achievement. Unfortunately only nine of these studies met the standards for "evidence without reservation" in the What Works Clearinghouse standards and all focused on elementary teachers. Results revealed that intense, sustained professional development was directly related to student achievement. Perhaps more importantly, this study illuminates the lack of rigorous studies examining the relationship between teacher change and student outcomes, particularly at the secondary level.

Utilizing structural equation modeling, Wallace (2009) conducted a large scale study using six existing state and national databases. When controlling for teacher characteristics and teacher preparation programs, the structural equation model measured the effects of professional development and teacher practices on student achievement. The results indicated that professional development had moderate effects on teacher practice and small, but sometimes significant effects on student achievement. Wallace (2009) concluded that despite differences in samples, academic subjects, and types of assessment, the effects of professional development on teacher practice and student achievement were similar and consistent across analyses.

Effective professional development once implemented in the classroom may also narrow the achievement gap (Johnson et al., 2007; Lee, Deaktor, Enders, & Lambert, 2008). For example, Lee et al. (2008) examined the impact of a 3-year professional development program on science achievement of culturally and linguistically diverse elementary students. Results demonstrated significant increases each year on all measures of student achievement. The consistent positive results indicated professional development increased student achievement, especially for low-achieving, low socio-economic status and ELL students.

Despite the positive effects seen in these studies, professional development may not always result in student learning (Duffy et al., 1986; Saxe, Gearhart, & Nasir, 2001). It may take time for teachers to effectively transfer what they learn in professional development into practice, if at all. For example, Johnson et al. (2007) investigated the relationship between effective professional development and student achievement in science with a three year longitudinal study. Analysis showed a significant relationship between student achievement in science and teacher participation in whole-school, sustained, collaborative professional development. Interestingly, positive effects were found in years two and three, but not in year one. The authors suggested this may be due in part to the amount of time it took for teachers to effectively transfer professional development into practice.

While this literature indicates professional development can have a positive effect on student achievement (Wallace, 2009; Yoon et al., 2007), there are still many difficulties in showing clear links between professional development and student achievement (Borko, 2004; Desimone, 2009; Loucks-Horsley & Matsumoto, 1999). Evidence also suggests there is a lack of rigorous studies to support these links (Yoon et al., 2007). Thus, further research in this area is still needed to support and establish these links.

Factors Influencing Teacher Change

Teachers come to professional development opportunities with different backgrounds, confidence, and motivation. The schools and districts they work within have different policies, approaches, and visions. The size, resources, working conditions, and leadership styles of administrators are also unique. In Desimone's (2009) professional development model, these factors are considered part of the context that can influence teachers' experience with professional development and impact whether teacher change in beliefs, understandings, and/or practices is permanent. This section concentrates on these contextual professional development factors and whether or not they influence teacher change and ultimately increase student achievement.

Teacher Experience

Teacher experience (years in the classroom) is a critical factor to consider in professional development and teacher change (Smith, Hofer, Gillespie, Solomon & Rowe, 2003). Teachers who are in the beginning of their career or who have lower levels of formal education participate in more professional development than their counterparts (Livneh & Livneh, 1999). This is to be expected as these individuals recognize their need for more knowledge and a greater understanding of pedagogy. For example, Luft (2001) compared the beliefs and practices of beginning and experienced teachers after participation in an inquiry-based professional development. Results indicated that the beginning teacher group changed their beliefs more than their practices and the experienced teacher group changed their practices more than their beliefs (Luft, 2001). Beginning teachers may require more content matter support; thus, professional development may need to tailor activities to the various levels of teacher experience (Smith & Ingersoll, 2004).

Teacher experience also impacts the type of professional development teachers choose to attend (Lewis et al., 1999). For example, in a national survey of teachers, many beginning teachers choose to attend professional development focused on classroom management and new pedagogy (Lewis et al., 1999). More experienced teachers may seek professional development that will deepen their content knowledge and force them to think more deeply about the types of pedagogy they utilize in the classroom (Lewis et al., 1999). Regardless of where a teacher is in their career, it is clear teacher experience is a contextual factor affecting teacher's choice in professional development and ultimately changes in their practices and/or understandings.

Teacher Motivation

Teachers may have a variety of motivations for attending professional development including: salary increase, licensure reaccreditation, career mobility, and gaining new skills or knowledge (Stout, 1996). In one survey study of K-12 educators, two motivational factors, high internal motivation to learn (gaining new skills or knowledge) and high external motivation to learn (career mobility, licensure reaccreditation), predicted teachers' participation in professional development (Livneh & Livneh, 1999). Additionally, teachers who exhibit a strong motivation to attend professional development are more likely to change following participation (Smith et al., 2003). Thus, teacher motivation is a vital factor to consider in the study of professional development and teacher change.

Teacher Self-Efficacy

Another contextual factor related to teacher change is self-efficacy. Self-efficacy is defined as "beliefs in one's capabilities to organize and execute the courses of action required to manage prospective situations" (Bandura, 1995, pg. 2). Self-efficacy is related to the individual factors of teachers, including whether a teacher is beginning or more experienced (Ross, 1994). More experienced teachers seem to have more stable self-efficacy, while beginning teachers are still developing their self-efficacy (Ross, 1994). Irrespective of where teachers were in their career, teachers with stronger self-efficacy were identified as more likely to change their practices as a result of attending professional development (Guskey, 1988; Smylie, 1988). However, studies indicate teachers with strong self-efficacy did not change, no matter how long professional development lasted, but those with low self-efficacy increased their self-efficacy in proportion to the duration of the professional development (Roberts, Henson, Tharp, & Moreno, 2000).

Teachers can increase their self-efficacy by implementing new practices (Stein & Wang, 1988), and self-efficacy may increase more when teachers see these new practices work (Ross, 1998). Student achievement has also been related to stronger self-efficacy among teachers (Goddard, Hoy, & Hoy, 2000; Tschannen-Moran, Hoy, & Hoy, 1998). In one study, researchers found teachers' increased content knowledge led to increased self-efficacy, which led to increased motivation and persistence (Lakshmanan, Heath, Perlmutter & Elder, 2011). Taken together, this research indicates teacher self-efficacy is another important contextual factor to consider in professional development and teacher change.

School Culture

School culture is another context characteristic influencing teacher retention and classroom practices (Bianchini & Cavazos, 2007; McGinnis, Parker & Graeber, 2004). For example, in an interpretive case study of 8 teachers, school culture was found to be a key factor in influencing whether or not beginning teachers grew professionally and continued in the profession (McGinnis et al., 2004). In schools where there is there is a school culture of collegiality, the effectiveness of professional development in changing teacher practices increases (Bianchini & Cavazos, 2007; McGinnis et al., 2004). This collegiality creates an environment where professional communities can develop and teachers are able to learn and work together as they apply changes to their practices (Grossman, Wineburg, & Woolworth, 2000). Furthermore, the more collaboration there is within a school, the more teachers are committed to teaching, which may result in teachers being more open to new practices and knowledge (Rosenholtz, 1986).

Working Conditions

Working conditions, like full time versus part time, salary, and benefit levels, can have an effect on teacher turnover (Ingersoll, 2001). Teachers who are "dissatisfied" or who have low salaries, little support from administration, issues with student behavior, or have little input into decision making are more likely to leave teaching or move to different schools (Fullan, 2007). In a study of adult education teachers, the relationship between teacher change and working conditions was investigated (Smith et al., 2003). This study indicated three factors influenced the amount and type of change teachers experienced in their understandings and practices after participating in professional development:

1. Amount of prep time – teachers with more prep time were more likely to change.
2. Benefits – teachers who received one or more benefits (health or dental insurance, vacation, etc.) were more likely to change.
3. School situation – teachers who had a voice in decisions and who were part of schools taking action to address learner issues were more likely to change.

Poor working conditions may limit the amount of teachers' practices and understandings change and the permanence of that change.

Ongoing Leadership for Teacher Change

Beyond the contextual factors of teacher experience, motivation, self-efficacy, school culture, and working conditions, district leadership also plays a significant role in teacher change (Leithwood, Seashore-Louis, Anderson & Wahlstrom, 2004; Marsh, 2002). District leadership encompasses the roles of staff developers, subject-area supervisors, district coordinators, mentor teachers, school-board members, directors, and community members, but is most often focused on the role of the superintendent (Murphy & Hallinger, 1988; Petersen, 1999; Waters & Marzano, 2007). Ogawa and Bossert (1995) assert educational leadership is characteristic of the organization as a whole and that everyone in these roles helps shape the leadership a district provides. District leaders set the direction for reform efforts and professional development (Leithwood et al., 2004; Marsh, 2002). In Desimone's (2009) professional development model, leadership is one of the influencing contextual factors. Here we review the critical role leadership plays in teacher change and identify it as an area that should not just be a contextual factor, but should also play a more integral role in influencing teacher change and student achievement.

Leadership

School leadership plays a critical role in improving teachers' instruction through professional development and other administrative practices (Banilower et al., 2007; Corcoran, Fuhrman, & Belcher 2001). In addition, school leadership has been shown to have a significant impact on student achievement (Marzano, Waters, & McNulty, 2005). In fact, research suggests that school and district leadership may be second only to the teaching occurring in the classroom as having the most impact on student achievement (Leithwood et al., 2004). Leadership can prepare teachers for change by creating environments that allow for natural change in teachers when they see if and how new practices help students (Sparks, 1995). Likewise, schools without effective leadership or with a high principal turnover rate can result in a negative effect on teacher programs (Bollough, Kauchak, Crow, Hobbs, & Stoke, 1997).

The school district is a major provider of teachers' professional development (Spillane, 2002). According to Pianta (2011), districts spend thousands of dollars per teacher per year on professional development. Unfortunately, district-offered professional development is often ineffective, as it does not incorporate characteristics of professional development and is typically delivered in the form of short in-service workshops with little or no follow-up (Loucks-Horsley & Matsumoto, 1999; Pianta, 2011; Spillane, 2002.). These “one shot” workshops often lack coherence (Spillane, 2002), and instead of being content-focused they address administrative, management, or discipline issues (Desimone, Smith & Phillips, 2007; Pianta, 2011

Districts can have a strong influence on teaching and learning through high quality professional development (Desimone et al., 2002; Firestone, Mangin, Martinez, & Plovsky, 2005). Alignment of professional development with standards, development of continuous improvement efforts, and teacher involvement in the planning of professional development are successful effective professional development practices for districts (Desimone et al., 2002). Additionally, action-based research of three districts’ implementation of professional development indicated coherent, content-focused professional development planned by the district may have a positive effect on teaching and learning (Firestone et al., 2005).

District leaders not only support teachers’ instructional practices, they also have a role in increasing student achievement. Certain characteristics of school district leadership appear to define effective and successful districts. For example, Murphy and Hallinger (1988) studied the district leadership of 12 high performing school districts in California. The districts were selected based on high student achievement levels on standardized tests and controlled for socioeconomic status, previous achievement, and language proficiency. The authors determined that district effectiveness was associated with four broad categories: conditions, climate factors, characteristics of curriculum and instruction, and organizational dynamics. The authors found that successful districts had leaders that made decisions based on systematic analysis and application of data, superintendents who were actively involved in the development and implementation of curricular reforms, and structured district control with school autonomy.

In an extensive meta-analysis of 30 years of research, Marzano et al. (2005) explored the relationship between district leadership and student achievement. Using a definition of leaders that included principals, teacher-leaders, and district administrators, the authors found an average correlation of .25, from 69 empirical studies, between general leadership and student achievement. Marzano et al. identified the 21 leadership responsibilities that directly correlated with student achievement, including: monitoring and evaluating school curriculum, instruction, and assessment practices, creating a collaborative culture, working from a well-defined set of ideals and beliefs, maintaining knowledge of and involved with the curriculum, instruction, and assessment, and forming concrete goals. This study builds on previous studies by synthesizing the currently available research to identify the leadership responsibilities directly correlated with student achievement.

Taken together, these studies describe the characteristics of effective district leadership and indicate key practices of effective leadership (Leithwood et al., 2004; Marzano et al., 2005). For example, Copland and Knapp (2006) identified five practices leaders should adopt to improve student achievement in school districts: 1. Establishing a focus on learning, 2. Building professional communities that value learning, 3. Engaging external environments that matter for learning, 4. Acting strategically and sharing leadership, and 5. Creating coherence (p.24). While there is extensive research in the area of effective district leadership, all studies agree there is not a “recipe” or one set of tasks a leader should follow to be effective (e.g. Murphy & Hallinger, 1988). However, it is clear effective leadership includes collaboration and working together to support teacher instruction and student learning (Leithwood et al., 2004). Furthermore, research indicates student learning suffers when central office administrators do not provide the support teachers need (Honig & Copland, 2008).

Implications

Based on the research reviewed, there is support for and value in Desimone’s (2009) model (Figure 1). However, the leadership within the school and district may play a more prominent role than merely a context factor as represented in the current model. School districts are the primary providers of professional development for teachers (Birman et al., 2007; Pianta, 2011; Spillane, 2002). Some argue that school and district leadership are second only to teachers in the classroom in terms of influence on improving student achievement (Leithwood et al., 2004). Thus, school and district leadership should be emphasized more in the model than originally proposed by Desimone (2009). School leadership not only plans and designs formal professional development, but also provides ongoing support for teacher learning, which can ultimately affect student learning. Based upon this evidence, school and district leaders should be considered at the start of the path toward student achievement rather than as part of the context (Figure 2).

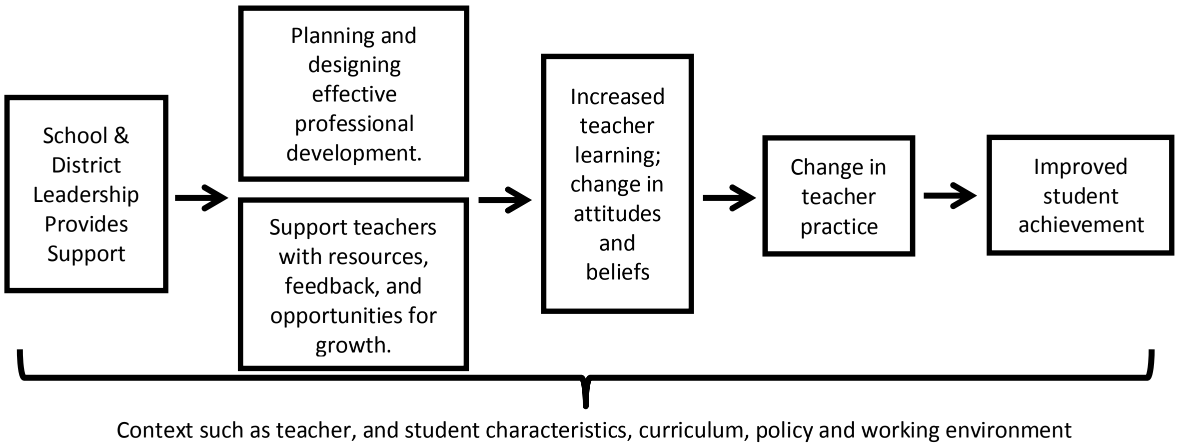

Figure 2. Proposed model for investigating the links between professional development and student achievement.

While schools and districts are not the only facilitators of professional development for teachers, they are the main provider (Birman et al., 2007; Pianta, 2011; Spillane, 2002). Therefore, it is critical to understand school and district leaders' views of professional development, their practices, and the factors that influence school and district leadership in choosing and designing professional development. These factors may provide insight into what types of professional development districts choose for teachers to experience. If the professional development selected and designed is characterized by content focus, active learning, coherence, duration, and collective participation, then an increase in teacher learning and changes in teacher practices would be expected (Desimone et al., 2002; Jeanpierre et al., 2005; Luft, 2001; Supovitz et al., 2000; Supovitz & Turner, 2000). This increased knowledge and change in practice may lead to improved student achievement (Buczynski & Hansen, 2010; Desimone, 2009; Johnson et al., 2007; Wallace, 2009; Yoon et al., 2007).

Furthermore, understanding how district leaders choose and implement professional development (either formal or ongoing) may also illuminate areas in which school and district leaders need professional development themselves. As school and district leaders evolve in their own professional practice, it could have a direct positive impact on both the teachers and students they serve. School and district leaders who benefit from consistent professional development may be more proactive in facilitating effective professional development for their district.

Subject-Area Coordinators

The review of the literature also reveals a gap in the research around the role of subject-area coordinators. Subject-area coordinators are individuals who are intimately involved in the administration and execution of leadership activities associated with curriculum and instruction (Spillane, Camburn, & Stitziel, 2007). These individuals are often part of district administration and are involved in the decisions that affect the instructional practices of teachers, such as administering the district-wide professional development or providing day-to-day support for teachers in their subjects. However, there is very little research on this population (Honig, 2006), despite their central role in the implementation and crafting of reforms in schools (Honig & Hatch, 2004).

For example, a few studies have investigated the role of science coordinators (Aoki, 2003; Lee, Leary, Sellers & Recker, 2013; Perrine, 1984; Roden, 2003). Research suggests that science coordinators have an influence over how teachers choose and use instructional resources (Knapp & Plecki, 2001). Furthermore, research suggests the experience and expertise of science coordinators may be a crucial factor in the support of first year teachers in the classroom (Roden, 2003). However, research also suggests that teachers and administrators have varying opinions about the role and duties of science coordinators (Madrazo & Hounshell, 1987; Madrazo & Motz, 1982) and actual practices of science coordinators vary widely from district to district (Lee et al., 2013), Thus, more research is needed to explore the role of subject-area coordinators and how these leaders effectively provide support for teacher change (e.g. PCAST, 2010; Perrine, 1984).

Conclusion

High quality professional development is a crucial component of almost every proposal for improving education (Guskey, 1986; Guskey, 2002). The research reviewed here reveals that under the right conditions professional development may help teachers be more effective and may also result in gains in student achievement (Yoon et al., 2007). Yet, many factors including teacher motivation, school culture, and working conditions mediate the effects of professional development. This review also highlights the critical role of district leaders in supporting teacher change in beliefs, understandings, and/or practices. However, existing models of professional development fail to consider the integral role of school and district leadership (e.g. Desimone, 2009; Loucks-Horsley & Matsumoto, 1999). In particular, more research needs to explore the role of subject-area coordinators in providing domain-specific professional development (Luft & Hewson, 2013; PCAST, 2010). It is critical for us to consider the role of school and district leaders in facilitating teacher change if we want to have a more complete picture of the role of professional development in facilitating teacher and ultimately student learning.

References

Aoki, J. M. (2003). *The perceptions of inquiry held by greater Houston area science supervisors*. (Doctoral dissertation).

Bandura, A. (Ed.). (1995). *Self-efficacy in changing societies*. Cambridge university press.

Banilower, E. R., Heck, D. J., & Weiss, I. R. (2007). Can professional development make the vision of the standards a reality? The impact of the National Science Foundation's Local Systemic Change through teacher enhancement initiative. *Journal of Research on Science Teaching, 44*, 375-395.

Bianchini, J. A., & Cavazos, L. M. (2007). Learning from students, inquiry into practice, and participation in professional communities: Beginning teachers' uneven progress toward equitable science teaching. *Journal of Research in Science Teaching*, *44*, 586-612.

Birman, B. S., Desimone, L., Porter, A. C., & Garet, M. S. (2000). Designing professional development that works. *Educational Leadership*, *57*(8), 28-33.

Bollough, R. V., Kauchak, D., Crow, N., Hobbs, S., & Stoke, D. (1997). Professional development schools: Catalysts for teacher and school change. *Teaching and Teacher Education*, *13*, 153–169.

Borko, H. (2004). Professional development and teacher learning: Mapping the terrain. *Educational Researcher, 33*(8), 3-15.

Boyle, B., Lamprianou, I., & Boyle, T. (2005). a longitudinal study of teacher change: What makes professional development effective? Report of the second year of the study. *School Effectiveness and School Improvement 16*, 1-27.

Buczynski, S. & Hansen, C. B. (2010). Impact of professional development on teacher practice: Uncovering connections. *Teaching and Teacher Education, 26,* 599-607.

Carey, K. (2004). The real value of teachers: Using new information about teacher effectiveness to close the achievement gap. *Thinking K–16, 8*(1), 3–42.

Cohen, D. K., & Hill, H. C. (2000). Instructional policy and classroom performance: The mathematics reform in California. *Teachers College Record*, *102*, 294–343.

Copland, M. A., & Knapp, M. S. (2006). *Connecting leadership with learning: A framework for reflection, planning and action.* Alexandria, VA: Association for Supervision and Curriculum Development.

Corcoran T., Fuhrman, S. H. & Belcher, C. L. (2001). The district role in instructional improvement. *The Phi Delta Kappan, 83*(1), 78-84.

Darling-Hammond, L. (1999). *Teacher quality and student achievement: A review of state policy evidence*. Seattle, WA: Center for the Study of Teaching and Policy, University of Washington.

Desimone, L. M. (2009). Improving impact studies of teachers' professional development: Toward better conceptualizations and measures. *Educational Researcher, 38*, 181-199.

Desimone, L. M., Porter, A. C., Garet, M. S., Yoon, K. S. & Birman, B. F. (2002). Effects of professional development on teachers' instruction: Results from a three-year longitudinal study. *Educational Evaluation and Policy Analysis, 24*, 81-112.

Desimone, L. M., Smith, T. M., & Phillips, K. J. R. (2007). Does policy influence mathematics and science teachers' participation in professional development? *Teachers College Record, 109*, 1086-1122.

Duffy, G. G., Roehler, L. R., Meloth, M. S., Vavrus, L. G., Book, C., Putnam, J., & Wesselman, R. (1986). The relationship between explicit verbal explanations during reading skill instruction and student awareness and achievement: A study of reading teacher effects. *Reading Research Quarterly*, *21,* 237-252.

Firestone, W. A., Mangin, M. M., Martinez, M. C. & Plovsky, T. (2005). Leading coherent professional development: A comparison of three districts. *Educational Administration Quarterly, 41,* 413-448.

Fishman, B. J., Marx, R. W., Best, S., & Tal, R. T. (2003). Linking teacher and student learning to improve professional development in systemic reform. *Teaching and teacher education*, *19*, 643-658.

Fullan, M. (2007). Change the terms for teacher learning. *National Staff Development Council 28*(3), 35-36.

Garet, M. S., Porter, A. C., Desimone, L., Birman, B., & Yoon, K. S. (2001). What makes professional development effective? Results from a national sample of teachers. *American Educational Research Journal, 38*, 915–945.

Gerard, L. F., Varma, K., Corliss, S. B., & Linn, M. C. (2011). Professional development for technology-enhanced inquiry science. *Review of Educational Research*, *81*(3), 408-448.

Goddard, R. D., Hoy, W. K., & Hoy, A. W. (2000). Collective teacher efficacy: Its meaning, measure, and impact on student achievement. *American Educational Research Journal, 37*, 479–507.

Grierson, A. L., & Woloshyn, V. E. (2013). Walking the talk: Supporting teachers' growth with differentiated professional learning. *Professional Development in Education, 39*, 401-419.

Grossman, P., Wineburg, S., & Woolworth, S. (2000). What makes teacher community different from a gathering of teachers? (Occasional paper). Washington, DC: Center for the Study of Teaching and Policy and Center on English Learning & Achievement.

Guskey, T. R. (1986). Staff development and the process of teacher change. *Educational Researcher, 15*(5), 5-12.

Guskey, T. R. (1988). Teacher efficacy, self-concept, and attitudes toward the implementation of instructional innovation. *Teaching & Teacher Education, 4*, 63–69.

Guskey, T. R. (1997). Research needs to link professional development and student learning. *Journal of Staff Development, 18*(2), 36–40.

Guskey, T. R. (1999). Moving from means to ends. *Journal of Staff Development, 20*(1), 48.

Guskey, T. R. (2002). Professional development and teacher change. *Teachers and Teaching: theory and practice, 8*, 381-391.

Guskey, T. R., & Sparks, D. (1996). Exploring the relationship between staff development and improvements in student learning. *Journal of Staff Development, 17*(4), 34–38.

Hattie, J. (2008). *Visible learning: A synthesis of over 800 meta-analyses relating to achievement.* New York, NY: Routledge.

Haycock, K. (1998). Good teaching matters . . . a lot. *Thinking K-16, 3*(2), 3–14.

Heller, J. I., Daehler, K. R., Wong, N., Shinohara, M. & Miratrix, L. W. (2012). Differential effects of three professional development models on teacher knowledge and student achievement in elementary science. *Journal of Research in Science Teaching, 49,* 333-362.

Hewson, P. W. (2007). Teacher Professional Development in Science. In S.K. Abell & N.G. Lederman (Eds.), *Handbook of research on science education.* London: Lawrence Erlbaum & Associates, Publishers.

Honig, M. I. (2006). Street-level bureaucracy revisited: Frontline district central-office administrators as boundary spanners in education policy implementation. *Educational Evaluation and Policy Analysis*, *28*, 357-383.

Honig, M. I., & Copland, M. A. (2008). Reinventing District Central Offices to Expand Student Learning: Issue Brief. *Center for Comprehensive School Reform and Improvement*.

Honig, M. I., & Hatch, T. C. (2004). Crafting coherence: How schools strategically manage multiple, external demands. *Educational Researcher*, *33*(8), 16-30.

Ingersoll, R. M. (2001). Teacher turnover and teacher shortages: An organizational analysis. *American educational research journal, 38*, 499-534.

Jeanpierre, B., Oberhauser, K., & Freeman, C. (2005). Characteristics of professional development that effect change in secondary science teacher's classroom practices. *Journal of Research in Science Teaching, 42*, 668-690.

Johnson, C. C., Kahle, J. B., & Fargo, J. D. (2007). A study of the effect of sustained, whole-school professional development on student achievement in science. *Journal of Research in Science Teaching, 44*, 775-786. doi:10.1002/tea.20149

Kennedy, M. M. (1998). *Form and substance in in-service teacher education* (Research monograph no. 1). Arlington, VA: National Science Foundation.

Kennedy, M. M. (1999). *Form and substance in Mathematics and Science Professional Development.* Madison, WI: University of Wisconsin at Madison, National Institute for Science Education.

Kennedy, M. M. (2005). *Inside teaching: How classroom life undermines reform.* Cambridge, MA: Harvard University Press.

Knapp, M. (2003). Professional development as a policy pathway. *Review of Research in Education, 27*, 109–157.

Knapp, M. S., & Plecki, M. L. (2001). Investing in the renewal of urban science teaching. *Journal of Research in Science Teaching*, *38*, 1089-1100.

Lakshmanan, A., Heath, B. P., Perlmutter, A., & Elder, M. (2011). The impact of science content and professional learning communities on science teaching efficacy and standards-based instruction. *Journal of Research in Science Teaching*, *48*, 534-551.

Lee, O., Deaktor, R., Enders, C., & Lambert, J. (2008). Impact of a multiyear professional development intervention on science achievement of culturally and linguistically diverse elementary students. *Journal of Research in Science Teaching, 45*, 726-747. doi:10.1002/tea.20231

Lee, V. R., Leary, H. M., Sellers, L., & Recker, M. (2013). The Role of School District Science Coordinators in the District-Wide Appropriation of an Online Resource Discovery and Sharing Tool for Teachers. *Journal of Science Education and Technology*, 1-15.

Leithwood, K., Seashore-Louis, K., Anderson, S., & Wahlstrom, K. (2004). *How leadership influences student learning.* Minneapolis, MN: University of Minnesota, Center for Applied Research and Educational Improvement.

Lewis, L., Parsad, B., Carey, N., Bartfai, N., Farris, E., & Smerdon, B. (1999). Teacher quality: A report on the preparation and qualifications of public school teachers (NCES 1999-080). Washington, DC: National Center for Education Statistics, U.S. Department of Education.

Little, J. W. & Wong, N. (2007). *Conceptualizing the contribution of facilitation to professional learning opportunity.* Paper presented at the American Educational Research Association Annual Meeting, Chicago, Illinois.

Livneh, C., & Livneh, H. (1999). Continuing professional education among educators: Predictions of participation in learning activities. *Adult Education Quarterly, 49*, 91–106.

Loucks-Horsley, S., & Matsumoto, C. (1999). Research on professional development for teachers of mathematics and science: The state of the scene. *School Science and Mathematics, 99*, 258-271.

Loucks-Horsley, S., Stiles, K.E., Mundry, S., Love, N., & Hewson, P.W. (2010). *Designing professional development for teachers of science and mathematics* (3rd Ed.). Thousand Oaks, CA: Corwin Press.

Luft, J. A. (2001). Changing inquiry practices and beliefs: The impact of an inquiry-based professional development programme on beginning and experienced secondary science teachers. *International Journal of Science Education, 23*, 517-534.

Luft, J. A., Firestone, J. B., Wong, S. S., Ortega, I., Adams, K., & Bang, E. (2011). Beginning secondary science teacher induction: A two-year mixed methods study. *Journal of Research in Science Teaching, 48,* 1199-1224.

Luft, J. A. & Hewson, P. W. (2013, in press). Research on teacher professional development programs in science. In In S.K. Abell & N.G. Lederman (Eds.), *Handbook of research on science education (Second Edition).* London: Lawrence Erlbaum & Associates, Publishers.

Madrazo, G. M. & Hounshell, P. B. (1987). Science supervisor: Results of research in science supervision. *Science Education, 71*(1), 9-14.

Madrazo, G., & Motz, L. (1982). Science Supervisors--An Endangered Species? *Science Teacher*, *49*(9), 42.

Marsh, J. A. (2002). How districts relate to states, schools, and communities. In A. Hightower, M. S. Knapp, J. A. Marsh, & M. W. McLaughlin (Eds.), *School districts and instructional renewal* (pp. 25-40). New York: Teachers College Press.

Marzano, R. J., Waters, T., & McNulty, B. A. (2005). School *leadership that works: From research to results.* Denver, CO: Mid-continent Research for Education and Learning.

McGinnis, J., Parker, R., & Graeber, C. A. (2004). A cultural prospective of the induction of five reform-minded beginning mathematics and science teachers. *Journal of Research in Science Teaching, 41*, 720-747.

Murphy, J., & Hallinger, P. (1988). Characteristics of instructionally effective school districts. *The Journal of Educational Research, 81*, 175-181.

Ogawa, R. & Bossert, R. (1995). Leadership as an organizational quality. *Educational Administration Quarterly, 31*, 224-244.

Ottoson, J. M. (1997). After the applause: Exploring multiple influences on application following an adult education program. *Adult Education Quarterly, 47*, 92–107.

Perrine, W. G. (1984). Teacher and supervisory perceptions of elementary science supervisors. *Science Education, 68,* 3-9.

Petersen, G. J. (1999). Demonstrated actions of instructional leaders: An examination of five California superintendents. *Educational Policy Analysis Archives*, *7*(18).

Pianta, R. C. (2011). Teaching children well: New evidence based approaches to teacher professional development and training. *Center for American Progress, 11,* 1-36.

Porter, A. C., Garet, M. S., Desimone, L. D., Yoon, K. S., & Birman, B. F. (2000). *Does professional development change teaching practice? Results from a three-year study: Executive summary.* Washington, DC: U.S. Department of Education, Office of the Undersecretary.

President's Council of Advisors on Science and Technology (2010). Prepare and Inspire: K-12 Education in Science, Technology, Engineering, and Math (STEM) for America's Future. Retrieved from http://www.whitehouse.gov/sites/default/files/microsites/ostp/pcast-stem-ed-final.pdf

Roberts, J. K., Henson, R. K., Tharp, B. Z., & Moreno, N. (2000). *An examination of change in teacher self-efficacy beliefs in science education based on the duration of in-service activities.* Paper presented at the annual meeting of the American Educational Research Association, Dallas, TX.

Roden, J. (2003). Bridging the Gap: the role of the science coordinator in improving the induction and professional growth of newly qualified teachers. *Journal of In-Service Education*, *29*(2), 201-220.

Rosenholtz, S. (1986). Educational reform strategies: Will they increase teacher commitment? *American Journal of Education, 95*, 543–562.

Ross, J. A. (1994). The impact of an in-service to promote cooperative learning on the stability of teacher efficacy. *Teaching & Teacher Education, 10*, 381–394.

Ross, J. A. (1998). Antecedents and consequences of teacher efficacy. In J. Brophy (Ed.), *Advances in research on teaching* (Vol. 7, pp. 49–74). Greenwich, CT: JAI.

Sanders, W. L., & Rivers, J. C. (1996). *Cumulative and residual effects of teachers on future student academic achievement.* Knoxville: University of Tennessee.

Saxe, G. B., Gearhart, M., & Nasir, N. S. (2001). Enhancing students' understanding of mathematics: A study of three contrasting approaches to professional support. *Journal of Mathematics Teacher Education, 4*, 55–79.

Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher, 15*(2), 4-14.

Smith, C., Hofer, J., Gillespie, M., Solomon, M., & Rowe, K. (2003). *How teachers change: A study of professional development in adult education* (NCSALL Rep. No.25). Boston: National Center for the Study of Adult Learning and Literacy.

Smith, T., & Ingersoll, R. (2004). What are the effects of induction and mentoring on beginning teacher turnover? *American Educational Research Journal, 41,* 681-714.

Smylie, M. A. (1988). The enhancement function of staff development: Organizational and psychological antecedents to individual teacher change. *American Educational Research Journal, 25*, 1–30.

Sparks, D. (1994). A paradigm shift in staff development. *Journal of Staff Development, 15*(4), 26–29.

Sparks, D. (1995). Focusing staff development on improving student learning. In G. Cawelti (Ed.), *Handbook of research on improving student achievement* (pp. 163–169). Arlington, VA: Educational Research Service.

Spillane, J. P. (2002). Local theories of teacher change: The pedagogy of district policies and programs. *Teachers College Record, 104*, 377-420.

Spillane, J. P., Camburn, E. M., & Stitziel, P. A. (2007). Taking a distributed perspective to the school principal's workday. *Leadership and Policy in Schools*, *6*, 103-125.

Stein, M. K., Smith, M. S., & Silver, E. A. (1999). The development of professional developers: Learning to assist teachers in new settings in new ways. *Harvard Educational Review*, *69*, 237-269.

Stein, M. K., & Wang, M. C. (1988). Teacher development and school improvement: The process of teacher change. *Teaching & Teacher Education, 4*, 171–187.

Stout, R. T. (1996). Staff development policy: Fuzzy choices in an imperfect market. *Education Policy Analysis Archives, 4*(2). Retrieved November 26, 2013 from http://epaa.asu.edu/ojs/article/view/625/747

Stronge, J. H. (2010). *Effective teachers = student achievement: What the research says.* Larchmont, NY: Eye on Education.

Supovitz, J. A., Mayer, D. P., & Kahle, J. B. (2000). Promoting inquiry-based instructional practice: The longitudinal impact of professional development in the context of systemic reform. *Educational Policy, 14*, 331-356. Doi: 10.1177/0895904800014003001

Supovitz, J. A., & Turner, H. M. (2000). The effects of professional development on science teaching practices and classroom culture. *Journal of Research in Science Teaching, 37*, 963–980.

Tschannen-Moran, M., Hoy, A. W., & Hoy, W. K. (1998). Teacher efficacy: Its meaning and measure. *Review of Educational Research, 68*, 202–248.

Wallace, M. R. (2009). Making sense of the links: Professional development, teacher practices, and student achievement. *Teachers College Record, 111*, 573-596.

Waters, J. T., & Marzano, R. J. (2007). School district leadership that works: The effect of superintendent leadership on student achievement. *ERS Spectrum, 25*(2), 1-12.

Whitehurst, G. (2002, March 5). *Research on teacher preparation and professional development.* Speech given at the White House Conference on Preparing Quality Teachers. Retrieved November 26, 2013, from http://www.stcloudstate.edu/tpi/initiative/documents/assessment/Scientifically%20Based%20Reserach%20on%20Teacher%20Quality.pdf

Wilson, S. M. (2013). Professional development for science teachers. *Science, 340,* 310-313.

Yoon, K. S., Duncan, T., Lee, S. W.-Y., Scarloss, B., & Shapley, K. (2007). *Reviewing the evidence on how teacher professional development affects student achievement* (Issues & Answers Report, REL 2007–No. 033). Washington, DC: U.S. Department of Education, Institute of Education Sciences, National Center for

Education Evaluation and Regional Assistance, Regional Educational Laboratory Southwest.

CHAPTER THREE

STUDY TWO

Supporting the Supporters: VISTA Professional Development for Science Coordinators

Brooke A. Whitworth, Randy L. Bell, Jennifer L. Maeng, & Amanda L. Gonczi

Abstract

We investigated changes in district science coordinators' understandings and practices following their participation in a state-wide professional development experience designed specifically for science coordinators. Participants included 8 male and 20 female science coordinators from 23 different school districts in Virginia. Data included pre-, post-, and delayed-post survey responses, follow-up interviews, and observations of the professional development and of science coordinators at work in their district. Results indicated that science coordinator understandings about pedagogy and their job responsibilities changed following the professional development and were aligned with goals of the professional development. However, coordinators' practices following professional development did not fully reflect their understandings about pedagogy. Participants also reported having little authority within their districts to change science instruction, which hindered their ability to implement what they had learned. Results suggest that science coordinators have a limited ability to affect change in a district's

infrastructure; therefore, professional development efforts should be broadened to include other district stakeholders.

Introduction

Professional development has become the key method for improving science teachers' current understandings and practices in order to meet the needs of new reform efforts (Hewson, 2007). Most frequently, school districts are the primary provider of professional development, spending billions of dollars on professional development for their teachers each year (Birman et al., 2007; Pianta, 2011; Spillane, 2002). In providing teacher professional development, school districts play a key role in improving teaching and learning (Corcoran, Fuhrman & Belcher, 2001). School districts offer professional development to teachers in several different ways, including: hiring outside companies, utilizing local university resources, peer teaching, creating opportunities for teachers to interact with one another, and using curriculum coordinators to develop and deliver professional development. However, a district's effectiveness in improving teaching and learning is largely dependent on the decisions of district administrators including science, math, and testing coordinators, etc. (Firestone, Mangin, Martinez & Plovsky, 2005).

A science coordinator is usually a district administrator who holds at least a Master's of Education and is experienced in the classroom (Edmondson, Sterling, & Reid, 2012). In most districts, the science coordinator is responsible for overseeing professional development for science teachers and the development of the science curriculum. However, very little is known about district science coordinators' role in the district or how they support teachers. As early as 1966 the science coordinator position was advocated for by Reinisch (1966) as he identified the need for “science consultants” at the elementary level. Reinisch (1966) made the following assertion:

> One of the major weaknesses in any elementary school science program is the failure to provide for science consultants. The difficulty of acquiring adequate background in the six major content areas of science can be well understood and appreciated. For the schools that use the “self-contained classroom” plan or organization, some means must be found in order to develop a sound well-planned science program. Thus far, the use of science consultants seems to offer the best solution. (p. 54)

Reinisch (1966) advocated for a specialized science “consultant” who would support teachers in learning about new methods and new curriculum developments through professional development and would advise the district on curriculum and act as a resource for science education.

Beinsenherz & Yager (1991), in giving an overview of the necessity of the district science coordinator position state:

> With a strong science supervisor who is committed to science education and capable of providing leadership with the district, a stronger commitment to science education will develop that will increase the scientific literacy of students in all schools within the district. (p. 155)

As science coordinators can have a significant impact on a district’s effectiveness, it is critical for these individuals to have the support and time necessary to fulfill this role (Beinsenherz & Yager, 1991). This suggests the critical need to not only achieve a more in-depth understanding of the science coordinator role but to also investigate the support coordinators receive (Luft & Hewson, 2013). This study explores one professional development program designed specifically to support district science coordinators.

District Science Coordinators

In general, the literature on science coordinators is meager; however, there are a few investigations that look specifically at science coordinators. Teachers and science coordinators often have different expectations of each other's practices (Madrazo & Hounshell, 1987; Perrine, 1984). The role of the science supervisor needs to be continuously evaluated in order to understand the changing attitudes and different perceptions of this role (Madrazo & Hounshell, 1987). These findings suggest the need to more clearly define the science coordinator role so all district stakeholders (e.g. principals, teachers, district administrators) are on the same page.

Research identifies two main components as critical to supervisory effectiveness: providing teachers with content and pedagogical supports and effective communication with teachers (Perrine, 1984). Perrine (1984) indicates that science coordinators provide teachers with content-area knowledge and respond proactively to teachers' needs. Similarly, administrators in subject area supervisory positions can be perceived by teachers, principals, and other supervisors as having a high impact on the improvement of instruction (Tracy, 1993). Taken together, these results imply the science coordinator position may have a perceived positive impact on teacher instruction.

Science coordinators may not have a complete and/or accurate view of effective professional development (Rogers et al., 2007); consequently, the professional development offered by coordinators may not be as effective as intended. In one study, teacher views of effective professional development provided by subject-area content specialists included classroom application, teacher as learner, and teacher networking (Rogers et al., 2007). Content specialists viewed effective professional development as having classroom application, including opportunities for teachers as learners, the need to develop collegial relationships with teachers, and improve teacher knowledge (Rogers et al., 2007). These views do not align with characteristics of effective professional development (e.g. Desimone, 2009; Loucks-Horsley, Stiles, Mundry, Love & Hewson, 2010).

Other studies suggest the leadership provided by district level staff is critical for districts focused on increasing student achievement (Copeland & Knapp, 2006; Honig, 2006). As science coordinators can have a significant impact on a district's effectiveness, it is important for these individuals to have the support and time necessary to fulfill this role (Beinsenherz & Yager, 1991). The current research in this area is sparse, suggesting the critical need to not only achieve a more in-depth understanding of the science coordinator role but to also investigate the support coordinators are receiving themselves. Doing so has the possibility to further illuminate science coordinator's views of professional development offered to teachers, their practices, and areas in which science coordinators themselves need professional development to support high-quality science instruction.

High-Quality Science Instruction

Hands-on, student-centered instruction allowing students to construct their own knowledge has been the focus of recent reforms-based documents (National Research Council [NRC], 1996, 2000, 2007, 2012). A multitude of professional development has focused on supporting teachers in transforming their lecture-based, teacher-centered classrooms to active, engaging, student-centered classrooms (Duschl, Schweingruber, & Shouse, 2007; NRC, 1996; Wilson, 2013). A variety of reforms-based pedagogies have been recommended as effective for helping teachers create this type of classroom environment including problem-based learning, inquiry, and the nature of science (Hmelo-Silver, 2004; NRC, 1996, 2012). Science coordinators need to have a solid understanding of these pedagogies in order to effectively educate and support teachers in implementing these strategies.

Problem-Based Learning

Problem-based learning (PBL) is one teaching approach where students work in collaboration to research and solve a real-world science problem (Hmelo-Silver, 2004; Sterling, 2007). Activating student interests and addressing student needs is crucial for PBL instruction to be effective (Sterling & Frazier, 2006; Sterling, 2007). Implementing PBL has the potential to engage students in active, inquiry-based learning, increase achievement and content understanding, and provide an opportunity to engage the community in student learning (Hmelo-Silver, 2004; Sterling, 2006; Sterling, Matkins, Frazier, & Logerwell, 2007). Teachers perceive the implementation of PBL to be difficult and encounter barriers as they try to implement it in their classroom (Ertmer & Simons, 2006; Ertmer et al., 2009; Fryckholm, 2004; Hmelo-Silver, 2004). Consequently, it is essential for teachers to be supported in the process of PBL implementation. Science coordinators may struggle with knowing how to guide and support teachers and receiving professional development about PBL may aid them in this endeavor.

Inquiry

Inquiry-based learning can lead to improvements in student understandings and achievement (e.g. Bransford, Brown, & Cocking, 2000); thus, it is a crucial aspect of high quality science instruction. Inquiry is an important component of science instruction that aids students in developing scientific literacy and allowing them to practice scientific process skills (NRC, 1996). Simply, inquiry is defined as a process where students answer research questions through data analysis (Bell, Smetana, & Binns, 2005). In implementing inquiry, it is important for teachers to scaffold instruction so students have opportunities to develop the necessary skills to design and conduct investigations (Peters, 2009). Inquiry instruction should also integrate and appropriately address instructional objectives (Luft, Bell, & Gess-Newsome, 2008). Teachers often encounter barriers in their attempts to implement inquiry in the classroom (Anderson, 2002; Keys & Bryan, 2001). Thus, supporting teachers in implementing inquiry in the classroom and developing their understandings around inquiry is crucial. Science coordinators should also have an in-depth knowledge about inquiry and have the skills needed to support their teachers in the implementation of inquiry.

Nature of Science

A vital component of scientific literacy is the nature of science (NOS) (Bybee, 1997). NOS comprises tenets for exploration (NRC, 1996) and refers to science as a way of knowing. There are a variety of views on what constitutes NOS, but there are some tenets agreed on 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.

Research indicates explicit instruction around NOS with reflective discussions may be effective in helping students develop appropriate understandings of NOS (e.g. Abd-El-Khalick & Akerson, 2004; Akerson & Hanuscin, 2007; Bell, Abd-El-Khalick, & Lederman, 1998). NOS instruction helps students to understand the big picture of what science is and how it works; thus, it encourages the broader reforms in science education the goal of high-quality science instruction.

Often teachers hold deficient views of the NOS (Akerson, Morrison, & McDuffie, 2006; Smith & Anderson, 1999; Tsai, 2002) and struggle integrating NOS into classroom instruction (Abd-El-Khalick, Bell, & Lederman, 1998; Bell, Lederman, & Abd-El-Khalick, 2000). Even when they hold complete understandings teachers appear to have difficulty transferring their understandings into practice (e.g., Abd-El-Khalick et al., 1998; Akerson & Abd-El-Khalick, 2003; Trumbull, Scrano, & Bonney, 2006). Thus, it is not unreasonable to believe that science coordinators may also struggle with understanding NOS and find it difficult to support teachers in integrating it into their instruction.

VISTA Professional Development

The Virginia Initiative for Science Teaching and Achievement (VISTA) professional development program aims to build an infrastructure to support sustained, intensive science teacher professional development to increase student performance. In order to build this infrastructure, VISTA provides four professional development opportunities for different groups of educators: an Elementary Science Institute (ESI) for in-service elementary teachers (grades 4-6), a Secondary Teacher Program (STP) for uncertified, provisionally licensed, and first-year secondary (grades 6-12) science teachers, a New Science Coordinator Academy (NSCA) and a Science Education Faculty Academy (SEFA). VISTA focuses on PBL, inquiry, and the NOS instruction as reforms-based practices that have been shown to increase student achievement (Akerson & Abd-El-Khalick, 2003; Delisle, 1997; Hmelo-Silver, 2004; Krynock & Krynock, 1999; NCMSTTC, 2000; NRC, 1996; NRC, 2007; Shack, 1993; Stepien & Gallagher, 1993). This study focuses on the VISTA NSCA, professional development specifically designed for science coordinators. Because one of the goals of VISTA is for science coordinators to be able to transfer what they learn during the professional development into effective practice within their district, VISTA draws from both a situated learning framework and characteristics of effective professional development.

Situated Learning

Situated learning theory suggests knowledge is created as individuals interact with their environment to achieve a goal (McLellan, 1996). It recognizes learning as a situated and contextualized process that is continually occurring. The individual and the context are not separate, but are influencing and changing (or constructing) each other (McLellan, 1996). Furthermore, the context includes the physical, social, ethical, and historical norms that affect how people interact with the objects in their environment and with each other. McLellan (1996) identified key components of a situated learning model as: reflection, cognitive apprenticeship, collaboration, coaching, opportunities for multiple practice, and the articulation of learning skills. Table 1 defines these components and provides strategies for integrating these components into instruction.

The present investigation is the first, to our knowledge, that explores the effectiveness of a professional development program designed specifically for district science coordinators that is aligned with situated learning theory.

Table 1

Situated Learning Components and Strategies for Implementation

Component	Definition	Strategies
Reflection	Students consider what they have learned and integrate it with their own experiences.	Process time, Think-Share-Pair, Written reflections
Cognitive Apprenticeship	Students participate in authentic practices in authentic contexts.	Work with and shadow experts in the field
Collaboration	Students construct their knowledge through social interactions.	Collective problem-solving, Opportunity to take on multiple roles, Developing group skills
Coaching	Instructor guides student learning rather than providing direct instruction.	Active learning opportunities, Hands-on activities
Opportunities for multiple practice	Students receive repeated opportunities to practice and develop skills.	Repeated practice of skills when learning new content in authentic context
Articulation of learning skills	Students articulate their thinking, knowledge, reasoning, and problem-solving processes.	Discussions, Journal writing, Teaching what they've learned

Characteristics of Effective Professional Development

Research suggests a clear consensus regarding the key characteristics of professional development associated with changes in teacher learning, classroom practices, and student achievement (Desimone, 2009). These key characteristics include: content focus, active learning, coherence, duration and collective participation (Birman, Desimone, Porter & Garet, 2000; Garet, Porter, Desimone, Birman & Yoon, 2001; Loucks-Horsley et al., 2010).

Content focus refers to the ability of professional development to support teachers in understanding subject matter, learners and learning, and teaching methods (Loucks-Horsley & Matsumoto, 1999). Generic professional development focusing on methods alone is ineffective (Cohen & Hill, 1998; Kennedy, 1998). It is important for professional development to focus on content and methods in order to increase teacher learning and skills (Birman et al., 2000; Desimone, 2009; Kennedy, 1999; Loucks-Horsley & Matsumoto, 1999).

Teachers should be engaged in *active learning* during professional development (Desimone, 2009). This can take numerous forms including: observing other teachers, observing or videotaping lessons with opportunities for reflection, reviewing and analyzing student work, leading or participating in discussions, developing lesson plans, or practicing a teaching method in a group setting. This list is not exhaustive but highlights the type of activities that lead to effective professional development (Garet et al., 2001).

The third characteristic of effective professional development is *coherence*. Coherence is the ability of professional development to be integrated into a program of teacher learning (Birman et al., 2000). In order for professional development to be effective it must build on previous activities, be followed by future professional development activities, be consistent with teacher goals, and draw teachers into dialogues about their experiences with other teachers and administrators in their own school (Birman et al., 2000). Finally, it is critical for the professional development to be well-aligned with the national, state, district, and school policies and standards (Desimone, 2009).

Duration is another characteristic of effective professional development. Duration refers to the total hours of the professional development and the amount of time over which the professional development occurs (Desimone, 2009). Longer professional development spread out over time, like a semester or a full year, tends to have more content focus, active, and coherence than shorter professional development (Birman et al., 2000). Research indicates the duration must be sufficient (approximately 80 hours) in order for teacher change to occur (Cohen & Hill, 2001; Supovitz & Turner, 2000).

A final characteristic of effective professional development is *collective participation*. Collective participation occurs when teachers from the same school, department, subject, or grade attend professional development together (Desimone, 2009). The presence of teachers from similar arenas enables conversations and discussions that enhance teacher learning through increased active learning and coherence (Birman et al., 2000; Borko, 2004; Loucks-Horsley & Matsumoto, 1999). Other advantages include the ability of teachers to discuss changes to their curriculum as a group and the opportunity to develop a professional learning community (Birman et al., 2000).

Purpose

The lack of research presently available on district science coordinators warrants further research about the interactions between science coordinators' understandings, professional development they both receive and offer, teaching strategies used in the science classroom, and the role of a district science coordinator. The purpose of this study was to investigate science coordinators' understandings and practices following their participation in the VISTA NSCA, and to evaluate the effectiveness of the professional development. A second purpose was to better understand the role a science coordinator plays in a school district by characterizing the support and professional development provided by science coordinators to teachers in their district. The following research questions guided this study:

1. In what ways did VISTA science coordinators' understandings change following participation in the VISTA New Science Coordinator Academy?
2. In what ways did science coordinators' practices provide support for teachers in their districts after participating in VISTA?

By exploring how science coordinators' understandings and practices change as a result of VISTA professional development, we can more fully characterize the understandings and practices of science coordinators. We can also begin to look at how science coordinators provide support for teachers in their district and if the professional development they provide to teachers is aligned with VISTA goals and instruction.

Methods

From within an interpretative paradigm (Erickson, 1986), an embedded concurrent mixed methods design (Creswell & Plano Clark, 2011), was adopted to explore the understandings and practices of science coordinators. Within this design, quantitative and qualitative data were collected and analyzed throughout the study. The interpretations resulting from this analysis draw on both the quantitative and qualitative data (Figure 1). Descriptions of the context and participants are provided next, followed by the data collection and analysis methods.

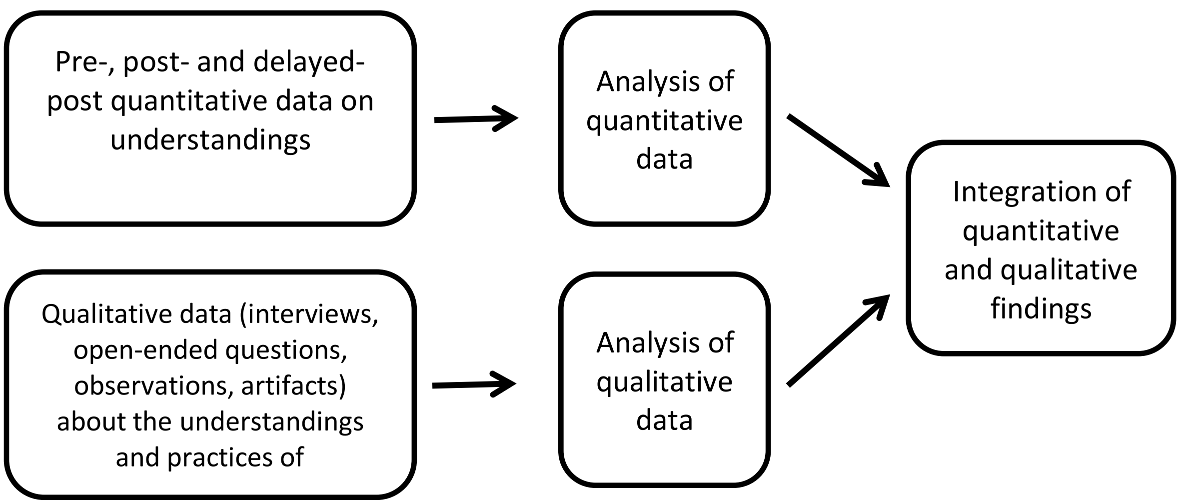

Figure 1. Research design.

Context

The VISTA NSCA occurred over a total of five-days and was facilitated by a team of six instructors. The five-days were split into a three-day session in the fall and a two-day follow-up in the spring. During this time participants engaged in activities, presentations, and discussions that moved them toward accomplishing the stated goals of the NSCA. These goals and objectives (Edmondson et al., 2012, p.7) are outlined below:

1. Learn to make improvements in leadership, teacher learning, quality teaching, and student learning.
2. Develop a common understanding of inquiry, NOS, and PBL.
3. Identify aspects of effective science teaching and learning.
4. Compare district models of creating standards-based science curricula.
5. Investigate data sources available to use to provide a focus to improve district science programs.
6. Develop a science program strategic plan.

These first three goals targeted improving coordinators understanding of inquiry, NOS, and PBL and how to implement these pedagogies into the classroom and in their own practice. The last three goals focused on certain job responsibilities of science coordinators and improving how coordinators understand and approach these responsibilities.

During the NSCA professional development, each day began with an overview of the topics and concluded with a participant-written reflection. Opportunities for collaboration, reflection, and discussion were provided throughout each day. On the first day coordinators were introduced to the VISTA project and engaged in a professional development simulation game that helped them realize the importance of having a vision and plan for their district. On day two, coordinators were introduced to the reform-based science teaching practices VISTA emphasizes, including PBL, inquiry, and the NOS. The instructors then led the coordinators through an activity to aid them in identifying components of effective teaching and provided instruction on how to use observation protocols for effective science instruction. The coordinators then participated in a session on developing standards-based curriculum and looked at the alignment of their own curriculum. Using this information, coordinators began to evaluate where changes might be needed. Moving toward the development of district strategic plans was the focus of day three. This included using data analysis to evaluate science programs, the process of assessing science programs, and then the opportunity to start writing and developing strategic plans for their own district.

In the months between the three-day session in the fall and the two-day session in the spring, science coordinators were expected to work on developing their district strategic plan and to engage in reading the resources provided by VISTA. Coordinators kept records of the work they engaged in related to VISTA and turned this in at the end of the year. The NSCA instructors provided feedback to the coordinators during this time and were available to support coordinators as needed. When coordinators returned for the final two days of the NSCA in the spring, they focused on finalizing their strategic plans, learning about creating professional learning communities in their districts, and using professional development protocols on the fourth-day. Finally, on the last day of the NSCA, coordinators continued to focus on what effective science instruction should look like and reflected on their own professional goals to support science programs. Instructors also provided coordinators with electronic access to all of the resources they used during the NSCA. This included PowerPoints™, handouts, worksheets, articles, and descriptions of activities completed.

McLellan's (1996) situated learning model emphasizes: reflection, cognitive apprenticeship, collaboration, coaching, opportunities for multiple practice, and the articulation of learning skills. This aligned well with VISTA professional development because of the professional development's emphasis on content focus, active learning, coherence, duration and collective participation (Table 2). *Reflection* was incorporated into the NSCA daily as coordinators are asked to submit reflections as exit tickets at the end of each day. They were also asked to periodically submit reports reflecting on their use of what they learned at the NSCA. This provided not only opportunities for further reflection, but also reinforced *active learning*, *coherence* and *duration*. Reflection is one way participants were actively engaged in their learning. Coherence and duration were emphasized by requesting reflection throughout the professional development and the year because coordinators were asked to continue the dialogue about their experiences after the professional development.

Cognitive apprenticeship was built into the NSCA as coordinators were given opportunities to experience activities as a student would, in order to teach about PBL, inquiry and the NOS. They were also given opportunities to practice observing and evaluating these reform-based practices through the use of rubrics and videos and were given resources to use in professional development they offer. Coordinators were also asked to begin the development of a strategic plan, which they did using documents from their district and in discussion with other coordinators. Coordinators were given a *content focus* in these experiences and were involved in *active learning* and *collective participation* which allows their learning to have an authentic context within a social environment.

Table 2

Relationship Between the Components of the VISTA NSCA Professional Development, the Situated Learning Model, and the Characteristics of Effective Professional Development

Component of NSCA PD	**Alignment with Situated Learning Model**
PBL, Inquiry, NOS Activities	Cognitive Apprenticeship Collaboration Coaching
Evaluating Teaching Practices	Cognitive Apprenticeship Coaching
Using data to inform decisions	Reflection Authentic Context Opportunities for Multiple Practice
Strategic Plan Development	Reflection Authentic Context Opportunities for Multiple Practice Coaching
PD Instructor's Role	Cognitive Apprenticeship Articulation of Learning Skills Coaching
Attending with individuals with same job responsibilities	Authentic Context Collaboration

Opportunities for multiple practice were provided to coordinators during the NSCA as they develop strategic plans and go through multiple feedback cycles with peers and instructors. It also provided them multiple opportunities to evaluate instruction for effective practice and to practice using data to inform decisions about science teaching in their districts. These opportunities provided more instances of *active learning* and *coherence* for coordinators. *Articulation of learning skills* occurred through discussions instructors lead with the coordinators, discussions coordinators have with one another and through the reflections coordinators are asked to complete each day. This practice created *coherence* and had a *content focus* for participating coordinators. The VISTA NSCA professional development aligned well with the situated learning model discussed and incorporated the characteristics of effective professional development.

Participants

Participants in this study included all of the individuals in the first two cohorts of the VISTA NSCA. There were 8 males and 20 females, from 23 different school districts in Virginia, ranging from 30 to 58 years of age. Participants included 1 Asian, 5 African-Americans, and 22 Caucasians. All of the participants were in leadership positions in their respective school division and 21 of total 28 participants had experience leading science professional development. Participants' amount of administrative and/or supervision experience in their current role ranged from no experience to 13 years. Table 3 provides the science coordinator's gender, highest degree earned or in progress, position in the district, and years in their current position.

Table 3

NSCA Participant Demographic Information (n=28)

Gender	Female	20 (72%)
	Male	8 (28%)
Highest Degree	M.Ed. or MS	17 (61%)
	Ed.D. or Ph.D in progress	4 (14%)
	Ed.D. or Ph.D.	7 (25%)
Current Position	District Science Coordinator or Specialist	18 (64%)
	Science Lead Teacher or Instructional Coach	5 (18%)
	Other[1]	5 (18%)
Years in Position	0-2	10 (36%)
	3-5	11 (39%)
	6-7	3 (11%)
	>7	4 (14%)

Note: [1] Principals, central office administrators, beginning teacher advisors, department chair

Data Collection

Data collection included: pre, post, and delayed-post surveys of participants in the NSCA, semi-structured interviews with science coordinators, principals and teachers, and observations of district science coordinators. This variety of data allowed for the triangulation of data. 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. Each of type of data is described in detail below.

NSCA Perceptions Survey. The purpose of this survey was to elicit participants' perceptions about their ability to evaluate and implement professional development associated with PBL, NOS, and inquiry science instruction. This survey contained 14 Likert-scale items and was administered as a pre-, post- and delayed-post survey (Appendix A). The Likert-scale ranged from 1 (not very proficient) to 5 (highly proficient). Nine of the 14 items assessed the participants' understanding of and capacity to evaluate and implement professional development associated with PBL, NOS, and inquiry science instruction. The other five Likert-scale items assessed participants' proficiency in supporting research-based and standards-based science instruction, using data to improve district science programs, and developing division-wide strategic planning for science education. The post-survey was administered at the end of NSCA. In addition to the questions on the pre-survey, it contained four open-ended questions designed to elicit participants' perceptions of the NSCA professional development and the quality of the NSCA professional development experience

(Appendix B). The pre- and post-NSCA Perceptions surveys were completed by 25 of the 28 participants (89%).

One year after attending the NSCA, participants were emailed a link to the Delayed-Post Perceptions survey and 22 of the 28 participants responded (79%), 21 of the 28 completed all three surveys (75%). In addition to the Likert scale items on the pre/post survey, the delayed-post survey also included eight open-ended questions designed to elicit participants' perceptions of the effectiveness of the NSCA. It also ascertained the perceptions of NSCA participants' experience a year later and how they have incorporated aspects of the NSCA into their practice (Appendix C). Furthermore, it addressed how the science coordinators implemented learned concepts during the VISTA NSCA in their own district. This survey also included the same 14 Likert-scale items as the pre- and post- survey.

Delayed-post NSCA interviews. Following initial analysis of the delayed-post NSCA survey, 9 participants (32%) participated in a follow-up semi-structured interview about their experiences during and following the academy (Appendix D). The interview protocol provided insight into how or if participants utilized the training they received at the NSCA. The interviews lasted approximately 1 hour. Interviews were tape-recorded, transcribed and initial inferences and interpretations were added.

NSCA school-level infrastructure principal follow-up interview. This interview was administered to three elementary principals whose science coordinator participated in the NSCA and whose schools were participating in the VISTA ESI (Appendix E). It allowed for characterization of the interactions principals had with their science coordinator and about science teaching in their schools. Each interview lasted approximately 30 to 45 minutes. The interviews were tape recorded, transcribed, and then initial inferences and interpretations were added.

NSCA school-level infrastructure teacher follow-up interview. This interview was administered to eight teachers whose science coordinator participated in the NSCA and whose schools were participating in the VISTA ESI (Appendix F). 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 1 hour, were tape recorded, and transcribed for analysis.

Observations. Observations were performed to determine how science coordinators planned for and implemented professional development and to observe the activities coordinators participated in during the NSCA. These observations occurred on six occasions for a total of 45 hours. Four days (32 hours) of observations occurred during the NSCA. Observations were made about activities science coordinators participated in, their engagement with the material, the methods used by the implementation team to deliver instruction, the presence of characteristics of effective professional development, and components of the situated learning model. Observations illuminated the behaviors and interactions participants were involved in and allowed for meaning making to occur as aligned with an interpretive paradigm. Another observation occurred during at an eight hour professional development conference day four participants planned for elementary teachers in the region. During this observation, the first researcher shadowed one of the science coordinators and explored how she planned for and implemented the professional development. A final observation occurred at the district office of one of the participants where 3 hours of district meetings and 2 hours of interactions between the coordinator and her colleagues were observed. This observation provided insight into the coordinator's job responsibilities and commitments. Observation field notes captured descriptions of the professional development provided to teachers during the professional development, interactions between the coordinator, teachers and colleagues, and commentary provided by the coordinator throughout the observations about her thoughts and decisions. Aspects of the situated learning model and characteristics of effective professional development were also noted as they were observed. Transcription and initial analysis of hand-written field notes occurred within two days of the original observations.

Data Analysis

Data from each participant's pre-, post-, and delayed-post NSCA Perceptions survey were analyzed using a repeated measures design in order to allow each participant to serve as their own control. An aggregate summed score of three survey items (Questions 2, 3 and 4) assessing inquiry was calculated for each participant. Aggregate summed scores of three survey items for PBL (Questions 8, 9 and 10), and NOS (Questions 5, 6, and 7) were also calculated. Other items analyzed included the participants' ability to support high-quality research-based science instruction and to develop a strategic plan for their respective districts. The data were assumed to follow an additive model (i.e., scores for each participant were assumed to have the same trend over the three time points). Follow-up non-orthogonal simple contrasts were used to determine whether the scores selected on the pre-survey differed significantly from the scores received on the post- and delayed-post surveys. Alpha slippage was controlled for through the use of a Bonferroni adjustment (i.e., both contrasts were evaluated at a per comparison alpha rate of .05/2 = .025). To determine whether the F statistics were properly distributed, the homogeneity of difference in score variances was also assessed (i.e., sphericity).

A two-step analytic induction approach was employed to analyze the qualitative data (Erickson, 1986) in this interpretive study. First, all survey, interview transcripts and observation reports were imported into a data analysis software program, NVivo. We then studied the data set holistically in order to inductively generate assertions. Throughout the duration of the fieldwork, the entire data set was read and re-read. Seven initial assertions were generated through this process.

The second step involved searching for confirming and disconfirming evidence to warrant the assertions. NVivo qualitative research software facilitated the process of coding data that supported or refuted each assertion. The initial assertions were revised in light of this data, resulting in five assertions well-supported by the entirety of the data corpus. Evidence to support these five assertions is presented in the form of quotes, vignettes, and observational notes. The generation and refining of assertions was completed through collaboration and discussion with a group of researchers. This process helped provide reliability to the findings.

For example, in generating the first round of assertions the researchers observed that coordinators understood inquiry was important and that this was evident in their practice. We also noted that science coordinators had clear understandings of NOS and PBL, which was consistent with the goals of VISTA, but we did not see this evidenced in their practices. Understandings versus practices of inquiry, NOS, and PBL were initially coded as separate assertions; however, when the data was searched the second time it was determined that these assertions should be merged together in two separate assertions to accurately answer the research questions. Thus, through discussion with other researchers it was decided that science coordinators understandings were aligned with VISTA goals in response to the first research question and that their practices did not fully reflect their understandings in response to the second research question.

Potential threats to the validity of the design were addressed throughout the study (Creswell & Plano Clark, 2011). During the data collection, qualitative and quantitative data were collected from the same population and contradictory results were explored. Multiple methods were utilized in the study as suggested by Erickson (1986), including: surveys, observations, and interviews. Furthermore, unobtrusive data collection procedures were utilized and the analysis was consistently framed by guiding questions and the recognition of the researcher as instrument for conducting the research.

Results

The purpose of this study was twofold. First, we sought to assess how science coordinators' understandings did or did not change following their participation in the

VISTA NSCA. Second, we wanted to characterize the practices of science coordinators and how these practices aligned or did not align with the goals of the VISTA NSCA. An overview of the quantitative results is presented first. These results are then integrated with the five assertions related to science coordinators' understandings and practices that were generated through analytic induction. Figure 2 depicts how the assertions are related to the research questions and summarizes each assertion. Then, in the sections that follow, each is discussed in detail with vignettes and supporting examples from the data.

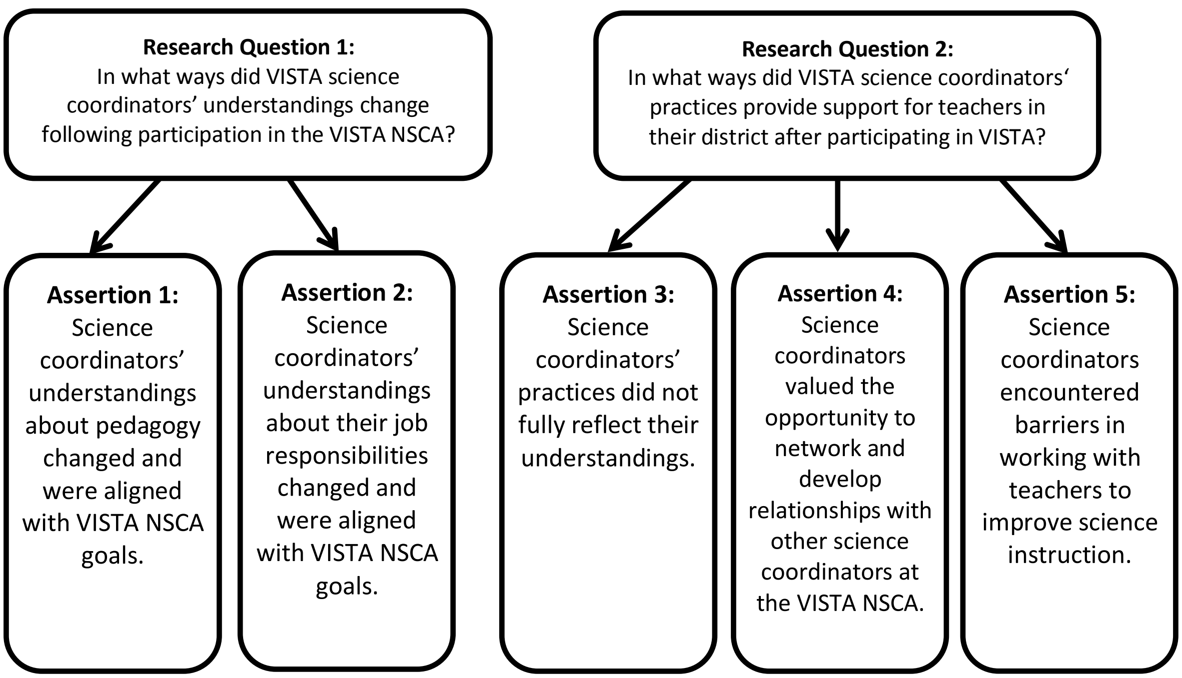

Figure 2. Relationship of research questions to the assertions developed.

Changes Following Participation in the NSCA

Results suggest attending the NSCA improved participants' perceptions of their proficiency and understanding of, ability to develop professional development for, and evaluation of teachers' inquiry, NOS, and PBL instruction, their capacity to improve science instruction, and to develop a strategic plan for science instruction. Furthermore, the results indicate these improvements were maintained a year following their attendance (Table 4). These results are discussed in greater detail in relationship to the relevant assertions they support.

Table 4

Changes in Participants' Perceptions of Their Proficiency and Confidence on Selected Outcomes (n = 21)

	Supporting science instruction^ M (SD)	Inquiry+ M (SD)	NOS+ M (SD)	PBL+ M (SD)	Strategic Planning^ M (SD)	Using data to improve instruction^ M (SD)
Pre	3.33 (1.02)	9.43 (2.79)	8.12 (2.50)	8.81 (3.14)	2.71 (1.19)	3.36 (1.09)
Post	3.62 (0.92)	11.95 (2.36)*	10.74 (2.46)*	11.67 (2.15)*	3.67 (1.06)*	4.00 (0.71)*
Delayed-Post	3.95 (0.86)	12.48 (2.29)	11.38 (2.52)	12.33 (2.80)	3.86 (0.96)	4.14 (0.91)

Note: ^Indicates a 1-5 point scale. +Indicates an aggregate score of three items with a total possible score of 5-15 points. *Indicates statistical significance at $p < 0.05$.

Assertions

<u>Assertion 1: Science coordinators' understandings about pedagogy changed and were aligned with VISTA NSCA goals.</u>

The VISTA NSCA had three goals targeted at improving science coordinators' understanding and ability to identify and evaluate new types of pedagogy: learning to make improvements in leadership, teacher learning, quality teaching, and student learning, developing a common understanding of inquiry, NOS, and PBL, and identifying aspects of effective science teaching and learning. As part of the NSCA coordinators explored inquiry, NOS, and PBL definitions, participated in activities that modeled these pedagogies, and discussed how to identify and evaluate these practices in the classroom. Science coordinators' understandings about inquiry, NOS, and PBL were improved and aligned with VISTA NSCA goals after participating in the Academy. These changes are discussed in detail below.

Inquiry. Prior to attending the NSCA, science coordinators had a wide range of definitions for inquiry. Some coordinators simply said "I don't know" (Pre-NSCA Survey), while others attempted to provide some type of definition. For example, James defined inquiry as, "Teaching through having the students do hands-on activities where they learn the science concepts by activities reinforced with lecture, discussion, vocabulary, etc." (Pre-NSCA Survey). Drake defined it as, "Inquiry instruction is a student centered strategy that allows the questions that the students generate to guide the lessons and activities" (Pre-NSCA Survey). None of these definitions were aligned with the definition used by VISTA: students ask questions, collect, and analyze data and use evidence to solve problems. However, following the NSCA science coordinators definitions were more aligned with the VISTA definition as exemplified in Chloe's definition: "Inquiry instruction allows students to develop questions and design experiments to test those ideas" (Post-NSCA Survey).

These results are further substantiated by the statistical results obtained for the items assessing coordinators' perceptions of their ability to identify, evaluate, and enhance teachers' science instruction. Mauchly's chi-square approximation confirmed sphericity of the data, (i.e. homogeneity of difference in score variances was not violated), $\chi^2(2) = .771$, $p = .68$. Tukey's test of additivity established the data followed an additive model, (i.e. scores for each time period were assumed to have same trend over the three time points), $F\ (1, 39) = 1.08$, $p = .31$. The mean score on coordinators' perceptions of their ability to identify, evaluate, and enhance teachers' inquiry instruction was statistically significant, $F\ (2, 40) = 22.65$, $p < .001$. Follow-up non-orthogonal contrasts between the pre-, post- and delayed-post evidenced there was a significant increase in scores, with a possible range of 5-15, from the pre- ($M = 9.43$) to post- ($M = 11.95$), $F\ (1, 20) = 23.22$, $p < .001$. However, there was no significant increase from post- to delayed-post ($M = 12.48$), $F\ (1, 20) = 1.419$, $p = .248$. Omega squared indicated 35% of the variance in the participants' scores on inquiry instruction was attributable to the times when the scores were evaluated. This suggested coordinators' understood inquiry was an appropriate method to teach science and this understanding was maintained a year later.

Nature of Science. Prior to attending the NSCA science coordinators had varied definitions for the NOS. Some coordinators left the question blank or said "I don't know" (Pre-NSCA Survey). Some appeared to have no prior experience with NOS as evidenced by Sierra's answer, "Not real sure what is being asked. I can guess that it is instruction where students are actively involved in the learning process" (Pre-NSCA Survey). Still, others like Matt had partially accurate views: "A method used to develop ideas about the world by way of observing, thinking, experimenting, and validating" (Pre-NSCA Survey). Only two teachers had complete understandings of NOS prior to attending the NSCA.

VISTA defines the NOS as: students learning the values and assumptions inherent to the development of scientific knowledge, including: scientific knowledge is empirical, reliable and tentative, based on observation and inference, scientific theories and laws are different and many methods are employed to develop scientific knowledge. After the NSCA, some coordinators, like Brenda, still maintained an inaccurate view of NOS: "Science instruction involves many and layered levels of engagement between and among students and teacher/facilitator. There are opportunities for direct instruction, facilitation, open-ended, convergent, and problem solving. Inquiry is the driving force behind good science instruction" (Post-NSCA Survey). However, the majority of the science coordinators evidenced accurate definitions of the NOS as evidenced by Chloe's NOS definition:

> Nature of science encompasses 7 key components dealing with what science is (and isn't) and what scientists do. Instruction should be interwoven into the content and not dealt with as a stand-alone. Teachers need to move away from 'the' scientific method and need to emphasize the test ability and changing nature of scientific knowledge. (Post-NSCA Survey)

Significant differences between pre- and post-survey items suggested coordinators felt proficient and confident in identifying, evaluating, and enhancing NOS instruction. Mauchly's chi-square approximation confirmed that sphericity was obtained, χ^2 (2) = .356, p = .84. Tukey's test of additivity revealed the data followed an additive model, F (1, 39) = .008, p = .93. The mean score on coordinators' perceptions of their ability to identify, evaluate, and enhance teachers' NOS instruction, with a range of 5-15, was found to be statistically significant, F (2, 40) = 20.88, p < .001. Follow-up non-orthogonal contrasts between the pre-, post- and delayed-post showed there was a significant increase in scores from the pre- (M = 8.12) to post- (M = 10.74), F (1, 20) = 22.69, p < .001. However, there was not a significant increase in scores from post- to delayed-post (M = 11.38), F (1, 20) = 1.34, p = .261. Omega squared indicated 35% of the variance in the participants' scores on NOS instruction was attributable to the timing of the surveys. This indicates the perceptions of their understandings of the NOS were improved from pre- to post- and these changes were maintained a year after their attendance.

Problem-based Learning. Before attending the NSCA science coordinators' definitions of PBL appeared to indicate partial understandings of the VISTA definition: students solving a problem with multiple solutions like a scientist would in an authentic context, where both the problem and context are meaningful to students. Jossi's PBL definition was representative of how coordinators responded:

> Problem-based learning is learning that takes place while investigating a problem related to a particular content area. It requires the learner to navigate through the scientific process while applying what was learned previously (prior knowledge) and discovering new knowledge in an effort to solve a real-world problem. (Pre-NSCA Survey)

Another common answer was similar to Janet's response: "Problem based learning is where students learn content through solving problems. Investigating the application of the content in real world situations" (Pre-NSCA Survey). After attending the NSCA, those definitions that evidenced some understanding moved toward having a more complete understanding of the VISTA definition.

These results were supported further by the quantitative results. For PBL, Mauchly's chi-square approximation revealed sphericity had been violated, $\chi^2(2) = 6.73$, $p = .035$, therefore degrees of freedom were corrected using Huynh-Feldt estimates of sphericity ($\varepsilon = .82$). Tukey's test of additivity confirmed the data followed an additive model, $F\ (1, 39) = .100$, $p = .75$. The mean score with a range of 5-15 on coordinators' perceptions of their ability to identify, evaluate, and enhance teachers' PBL instruction was statistically significant, F (1.64, 32.89) = 17.435, $p < .001$. Follow-up non-orthogonal contrasts between the pre-, post- and delayed-post indicated there was a significant increase in scores from the pre- (M = 8.81) to post- (M = 11.67), F (1, 20) = 14.87, p = .001. However, there was no significant increase in scores from post- to delayed-post (M = 12.33), F (1, 20) = 2.37, p = .139. Omega squared showed 33% of the variance in the scores on PBL instruction was attributable to the time when the scores were evaluated.

Assertion 2: Science coordinators' understandings about their job responsibilities changed and were aligned with VISTA NSCA goals.

The VISTA NSCA had three goals targeted at improving science coordinators' understanding about their job responsibilities: comparing district models of creating standards-based curriculum to support science instruction, investigating how to use data sources to improve district programs, and developing a science program strategic plan. As part of the NSCA, science coordinators learned about and practiced aligning curriculum to support science instruction, practiced using data to inform professional development and identify needs within their programs, and worked toward developing a strategic plan. Science coordinators' understandings about using data and developing a strategic plan were improved after attending the NSCA and are discussed in more detail below.

Supporting science instruction. Prior to attending the NSCA science coordinators were confident in their understandings and ability to support high quality science instruction. This is to be expected of science coordinators as this is a major facet of their job. Quantitative data supported these findings. Mauchly's chi-square approximation confirmed sphericity, $\chi^2(2) = 2.86$, $p = .24$. Tukey's test of additivity revealed the data followed an additive model, $F(1, 39) = .15$, $p = .70$. The mean score with a range of 1-5 for coordinators' perceptions of their ability to support high quality, research-based science instruction was statistically significant, $F(2, 40) = 4.03$, $p = .025$. Follow-up non-orthogonal contrasts between the pre-, post- and delayed-post indicated there was no significant increase in scores from the pre- ($M = 3.33$) to post- ($M = 3.62$), $F(1, 20) = 1.538$, $p = .229$ nor from post- to delayed-post ($M = 3.95$), $F(1, 20) = 3.684$, $p = .069$. While there was no significant increase from pre- to post- to delayed-post, the mean was found to be statistically significant.

Using data to improve instruction. During the NSCA, instruction about various types of data science coordinators could use in their practice to improve science instruction was delivered by the implementers. Coordinators also had multiple opportunities to practice analyzing data to evaluate teacher performance, investigate the alignment of curriculum, and to inform the design of their strategic plans. Science coordinators identified this aspect of the Academy as one of the most valuable as represented by James response, "Analyzing achievement data in science" (Delayed-post NSCA Survey). Science coordinators appeared to understand the importance of using data to support science instruction and this was further substantiated by the statistical results.

Mauchly's chi-square approximation confirmed that sphericity was obtained, $\chi^2(2) = .363$, $p = .83$. Tukey's test of additivity established the data followed an additive model, $F(1, 39) = 2.76$, $p = .10$. The mean score on coordinators' perceptions of their ability to use data to improve instruction was found to be statistically significant, $F(2, 40) = 9.12$, $p = .001$. Follow-up non-orthogonal contrasts between the pre-, post- and delayed-post with a range from 1 to 5 evidenced there was a significant increase in scores from the pre- ($M = 3.36$) to post- ($M = 4.00$), $F(1, 20) = 11.15$, $p = .003$. However, there was no significant increase from post- to delayed-post ($M = 4.14$), $F(1, 20) = .588$, $p = .452$. This suggested coordinators' understood using data to improve their science program was important to their job responsibilities and this understanding was maintained a year later.

Developing a strategic plan. Instruction was provided on how to develop a strategic plan and coordinators were given examples during the NSCA. Science coordinators worked on a rough draft and solicited feedback from peers and NSCA leaders during the professional development. This instruction on the development of a strategic plan resulted in science coordinators understanding a strategic plan was necessary for their district and taking steps to implement one in their districts.

This was evidenced by the majority of science coordinators discussing some aspect of a strategic plan when asked how they have used what they learned at the NSCA. For example, Diane wrote, "It has helped me understand the need for a division-level set of goals for science instruction." Marie answered, "The information shared has helped me strengthen some areas such as writing a strategic plan for my district."

Another science coordinator, Bob, answered "The model strategic plan: this way of thinking gave me a jumping-off point in developing a similar model within my own school district." When interviewed Bob expanded on his survey response:

> Being able to sit down with a sample strategic plan. One of the implementers brought a sample strategic plan from his work in a district so that we could use that as a jumping off point for our own next steps….we don't often have folks sitting and thinking about that level of strategy when thinking about the programs we offer. So just being able to have that and the model and other folks to collaborate with in terms of their ideas, what strategies they're taking on to meet their goals. I think that that was really powerful for me. (Delayed-Post NSCA Interview)

The science coordinators valued the instruction on strategic planning at the NSCA and understood a strategic plan for science instruction was important. The insight provided by implementers who had previously served as science coordinators and the opportunity to collaborate and work with others aided the science coordinators in creating a strategic plan. This evidences the importance of cognitive apprenticeship and collaboration in the NSCA and the importance of active learning, coherence and collective participation as effective characteristics of professional development. In giving science coordinators the time to develop their own strategic plan in collaboration with others, the NSCA provided opportunities for them to understand the importance of a strategic plan.

The statistical results from participants on strategic planning supported these qualitative results. Mauchly's chi-square approximation revealed that sphericity was obtained, $\chi^2(2) = 1.97$, $p = .37$. Tukey's test of additivity evidenced the data followed an additive model, $F(1, 39) = .554$, $p = .46$. The mean score with a range from 1 to 5 on coordinators' perceptions of their ability to develop a strategic plan for their respective districts was found to be statistically significant, F (2, 40) = 13.35, p < .001. Follow-up non-orthogonal contrasts between the pre-, post- and delayed-post indicated there was a significant increase in scores from the pre- (M = 2.71) to post- (M = 3.67), F (1, 20) = 12.31, p = .002. However, there was no significant increase in scores from post- to delayed-post (M = 3.86), F (1, 20) = .792, p = 0.384. Omega squared showed 26% of the variance in the scores on strategic planning was attributable to the timing of the surveys. The significant difference found in pre- to post-survey scores for the coordinators' perceptions of their ability to develop a strategic plan is evidence of the coordinators' ability to transfer what they learned. Furthermore, the statistical results revealed there was no reversion from the post- to delayed-post survey as there was no significant difference in these scores. This suggests that not only do coordinators believe strategic plans are important, but also that this change was retained a year after the professional development.

Assertion 3: Science coordinators' practices did not fully reflect their understandings.

Science coordinators made gains and improvements in inquiry, NOS, and PBL understandings, using data to improve instruction, and developing a strategic plan. However, science coordinator practices did not fully reflect their new understandings for all of the NSCA goals. Science coordinators' practices reflected their understandings in inquiry, using data to improve instruction, and developing a strategic plan. However, their practices did not fully reflect their understandings of NOS and PBL.

Inquiry. All science coordinators valued the instruction on inquiry and mentioned it as one of the components they used with their teachers in professional development. In her survey, Helen wrote:

> I really liked learning about the definitions of inquiry vs. hands-on science vs. problem-based learning. We tend to use them as synonyms, but they are very different things. A good science program has components of all of these things, and the method of instruction should support the content. I also liked learning about the different stages of inquiry; it can help teachers understand how to scaffold their teaching for their students. Too often, teachers try an inquiry lesson that is too advanced for their students, and when it doesn't work, they never try it again. Understanding about the levels of inquiry gives teachers a road-map to follow with their students. (Delayed-Post NSCA Survey)

This statement was representative of what science coordinators wrote about the value of inquiry. Similarly, Ann indicated she incorporated inquiry into professional development:

> … inquiry was implemented with my teachers that when we had professional development days this past year, in fact I called in, that's another benefit of the Academy, I called in Amy [Academy instructor] to assist me presenting those two concepts. … part of my strategy was to take that and make sure we all got on the same page as far as what those terms mean. And also hands-on science, teachers have a lot of misconceptions about what that meant as well. (Delayed-Post NSCA Interview)

As a result of her participation in the NSCA, Ann developed and implemented professional development focused on inquiry and hands-on instruction at the beginning of her school year. She also asked a NSCA instructor to assist her and provide her support in implementing this professional development, which suggested some transfer of learning occurred from the professional development into the practice of science coordinators.

Coordinators were first introduced to inquiry during the NSCA by discussing why inquiry is such an important topic in science education. Implementers then introduced the VISTA definition of inquiry and asked coordinators to consider various classroom labs and activities and determine whether it was inquiry according to the VISTA definition. NSCA implementers then introduced the levels of inquiry and had coordinators participate in a hands-on, inquiry activity called the Rusty Nail Lab (Observation). Following this activity, coordinators discussed the need to scaffold inquiry for teachers and students and how they might do this type of professional development for their teachers. Throughout the NSCA, inquiry was a topic that was revisited and implementers emphasized how important inquiry is to increasing student engagement and achievement. The NSCA approach to inquiry was highly contextualized and encouraged coordinators to think about how they would implement professional development for their teachers. This may have contributed to the transfer of learning into practice coordinators appeared to experience.

Furthermore, science coordinators discussed how they utilized the resources provided by the VISTA NSCA to help them implement professional development for teachers. One representative example is described by Ken:

> I used a lot of the strategies from the Academy. It was integrated in the professional development workshops that were provided to all science teachers, both new and veteran. I also modified the PowerPoint™ materials [about inquiry] from the NSCA and shared it with teachers and other administrators in our district. The handouts were very helpful, too. Those were given to new teachers. (Delayed-Post NSCA Survey)

Other coordinators had similar responses and found the resources provided by the NSCA to be helpful in providing instruction to teachers on inquiry. It was also apparent the materials provided by the NSCA for inquiry were relevant and contextualized for how science coordinators would use the materials. The use of these materials by coordinators in their practice evidences transfer of learning occurred.

Nature of Science. Science coordinators' understandings of nature of science improved after attending the NSCA, but this was not fully reflected in their practices. NOS was not consistently mentioned as an area where participants provided professional development for teachers, like they consistently mentioned for inquiry; nor was it observed. When Diane was asked about her intention to address NOS in her practice, she said "Um, uh, I don't have that firmed up in my head on an approach for that" (Post Interview). Alex said:

> Yeah, I think certainly with the curriculum changes coming. I mean, the state SOL changes, but ours will be not next year, but the following year. Our thoughts are as part of what we're doing with these pull-outs [for inquiry], and then we would still do additional professional development. Embedding some of those things more explicitly, about nature of science within some of the things that we're doing. (Post Interview)

Alex was in the process of providing inquiry professional development to his teachers and did not have an explicit plan for how he would implement nature of science into his professional development. This was representative of science coordinators' response to implementing nature of science professional development. Many had the intention to implement NOS PD but there was little evidence that it was actually being implemented into participants' practice.

During the NSCA, NOS was introduced through a card sort where coordinators placed statements about NOS into yes, no, and don't know piles and then discussed their piles with partners (Observation). Following the card sort, implementers introduced the tenets of the NOS, how coordinators might evaluate NOS in the classroom, and the importance of instruction around NOS being explicit. Implementers then presented NOS scenarios for the coordinators to discuss. The NSCA introduced the topic but did not contextualize the instruction on NOS for individuals who would be delivering professional development on NOS. It may be that the resources and/or instruction for nature of science were less relevant and contextualized. It may also be that inquiry was perceived as being a more pertinent topic to cover with teachers.

Problem-based Learning. Similar to NOS, science coordinators' understandings of PBL improved after attending the NSCA, but this was not reflected in their practices. When asked about her experience with PBL at the NSCA, Lisa said:

> I think that problem-based learning needed to be, actually talked about a lot more. I felt like that was just given cursory attention. And I think there needed to be a distinction between problem vs. project-based learning myself. That there needs to be a distinction between project-based learning and problem-based learning, because they're not the same thing. So that's really important and I think that needs to be discussed, especially with principals, with administrators because they don't often get that distinction. And often, it's the gifted centers, it's the gifted classes that do the problem-based learning. But I think that needs to be tied in a lot to inquiry-based learning and this whole idea of these long science projects that are often just tied to science fairs. So I think we need to get away, and this is a good place, a good venue to kind of plant the seed, that good long term problem-based science can be done with these science projects. You don't necessarily have to go to fairs, but you can still do them, and they still should be done. (Post-Interview)

In general, science coordinators did not mention PBL as an area where they did professional development for their teachers. Lisa's experience with the PBL session at the NSCA indicated the need for time (duration) to be spent on this topic in order for science coordinators to transfer this topic into their practice.

PBL instruction during the NSCA began with coordinators participating in a "Duck

Lab" (Observation). This activity allowed coordinators to experience a shortened version of a PBL unit. Participants completed one activity and then discussed what some of the other activities would be in the PBL unit. Participants also discussed the use of question maps and provided examples of past PBL units. The instruction on this topic did not provide coordinators an authentic context to learn about how to provide PBL professional development. The coordinators did not experience the whole unit, nor did they experience it as they might use it in professional development with teachers making this experience less authentic. This may have impacted coordinators' ability to transfer their PBL understandings into practice.

Using data to improve instruction. Results indicated that science coordinators' understanding of using data to improve instruction improved after attending the NSCA. These understandings were also reflected clearly in their practice. For example, Beth described using data to inform what type of professional development she would offer, and using state assessment data to inform benchmark assessments for the district. Ann explained how she was currently implementing what she had learned about using data in the district:

> We've done a lot with the teacher evaluation process that's come up from the state and we're looking very closely at how to help teachers monitor student growth in their classroom. Instead of just making sure that they deliver the instruction but also how are those students growing as a result of your delivery. So our team, our curriculum and instruction team, which I'm a part of at the division level, has worked a great deal and continue to work on how to get examples for teachers to use that would best show that growth. So that's data that, we're actually gonna teach the teachers how to collect the data on their own students, where the greatest need is and move forward with that. (Delayed-Post Interview)

Science coordinators used data to inform their practice in a variety of ways. They used it to inform professional development needs, to design benchmark tests, to help teachers think about how to collect their own data for the teacher evaluation process, and to help schools identify science content areas where they needed to grow. The contextualized nature of the NSCA and the opportunities for multiple practice allowed coordinators to be able to transfer these understandings into their daily practice.

Developing a strategic plan. Science coordinators had a clear understanding of the importance of developing a strategic plan after participating in the NSCA. Not only did science coordinators value the time to work on strategic plans, they also continued with the process of developing and implementing a strategic plan upon returning to their districts. When asked about her use of the strategic plan instruction from the NSCA, Beth answered:

> One of the things that we did, we really looked at our plan for science. We didn't have a solid plan in place, but – for any of the content areas – but, when I brought that information back one of my goals was to make sure that we had a science plan, a plan for science, a five-year plan. And currently we are in the middle of working on all of the different content at the same time. (Delayed-Post NSCA Interview)

Beth clearly identified the need for a five-year strategic plan for science for her district and made it one of her personal goals to develop one. She also brought back to her district what she had learned about the process of developing a strategic plan to share with other content coordinators in her district and, at the time of the study, was in the process of developing the plan to be implemented in future years. This suggested coordinators are transferring what they are learning at the NSCA into their practice within the district.

For example, all of the interviewed science coordinators, except Carrie, were in the process of developing or implementing a strategic plan for their district. When asked about her use of the strategic plan, Carrie responded, “No. We have a division-wide strategic plan that we are working on and it's been a work in progress for several months” (Delayed-Post NSCA Interview). The presence of the division-wide strategic plan under development in Carrie’s district eliminated the need for her to develop her own strategic plan for science instruction. However, it was evident the other coordinators valued and implemented the instruction on strategic planning into their practice.

<u>Assertion 4: Science coordinators valued the opportunity to network and develop relationships with people in similar jobs at the VISTA NSCA.</u>

All science coordinators placed great value on the opportunity to meet and work with colleagues during the NSCA. Ann’s interview reflected this. When she was asked what components she valued at the NSCA she noted, “I think the camaraderie of being with other district leaders and sharing in a network as far as resources and support for each other” (Delayed-Post NSCA Interview). Similarly, Marie wrote, “I found the collaboration with colleagues valuable.” Diane answered, “The networking has given me some contacts to consult for ideas.” In his survey, Bob said, “Networking with others in similar roles: leadership roles tend to be isolated in nature, and this opportunity gave me ways to learn from others.” Beth explained in her interview:

> The collaboration between the different people that we got to work with, from the specialists who came in to just other people that have the same type job as I have and seeing what's going on in their district and sharing that information, sharing resources. Every day was a different learning experience, but every day it was something that I could bring back. (Delayed-Post NSCA Interview)

It was clear science coordinators valued the opportunity to interact and work with others in similar positions. In providing science coordinators the opportunity to interact with other leaders in similar positions, the NSCA professional development fostered collaboration and coherence for the coordinators. As a result, science coordinators also understood that this type of networking was valuable and could enhance their practice.

Not only did science coordinators establish relationships with one another during the NSCA, these relationships continued in some form after the NSCA ended. The collaboration, collective participation, and coherence established by the NSCA fostered relationships that were sustained a year later. In some cases, the continued connection was limited to e-mail, the sharing of resources on the NSCA DropBox™ or through re-connections at regional or state conferences. In other cases, science coordinators developed a deeper relationship and continued their support and interactions a year after the end of the NSCA. The following vignette developed from an observation of Ann during the implementation of region-wide science teaching professional development for elementary teachers reflected how some of these deeper relationships have continued after the NSCA.

> Diane, Beth and Linda, all from the VISTA NSCA, were on the committee Ann created to help her plan for and implement the professional development day. At the beginning of the conference, Diane, Beth and Linda sit at the registration table checking teachers in and making sure they have the correct lunch choice.

> Ann talks with teachers and goes over to check in with the registration table. She hugs Beth and then talks with them about the lunches. She expresses concern about having enough lunches for the day and they tell her to not worry about it that it will all work out. Linda tells Ann that one presenter claims she is not the schedule. At first there is a moment of panic but Diane finds her on the schedule. Beth asks, "Why did she make such a big deal about it?" Beth says, "She's just like that." Ann seems satisfied that the "crisis has been averted" and moves on to talk with other teachers as more are entering to check-in. Throughout the day Diane, Beth and Linda take on various responsibilities including checking the rooms for the appropriate materials, counting heads in each session to keep track of the most popular ones, handing out lunches and helping to hand out prizes at the end of the day. The four have constant check-ins and deal with issues together as they come up. (Observation)

It is apparent from this observation that these four science coordinators formed supportive relationships at the NSCA. In her interview, Ann further described the change in her relationships with science coordinators as a result of the NSCA:

> There's more of a personal relationship that we can call each other and I see more of a collegiality. That we don't feel like it's a me against them but it's more, hey I've got it, if you can use it, take it. (Delayed-Post NSCA Interview)

The collaborative nature of the VISTA NSCA professional development allowed for personal relationships to be developed and fostered between science coordinators. Science coordinators viewed these relationships as an opportunity to enhance their practice and have continued those relationships beyond the NSCA. This evidences the important role of collaboration in professional development experiences to foster learning.

<u>Assertion 5: Science coordinators encountered barriers in working with teachers to improve science instruction.</u>

Science coordinators did not perceive having much power in their districts. A conversation with Ann during an observation reflected this:

> I asked Ann, "Do you do a lot of professional development with schools?" Ann explains that yes she does, but a lot of schools in her district still don't have interest. She says she tries to develop relationships with excited teachers at conferences. She says they are more likely to invite her to their schools if they have a relationship with her and that she follows up with emails after conferences to see if she can help in any way. (Field notes, Observation)

Ann had no influence or final say in whether or not she was allowed to do professional development with schools. The schools that were interested invite her in, but if there is no interest then she has no method or recourse for working with those teachers. In this case, there was literally no opportunity for science coordinators to transfer their learning into practice because they are constrained by their ability to institute required professional development opportunities. In an interview with Ann, she noted:

> I typically don't get elementary on professional development days and I usually will wind up doing little workshops at the school. And that was again another reason why I focused my attention on K-5 for this conference I just did. (Delayed-Post NSCA Interview)

This was representative of what other science coordinators said about science instruction professional development in their district. For example Carrie shared, "I do have instructional math division-wide meetings and reading specialist meetings. They are the focus and they have been monthly," when talking about the opportunities she has to provide professional development to elementary teachers in her district (Delayed-Post NSCA Interview). Carrie focused on reading and math because at the elementary level there was less focus on science. In Virginia there are reading and math end-of-course tests administered every year, but at the elementary level science end-of-course tests are only administered in third and fifth grade. Teachers, principals and coordinators interpreted this to mean professional development needs to focus more on math and reading at the elementary level. Beth provided a similar response, "we also have instructional focus meetings and usually those meetings really consists of reading and math professional development" (Delayed-Post NSCA Interview). Beth also perceived she cannot focus on science because of the need to focus on reading and math at the elementary level. The data indicated that coordinators perceived having little power in determining the amount of time given for science professional development in their districts and felt constrained by the need to focus on reading and math.

Another example of the lack of power science coordinators possessed in their district is represented by the following vignette.

> Ann sat talking with another content coordinator during a curriculum team meeting at the district office. Ann talked about how she was recently consulted by a principal on the hiring of a new teacher. Ann strongly suggested the principal not hire this candidate and that he look for a new one. The principal ignored Ann's suggestion, hired the teacher and subsequently the teacher had difficulty teaching in the classroom. The principal then called Ann and asked her to work with the teacher and help move him toward good instruction. Ann expressed her frustration with her colleague over the situation. At the point, another content coordinator entered the room and complained of the exact same incident in another content area. The coordinators were clearly frustrated with their lack of power and ability to influence decisions in the district. (Observation)

While this vignette described a power issue with hiring, it also illuminated how administrators expected coordinators to fix the situation. As a result of the situation described, Ann had to spend more time working with one teacher on improving his practice rather than working with groups of teachers to improve science instruction across the district. Science coordinators had a myriad of responsibilities and when suggestions they made were not heeded, their ability to improve instruction was hindered. The lack of power science coordinators perceive in the district influenced their ability to effect change in science instruction.

Another barrier coordinators encountered was the reduction in time allotted for teaching science at the elementary level as a result of state-mandated tests. Across the board, principals, teachers and science coordinators indicated the amount of time teaching science has been reduced over the past years. One principal, Mary said, “Our science and social studies have been whittled down sometimes to 30 minutes and that's just not enough time” (Principal Interview). Part of this is due to the focus put on reading and math at the elementary level.

Teachers and principals confirmed the emphasis on reading and math at the elementary level and attributed it to the time needed to prepare for state-mandated tests in these areas. Another principal, Hannah explains:

> We don't have a tremendous amount of ongoing science instruction associated with SOLs, but we have quite a bit of resource materials. So I think that's an area that would benefit from some more focus, but I also think that it's the stepchild to the reading and the math. (Principal Interview)

Hannah’s response was representative of how science coordinators, principals, and teachers reference science instruction in comparison to math and reading at the elementary level. In this case, Hannah referred to science as the “stepchild,” others said it took a “back seat,” some said it was on the “back burner;” in all cases it was evident science was not a priority at the elementary level and that there was not enough time to teach it. Sue noted, “We’re strapped for time, there’s just not enough time to teach it all” (Teacher interview). With such little emphasis on science at the elementary level, it appears participants were given fewer opportunities to support science instruction through district planned professional development.

Discussion

This study investigated what ways, if any, science coordinators' understandings and practices changed following their participation in the VISTA NSCA. There were clear connections between the situated learning model and the incorporation of the characteristics of effective professional development in the VISTA NSCA. The results of this study suggest professional development aligned with McLellan's (1996) model for situated learning may encourage the transfer of learning from the professional development into the understandings and some of the practices of district science coordinators.

Aligning Professional Development with Situated Learning

Science coordinators changed their understandings and most of the targeted practices, and these changes were maintained a year after the NSCA. These results suggest the potential of linking professional development activities to characteristics of effective professional development and a situated learning perspective. Science coordinators valued the instruction on inquiry during the NSCA and understood it was an appropriate method for teaching science. Furthermore, coordinators not only understood it was an appropriate method, they also transferred their learning into practice by implementing professional development on inquiry within their districts. The active learning opportunities provided by the NSCA and the relevancy of the resources enhanced this transfer of learning. These findings suggest that providing instruction in multiple contexts and utilizing multiple, broad examples facilitate the transfer of students' knowledge to new settings (NRC, 2000). This extends previous research by applying it to adult learning transfer rather than student learning transfer (Engle, Lam, Meyer, & Nix, 2012; NRC, 2000).

In the professional development science coordinators provided to teachers, they emphasized inquiry, consistent with the goals and instruction of the VISTA NSCA. This indicates the relevant and socially contextualized nature of the NSCA supplied and provided coordinators with activities they could use with their own teachers. It also supports Perrine's (1984) finding that two of the most important components of the coordinator role are providing teachers with content and pedagogical supports and engaging in effective communication with teachers. However, more work is needed to understand how coordinators implemented professional development for teachers. It is unclear if professional development was implemented exactly as it was presented in the NSCA or if the implementation was modified in some way. It is also unclear if the professional development was implemented utilizing the characteristics of effective professional development. During the NSCA, science coordinators were provided with resources about how to do effective professional development, but there was no explicit instruction around this topic. Thus, it may be unrealistic to expect science coordinators to incorporate the characteristics of effective professional development into their own practice. Regardless, it is evident science coordinators were implementing professional development to educate teachers about inquiry.

In contrast to the way science coordinators' practices fully reflected their understandings of inquiry, science coordinator practices did not fully reflect their understandings of NOS and PBL. Science coordinators did not appear to transfer their NOS and PBL understandings into practice. As evidenced by observations of the NSCA, it may be that the professional development around NOS and PBL was not contextualized enough for coordinators to transfer their understandings to practice. The implementers introduced these topics, but did not contextualize how this type of professional development might be implemented for teachers. These findings suggest there may not have been a sufficient mixture of general principles and specific examples in the professional development (NRC, 2000).

Furthermore, it may suggest the need for there to be more time spent on these topics during the NSCA in order for transfer to occur. During the NSCA, very little time was spent on NOS and PBL; thus, more in-depth time on the topic may have allowed for the implementers to contextualize these topics more effectively for the coordinators. Additionally, the VISTA NSCA did not take a process skills-based approach to teaching NOS as suggested by Matkins and Bell (2007) and Mulvey (2012). Utilizing a process skills-based approach with inservice teachers, Mulvey (2012) found teachers substantially improved their NOS understandings and more importantly, were teaching the NOS regularly in their classrooms. It may be that implementers need to consider taking a more process skills-based approach to the NOS professional development sessions if they want to see changes in science coordinator practices around this topic.

The NSCA provided a social context for coordinators to engage in active learning with a clear content focus and to develop and create a product directly related to their everyday practice. Science coordinators had opportunities to analyze data and collaborate on their strategic plans with other coordinators on multiple occasions and to receive feedback from instructors. As a result of these practices, the evidence clearly indicated science coordinators understood the importance of a strategic plan and changed their practices by developing and/or implementing one. Evidence also showed coordinators used data to improve science instruction and to guide the content of their strategic plans. This confirmed the importance of including active learning (Garet et al., 2001), content focus (Birman et al., 2000; Cohen & Hill, 1998; Kennedy, 1999), and collaboration (Birman et al., 2000; Borko, 2004) into professional development in order to affect changes in participants' practices.

The social context fostered throughout the implementation of the NSCA provided science coordinators the opportunity to develop relationships with peers. Coordinators were often in dialogue with one another and participated in group discussions frequently throughout the professional development. In so doing, science coordinators perceived value in developing relationships with like peers in other districts to support and enhance their practice and many of these relationships were maintained a year later. This underscores the importance of incorporating coherence and collective participation (Birman et al., 2000; Desimone, 2009; Loucks-Horsley & Matsumoto, 1999) into professional development provided to district science coordinators. These prior studies investigated the incorporation of these aspects of professional development for teachers, but the current study indicates these characteristics are also important for professional development designed specifically for science coordinators.

The incorporation of two situated learning components, collaboration and an authentic context, into the NSCA appeared to have the most impact on whether coordinators transferred their learning into practice. Similarly Bell, Maeng, and Binns (2013) identified collaboration and an authentic context as key components in supporting preservice teachers in integrating technology into their lessons. Bell, Maeng, and Binns (2013) also suggested cognitive apprenticeship, coaching, and multiple opportunities for practice as important in preparing preservice science teachers for technology use in the classroom. These components were also integrated into the NSCA; however, coordinators did not appear to benefit from these components as much as the preservice teachers in the Bell, Maeng, and Binns (2013) study. Science coordinators, in contrast to preservice teachers, have more knowledge and teaching and learning experience; thus, the need for cognitive apprenticeship, coaching, and multiple opportunities for practice during professional development may be less than for preservice teachers. The specific components of situated learning impacting the transfer of learning as a result of professional development may be different depending on the audience.

Barriers Encountered

The findings also suggest science coordinators perceived at least two barriers in supporting their teachers. Science coordinators perceived a lack of power in their districts, which may hinder their effectiveness in improving science instruction. They rarely had input into the hiring decisions made about science teachers and had little input about the amount of time allotted for science professional development in their districts. This finding furthers our understanding of the district science coordinator role, but it also suggests science coordinators' effectiveness within a district may be hindered. The decisions made by these district administrators may have less effect in improving teaching and learning than previously thought.

Another barrier to science coordinators providing support to teachers was the perception that time for science instruction has been reduced as a result of state-mandated tests and a focus on math and reading at the elementary level. This builds on previous work that identifies high-stakes testing as a barrier to the implementation of reforms-based practices in science by teachers (Anderson, 2002; Keys, 2001). The present study illuminates that high-stakes testing was a barrier experienced by science coordinators and may indicate this is a systematic barrier impacting the improvement of science teaching and achievement in a district. This is further supported by recent results from the National Survey of Science and Mathematics Education report which found that in the elementary grades 27% of schools felt there was insufficient time to teach science (Banilower et al., 2013).

Implications

To our knowledge, this is the first study that investigates how science coordinators are supported themselves and how they are supporting teachers in professional development following a professional development program designed specifically for science coordinators. The emphasis placed on an authentic learning environment within a social context, as aligned with situated learning, by the VISTA NSCA promoted changes in the understandings and some practices of science coordinators. This indicates the relationship between the situated learning model, characteristics of effective professional development, and the activities of the NSCA may be an appropriate way to design professional development for science coordinators. The present study also extends previous investigations (Madrazo & Hounshell, 1987; Perrine, 1984; Tracy, 1993) in that it provides more detailed information about the role of the science coordinator. It provides a clearer picture of the types of support coordinators provide to teachers, as well as the methods coordinators use to provide that support.

These results warrant further study to determine how well-aligned science coordinators' implementation of professional development for teachers is with the NSCA's goals and instruction and with characteristics of effective professional development. If science coordinators implement professional development that does not incorporate aspects of effective professional development, then changes in teacher learning, classroom practices, and student achievement may not be evident as suggested by Desimone (2009) and Firestone et al. (2005). These results plainly point to how difficult and complex it is to implement effective professional development to improve individuals' understandings and practice, let alone improve teacher understandings and practices and student understandings. While the NSCA improved science coordinators' understandings, their subsequent practices did not fully reflect their understandings. Ideally, we would expect science coordinators' practices to then impact teacher understandings and practices, but realistically there will also be barriers in this transfer as well. The complicated nature of using professional development to ultimately improve student understanding is depicted in Figure 3.

Utilizing professional development to improve student achievement is complicated and hindered by barriers at every step. A vast amount of research focuses on the last three steps of the Figure 3 (Desimone, 2009; Whitworth, 2014; Yoon, Duncan, Wen-Yu Lee, Scarloss, & Shapley, 2007); however, there is very little research focused on the first three steps of the figure (Luft & Hewson, 2013). This study attempts to begin that research to determine what diminishes the impact of professional development as it trickles down to the subsequent steps. Any assumption that the professional development impact on student achievement is straightforward and uncomplicated is naïve. Future research should focus on gaining a deeper understanding of these mediating factors and to seek how to keep these factors from becoming barriers.

There are also implications for the VISTA professional development implementation team. If the power issue perceived by these science coordinators is experienced in all districts, the ability of science coordinators to effect change in the infrastructure of the state may be limited. As states look toward building and affecting change in their infrastructure for science teaching and achievement, they may need to consider implementing a professional development opportunity for principals or superintendents, in addition to science coordinators. In addition, the current requirement of state-mandated tests in math and reading and the importance placed on such tests at the elementary level should be further investigated to understand the full impact this requirement has on the teaching of science. Furthermore, the implementation may need to consider spending more time on NOS and PBL in order to see changes in science coordinator practices.

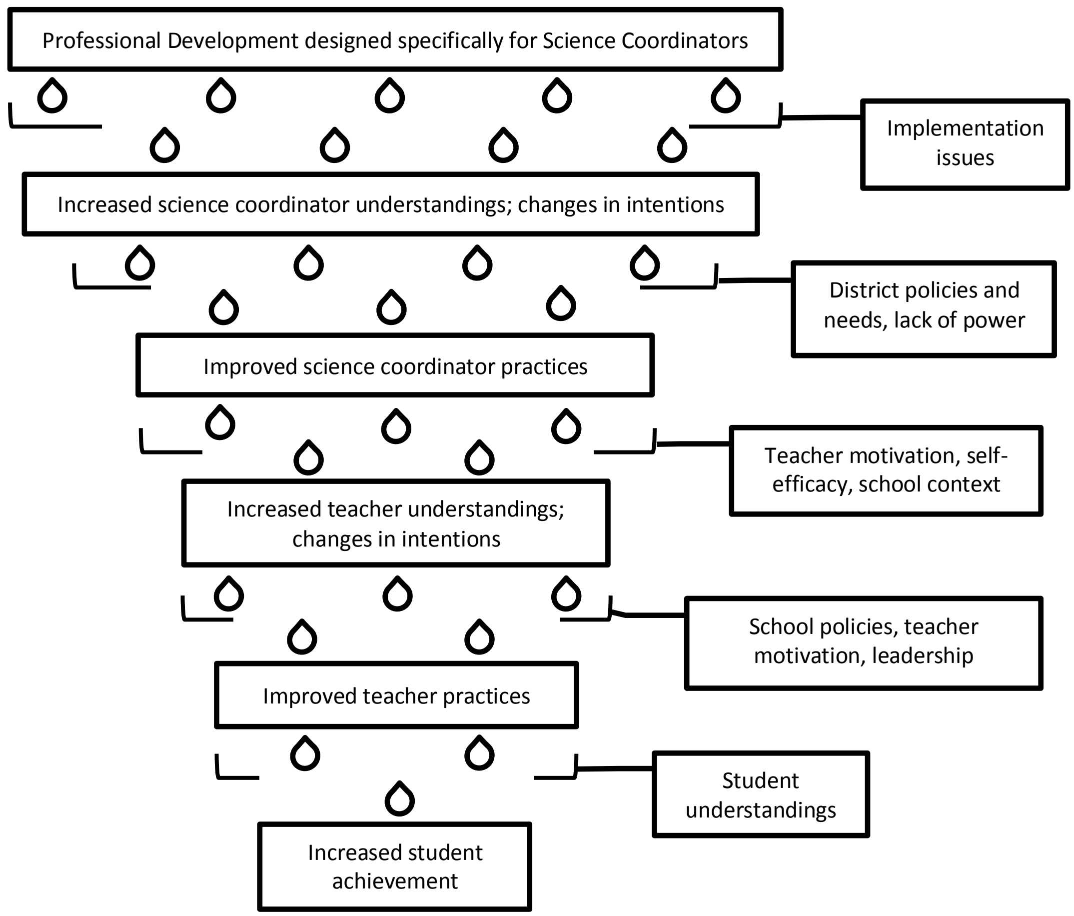

Figure 3. An illustration of the diminishing systematic impact of professional development for science coordinators on increasing student achievement.

One interesting finding is the participating science coordinators indicated the NSCA was the first opportunity they had to network and work with peers in similar positions. Tracy (1996) noted individuals who occupy district subject-area supervisor positions see themselves as ignored by the academic community. The findings of the present study support Tracy's finding. Given the significant role science coordinators play in supporting science teachers and instruction within a district, it is surprising there is not more focused professional development available to support these individuals. While Goldberg (1970) advocated the need for science supervisors to be educated and trained and a formal program was suggested, few educational opportunities for science coordinators exist, whether formal or informal. One of the few, if only opportunities designed specifically for new science coordinators, the VISTA NSCA, provided situated professional development, characterized by components of effective professional development. Specifically incorporating collaborative, social, contextualized, authentic, active learning experiences with a clear content-focus resulted in the transfer of learning into practice following professional development. The NSCA professional development explored in this study provides an effective model of professional development for science coordinators that states and districts can emulate to support their supporters.

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References

Abd-El-Khalick, F. S., Bell, R. L., & Lederman, N. G. (1998). The nature of science and instructional practice: Making the unnatural natural. *Science Education, 82,* 417-436.

Abd-El-Khalick, F. S., & Akerson, V. L. (2004). Learning as conceptual change: Factors mediating the development of preservice elementary teachers' views of nature of science. *Science Education, 88,* 785–810.

Akerson, V. L., & Abd-El-Khalick, F. (2003). Teaching elements of nature of science: A yearlong case study of a fourth-grade teacher. *Journal of Research in Science Teaching*, *40*, 1025-1049.

Akerson, V., & Hanuscin, D. (2007). Teaching nature of science through inquiry: Results of a three-year professional development program. *Journal of Research in Science Teaching. 44*, 653-680.

Akerson, V. L., Morrison, J. A., & McDuffie, A. R. (2006). One course is not enough: Preservice elementary teachers' retention of improved views of nature of science. *Journal of Research in Science Teaching, 43,* 194-213.

Anderson, R. D. (2002). Reforming science teaching: What research says about inquiry. *Journal of Science Teacher Education, 13,* 1-12.

Banilower, E. R., Smith, P. S., Weiss, I. R., Malzahn, K. A., Campbell, K. M., & Weis, A. M. (2013). Report of the 2012 National Survey of Science and Mathematics Education. Chapel Hill, NC: Horizon Research, Inc.

Beinsenherz, P. C. & Yager, R. E. (1991). The school science supervisor: A necessity for a quality program. *School of Science and Mathematics, 91*, 152-156.

Bell, R. L., Lederman, N. G., & Abd-El-Khalick, F. S. (2000). Developing and acting upon one's conception of the nature of science: A follow-up study. *Journal of Research in Science Teaching, 37,* 563-581.

Bell, R. L., Maeng, J. L., & Binns, I. C. (2013). Learning in context: Technology integration in a teacher preparation program informed by situated learning theory. *Journal of Research in Science Teaching*, *50*, 348-379.

Bell, R., Smetana L., & Binns I. (2005). Simplifying inquiry instruction: Assessing the inquiry level of classroom activities. *The Science Teacher, 72* (7), 30–33.

Birman, B. S., Desimone, L., Porter, A. C., & Garet, M. S. (2000). Designing Professional Development That Works. *Educational Leadership*, *57*(8), 28-33.

Birman, B., Le Floch, K. C., Klekotka, A., Ludwig, M., Taylor, J., Walters, K., Wayne, A., Yoon, K. (2007). *State and local implementation of the No Child Left Behind Act: Vol. 2. Teacher quality under NCLB: Interim report.* Washington, DC: U.S. Department of Education; Office of Planning, Evaluation and Policy Development; Policy and Program Studies Service.

Borko, H. (2004). Professional development and teacher learning: Mapping the terrain. *Educational Researcher, 33*(8), 3-15.

Bransford, J. D., Brown, A. L., & Cocking, R. R. (Eds.). (2000). *How people learn: Brain, mind, experience, and school.* Washington, D. C.: National Academy Press.

Bybee, R. (1997). *Achieving scientific literacy: From purposes to practices*. Portsmouth, NH: Heinemann.

Cohen, D. K., & Hill, H. C. (1998). *Instructional policy and classroom performance: The mathematics reform in California* (RR-39). Philadelphia: Consortium for Policy Research in Education.

Copeland, M. A., & Knapp, M. S. (2006). *Connecting leadership with learning: A framework for reflection, planning and action.* Alexandria, VA: Association for Supervision and Curriculum Development.

Corcoran T., Fuhrman, S. H. & Belcher, C. L. (2001). The district role in instructional improvement. *The Phi Delta Kappan, 83*(1), 78-84.

Creswell, J. W. & Plano Clark, V. L. (2011). *Designing and conducting mixed methods research (2nd Ed.).* Thousand Oaks, CA: Sage.

Delisle, R. (1997). *How to use problem-based learning in the classroom.* Alexandria, VA: Association for Supervision and Curriculum Development.

Desimone, L. M. (2009). Improving impact studies of teachers' professional development: Toward better conceptualizations and measures. *Educational Researcher, 38*, 181-199.

Driver, R., Leach, J., Millar, R., & Scott, P. (1996). *Young people's images of science*. Philadelphia: Open University Press.

Duschl, R. A., Schweingruber, H. A., & Shouse, A. W. (Eds.). (2007). *Taking science to school: Learning and teaching science in grades K-8*. National Academies Press.

Edmondson, M. E., Sterling, D., & Reid, V. (2012). *Investigating the impact of a new science coordinator/liaison academy.* Paper presented at the Annual meeting of the National Association of Research in Science Teaching, Indianapolis, IN.

Engle, R. A., Lam, D. P., Meyer, X. S., & Nix, S. E. (2012). How does expansive framing promote transfer? Several proposed explanations and a research agenda for investigating them. *Educational Psychologist, 47*, 215-231. DOI: 10.1080/00461520.2012.695678

Erickson, F. (1986). Qualitative methods in Research on teaching. In M. Wittrock (Ed.), *Handbook of Research on Teaching*, (3rd Ed.), pp. 119-161. New York: Macmillan.

Ertmer, P. A., & Simons, K. D. (2006). Jumping the PBL implementation hurdle: Supporting the efforts of K-12 teachers. *Interdisciplinary Journal of Problem-based Learning, 1*(1), 40-54.

Ertmer, P. A., Glazewski, K. D., Jones, D., Ottenbreit-Leftwich, A., Goktas, Y., Collins, K., Kocaman, A. (2009). Facilitating technology-enhanced problem-based learning (PBL) in the middle school classroom: An examination of how and why teachers adapt. *Journal of Interactive Learning Research, 20*(1), 35-54.

Firestone, W. A., Mangin, M. M., Martinez, M. C. & Plovsky, T. (2005). Leading coherent professional development: A comparison of three districts. *Educational Administration Quarterly, 41,* 413-448.

Fryckholm, J. (2004). Teachers' tolerance for discomfort: Implications for curricular reform in mathematics. *Journal of Curriculum and Supervision, 19*, 125-149.

Garet, M. S., Porter, A. C., Desimone, L., Birman, B. F., & Yoon, K. S. (2001). What makes professional development effective? Results from a national sample of teachers. *American Educational Research Journal, 38*, 915-945.

Goldberg, H. P. (1970). The education of the science supervisor. *School of Science and Mathematics, 70,* 363-365.

Hewson, P. W. (2007). Teacher Professional Development in Science. In S.K. Abell & N.G. Lederman (Eds.), *Handbook of research on science education.* London: Lawrence Erlbaum & Associates, Publishers.

Hmelo-Silver, C. E. (2004). Problem-based learning: What and how do students learn?. *Educational Psychology Review*, *16*, 235-266.

Honig, M. I. (2006). Street-level bureaucracy revisited: Frontline district central office administrators as boundary spanners in education policy implementation. *Educational Evaluation and Policy Analysis, 28*(4), 357-383.

Kennedy, M. M. (1998). *Form and substance in in-service teacher education* (Research monograph no. 1). Arlington, VA: National Science Foundation.

Kennedy, M. M. (1999). *Form and substance in Mathematics and Science Professional Development.* Madison, WI: University of Wisconsin at Madison, National Institute for Science Education.

Keys, C. W., & Bryan, L. A. (2001). Co-Constructing inquiry-based science with teachers: Essential research for lasting reform. *Journal of Research in Science Teaching, 38*, 631-645.

Krynock, K., & Krynock, L. (1999). Problem solved: How to coach cognition. *Educational Leadership, 50,* 29-32.

Lederman, N.G. (2007). Nature of science: past, present, and future. In S.K. Abell & N.G. Lederman (Editors), *Handbook of research on science education* (pp. 831-880). Mahwah, NJ: Lawrence Erlbaum Associates.

Loucks-Horsley, S., & Matsumoto, C. (1999). Research on professional development for teachers of mathematics and science: The state of the scene. *School Science and Mathematics, 99*, 258-271.

Loucks-Horsley, S., Stiles, K.E., Mundry, S., Love, N., & Hewson, P.W. (2010). *Designing professional development for teachers of science and mathematics* (3rd Ed.). Thousand Oaks, CA: Corwin Press.

Luft, J., Bell, R.L., & Gess-Newsome, J. (Eds.) (2008). *Science as Inquiry in the Secondary Setting*. Arlington: National Science Teachers Association Press.

Luft, J. A. & Hewson, P. W. (2013, in press). Research on teacher professional development programs in science. In In S.K. Abell & N.G. Lederman (Eds.), *Handbook of research on science education (Second Edition).* London: Lawrence Erlbaum & Associates, Publishers.

Madrazo, G. M. & Hounshell, P. B. (1987). Science supervisor: Results of research in science supervision. *Science Education, 71*(1), 9-14.

Matkins, J. J., & Bell, R. L. (2007). Awakening the scientist inside: Global climate change and the nature of science in an elementary science methods course. *Journal of Science Teacher Education, 18*, 137–163.

McComas, W. F., & Olson, J. K. (1998). The nature of science as expressed in international science education standards documents: A qualitative consensus analysis. In W. F. McComas (Ed.), *The nature of science in science education: Rationales and strategies* (pp. 41–52). Dordrecht, the Netherlands: Kluwer Academic Press.

McLellan, H. (1996). Situated learning: Multiple perspectives. In H. McLellan (Ed.), *Situated learning perspectives* (pp. 5-17). New Jersey: Educational Technology Publications.

Mulvey, B. (2012). *Learning and teaching about the nature of science through process skills* (Doctoral dissertation).

National Commission on Mathematics and Science Teaching for the 21st Century. (2000). *Before it's too late.* U.S. Department of Education

National Research Council. (1996). *National science education standards.* Washington, DC: National Academy Press.

National Research Council. (2000). How people learn: Brain, mind, experience and school. Washington, D.C.: National Academies Press.

National Research Council. (2007). *Taking science to school: Learning and teaching science in grades K-8.* Washington, DC: National Academy Press.

National Research Council. (2012). *A framework for K-12 science education: Practices, crosscutting concepts, and core ideas*. Washington, DC: The National Academies Press.

Perrine, W. G. (1984). Teacher and supervisory perceptions of elementary science supervisors. *Science Education, 68,* 3-9.

Peters, E. E. (2009). Shifting to a student-centered science classroom: An exploration of teacher and student changes in perceptions and practices. *Journal of Science Teacher Education*. Retrieved from http://www.springerlink.com/content/t1r9620275t82502/fulltext.pdf.

Pianta, R. C. (2011). Teaching children well: New evidence based approaches to teacher professional development and training. *Center for American Progress, 11,* 1-36.

President's Council of Advisors on Science and Technology (2010). Prepare and Inspire: K-12 Education in Science, Technology, Engineering, and Math (STEM) for America's Future. Retrieved from http://www.whitehouse.gov/sites/default/files/microsites/ostp/pcast-stem-ed-final.pdf

Reinisch, B. (1966). The need for science consultants. *Science Education, 50,* 52-54.

Rogers, M. P., Abell, S., Lannin, J., Wang, C., Musikul, K., Barker, D. & Dingman, S. (2007). Effective professional development in science and mathematics education: Teachers' and facilitators' views. *International Journal of Science and Mathematics Education, 5*, 507-532.

Shack, G. D. (1993). Involving students in authentic research. *Educational Leadership, 50,* 8-12.

Smith, D. C., & Anderson, C. W. (1999). Appropriating scientific practices and discourses with future elementary teachers. *Journal of Research in Science Teaching, 36,* 755-776.

Spillane, J. P. (2002). Local theories of teacher change: The pedagogy of district policies and programs. *Teachers College Record, 104*, 377-420.

Stepien, W., & Gallagher, S. (1993). Problem based learning: As authentic as it gets. *Educational Leadership, 50,* 25-28.

Sterling, D. R. (2007). Modeling Problem-Based Instruction. *Science and Children, 45*(4), 50-53.

Sterling, D. R. & Frazier, W. M. (2006). Collaboration with Community Partners. *The Science Teacher, 73*(4), 28-31.

Sterling, D. R., Matkins, J. J., Frazier, W. M., & Logerwell, M. G. (2007). Science camp as a transformative experience for students, parents, and teachers in an urban setting. *School Science and Mathematics, 107,* 134-148.

Supovitz, J. A., & Turner, H. M. (2000). The effects of professional development on science teaching practices and classroom culture. *Journal of Research in Science Teaching, 37*, 963-980. Doi: 10.1002/1098-2736(200011)37

Tracy, S. J. (1993). The overlooked position of subject area supervisor. *Clearing House, 67*(1), 25.

Tracy, S. J. (1996). The structural and functional implications of a school district's creation of subject-area supervisor positions. *Journal of Personnel Evaluation in Education, 10,* 297-312.

Trumbull, D.J., Scrano, G., & Bonney, R. (2006). The relations among two teachers' practices and beliefs, conceptualizations of the nature of science, and their implementation of student independent inquiry projects. *International Journal of Science Education, 28,* 1717–1750.

Tsai, C. C. (2002). Nested epistemologies: Science teachers' beliefs of teaching, learning, and science. *International Journal of Science Education, 24,* 771-783.

Whitworth, B. A. (2014). *Professional development and teacher change: The missing leadership link* (Doctoral dissertation).

Wilson, S. M. (2013). Professional development for science teachers. *Science, 340,* 310-313.

Yoon, K. S., Duncan, T., Lee, S. W.-Y., Scarloss, B., & Shapley, K. (2007). *Reviewing the evidence on how teacher professional development affects student achievement* (Issues & Answers Report, REL 2007–No. 033). Washington, DC: U.S. Department of Education, Institute of Education Sciences, National Center for Education Evaluation and Regional Assistance, Regional Educational Laboratory Southwest.

Appendix A
Likert-scale items on Pre-, Post- and Delayed-Post NSCA Perceptions Survey

Please rate your ability to perform the following activities in your role as science coordinator.
(Circle the number after each statement that best describes your *current* proficiency.)

		Not very Proficient		Proficient		Highly Proficient
1.	Support high quality, research-based science instruction at all levels.	1	2	3	4	5
2.	Identify key aspects of inquiry instruction.	1	2	3	4	5
3.	Evaluate key aspects of inquiry instruction	1	2	3	4	5
4.	Enhance teachers' inquiry instruction through professional development.	1	2	3	4	5
5.	Identify key aspects of nature of science instruction.	1	2	3	4	5
6.	Evaluate key aspects of nature of science instruction	1	2	3	4	5
7.	Enhance teachers' nature of science instruction through professional development.	1	2	3	4	5
8.	Identify key aspects of problem based learning instruction.	1	2	3	4	5
9.	Evaluate key aspects of problem based learning instruction	1	2	3	4	5
10.	Enhance teachers' problem based learning instruction through professional development.	1	2	3	4	5
11.	Compare/contrast different models of standards-based science curricula.	1	2	3	4	5
12.	Use available data to evaluate and improve district science programs and instruction.	1	2	3	4	5
13.	Develop a strategic plan for science teaching and learning in your school division.	1	2	3	4	5
14.	Enhance your school division's infrastructure to support effective science teaching and learning.	1	2	3	4	5

Appendix B
Example Questions from 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
Example Questions from 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. The VISTA New Science Coordinator Academy (NSCA) is comprised of five days of professional development at GMU, a dropbox of resources, and attendance at the VSELA conference.
   A. Which components of VISTA NSCA did you find to be most valuable? Why?
   B. Describe any components of the VISTA NSCA that you did not find valuable. Why?

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

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

4. 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.) What topics did this professional development address?
   B. If the VISTA NSCA impacted the offering, describe how (e.g. used materials from NSCA, provided the idea for the session, etc.)?

5. Thinking about your responses to Question 4, 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 4, estimate the numbers within each population **indirectly** impacted by your activities:
   Inservice teachers: ____ PK-12 students: ____

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

8. 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
Delayed-Post NSCA Interview

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

Date ___________________________ **Participant ID:___________**

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?
4. 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
5. How do you interact with principals in your district? With teachers? With VISTA coaches?
6. 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.
7. Describe the strategic plan for science your district.
8. 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?
9. 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?
10. 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?

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

Appendix E

NSCA School-level Infrastructure 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.

Date ___________________________ **Name: ________________________**

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 F

NSCA School-level Infrastructure 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.

Date ____________________________ **Name:** __________________

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.

CHAPTER FOUR

STUDY TWO

Exploring Practices of Science Coordinators Participating in Targeted Professional Development

Brooke A. Whitworth, Jennifer L. Maeng, and Randy L. Bell

Abstract

This study explored district science coordinators' practices supporting teachers' science instruction and how they designed and implemented professional development for teachers in their districts following their participation in the Virginia Initiative for Science Teaching and Achievement New Science Coordinator Academy. This qualitative case study comprised 3 district science coordinators from three different districts in Virginia and principals and teachers from those districts. Data sources included observations of science coordinators at work, 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, materials, resources, websites, walk-throughs, and professional development. They employed a variety of professional development strategies including in-service days, one-on-one

professional development, after-school opportunities, and integrating science with other subjects. However, these varied across coordinators and it appeared district characteristics and science coordinator teaching backgrounds were critical factors that influenced their practice. Finally, all 3 coordinators' practices aligned with at least some of the goals of the professional development, which suggests that professional development for science coordinators that aligns with a situated learning model may be effective in facilitating transfer of knowledge 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 toward science coordinators. This study contributes 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 great 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 implement 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.

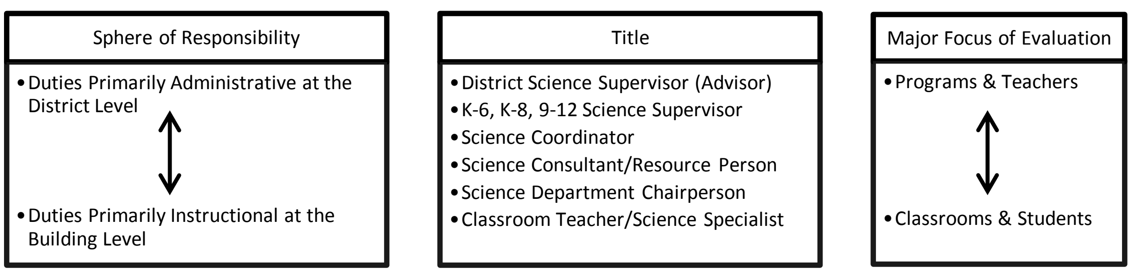

Figure 1. Taxonomy of positions related to supervision of school science (Adapted from McComas, 1993).

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). 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 toward 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). 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 only identified active learning, coherence, and collective participation as 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 are in 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 (2014) 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 the factors influencing 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., 2014) and thus potentially influence 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., 2014). Coordinators may need more support in facilitating professional development (Rogers et al., 2007) and in transferring their understandings into practice (Whitworth et al., 2014). 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 important for the PBL instruction to activate student interests and address 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.

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-Khalick, & 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.

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 was to build infrastructure to support sustained, intensive science teacher professional development to increase student performance. To support these goals, VISTA provided 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).

VISTA provided 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 focused 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 focused 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 instructional 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. 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 professional development with science coordinators (Whitworth et al., 2014). 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 this 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 how science coordinators define and make meaning of reforms and to understand what they actually do in practice, and the alignment of those practices with VISTA NSCA goals, a qualitative case-study approach (Yin, 2014) framed within an interpretive paradigm was employed. 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. (Edmondson et al., 2012, p.7)

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 in Whitworth et al. (2014).

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 to implement 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 Type	District Size
Alex	Yellow County	Suburban	Large
Ann	Brown County	Rural	Mid-sized
James	Blue City	Urban	Small

Alex's district. Alex, a member of the first NCSA cohort, 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	5th	2	Ruby
		Kara	5th	1	
		Justin	5th	4	
		Amy	4th	3	
Longwood	Treatment	Casey	4th	13	Janette
		Drew	4th & 5th	9	
North Fork	Control	Lee Anne	5th	13	Rosa
		Linda	5th	6	

Ann's district. Ann was also 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.

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.

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	

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 western 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	4th & 5th	19	Patrick
Washington	Treatment	Abigail	5th	2	Grace
		Rebekah	4th	11	
Kennedy Middle	Treatment	Luke	6th	29	Clayton
		Jordan	6th	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 incorporated aspects of the NSCA into their practice (Appendix C).

Observations. Observations served two purposes: to describe the activities coordinators participated in during the NSCA and to determine how science coordinators planned for and implemented 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, over a 3-month period participants were purposefully observed whenever they were providing professional development. 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.

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.

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. 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 research team defined major themes derived from the data. Evidence to support these similarities and differences was 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 new secondary teachers in the district could improve their practice twice during the fall semester (Observation). He 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 beginning 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 the 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 encouraged teachers and supported 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 during those sessions always emphasized a literacy or math component.

The professional development Ann provided came in a variety of ways, but focused on the elementary level (Observations). Ann was more comfortable with elementary teachers as this was where the vast majority of her experience laid, 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). The day provided a variety of professional development to elementary teachers 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 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 western 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 supported them with professional development and provided 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 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. First, 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).

Second, 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).

Third, 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 professional development. James indicated inquiry had been a focus in previous years (Post Interview), but it is unclear how aligned this previous professional development 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 conducted 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.

How each coordinator provided teacher support was different across coordinators. 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 have contributed 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. It was not always possible for Ann and James to provide this type of professional development, because of a lack of staff and time.

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 emphasis on NOS in the Virginia Standards of Learning. 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 may 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 was 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. 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's results 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 work one-on-one with teachers in her district. These opportunities permitted her to attend to teachers' immediate classroom needs. This let Ann 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 science 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 lend tacit support to 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 all 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, professional development 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; Fryckholm, 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 reported 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 state 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 across the state. 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 had 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. 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 collaboration and articulation of learning skills. 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.

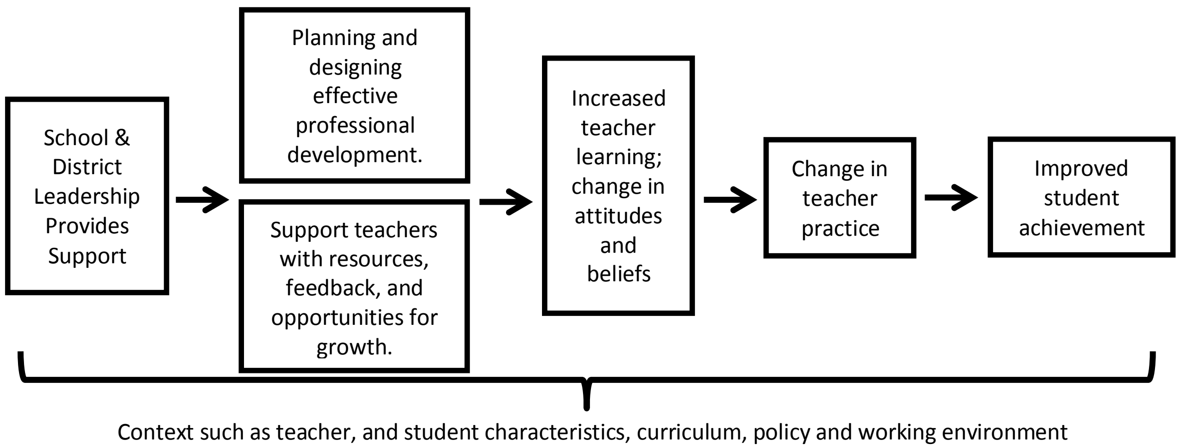

Figure 2. Proposed model for investigating the links between professional development and student achievement.

This study also indicates science coordinators are planning and designing professional development and attempting to support teachers through resources, feedback, and opportunities for growth as suggested by the professional development model in Figure 2. The results of the present study provide insight into the first two steps of this model and show how these steps are enacted within districts. Research that allows for generalizability of the findings of the present study would be of interest as would whether or not the professional development and support provided by science coordinators is effective. If teachers are not impacted by the work of coordinators, there are important implications for policy and district leadership. If teachers are impacted by the work of coordinators, then it is essential to identify how and if coordinators need more support and what can be done to enhance their work with teachers. Future research should investigate whether the critical factors and barriers encountered by coordinators in this study are also experienced by others. Ultimately, understanding the role of science coordinators in supporting teachers and teacher changes in understandings and practices is necessary to understand how to improve student achievement in science.

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References

Abd-El-Khalick, F. S., Bell, R. L., & Lederman, N. G. (1998). The nature of science and instructional practice: Making the unnatural natural. *Science Education, 82,* 417-436.

Abd-El-Khalick, F. S., & Akerson, V. L. (2004). Learning as conceptual change: Factors mediating the development of preservice elementary teachers' views of nature of science. *Science Education, 88,* 785–810.

Akerson, V. L., & Abd-El-Khalick, F. (2003). Teaching elements of nature of science: A yearlong case study of a fourth-grade teacher. *Journal of Research in Science Teaching*, *40*, 1025-1049.

Akerson, V., & Hanuscin, D. (2007). Teaching nature of science through inquiry: Results of a three-year professional development program. *Journal of Research in Science Teaching. 44*, 653-680.

Akerson, V. L., Morrison, J. A., & McDuffie, A. R. (2006). One course is not enough: Preservice elementary teachers' retention of improved views of nature of science. *Journal of Research in Science Teaching, 43,* 194-213.

Anderson, R. D. (2002). Reforming science teaching: What research says about inquiry. *Journal of Science Teacher Education, 13*, 1-12.

Banilower, E. R., Smith, P. S., Weiss, I. R., Malzahn, K. A., Campbell, K. M., & Weis, A. M. (2013). *Report of the 2012 National Survey of Science and Mathematics Education*. Chapel Hill, NC: Horizon Research, Inc.

Beinsenherz, P. C. & Yager, R. E. (1991). The school science supervisor: A necessity for a quality program. *School of Science and Mathematics, 91*, 152-156.

Bell, R. L., Abd-El-Khalick, F., & Lederman, N. G. (1998). Implicit versus explicit nature of science instruction: An explicit response to Palmquist and Finley. *Journal of Research in Science Teaching, 35,* 1057–1061.

Bell, R. L., Lederman, N. G., & Abd-El-Khalick, F. S. (2000). Developing and acting upon one's conception of the nature of science: A follow-up study. *Journal of Research in Science Teaching, 37,* 563-581.

Bell, R., Smetana L., & Binns I. (2005). Simplifying inquiry instruction: Assessing the inquiry level of classroom activities. *The Science Teacher, 72* (7), 30–33.

Berliner, D. C. (2001). Learning about and learning from expert teachers. *Educational Researcher, 35,* 463–482.

Birman, B. S., Desimone, L., Porter, A. C., & Garet, M. S. (2000). Designing professional development that works. *Educational Leadership*, *57*(8), 28-33.

Boyd, V. (1992). *School context. Bridge or barrier to change?* Austin, TX: Southwest Educational Development Laboratory. Retrieved from http://files.eric.ed.gov/fulltext/ ED370216.pdf.

Bransford, J. D., Brown, A. L., & Cocking, R. R. (Eds.). (2000). *How people learn: Brain, mind, experience, and school.* Washington, D. C.: National Academy Press.

Bybee, R. (1997). *Achieving scientific literacy: From purposes to practices*. Portsmouth, NH: Heinemann.

Creswell, J. W. (2009). *Qualitative inquiry and research design: Choosing among five traditions* (3rd Ed). Thousand Oaks, CA: Sage.

Delisle, R. (1997). *How to use problem-based learning in the classroom.* Alexandria, VA: Association for Supervision and Curriculum Development.

Desimone, L. M. (2009). Improving impact studies of teachers' professional development: Toward better conceptualizations and measures. *Educational Researcher, 38*, 181-199.

Dillon, H. (2001). Instructional coordinators. *Occupational Outlook Quarterly*, *45*(1), 20-22.

Driver, R., Leach, J., Millar, R., & Scott, P. (1996). *Young people's images of science*. Philadelphia: Open University Press.

Duschl, R. A., Schweingruber, H. A., & Shouse, A. W. (Eds.). (2007). *Taking science to school: Learning and teaching science in grades K-8*. National Academies Press.

Edmondson, M. E., Sterling, D., & Reid, V. (2012). *Investigating the impact of a new science coordinator/liaison academy.* Paper presented at the Annual meeting of the National Association of Research in Science Teaching, Indianapolis, IN.

Erickson, F. (1986). Qualitative methods in Research on teaching. In M. Wittrock (Ed.), *Handbook of Research on Teaching*, (3rd Ed.), pp. 119-161. New York: Macmillan.

Ertmer, P. A., & Simons, K. D. (2006). Jumping the PBL implementation hurdle: Supporting the efforts of K-12 teachers. *Interdisciplinary Journal of Problem-based Learning, 1*(1), 40-54.

Ertmer, P. A., Glazewski, K. D., Jones, D., Ottenbreit-Leftwich, A., Goktas, Y., Collins, K., Kocaman, A. (2009). Facilitating technology-enhanced problem-based learning (PBL) in the middle school classroom: An examination of how and why teachers adapt. *Journal of Interactive Learning Research, 20*(1), 35-54.

Fryckholm, J. (2004). Teachers' tolerance for discomfort: Implications for curricular reform in mathematics. *Journal of Curriculum and Supervision, 19*, 125-149.

Gallagher, K. L., & Ford, K. J. (2002). 90 min a day aims to create a new culture. *Journal of Staff Development, 23*(4), 65-68.

Glaser, B. G. (1965). The constant comparative method of qualitative analysis. *Social Problems, 12,* 436-445.

Glaser, B. G. & Strauss, A. (1967). *The discovery of grounded theory: Strategies for qualitative research.* Chicago: Aldine Publication.

Haynes, S. N., Richard, D., & Kubany, E. S. (1995). Content validity in psychological assessment: A functional approach to concepts and methods. *Psychological assessment*, *7*, 238.

Henry, G. T., Bastian, K. C., & Fortner, C. K. (2011). Stayers and Leavers Early-Career Teacher Effectiveness and Attrition. *Educational Researcher*, *40*(6), 271-280.

Hmelo-Silver, C. E. (2004). Problem-based learning: What and how do students learn?. *Educational Psychology Review*, *16*, 235-266.

Hmelo-Silver, C. E., Duncan, R. G., & Chinn, C. A. (2007). Scaffolding and achievement in problem-based and inquiry learning: A response to Kirschner, Sweller, and Clark (2006). *Educational Psychologist, 42*, 99-107.

Ingersoll, R. M. (2003). Is there a shortage among mathematics and science teachers? *Science Educator, 12*(1), 1-9.

Jorgenson, O., MacDougall, G., & Llewellyn, D. (2003). Science leadership in an era of accountability: A call for collaboration. *Science Educator, 12*(1), 59-64.

Keys, C.W., & Bryan, L.A., (2001). Co-constructing inquiry-based science with teachers: Essential research for lasting reform. *Journal of Research in Science Teaching, 38* (631-645).

Kirschner, P. A., Sweller, J., & Clark, R. E. (2006). Why minimal guidance during instruction does not work: An analysis of the failure of constructivist, discovery, problem-based, experiential, and inquiry-based teaching. *Educational Psychologist, 41*, 75-86.

Krynock, K., & Krynock, L. (1999). Problem solved: How to coach cognition. *Educational Leadership, 50,* 29-32.

Lederman, N.G. (2007). Nature of science: past, present, and future. In S.K. Abell & N.G. Lederman (Editors), *Handbook of research on science education* (pp. 831-880). Mahwah, NJ: Lawrence Erlbaum Associates.

Leithwood, K. (2012). Core practices: The four essential components of the leader's repertoire. In K. Leithwood & K. Seashore-Louis (Eds.), *Linking leadership to student learning* (pp. 57-67). San Francisco, CA: John Wiley & Sons, Inc.

Little, J. (1982). Norms of collegiality and experimentation: Workplace conditions of school success. *American Educational Research Journal, 19*, 325-340.

Loucks-Horsley, S., & Matsumoto, C. (1999). Research on professional development for teachers of mathematics and science: The state of the scene. *School Science and Mathematics, 99*, 258-271.

Loucks-Horsley, S., Stiles, K.E., Mundry, S., Love, N., & Hewson, P.W. (2010). *Designing professional development for teachers of science and mathematics* (3rd Ed.). Thousand Oaks, CA: Corwin Press.

Luft, J., Bell, R.L., & Gess-Newsome, J. (Eds.) (2008). *Science as Inquiry in the Secondary Setting*. Arlington: National Science Teachers Association Press.

Luft, J. A. & Hewson, P. W. (2013, in press). Research on teacher professional development programs in science. In In S.K. Abell & N.G. Lederman (Eds.), *Handbook of research on science education (Second Edition).* London: Lawrence Erlbaum & Associates, Publishers.

Madrazo, G. M. & Hounshell, P. B. (1987). Science supervisor: Results of research in science supervision. *Science Education, 71*(1), 9-14.

Maeng, J. L. & Bell, R. L. (2012). *Outcomes of the Virginia Initiative for Science Teaching and Achievement (VISTA) Professional Development.* Paper presented at the Annual meeting of the National Association of Research in Science Teaching, Indianapolis, IN.

McComas, W. F. (1993). The nature of science supervision: A review of the literature with implications for practice. *Sourcebook for Science Supervisors*, 19-29.

McComas, W. F., & Olson, J. K. (1998). The nature of science as expressed in international science education standards documents: A qualitative consensus analysis. In W. F. McComas (Ed.), *The nature of science in science education: Rationales and strategies* (pp. 41–52). Dordrecht, the Netherlands: Kluwer Academic Press.

Merriam, S. B. (1998). *Qualitative research and case study applications in education* (2nd Ed.). San Francisco, CA: Jossey-Bass.

Minner, D. D., Levy, A. J., & Century, J. (2010). Inquiry-based instruction – What is it and does it matter? Results from a research synthesis years 1984 to 2002. *Journal of Research in Science Teaching*, *47*, 474-496. Doi: 10.1002/tea.20347

National Commission on Mathematics and Science Teaching for the 21st Century. (2000). *Before it's too late.* U.S. Department of Education.

National Research Council. (1996). *National science education standards.* Washington, DC: National Academy Press.

National Research Council. (2000). *Inquiry and the national science education standards: A guide for teaching and learning.* Washington DC: National Academic Press.

National Research Council. (2007). *Taking science to school: Learning and teaching science in grades K-8.* Washington, DC: National Academy Press.

National Research Council. (2012). *A framework for K-12 science education: Practices, crosscutting concepts, and core ideas*. Washington, DC: The National Academies Press.

Newman, I., & McNeil, K. A. (1998). *Conducting survey research in the social sciences*. Lanham, MD: University Press of America.

Patton, M. Q. (1987). *How to use qualitative methods in evaluation.* Thousand Oaks, CA: Sage Publication.

Perrine, W. G. (1984). Teacher and supervisory perceptions of elementary science supervisors. *Science Education, 68,* 3-9.

Peters, E. E. (2009). Shifting to a student-centered science classroom: An exploration of teacher and student changes in perceptions and practices. *Journal of Science Teacher Education*. Retrieved from http://www.springerlink.com/content/t1r9620275t82502/fulltext.pdf

President's Council of Advisors on Science and Technology (2010). Prepare and Inspire: K-12 Education in Science, Technology, Engineering, and Math (STEM) for America's Future. Retrieved from http://www.whitehouse.gov/sites/default/files/microsites/ostp/pcast-stem-ed-final.pdf

Reinisch, B. (1966). The need for science consultants. *Science Education, 50,* 52-54.

Rogers, M. P., Abell, S., Lannin, J., Wang, C., Musikul, K., Barker, D. & Dingman, S. (2007). Effective professional development in science and mathematics education: Teachers' and facilitators' views. *International Journal of Science and Mathematics Education, 5*, 507-532.

Schwartz-Shea, P & Yanow, D. (2012). *Interpretive research design: Concepts and processes.* New York, NY: Routledge.

Shack, G. D. (1993). Involving students in authentic research. *Educational Leadership, 50,* 8-12.

Smith, D. C., & Anderson, C. W. (1999). Appropriating scientific practices and discourses with future elementary teachers. *Journal of Research in Science Teaching, 36,* 755-776.

Strauss, A. & Corbin, J. (1990). *Basics of qualitative research: Grounded theory procedures and techniques.* Newbury Park, CA: Sage.

Stepien, W., & Gallagher, S. (1993). Problem based learning: As authentic as it gets. *Educational Leadership, 50,* 25-28.

Sterling, D. R. (2007). Modeling Problem-Based Instruction. *Science and Children, 45*(4), 50-53.

Sterling, D. R. & Frazier, W. M. (2006). Collaboration with Community Partners. *The Science Teacher, 73*(4), 28-31.

Sterling, D. R., Matkins, J. J., Frazier, W. M., & Logerwell, M. G. (2007). Science camp as a transformative experience for students, parents, and teachers in an urban setting. *School Science and Mathematics, 107,* 134-148.

Tracy, S. J. (1993). The overlooked position of subject area supervisor. *Clearing House, 67*(1), 25.

Tracy, S. J. (1996). The structural and functional implications of a school district's creation of subject-area supervisor positions. *Journal of Personnel Evaluation in Education, 10,* 297-312.

Tracy, S. J. & MacNaughton, R. (1993). *Assisting and assessing educational personnel: The impact of clinical supervision.* Boston, MA: Allyn Bacon.

Trumbull, D.J., Scrano, G., & Bonney, R. (2006). The relations among two teachers' practices and beliefs, conceptualizations of the nature of science, and their implementation of student independent inquiry projects. *International Journal of Science Education, 28,* 1717–1750.

Tsai, C. C. (2002). Nested epistemologies: Science teachers' beliefs of teaching, learning, and science. *International Journal of Science Education, 24,* 771-783.

Virginia Department of Education [VDOE]. (2009). *Virginia school divisions locale descriptions.* Retrieved from http://www.doe.virginia.gov/directories/sch_division_locales_schedules /school_divsion_locale_descriptions.pdf

Whitworth, B. A., Bell, R. L., Maeng, J. L., & Gonczi, A. L. (2014). Supporting the supporters: VISTA professional development for science coordinators. (Doctoral Dissertation).

Yin, R. K. (2014). *Case study research: Design and methods* (5th Ed.). Thousand Oaks, CA: Sage.

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 **directly** 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.

CHAPTER FIVE

Conclusion

The purpose of this three-paper dissertation was to explore the critical role of a district science coordinator in supporting teacher learning. The first paper (Chapter Two) surveyed the literature on effective professional development, teacher change, and the factors influencing changes in science teacher's understandings, beliefs, and practices. As a result of this review, the roles of school and district leaders were identified as critical factors missing from the professional development models. School district leaders play a substantial role in supporting teachers through professional development and ongoing leadership. As such, these individuals should not be seen as a contextual factor influencing teacher change as a result of professional development, but as an integral part of the process. Thus, a revised professional development model was proposed (Figure 1).

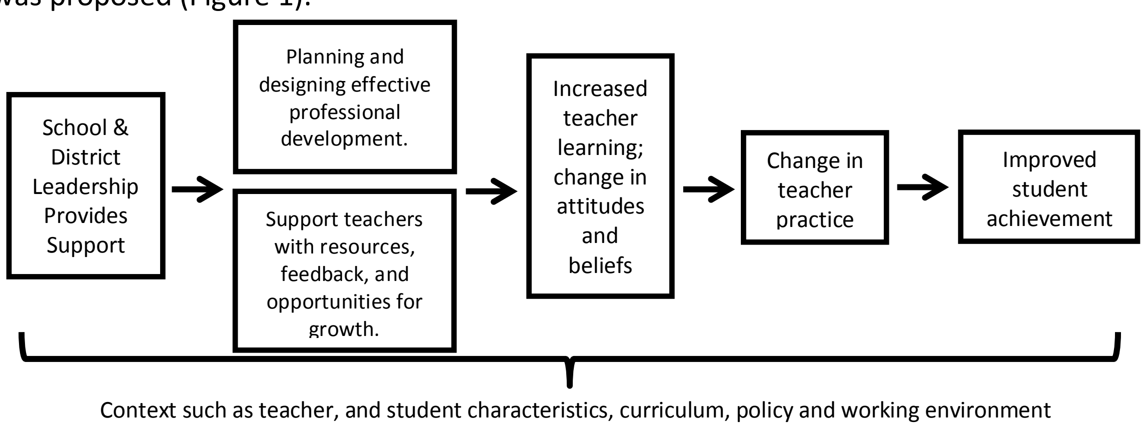

Figure 1. Proposed model for investigating the links between professional development and student achievement.

The second and third papers (Chapter Three and Four) evaluated different outcomes of the Virginia Initiative for Science Teaching and Achievement (VISTA) New Science Coordinator Academy (NSCA) professional development. Chapter Three indicated science coordinators' understandings changed and were maintained a year following the NSCA. However, their understandings were not fully reflected in their practices. Specifically, coordinators did not transfer their understandings about PBL and NOS into practice. Results suggested the NSCA professional development around these topics may not have been as situated and contextualized as needed for transfer of learning to occur. Furthermore, participants identified state-mandated testing at the elementary level and a lack of power within their districts as barriers to their ability to affect change in the district.

Chapter Four further investigated how coordinators designed and implemented professional development and their practices in supporting science teachers' instruction. The results of this investigation revealed that coordinators support teachers in a variety of ways, using varied professional development strategies, and their practices were aligned with the majority of the NSCA goals. The teaching background of science coordinators and district characteristics were identified as critical factors that influenced their practices. Similar to the barriers found in the second study, state-mandated testing at the elementary level, lack of time for professional development, lack of power to require professional development for science teachers, and difficulties creating science content-focused professional development in small districts were identified as barriers to affecting change in science instruction within districts.

Three key themes emerge from the results of these papers. First, several critical factors influence whether or not science teachers and science coordinators make changes in their understandings, beliefs, and practices. Second, science coordinators encounter barriers in their endeavors to support science teachers. And third, situated professional development guided by the principles of effective professional development may result in changes in science coordinator understandings and practices. Each of these themes is discussed in more detail below.

Critical Factors

Several critical factors influence whether teachers experience change as a result of professional development. These factors included teacher experience, motivation, and self-efficacy, as well as school culture, working conditions, and school and district leadership. In addition, school and district leadership was identified as an important factor influencing student achievement (Leithwood, Seashore-Louis, Anderson & Wahlstrom, 2004). Given the significant role of leadership in impacting changes in science teachers' understandings, beliefs, and practices and student achievement we propose school and district leaders play an integral role within the professional development model (Figure 1).

In exploring the role of a district science coordinator, other critical factors including the teaching background of the coordinator and district size appeared to influence the effectiveness of coordinators in supporting science teachers. These included the teaching background of the coordinator and the size of the district. The teaching background of the coordinator, elementary or secondary, seemed to affect their ability to support all content areas and grade levels. The coordinator with an elementary level had difficulty supporting secondary teachers in their roles and in building a rapport with those teachers.

District size also influenced the ability of coordinators to support teachers. The coordinator in the smallest district held more responsibilities, which limited his ability to work with teachers. The coordinator in the large district was able to provide professional development by grade level; thus, teachers had highly contextualized and content-focused professional development experiences. However, the coordinator in the mid-size district had the most contact with her teachers and the time to develop supportive working relationships with her teachers.

Barriers

Science coordinators encountered barriers in attempting to improve teacher learning and practices. State-mandated testing in reading and math was identified as limiting the amount of time for science instruction at the elementary level. Furthermore, the lack of power coordinators had in hiring decisions and in requiring professional development constrained coordinators' ability to work with and support teachers. Coordinators found it difficult to reach all teachers in meaningful ways.

The results of these studies continue to suggest the complicated nature of using professional development to improve student understanding. The path to improving student achievement through professional development is complicated and may be hindered at every step (Figure 2). The impact of professional development is diminished at every step and research must begin to seek ways to understand these mediating factors and how to keep these factors from becoming barriers.

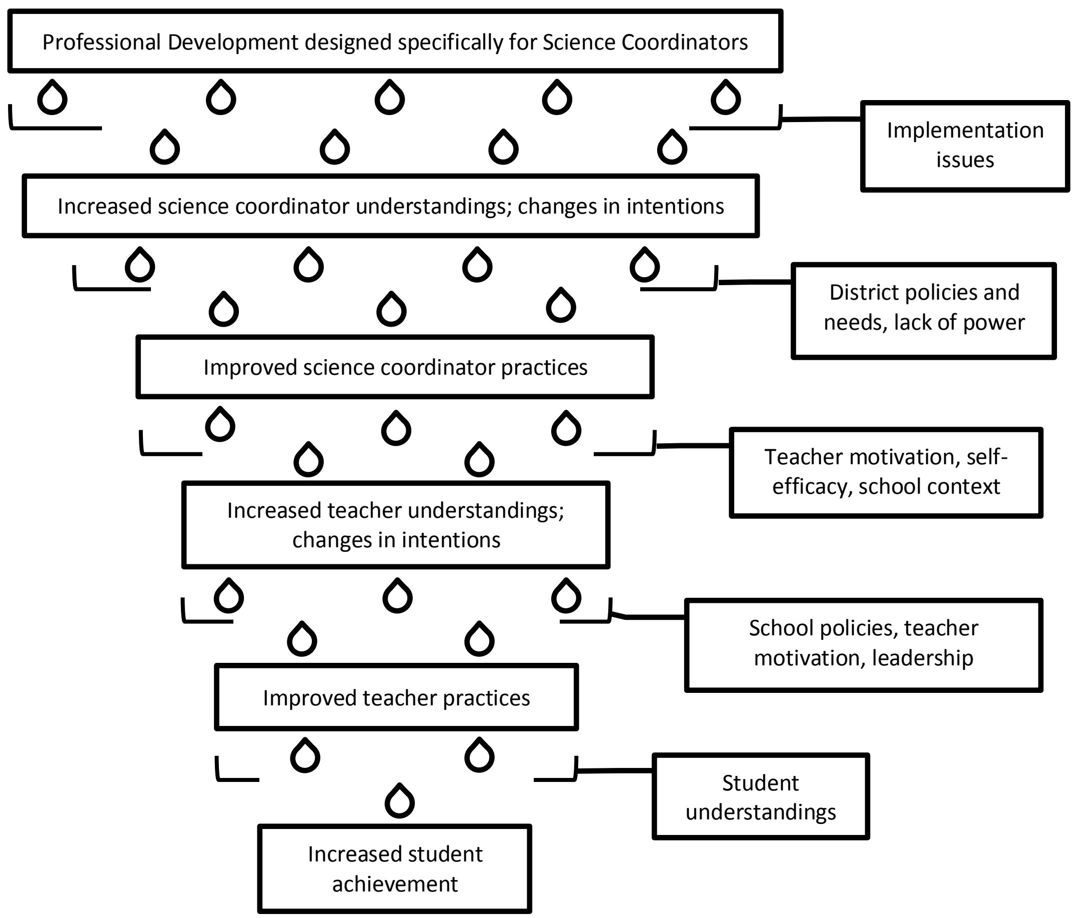

Figure 2. An illustration of the diminishing systematic impact of professional development for science coordinators on increasing student achievement.

Professional Development

Across the three papers, a case was made for effective, situated professional development in changing teacher and science coordinator understandings and practices. In Chapter Two, active learning, content-focus, coherence, collective participation, and duration, were acknowledged as well-known design elements and conditions of professional development that are most successful in promoting teacher change in understandings, beliefs, and practices and/or affecting student achievement (Birman, Desimone, Porter, & Garet, 2000; Desimone, 2009; Garet, Porter, Desimone, Birman, & Yoon, 2001; Luft & Hewson, 2013). These characteristics were incorporated with a situated framework in the approach taken by the VISTA NSCAT. This approach was effective in changing the understandings of science coordinators, but not necessarily effective in changing their practices related to problem-based learning and nature of science instruction. Science coordinators' practices may not have fully changed because the NSCA may not have situated and contextualized the professional development around those topics as effectively.

While the VISTA NSCA appears to have had some success in changing the understandings and practices of coordinators, these results suggest there are still areas for improvement. However, the value coordinators found in attending the NSCA and having the opportunity to attend professional development designed specifically for coordinators should not be ignored. Science coordinators consistently mentioned the NSCA was the first opportunity they had to network, develop relationships, and collaborate with their peers. Given these relationships were continuing a year later and were still growing, the situated nature of the NSCA appeared to be successful in fostering an environment where coordinators could connect.

Future Research

The research on the critical role of district science coordinators is just beginning. There is much we still need to learn about individuals who serve in this role, the supports they need, and the support they provide to teachers to improve student achievement. Future research should examine the role of science coordinators in providing professional development and support to teachers as suggested by the proposed professional development model (Figure 1). Researchers should also continue to investigate the barriers and mediating factors that diminish the effects of professional development (Figure 2). It is also important to look more closely at the impact science coordinator work has on the teachers and ultimately, the students they serve. Exploring the critical role of the district science coordinator is imperative if we want to continue to investigate how to improve student achievement in science through science teacher professional development.

References

Birman, B. S., Desimone, L., Porter, A. C., & Garet, M. S. (2000). Designing Professional Development That Works. *Educational Leadership*, *57*(8), 28-33.

Desimone, L. M. (2009). Improving impact studies of teachers' professional development: Toward better conceptualizations and measures. *Educational Researcher, 38*, 181-199.

Garet, M. S., Porter, A. C., Desimone, L., Birman, B., & Yoon, K. S. (2001). What makes professional development effective? Results from a national sample of teachers. *American Educational Research Journal, 38*, 915–945.

Leithwood, K., Seashore-Louis, K., Anderson, S., & Wahlstrom, K. (2004). *How leadership influences student learning.* Minneapolis, MN: University of Minnesota, Center for Applied Research and Educational Improvement.

Luft, J. A. & Hewson, P. W. (2013, in press). Research on teacher professional development programs in science. In In S.K. Abell & N.G. Lederman (Eds.), *Handbook of research on science education (Second Edition).* London: Lawrence Erlbaum & Associates, Publishers.