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RESEARCH ARTICLE

Exploring practices of science coordinators participating in targeted professional development

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This study describes how district science coordinators supported teachers and implemented professional development in their districts following participation in the Science Coordinator Academy. This qualitative descriptive case study comprised three district science coordinators from three districts in a mid-Atlantic state, as well as principals and teachers from those districts. Data sources, including observations, surveys, artifacts, and interviews, were analyzed using the framework method (Gale, Heath, Cameron, Rashid, & Redwood, 2013). District context, science coordinator background, and collaboration were salient factors that influenced coordinator practices and coordinators' abilities to impact teacher change. We hypothesize that the development of a coaching relationship, facilitating collaboration among teachers, utilizing the characteristics of effective professional development, and promoting reflection through modeling and feedback may be the most important reflection-growth model of instructional leadership (Blase & Blase, 1999) practices for science coordinators to enact when working with teachers.

KEYWORDS

district leadership, professional development, science coordinators, teacher education

1 | INTRODUCTION

The President's Council of Advisors on Science and Technology ([PCAST], 2010) recently advised, "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 meet this goal, professional development that addresses best practices in STEM education is necessary (PCAST, 2010). As the primary approach to professional development for in-service teachers is district based (Desimone & Garet, 2015), it is critical to understand how those who develop and implement district-based professional development support teachers. In addition, a recent comprehensive review of the literature on professional development identified that professional development programs implemented by educational leaders whose understanding of teaching and learning is limited are less effective than professional development programs implemented by those who have a strong understanding of teaching and learning (Kennedy, 2016). Currently, little research exists that addresses preparation for educational leaders to support teachers and deliver professional development (Kennedy, 2016; Luft & Hewson, 2014). Thus, this descriptive case study describes how science coordinators supported teachers in delivering high-quality science instruction after attending a science coordinator-specific professional development. Studies such as these have the potential to inform how science education leaders, including school district leaders, subject-area supervisors, and district science coordinators are prepared through professional development and subsequently support teachers in their districts.

2 | SCIENCE COORDINATORS

A science coordinator provides leadership within a specific school district to help improve students' scientific literacy (Beinsenherz & Yager, 1991). However, science coordinators often have other roles and responsibilities in supporting teachers within a school district (Whitworth, Maeng, Wheeler, & Chiu, 2017). Despite these competing responsibilities, district stakeholders including teachers, principals, and other supervisors agree science coordinators are well-positioned to improve science instruction by proactively responding to teachers' needs (Tracy, 1993, 1996; Tracy & MacNaughton, 1993). Science coordinators are typically responsible for planning and conducting district and school-based professional development for science teachers (Dillon, 2001), which is the primary source of professional development for most teachers (Pianta, 2011; Wilson, 2013).

Furthermore, individuals in this role may be a key factor in the support of first-year teachers (Roden, 2003). The role and practices of coordinators may vary widely from district to district (Lee, Leary, Sellers, & Recker, 2014; Whitworth et al., 2017), but they appear to have the potential to influence teachers in their role (Lee et al., 2014; Roden, 2003). Two critical responsibilities of science district leaders are providing content/pedagogical supports and effective communication with teachers about expectations (Perrine, 1984). Overall, the literature is clear that district science coordinators play an important role in supporting high-quality science instruction (Perrine, 1984; Tracy, 1993, 1996; Whitworth & Chiu, 2015) and subsequent student achievement (Beinsenherz & Yager, 1991; PCAST 2010; Reinisch, 1966). However, there has been increasing recognition of the lack of research in this area and the need to gain a deeper understanding of those who support teachers and provide professional development (Domina, Lewis, Agarwal, & Hanselman, 2015; Kennedy, 2016; Luft & Hewson, 2014).

2.1 | Effective professional development for science

Despite the limited research about those who provide professional development, researchers agree on several components of professional development that are likely to support teachers' practices (Desimone, 2009; Desimone & Garet, 2015; Kennedy, 2016; Luft & Hewson, 2014). These key components of effective professional development are (a) active learning: teachers are actively engaged in their learning rather than passively participating in professional development; (b) content focus: professional development focuses on specific content and how students learn it; (c) collective participation: teachers in the same grade, subject, or school participate together; (d) coherence: professional development activities align with the school, district, state policies, school curriculum and goals, and needs of students; and (e) sustained duration: professional development occurs over a period of time, like a semester or school year, and includes at least 20 contact hours (Desimone, 2009; Desimone & Garet, 2015; Kennedy, 2016; Luft & Hewson, 2014). Research suggests when these components are included in the professional development design and implementation, the professional development is more likely to result in improved teacher understandings, teacher practices, and student achievement (Desimone & Garet, 2015).

Furthermore, leadership influences whether or not teachers implement what they learned in professional development in their own classrooms (Desimone & Garet, 2015; Whitworth & Chiu, 2015). According to Desimone (2002), district and school leaders' support for professional development influence teachers' ability and motivation to implement new strategies and approaches promoted in professional development. Given the important role science coordinators play in supporting high-quality science instruction, it is important to understand the role these leaders play in supporting teachers and providing professional development (Kennedy, 2016).

2.2 | Professional development and science coordinators

Current research suggests science coordinators may have an incomplete view of what constitutes effective teacher professional development (Rogers et al., 2007). 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). The coordinators in this study 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).

To our knowledge, only one study has focused on outcomes following professional development designed specifically to meet science coordinator needs (Whitworth, Bell, Maeng, & Gonczi, 2017). Whitworth and colleagues (2017) reported coordinators' understandings of research-based science instruction (e.g., problem-based learning (PBL), nature of science (NOS), and scientific inquiry) and job responsibilities improved significantly following the professional development. Further, they reported writing and implementing a strategic plan, using data to support their practice, and implementing professional development to develop teachers' inquiry teaching and learning following the professional development. Although this study provides some evidence that professional development designed specifically for science coordinators can change coordinator understandings about research-based science instruction and their responsibilities, researchers concluded science coordinators may need more support in applying their understandings in their districts. The present study builds on Whitworth and colleagues (2017) by providing a detailed description of how three coordinators supported high-quality science instruction in their districts following a science coordinator-specific professional development.

3 | REFLECTION-GROWTH MODEL OF INSTRUCTIONAL LEADERSHIP

The reflection-growth model of instructional leadership (Blase & Blase, 1999) provides a framework for considering how science coordinators serve as leaders in their districts. Originally developed from teachers' perspectives of principals' exemplary instructional leadership, the reflection-growth model emphasizes the study of teaching and learning, utilizing the principles of effective professional development when working with teachers, developing coaching relationships with teachers, facilitating collaborative efforts among teachers, using research to inform and make decisions, and promoting reflection among teachers.

3.1 | High-quality instructional approaches in science

A Framework for K–12 Science Education suggests that scientific literacy is developed through student-centered instruction that emphasizes conceptual understanding and provides opportunities for students to learn about and engage in science and engineering practices (National Research Council [NRC], 2012). Research suggests science instruction that incorporates lessons designed to build students' skills and understanding of the practices necessary to conduct scientific investigations (e.g., scientific inquiry, PBL; e.g., Crawford, 2014; Hemlo-Silver, 2004; Osborne, 2014; Sterling, 2007) and understanding of the characteristics of the scientific endeavor (i.e., NOS; e.g., Driver, Leach, Millar, & Scott, 1996; Lederman, 2007; Lederman & Lederman, 2014; McComas, Clough, & Almazroa, 1998; Osborne, Collins, Ratcliffe, Millar, & Duschl, 2003) supports the development of scientific literacy. For example, when students learn about and engage in the scientific practices, they develop a deeper understanding of how scientific knowledge is generated (Osborne, 2014). Similarly, teaching NOS concepts helps students to understand the big picture of what science is and how it works (NGSS Lead States, 2013).

Scientific practices, which facilitate K–12 students' thinking and acting like scientists as they engage with science content practices, comprise the understandings and skills necessary to develop scientific knowledge or engage in scientific inquiry (NGSS Lead States, 2013; Osborne, 2014). At its simplest, scientific inquiry can be defined as "asking questions, collecting and analyzing data, and using evidence to solve problems" (Maeng & Bell, 2012, p. 3). Thus, scientific practices provide the foundation for scientific inquiry. Research suggests that engaging students in inquiry improves students' science achievement and develops their scientific literacy (e.g., Bransford, Brown, & Cocking, 2000; NRC, 2012; Osborne, 2014).

PBL is one framework for engaging students in authentic scientific inquiry. In PBL, students are presented with a complex, real-world science problem, work collaboratively to research and solve the problem, and make recommendations based on their findings (Crawford, 2014; Sterling, 2007). Incorporating PBL into instruction engages students in active, inquiry-based learning opportunities, increases student achievement and understandings, and presents opportunities for engaging communities in student learning (Crawford, 2014; Sterling & Frazier, 2006; Sterling, Matkins, Frazier, & Logerwell, 2007). The challenge to address a real-world problem activates student interest in science-related concepts and motivates learning through collaborative student-centered investigations (Crawford, 2014; Sterling, 2007; Sterling & Frazier, 2006). PBL also helps students view themselves as scientists and increases their ability to identify problem-solving strategies and resources (Drake & Long, 2009), which subsequently facilitate the development of students' scientific literacy. Effective PBL instruction is highly scaffolded and teacher-facilitated (Hmelo-Silver, Duncan, & Chinn, 2007). Scaffolds embedded within a PBL framework help make disciplinary thinking and strategies explicit to students; thus, increasing their scientific literacy by developing their understanding of how science works and what scientists do (Drake & Long, 2009; Hmelo-Silver et al., 2007; Kolodner et al., 2003).

In addition to engaging in the practices of scientists, research suggests that teaching students the characteristics of scientific knowledge, or the NOS also supports the development of students' scientific literacy (e.g., Lederman, 2007; NGSS Lead States, 2013). Science educators agree on several concepts about NOS that are appropriate for K–12 students to learn. These concepts include that scientific knowledge is empirically based, the product of both observation and inference, simultaneously reliable and tentative, involves creative thinking, and is inherently subjective. Students should also understand that scientists use many approaches to develop knowledge and that scientific theories and laws are different types of scientific knowledge (e.g., Driver et al., 1996; Lederman, 2007; McComas & Olson, 1998; NGSS Lead States, 2013, Appendix H). Teaching these NOS concepts supports students in understanding the big picture of what science is and how it works (NGSS Lead States, 2013). In teaching NOS, research consistently indicates explicit instruction in conjunction with reflective discussions is effective in developing accurate NOS understandings (e.g., Abd-El-Khalick & Akerson, 2004; Akerson & Hanuscin, 2007; Bell, Abd-El-Khalick, & Lederman, 1998).

PBL serves as an encompassing structure through which students can both engage in scientific inquiry and develop accurate NOS understandings. For example, within a PBL unit students investigate questions, analyze data, and integrate findings from multiple scientific investigations to help them solve the overarching problem. Through the inclusion of explicit NOS instruction in these investigations, students' understanding of the authenticity of the problem and how their work is similar to the work of scientists is facilitated. Figure 1 illustrates the relationship between inquiry, NOS, and PBL as they pertain to the development of scientific literacy.

Despite the efficacy of including instruction that engages students in inquiry and learning about NOS in supporting their scientific literacy development, research consistently identifies these aspects of science instruction as challenging for teachers to enact (e.g., Desimone & Garet, 2015). Further, while a PBL framework has the potential to provide an authentic real-world context for both inquiry and NOS instruction (Drake & Long, 2009; Hmelo-Silver et al., 2007; Kolodner et al., 2003), it is complex and often time consuming for teachers to plan and implement (Sterling et al., 2007). High-quality science instruction encompasses more than inquiry and NOS (i.e., assessment strategies, developing rapport with students); however, given the documented challenges teachers face including these constructs in their instruction, the focus of the science coordinator professional development attended by participants in the present study addressed these components explicitly. Taking into consideration their role in supporting science teachers' instruction, it is essential that science coordinators both understand and can support teachers in understanding and implementing these components of high-quality science instruction (i.e., inquiry, NOS) in their classrooms. This

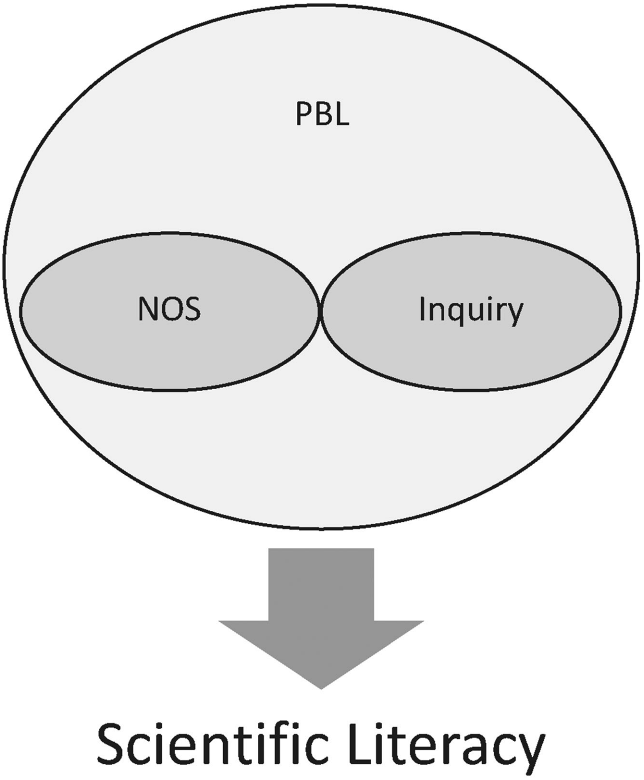

FIGURE 1 Relationship between PBL, scientific inquiry, and NOS

study builds on the results of Whitworth and colleagues (2017) that indicated significantly improved understandings of inquiry, NOS, and PBL for science coordinators who attended the professional development that served as the context of the present investigation.

4 | PURPOSE

District science leaders have the potential to be an integral part of supporting changes in science teacher beliefs, practices, and student achievement (Whitworth & Chiu, 2015; Figure 2). Results of prior studies suggest that science coordinator-specific professional development can improve science coordinators' understandings of research-based science instruction and their responsibilities (e.g., Whitworth et al., 2017). However, little research investigates the

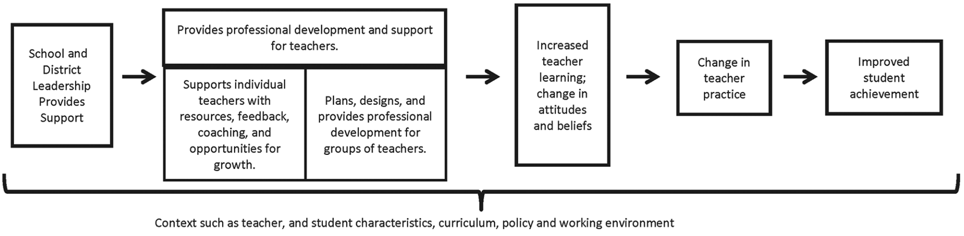

FIGURE 2 Proposed model for investigating the links between professional development and student achievement. Modified from Whitworth and Chiu (2015)

support science coordinators provide to facilitate teachers' high-quality science instruction (Kennedy, 2016; Luft & Hewson, 2014). The current study addresses this gap in the literature by describing how three science coordinator supported high-quality science instructional approaches within their districts after participating in a science coordinator-specific professional development. This study focuses on developing a deeper understanding of how science coordinators provide professional development and support for teachers (Step 2 of Figure 2) to inform future studies that address whether changes to teacher learning, attitudes, beliefs, and practices, and, ultimately, student achievement occurs as a result of this process. The research questions that guided this study were

1 How did science coordinators support teachers in their district following their participation in the Science Coordinator Academy?

- **a.** In what ways did science coordinators provide individual and group support for teachers to develop high-quality science instruction?
- **b.** How did science coordinators plan for and implement district-wide professional development to support high-quality science instruction?

4.1 | Methods

Many assumptions exist about how science coordinators support teachers, but little empirical research exists to support these assertions (e.g., Whitworth et al., 2017). Descriptive case study designs are appropriate when researchers seek to develop an in-depth and straightforward description of the phenomena under investigation (Creswell, 2009; Sandelowski, 2003). In the present study, observations and interviews were collected over a 3-month period 1 year following each of the three science coordinator's participation in the Science Coordinator Academy. Given the multiple data sources for each participant, a framework method, often used for the thematic analysis of data sources, served as the analytic approach and allowed for straightforward presentation of themes and cross-case comparison. Below, descriptions of the context and participants are provided, followed by the data collection and analysis methods.

4.2 | Context

4.2.1 | Statewide Initiative

The Statewide Initiative that served as the context for the present investigation was designed to support elementary and secondary teachers' high-quality, research-based science instruction by providing professional development on "inquiry-based and explicit NOS instruction in the context of PBL" (Maeng & Bell, 2012, p. 3). As described above, these components of high-quality science instruction were selected for emphasis in the Statewide Initiative because prior research indicates they are challenging for teachers to incorporate into instruction, yet they have the potential to support the development of students' scientific literacy and lead to greater student achievement in science.

Another goal of the Statewide Initiative was to build infrastructure to support sustained, intensive science teacher professional development to increase student performance by increasing the capacity of science coordinators and science education faculty to support research-based science instruction. Thus, the Statewide Initiative included four components: an Elementary Institute for elementary (Grades 4–6) teachers, a Secondary Institute for middle and high school science teachers (Grades 6–12), a Science Coordinator Academy for science coordinators, and a Faculty Academy for science education faculty. The present study focuses on the ways in which three science coordinators supported teachers in their district 1 year after they attended the Science Coordinator Academy.

4.2.2 | Science Coordinator Academy

The overarching goal of the Science Coordinator Academy was to help beginning science coordinators (i.e., in their first 5 years in the position) learn to support classroom teachers' instruction and, in conjunction with the other components of the Statewide Initiative, foster the development of a statewide infrastructure for science education. Specific goals included:

1. learning to make improvements in leadership, teacher learning, quality teaching, and student learning,
2. developing a common understanding of inquiry, NOS, and PBL,
3. identifying aspects of effective science teaching and learning,
4. comparing district models of and creating standards-based science curricula,
5. investigating data sources available to use to provide a focus to improve district science programs, and
6. developing a science program strategic plan (Edmondson et al., 2012, p. 7).

In brief, the Science Coordinator Academy occurred over a 5-day period, 3 days in the fall and 2 days in the spring, with follow-up and support between the two sessions. A total of five iterations of the Science Coordinator Academy occurred (one each from 2010 to 2015). Follow-up and support for the coordinators included email communication with instructors, assigned reading and work, and feedback on work between the fall and spring sessions. Coordinators also participated in the statewide leadership conference the fall after they attended the Science Coordinator Academy. A more in-depth description of the Science Coordinator Academy is described in Whitworth and colleagues (2017) and Appendix S1 in the Supporting Information.

4.3 | Participants

District science coordinators from across the state in their first 5 years in their position were invited to apply to the Science Coordinator Academy. Advertisements to recruit coordinators to attend the Science Coordinator Academy were sent through state listservs and made at statewide science conferences. Application and participation was voluntary. Of the 28 district science coordinators who participated in the first two cohorts of the Science Coordinator Academy (Table 1), Alex, Ann, and James, were purposefully selected to participate in the present study. Their selection for this study was based several factors including

1. their district's participation in the Elementary Institute component of the Statewide Initiative,
2. district characteristics (Table 2),
3. their expressed intention to implement professional development in the coming year, and

TABLE 1 Science coordinator academy year 1 and 2 participant demographic information

		Gender		Highest degree				Years In Administrative Position			
Year	Total	Female	Male	B.A. or B.S.	M.Ed. or M.S.	Ed.D. or Ph.D. (in progress) Ed.S.	Ed.D. or Ph.D.	0–2	3–5	6–7	>7
1	13	10 (77%)	3 (23%)	0 (0%)	6 (46%)	4 (31%)	3 (23%)	6 (46%)	4 (31%)	1 (8%)	2 (15%)
2	15	10 (67%)	5 (33%)	0 (0%)	11 (73%)	3 (20%)	1 (7%)	4 (27%)	8 (53%)	1 (7%)	2 (13%)
Total	28	20 (71%)	8 (29%)	0 (0%)	17 (61%)	7 (25%)	4 (14%)	10 (36%)	12 (43%)	2 (7%)	4 (14%)

TABLE 2 Demographic information for selected districts

Science coordinator	District	District type	District size
Alex	Yellow County	Suburban	Large
Ann	Brown County	Rural	Midsized
James	Blue City	Urban	Small

4. pre-to postprofessional development improvement similar to other science coordinators in their respective cohort of the Science Coordinator Academy.

The selection of these three coordinators was stratified across district characteristics with the goal of gaining multiple perspectives from coordinators working in different geographic locations in the state (western, central, and northern), different types of districts (rural, suburban, and city), and different size districts (small, midsized, and large). The state designations of location, type, and size were used to stratify participant selection on these factors (Virginia Department of Education, 2009).

Alex holds a B.S. in chemistry, an M.S. in chemistry, and a Ph.D. in science education leadership and taught chemistry for 9 years at the secondary level. At the time of the investigation, he had been in the position of *Supervisor of Science and Family Life Education* for Yellow County Schools for 3 years and supervised a staff of six. Ann held a B.A. in elementary education and a M.S. in curriculum and instruction. She taught at the elementary level for 28 years and had been the *science lead teacher Specialist* for 4 years in Brown County at the time of the study. James held a B.S. degree in geology and a M.S. in geosciences and taught physical science for 21 years at the secondary level prior to becoming the science coordinator for Blue City Public Schools. At the time of the study, he had been the science coordinator in Blue City Public Schools for 3 years. A complete description of each participant's demographics and their district context can be found in Appendix S2 in the Supporting Information. Pseudonyms are used for all districts, schools, and participants.

4.4 | Data collection

Data included Science Coordinator Academy delayed postsurveys, observations of science coordinators working in their districts, semistructured interviews with coordinators, principals, and teachers, and artifacts. Face and content validity for all surveys and interview protocols was supported through review by a panel of six 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 resulting in the final, validated instruments described below.

4.4.1 | Science coordinator academy delayed post-perceptions survey

Delayed post-perceptions surveys were administered as part of the Science Coordinator Academy approximately 1 year after completing the Science Coordinator Academy. The delayed postsurvey included open-ended questions designed to elicit coordinators' perceptions of the Science Coordinator Academy and how they incorporated aspects of the Science Coordinator Academy into their practice (Appendix S3 in the Supporting Information).

4.4.2 | Observations

Observations served to describe how science coordinators planned for and implemented professional development for teachers in their districts. A total of 87 hours was spent in the field. Each science coordinator was observed approximately 29 hours across 3 months at the beginning of the academic year. This extended observation period allowed the researcher to gain access to insiders' perspectives into their work within the district (Creswell, 2009). Each coordinator was observed multiple times when they provided professional development to teachers in their district. Additional observations included meetings they were in charge of and school walk-throughs. Field notes included information about how coordinators talked or taught about PBL, NOS, and inquiry, how they interacted with teachers and the practices they enacted when delivering professional development or supporting teachers. During all observations, the first author took the role of unobtrusive observer.

4.4.3 | Interviews

Science coordinators were interviewed both prior to beginning observations and after observations of them providing professional development to teachers in their district. Interviews of teachers and principals served were triangulated with science coordinator interviews and observations as described in the Analysis section, below. All interviews were digitally recorded, transcribed, and initial inferences and interpretations were added.

4.4.4 | Science coordinator interviews

After completing the Science Coordinator Academy, coordinators responded to a follow-up semistructured interview about their experiences during and following the Science Coordinator Academy (Appendix S4 in the Supporting Information). The interview protocol provided insight into how or if coordinators planned to use what they learned during the Science Coordinator Academy in their work and how, if at all, they intended to implement support for inquiry, NOS, and PBL instruction. Each interview lasted between 30 and 45 minutes.

After observing science coordinators in their districts, a second semistructured interview elicited coordinators' perspectives about the professional development they offered, affordances and hindrances of their district, their job description, and provided understanding about coordinators' perceptions of professional development and what topics are important to address, implementation of the Statewide Initiative professional development goals and the alignment between these goals and their practices (Appendix S5 in the Supporting Information). This interview lasted between 30 and 45 minutes.

4.4.5 | Principal and teacher interviews

Elementary school principals ($n = 8$) and teachers ($n = 21$) working in districts with science coordinators in the present investigation were selected to participate in interviews. Interviews sought to elicit the ways in which these principals and teachers interacted with the participants (Appendixes S6 and S7 in the Supporting Information). These interviews lasted approximately 30 minutes. Interview responses were triangulated with science coordinator interviews and observations.

4.4.6 | Artifacts

Various artifacts included materials used by science coordinators in professional development they delivered. These were collected during observations and interviews with the science coordinators and like principal and teacher interviews, were triangulated with participant interviews and observations.

4.5 | Data analysis

Data were analyzed using the framework method (Gale, Heath, Cameron, Rashid, & Redwood, 2013; Ritchie & Lewis, 2003). The framework method is a systematic method for categorizing and organizing qualitative data and is often used for the thematic analysis of semistructured interviews (Gale et al., 2013). Using this approach, first all the data were transcribed and then each districts' data were read and reread to become familiar with the data (Gale et al., 2013). A set of documents for one district included the Science Coordinator Academy delayed postsurveys, semistructured interviews, field notes, and artifacts.

Initially, each districts' set of documents were analyzed using deductively generated codes guided by the research questions and the reflection-growth Model of Instructional Leadership (Blase & Blase, 1999). Specifically, we applied the categories of the study of teaching and learning, utilizing the principles of effective professional development when working with teachers, developing coaching relationships with teachers, facilitating collaborative efforts among teachers, using research to inform and make decisions, and promoting reflection among teachers, identified in the reflection-growth model, to the data sources to illustrate how the coordinators enacted the features of instructional leadership. For example, evidence of science coordinators coaching teachers within their classroom was coded as "coaching."

During coding, open coding was used to ensure important aspects of the data were not missed (Gale et al., 2013). For example, James discussed his many responsibilities as being a barrier to his ability to support teachers well. Thus, an incident of this was coded as "barrier number of responsibilities." Throughout this process, "memos" reflecting common categories within and across participants were developed (Glaser & Strauss, 1967). NVivo^{TM} qualitative research software facilitated the process of coding and looking for patterns and differences. All coding was done independently, and consensus was reached through discussion.

After this initial coding, codes were grouped into categories evidencing effective instructional leadership characteristics from the reflection-growth Model and support for teachers (e.g., individual support and district-wide professional development) to create an analytical framework. Memos created during the initial coding helped to inform the analytical framework. This working analytical framework was then applied to each data set. During this review of the data, data were charted into the framework matrix. The final matrices that resulted from this analysis are provided in the Results. Matrices summarized the data by codes (columns) and cases (rows) and included references to evidence that supporting the coding (Gale et al., 2013). Additional memos were written while creating the matrices and interpreting the data to find common patterns and differences in the data (as in Glaser, 1965). Themes were identified from the matrices, and the most striking and relevant categories were identified. These categories included: teacher support, professional development, and district-level work. A final summary version of matrices by category was created.

Triangulation of multiple data sources (e.g., surveys, observations, interviews) during the analytic process, intercoder agreement, and revisiting data sources for evidence contributed to the trustworthiness of the findings (Creswell & Miller, 2000; Patton, 1987; Yin, 2014). Two researchers reviewed the data sources and discussed how characteristics of effective leadership, alignment with the Science Coordinator Academy, support of teachers, and professional development were evidenced in the data set. They also discussed additional categories (e.g., barriers and resources) and came to a consensus about how each coordinator supported and provided professional development to teachers in their district.

5 | RESULTS

This study described how science coordinators' supported teachers' high-quality science instructional approaches in their districts following participation in the Science Coordinator Academy. The cross-case comparison of the three coordinators detailed below illustrates the similarities and differences in the support they provided teachers in their districts, how they planned for and implemented professional development, their district-level work, and the ways in which their practices aligned with reflection-growth model of instructional leadership.

5.1 | Teacher support

Alex, Ann, and James each provided support to their teachers in multiple ways and enacted the characteristics of effective leadership differently. For example, all three developed and provided in-classroom support, access to physical or online resources and science materials, and attended administrative (e.g., committee and departmental) meetings. In doing so, coordinators were demonstrating practices that reflected three components of the reflection-growth Model of Instructional Leadership: emphasizing the study of teaching and learning, developing coaching relationships with teachers, and promoting reflection among teachers. Table 3 summarizes the matrix between the three coordinators for this category.

5.1.1 | In-classroom support

Each science coordinator provided classroom support to teachers through classroom observations and walk-throughs and visited teachers as requested by principals. They all provided suggestions and feedback to teachers for reflection during these visits. They also developed coaching relationships with the teachers that allowed them to support teachers in making improvements in the quality of their teaching.

For example, Ann observed teachers and provided them with feedback to improve their practice (postinterview). She utilized the inquiry rubric provided by the Science Coordinator Academy to help her identify and evaluate inquiry lessons in the classroom (delayed postsurvey). Ann also used one-on-one coaching with teachers (teacher and principal Interviews, postinterview). James, similarly, worked with the other instructional coordinators and principals to visit classrooms and look for specific instructional strategies being used by teachers (postinterview). He then used this to

TABLE 3 Teacher support category matrix

Teacher support category	In classroom support	Resources and supplies	Teacher and principal support
Alex	Observed teachers Gave feedback Field trips Career days	Website of resources Science materials Newsletter Emails Handbook	Limited Supports teachers mostly indirectly Highly administrative Committee meetings Department meetings
Ann	Observed teachers Gave feedback Coaching, one-on-one Modeling, prompted discussions	Website of resources Science materials Newsletter Emails Online video repository	Very supportive Encouraging Available Curriculum committee meetings Department meetings Modeled effective strategies Developed teacher leaders
James	Observed teachers Gave feedback	Website of resources Science materials Newsletter Emails Subject and grade-level listservs	Supportive and unavailable Administrative role split Committee meetings Department meetings Principal meetings Allowed opportunities for input

inform his feedback when working with teachers and to promote reflection. Besides observing teachers, Alex helped teachers implement field trips for the watershed program in his district and attended career days for schools when asked.

Unlike James and Alex, Ann was only responsible for one content area, which afforded her the time and ability to support teachers through one-on-one coaching. For example, Ann selected schools that were struggling significantly with their science scores and visited monthly with teachers at those schools (postobservation interview). During those visits, Ann taught one of their classes. While teaching, she modeled different instructional methods such as inquiry. Then, she and the teacher discussed the lesson. These discussions allowed the teacher to reflect on how they could change their own instruction based on what Ann modeled (postobservation interview).

5.1.2 | Resources and supplies

In addition to in-classroom support, each of the science coordinators regularly developed and disseminated physical or online repositories of resources for teachers. Each also worked to ensure that teachers had access to materials necessary to support their research-based instruction. Each sent a newsletter or email on a regular basis. In addition, each supplied teachers with materials as needed.

Each also supplied one unique resource to their teachers. For example, 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. Ann worked to develop a video library of different lessons to be posted on the district's website as a resource for teachers (postobservation 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 (postobservation interview). This was a resource accessed easily by teachers on their own time to get ideas and see instruction modeled. James created listserv 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, which facilitated collaboration among the teachers (teacher interviews). Through these resources and supplies, each coordinator stressed the importance of teaching and learning to their teachers. They provided resources that were based on research-based practices and were available for teachers to learn from and improve the quality of their teaching.

However, differences are evident in the amount of time and energy coordinators were able to put into the resources. Ann and Alex created resources, a video repository, and a handbook respectively, that necessitated substantial amounts of time and energy to develop. Ann had the time to create a video repository because of the dedicated nature of her role and support she had from the technology department. Alex was able to write a handbook because, in his large district, he had six assistant coordinators who he supervised and were able to support this effort. In contrast to these substantial efforts to create resources for teachers, James created listservs for his teachers to use and communicate with one another. While a valuable resource, it required minimal effort and time on James' behalf. This is indicative of the split nature of James' role between testing and science and the small size of his district.

5.1.3 | Teacher and principal perceptions of support

Each coordinator attended committee meetings and department meetings on a regular basis. This allowed coordinators to support teachers in making improvements in leadership, teacher learning, and quality teaching. Coordinators were also able to aid teachers in identifying aspects of effective science teaching and learning during these meetings. However, teachers' and principals' perceptions of the degree of support provided differed across coordinators. For example, teachers described Alex and James' support as "limited," and "supportive and unavailable," respectively, whereas teachers described Ann as "very supportive," "encouraging," and "available" (teacher interviews). They also indicated Alex 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 (postinterview). However, Alex's support was predominately from indirect sources. Alex had less day-to-day interactions with teachers and more administrative responsibilities than Ann or James. Owing to the size of the district and administrative responsibilities, he often relied on the website, school-level teacher leaders, or from others on his team (teacher and principal interviews).

Teachers indicated James 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 additional responsibilities as the district testing coordinator 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. He is usually doing something with testing" (teacher interview). These teacher responses suggest the split nature of James' role as science and testing coordinator impacted his ability to support teachers.

In contrast, teachers indicated Ann was very accessible and willing to support them in their instruction (teacher interviews). 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 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. (Teacher interview)*

Abby's experience with Ann is representative of how teachers and principals described her willingness to spend one-on-one time with them and their experience with her. Ann took time to model effective teaching practices with her teachers and allow opportunities for teachers to reflect and grow. In addition, Ann performed school walk-throughs throughout the year to support teachers and observed teachers when requested by principals (observations). It appeared Ann took a hands-on approach in supporting her teachers and was more involved in the day-to-day lives of her teachers than Alex and James.

It is likely the varied degrees of support from science coordinators perceived by teachers and principals in their districts were a result of their varied responsibilities, the perceived expertise of each coordinator, and district size. For Ann, her elementary background and comfort with these grade levels may have influenced her choices and practices to work more with elementary teachers. Given the large size of Alex's district, he developed a practice of generating teacher leaders in his district and finding multiple ways to support his teachers in their day-to-day work. The characterization of Alex's support by his teachers is expected given the contextual factors of his district. 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.

5.1.4 | Summary of teacher support

Coordinators all provided in-classroom support that provided opportunities for them to promote reflection among teachers through suggestions and feedback. Through these in-classroom observations, the coordinators developed coaching relationships with teachers themselves and were able to support teachers in making improvements in learning and teaching. Ann, for example, spent time modeling appropriate practices for teachers when she worked one-on-one with them and in her presentation of material in teacher leader meetings. Additionally, James facilitated collaboration among teachers by supplying them with access to listservs.

All the coordinators stressed the importance of teaching and learning through the resources and supplies they developed and made available to teachers and worked to help teachers identify aspects of effective teaching and learning. However, the amount of time and effort each coordinator was able to give to these ventures differed due to various contextual factors. Ann and Alex worked to develop teacher leaders who in turn would work in a coaching relationship with teachers in their schools. In James' district, the development of the coaching relationship among teachers was not observed; however, a direct coaching relationship between him and teachers was observed. In all the meetings, reflection was promoted by soliciting input and opinions from the teachers, coordinators seemed to feel this was an important piece of data to collect.

5.2 | Professional development

All three coordinators perceived professional development as a means to improve student achievement and teacher understanding. In addition, they all perceived professional development should be contextualized, practical, and immediately applicable in a classroom setting. 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. In providing professional development, the coordinators supported teachers in ways that aligned with four components of the reflection-growth model of instructional leadership: stressed the importance of the study of teaching and learning, utilized the principles of effective professional development when working with teachers, used research to inform and make decisions, and promoted reflection among teachers. A matrix of the cross-case analysis across the coordinators for the professional development category is provided in Table 4.

5.2.1 | Implementation and topics

The focus of each coordinators' professional development within their districts varied in terms of the topics addressed, format and timing of implementation, and the target audience.

TABLE 4 Matrix for professional development category

Professional development category	Topics addressed	Format and timing	Target audience(s)
Alex	Inquiry	In-service days prior to school In-service days during school Grade-level and Subject groups	Elementary teachers Secondary teachers Administrators
Ann	Inquiry Some NOS Supported PBL Targeted schools with high need Integration with reading & math	In-service days prior to school In-service days during school Grade-level and subject groups After school opportunities	Mostly elementary teachers Secondary teachers
James	Inquiry (in past years) NOS PBL strategies for principals Curriculum alignment	In-service days prior to school In-service days during school Vertical and subject groups	Elementary teachers Secondary teachers Administrators

5.2.2 | Topics addressed

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 worked to develop a common understanding of inquiry and encouraged its' implementation by teachers and principals in the district (observations, teacher and principal interviews). However, Alex did not implement professional development around NOS and PBL. In regards to NOS, Alex said:

> *I think NOS 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. (Postinterview)*

Alex viewed NOS as something more difficult to implement with his teachers; therefore, he had not yet considered how he would integrate it into the professional development for his district.

Alex's saw PBL as a more complicated pedagogy to incorporate into instruction; thus, he had not yet integrated it into his professional development (delayed postsurvey, postinterview). When asked about PBL, Alex stated: “We didn't spend as much time on PBL. … 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" (postinterview). Alex planned to implement PBL into some of the summer programs their district offered, but was not clear how he would implement it for day-to-day use by teachers.

Like Alex, Ann focused more on inquiry than on NOS and PBL. Observations indicated Ann struggled to understand NOS herself, even after attending the Science Coordinator Academy. In every observation of Ann, NOS was 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 that one of the tenets of NOS is that science uses multiple methods to produce knowledge, not a single approach (observation). There was no evidence in observation or in interviews with teachers and principals that Ann included PBL in her professional development beyond providing the appropriate definition when asked (observations). However, Ann supported her 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).

Owing to the focus on testing in math and reading at the elementary level in her district, Ann identified integration of science with other subjects as the key method of increasing student achievement. As such, Ann perceived she had to find ways to tie science to these subject areas (postobservation interview, teacher interviews). Ann said, “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” (postobservation interview). Thus, the professional development provided by Ann during sessions with elementary teachers always emphasized a literacy or math component.

Unlike Alex and Ann, James emphasized NOS based on what he was seeing in the data and because of the new focus on NOS in the state standards (postinterview). 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 (postinterview). One principal, Patrick revealed, “The Principal professional development, it was about focusing on PBL strategies for students on a regular basis” (principal Interview).

5.2.3 | Format and timing

Each coordinator provided professional development to both high school and elementary teachers during in-service days prior to school starting during in-service days (observations). However, 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 and also offered "Science Spots," 1 hour professional development opportunities teachers attended after school (observation, postobservation interview).

James 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). These subject area and vertical team meetings facilitated collaboration among the teachers. Ann and Alex did not have teachers regularly meeting in vertical teams to look at curriculum alignment. However, owing to the large size of Alex's district and his staff support, he was able to differentiate the professional development sessions provided on in-service and pullout days by grade-level and content area, based on the test data (observations).

5.2.4 | Target audience

The professional development Ann provided was often targeted toward elementary-level teachers (observations) as she identified these teachers as most in need of support for teaching science (postinterview). James was very balanced in providing professional development to elementary, secondary, and administrators in what seemed like equal amounts (observations, postinterview). Alex was also able to provide professional development to serve a variety of audiences in his district. Not only elementary and secondary teachers, but also principals and district leaders (observations). This leader-oriented professional development focused on defining inquiry, providing participants an inquiry experience, and helping administrators consider what they should be seeing in teachers' classrooms when they are teaching an inquiry-oriented lesson (observation).

5.2.5 | Summary of professional development

All the coordinators believed characteristics of effective professional development should be incorporated into the professional development they provided. For example, James and Ann focused on making their professional development content focused, coherent, and incorporated active learning. Likewise, Alex felt these characteristics were important in professional development, but he also felt it was important for professional development to have a significant duration. All of the coordinators promoted reflection among teachers by seeking input and opinions as a result of participating in their professional development. They all used data and research to inform what topics and types of professional development they would offer for teachers. Through professional development, the coordinators stressed the importance of the study of teaching and learning. Only Alex was able to differentiate professional development for his teachers, which allowed him to create more opportunities for collaboration among teachers at the same grade-level or content area.

5.3 | District-level work

In addition to supporting teachers through resources and in-classroom support and providing professional development on a variety of topics, coordinators also undertook a variety of district-level tasks such as using data to inform professional development and developing and implementing a strategic plan. These tasks evidenced the component of using research to inform and make decisions of the reflection-growth model of leadership. The matrix of the cross-case comparison around district-level work is provided in Table 5.

5.3.1 | Use of data

All of the science coordinators 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. When Alex was asked how he decided what topics to address in professional development, he responded, "Data. I mean in the simplest terms, data" (postobservation interview). Alex used the formative data he collected from teachers after professional development to inform future professional development offerings (postobservation 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 (postobservation interview).

TABLE 5 Matrix for district-level work category

District-level work category	Use of data	Strategic plan
Alex	Strategic Plan Planning professional development Identifying topics for professional development Identifying high need schools or teachers	Completed strategic plan Inquiry professional development for elementary Handbooks
Ann	Strategic Plan Planning professional development Identifying topics for professional development Identifying high need schools or content areas	Completed strategic plan Inquiry professional development for all teachers
James	Strategic Plan Planning professional development Identifying topics for professional development Identifying high need content areas	Strategic plan in progress NOS professional development for teachers

Ann also used data, but in a slightly different way. She used data to determine the schools she would work with one on one and support in improving teaching quality and student learning (postobservation interview). Additionally, she used data to help teachers identify student needs and content areas to which the district needed to give more attention (postobservation interview). Ann further utilized data to identify professional development topics teachers wanted and needed (postinterview).

During the school year, James analyzed student test data to determine the content areas in which teachers needed support (postobservation interview). James then developed and presented activities related to these content areas (observations). He also worked with teachers to analyze their own test data and helped them make decisions about areas they needed to rethink or give more focus (postinterview, teacher interviews).

5.3.2 | Strategic plan

At the time of the study, the coordinators were also all in the process of writing and/or implementing a strategic plan. For example, in Alex's strategic plan one of the major initiatives was to provide professional development for all elementary teachers on using inquiry in the classroom (postinterview). Two grades were chosen every year to attend pullout days and receive professional development around the inquiry lessons created for their grades in the *Elementary Inquiry Science Handbooks* (observations). Alex had the buy-in of his superintendent who encouraged teachers to implement hands-on, inquiry-based science lessons in the classroom at least once a week (postobservation interview, observations). Teachers and principals also mentioned this mandate (teacher and principal interviews).

Like Alex, 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” (postsurvey). 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. (Postinterview)*

Unlike Alex and Ann, James’ was still in the process of completing his 5-year strategic plan, but had worked towards developing the plan for the first 3 years. In so doing, he had focused on inquiry the first year and was focusing on NOS for the second year (observations, postinterview).

5.3.3 | Summary of district-level work

The coordinators all used research and data to inform and make decisions within their districts and in developing their strategic plans. However, the data were used in different ways by the coordinators. Alex and James used data to inform the type of professional development they would provide and Ann used data to inform what schools and content areas she would focus on each year.

5.4 | Summary of overall results

Comparison of these three science coordinators illuminates the similarities and differences in the teacher support, professional development, and district-level work. It also illustrates how the coordinators enacted characteristics identified in the reflection-growth model of instructional leadership in their practice. All three coordinators stressed the importance of teaching and learning in their professional development, facilitated collaboration among teachers during professional development and through listservs and meetings, used research to inform their practice and make decisions, and utilized characteristics of effective professional development when working with teachers. Ann and Alex worked toward fostering coaching relationships between teachers by developing teacher leaders (e.g., through teacher meetings) and all three of the coordinators took on a coaching role as they worked with teachers in their classrooms, whether doing observations, or working one on one with teachers. Furthermore, the coordinators worked to promote teacher reflection by providing suggestions and feedback to teachers in their observations, modeling best practices for teachers during professional development, and seeking input and opinions from teachers through evaluations of professional development and in committee meetings.

6 | DISCUSSION

This study described how science coordinators supported teachers individually and planned for and implemented professional development after participating in the Science Coordinator Academy. Specifically, we sought to describe how three coordinators support of teachers aligned with the Science Coordinator Academy goals. The findings of the present investigation contribute to the literature in three main areas. First, little literature exists that describes what science coordinators do and how they do it (Kennedy, 2016; Luft & Hewson, 2014). Our study begins to build a base of current science coordinator practices. Second, application of the reflection-growth model to characterize science coordinators' leadership practices is a novel use of a framework that is traditionally employed to school-level (i.e., principal) rather than district-level (e.g., science coordinator) leadership. Finally, by describing what practices science coordinators enacted, the study elucidates the gaps that may exist in science coordinators' understanding of how best to support high-quality science instruction. This has implications for professional development to support science coordinator practice.

6.1 | Science coordinator practices

Science coordinators engaged in a number of leadership practices including coaching, promoting reflection, and facilitating collaboration among teachers. In addition to these leadership practices, other factors including the district context (e.g., size) and coordinator's science and educational background emerged as factors that appeared to influence their capacity to support teachers' through professional development and individual support.

6.1.1 | Leadership practices

Blase and Blase's (1999) reflection-growth model identified five instructional leadership practices enacted by principals and their effects from the perspective of teachers. Our results indicate science coordinators engaged in some of the same leadership practices when working with their teachers as principals in the Blase and Blase (1999) study did.

These included stressing the importance of teaching and learning in their professional development, facilitating collaboration among teachers during professional development, using research to inform their practice and make decisions, and employing the characteristics of effective professional development when working with teachers. In addition, each of the coordinators took on a coaching role as they worked with teachers in their classrooms and promoted teacher reflection by providing suggestions, feedback, and praise to teachers in their observations.

However, unlike the principals in Blase and Blase (1999) study, the science coordinators in our study developed coaching relationships with teachers themselves in addition to creating coaching relationships by developing teacher leaders. This is consistent with the research that coordinators support teachers in ways principals cannot by providing content specific suggestions, feedback, and developing a nonevaluative relationship (Tracy, 1996; Tracy & MacNaughton, 1993). These findings further support the inclusion of district leadership in a model for investigating the links between professional development and student achievement rather than simply an influencing contextual factor found in previous models (Figure 2).

Another difference between the practices of principals and coordinators was that coordinators in the present study were not observed using praise to promote reflection among teachers. It is possible that coordinators do provide praise to teachers, but that this was not observed in our study. Giving praise to teachers in the settings that were the focus of observations of this study (e.g., during professional development, meetings, or classroom walk-throughs) may not have been appropriate and therefore not observed. We may see coordinators providing praise more often when interacting with teachers in one-on-one settings. Another explanation may be that coordinators use less praise with teachers because they are not in an evaluative role and are more focused on the coaching aspects of their role. Significantly, our results begin to build empirical research that illustrates the utility of the reflection-growth model of instructional leadership (Blase & Blase, 1999) in the context of science coordinator leadership.

6.1.2 | District context

Science coordinators in small, rural, or underfunded districts who have to take on other roles may not have the time or resources to support their teachers in improving instruction. For example, the small size of James' district required him to take on the responsibilities of science coordinator and testing coordinator, which limited his time in each role. This finding refines the results of prior research that suggests that science coordinators have a positive impact on teacher instruction (Tracy, 1993). Rather, the impact of science coordinators may vary depending on the responsibilities science coordinators undertake within their district further supporting the results of Lee and colleagues (2014).

One might expect a science coordinator in a small district to have the greatest one-on-one interaction with his or her teachers. However, this was not the case in our study. It appeared that the medium-sized district Ann worked in had sufficient infrastructure to allow her to work one-on-one with teachers, unlike James' small district and Alex's large district. This permitted her to attend to teachers' immediate classroom needs and incorporate more characteristics of effective professional development such as content focus and coherence (Birman, Desimone, Porter, & Garet, 2000; Desimone, 2009). Similar to the present study, teachers in Rogers et al. (2007) investigations indicated classroom application and teacher-as-learner were professional development strategies that supported them in their teaching. However, given the small sample size and qualitative nature of this study, our results simply indicate the need to investigate how district context might influence the role of coordinators more thoroughly.

6.1.3 | Coordinator background

Each science coordinator's teaching background appeared to impact on how coordinators supported and provided professional development to teachers and how they were perceived by teachers in their district. Alex and James' experience with science content areas at the secondary level allowed them to have the necessary knowledge to support the elementary teachers, whereas Ann's elementary education background afforded her extensive knowledge in curriculum and instruction. It is possible that over time Ann will develop a rapport with secondary teachers similar to that of James and Alex that will allow her more opportunities to support them; research suggests teachers become more confident and effective in their roles over time (Berliner, 2001; Henry, Bastian, & Fortner, 2011). Regardless, the background of the science coordinators appeared to be an important factor in their ability to support all teachers.

6.2 | Alignment with science coordinator academy goals

We did not compare science coordinators practices prior to the professional development with their practices described in the present study; therefore, we cannot attribute practices directly to professional development participation. However, it is heartening that many of the science coordinators' practices and attempts to support their teachers clearly aligned with the Science Coordinator Academy goals. For example, coordinators focused on either inquiry or NOS in the professional development showing an enactment of two of the goals from the Science Coordinator Academy: developing a common understanding of inquiry, NOS, and PBL, and identifying aspects of effective science teaching and learning. In addition, all of the coordinators were in the process of developing and/or implementing a science program strategic plan aligning with the sixth goal of the Science Coordinator Academy. Here we provide hypotheses about this alignment and potential for additional study.

6.2.1 | Developing an understanding of inquiry, NOS, and PBL

Not all of the science coordinators enacted inquiry, NOS, and PBL in their support for teachers. For example, Alex focused on inquiry, Ann on inquiry with some NOS, and James focused on inquiry in the past, but currently emphasized NOS. Research on the implementation of inquiry instruction is extensive (e.g., Hmelo-Silver et al., 2007; Kirschner, Sweller, & Clark, 2006; Minner, Levy, & Century, 2010); it is a research-based practice that is stressed in many reforms-based documents (NRC, 1996,2000, 2007, 2012); and it is an area in which 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 teachers often lack understanding of NOS (Akerson, Morrison, & McDuffie, 2006; Smith & Anderson, 1999; Tsai, 2002) and have difficulty in addressing NOS in classroom instruction (Bell et al., 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 be developing her confidence in teaching NOS. These results support the existing literature that teachers struggle with translating their understandings of NOS into instructional practice (e.g., Abd-El-Khalick, Bell, & Lederman, 1998; Akerson & Abd-El-Khalick, 2003; Trumbull, Scrano, & Bonney, 2006). However, the results of the present study extend this body of literature by beginning to describe the understandings and practices of science coordinators charged with providing professional development to support science teachers' research-based practices. Providing additional modeling of NOS instruction, opportunities for coordinators to practice professional development around NOS, or giving coordinators more opportunities for explicit discussions about how they work with teachers around NOS in the Science Coordinator Academy may help coordinators develop greater confidence and deepen their understanding of how to implement NOS professional development for teachers.

We hypothesize that 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. 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. Another contributing factor may be that during the Science Coordinator Academy instructors only modeled a portion of the PBL rather than the entire process. This may have led to the coordinators not having a clear vision of how to do PBL professional development with their teachers. Science Coordinator Academy instructors may need to provide additional information about providing PBL professional development teachers if they are not going to model the entire process; thus, adding additional days may be necessary to help coordinators be prepared to support teachers in implementing PBL.

6.2.2 | Strategic planning

Each coordinator used data to inform their practice and developed strategic plans informed by that data. As part of the Science Coordinator Academy, coordinators were required to turn in strategic plans for feedback. This requirement may have led to coordinators focusing on these practices. However, all the coordinators had not only written their strategic plan, they were also implementing. The implementation of these strategic plans evidenced an alignment with the Science Coordinator Academy goals. Instructors of professional development may want to consider incorporating tasks that require coordinators to submit products for feedback at a later date. Doing so may help professional development have more coherence, duration, and content focus; thus, resulting in greater coordinator change.

6.2.3 | Collaboration

An overarching goal of the Statewide Initiative of which the Science Coordinator Academy was one component was development of a statewide infrastructure to support science learning. This infrastructure building was evidenced through the collaboration observed among science coordinators. Collaboration incorporated into the Science Coordinator Academy resulted in coordinators having the opportunity for continued opportunities to work with other coordinators across the state. All three coordinators indicated the Science Coordinator Academy was a unique opportunity to meet and network with other coordinators. Our findings extend research on teacher professional growth that found working in isolation can inhibit teacher learning (Little, 1982) and that teacher learning can be suppressed without continual interactions (Gallagher & Ford, 2002). It may be that science coordinators focused on the collaborative aspect of the Science Coordinator Academy because it was a unique opportunity to work with peers for the coordinators who attended. To improve district effectiveness, we may need to find ways to increase opportunities for science coordinators to build relationships and support one another. This has the potential to reduce the isolation coordinators have in their workplace, especially for those in working in smaller districts.

6.3 | Implications

While this study describes the instructional leadership practices of science coordinators, it does not evaluate whether these coordinators' practices influence teachers. Identifying the practices of science coordinators is a necessary first step in understanding how science coordinators work with teachers. Given that similar practices enacted by coordinators in the present study were enacted by principals in the Blase and Blase (1999) study, it is possible coordinators may also have a direct effect on teacher practices and student achievement, similar to principals (Copland & Knapp, 2006; Marzano, Waters, & McNulty, 2005). If this is the case, then understanding what these practices are and how to develop them in science coordinators will be important for those who develop and implement professional development for science coordinators. Enhancing these practices in coordinators may bring about a greater amount of change in teacher practices and student achievement especially if coordinators and principals are working together. Knowledge gained in understanding these practices and the linkages between them will help researchers to further refine the professional development model as envisioned in Figure 2.

Results of this study suggest districts should consider having science coordinators who are focused on specific groups of teachers (i.e., elementary vs. secondary). This may allow for their support and professional development to have more coherence and be more content-focused; thus, the coordinators will be utilizing the principles of effective professional development when working with teachers in a more cohesive manner. However, given the fiscal limitations of many small districts, this may not be feasible. Therefore, professional development programs designed to support science coordinators in areas in which they do not have experience may be helpful. That is, professional development for science coordinators may be more effective if it is differentiated to meet their specific content and pedagogical needs. Another suggestion may be for coordinators in smaller districts to consider how they can develop relationships with other coordinators in districts nearby to combine professional development opportunities that can be differentiated more than if coordinators were working on their own.

Research that allows for generalizability of the findings of the present study would be of interest as would whether or not the professional development, support, and instructional leadership practices enacted and provided by science coordinators are effective. If teachers are not positively impacted by the work and practices of coordinators, there are important implications for policy and district leadership. If teachers are positively 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. It would also be of interest to discover if the instructional leadership practices enacted by coordinators influence teachers, similar to the ways principals influence teachers. We hypothesize that the development of a coaching relationship, facilitating collaboration among teachers, utilizing the characteristics of effective professional development, and promoting reflection through modeling and feedback may be the most important practices for science coordinators to enact when working with teachers.

7 | CONCLUSION

The findings of the present investigation indicate the application of the reflection-growth model of instructional leadership to science coordinators is appropriate. This study begins to provide empirical evidence for this model in the context of science coordinator leadership. Finally, we make suggestions regarding professional development to support science coordinators based on what coordinators enacted from their Science Coordinator Academy experience. Ultimately, understanding the role science coordinators play in supporting changes in teachers' understandings and practices is necessary to improve teacher change and student achievement in science.

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