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De-Marginalizing Science in the Elementary Classroom by Coaching Teachers to Address Perceived Dilemmas

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Abstract: This study identifies and explores the dilemmas experienced by three first-grade teachers in teaching elementary school science. The impact of coaching and teachers' career stages on how teachers reconcile their dilemmas was examined. Results of this comparative case study indicate teachers perceived tensions between focusing instructional practice on science versus the other school subjects, tensions between their responsibility to teach science and their lack of a science background, and tensions between using their curriculum as a script, supplement, starting point, or not all. Participants reconcile their common dilemmas in different ways. Extent of teaching experience; comfort level with teaching reading, writing, and mathematics; and the sense of accountability teachers feel to teach science are related to how effectively dilemmas are addressed. The amount of time spent with the science coach-researchers is tied to the amount of time science is

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taught and the extent to which teachers address dilemmas in reform-oriented ways.
Keywords: Science coach; elementary science; dilemmas; professional development

De-marginanalizando la ciencia en el aula de primaria entrenando a los docentes para abordar los dilemas percibidos
Resumen: Este estudio identificó y exploró los dilemas experimentados por tres maestros de primer grado en la enseñanza de ciencias en la escuela primaria. Se examinó el impacto del entrenamiento/coaching y las etapas de la carrera de los docentes y sobre cómo reconciliaron los dilemas. Los resultados de este estudio comparativo de casos indican que, cuando se trata de enseñanza de la ciencia, los profesores perciben tensiones entre centrarse en la práctica de instrucción en ciencia versus otras materias escolares, las tensiones entre su responsabilidad de enseñar la ciencia, la falta de una formación en ciencias, y las tensiones entre el uso de su plan de estudios como un guión, suplemento, punto de partida, o ninguna de esas alternativas. Los participantes reconciliaron los dilemas de diferentes maneras. Los niveles de experiencia en la enseñanza; nivel de comodidad con la enseñanza de lectura, escritura y matemáticas; y el sentido de responsabilidad que los maestros sentían para enseñar ciencias se relacionan con el grado de eficacia con los cuales abordaron los dilemas. La cantidad de tiempo que pasa con las entrenadores/coaches de ciencias se relaciona con la cantidad de tiempo que se enseñó ciencia y el grado en que los profesores abordan los dilemas con orientación reformista.
Palabras clave: entrenamiento/coaching científico; ciencia elemental; dilemas; desarrollo profesional.

De-marginanalizando a Ciência na formação de professores em sala de aula elementares para enfrentar os dilemas percebidos
Resumo: O presente estudo identificou e explorou os dilemas vividos por três professores de ensino de ciências na escola primária. Se analisou o impacto do treinamento e do momento na carreira dos professores em como eles reconciliaram os dilemas. Os resultados deste estudo comparativo de casos indicam que, quando se trata de ensino de ciências, os professores perceberam a tensão entre enfocar a prática educacional em ciência versus outras disciplinas escolares, tensões entre sua responsabilidade de ensinar ciência, a falta de conhecimentos científicos, e as tensões entre o uso do currículo como um script, suplemento, ponto de partida, ou nenhuma destas alternativas. Os participantes reconciliaram essos dilemas de maneiras diferentes. Os níveis de experiência de ensino; nível de conforto com o ensino da leitura, escrita e matemática; e o sentido de responsabilidade que os professores sentem para ensinar ciência se relacionam com a eficácia com que abordaram os dilemas. A quantidade de tempo com a treinadores/coaches científicos está relacionada com a quantidade de tempo do ensino da ciência e a medida em que os professores lidam com os dilemas com uma orientação reformista.
Palavras-chave: treinamento/coaches científicos; ciência fundamental; dilemas; desenvolvimento profissional.

Introduction

Science, technology, engineering, and mathematics (STEM) permeate every facet of our lives. In our increasingly interconnected and technologically-advanced world, it is now more important than ever that every student become literate in these fields in order to make responsible decisions. "Given that future innovation, global finance, and our very standard of living depend on mathematics and science knowledge, our students' unacceptable performance in these subjects constitutes nothing short of a national crisis" (Loucks-Horsley, Stiles, Mundry, Love, & Hewson, 2010, p. 6). With the release of the Next Generation Science Standards [NGSS] (Achieve, 2013), students, and thus their teachers, are being held to increasingly high standards. To develop a scientifically literate populace, students must acquire the motivation and foundational skills needed for success in science beginning at as early an age as possible. Unfortunately, in the current era of high-stakes testing, reading, writing, and mathematics dominate instructional time in the elementary classroom at the expense of science and social studies (Appleton, 2007; Center on Educational Policy, 2008; Crocco & Costigan, 2007). Further compounding the issue of making time for science is the fact that elementary teachers tend to have a limited content and pedagogical background in science (Fulp, 2002; Tilgner, 1990), which has an adverse impact on their confidence to teach this subject (Cochran & Jones, 1998; Gunning & Mensah, 2010).

It is widely agreed that professional development (PD) is the key to reform and that ongoing support situated in teachers' classroom practice is the optimal form of professional development (Davis, 2003; Putnam & Borko, 2000), especially given the complexity of decision-making that most elementary school teachers must confront in their daily practice. Teachers are not only faced with decisions about what to teach and how to teach it as they plan their instruction, but they encounter situations in-the-moment that require them to determine how best to proceed (e.g., classroom management issues, last-minute changes to the schedule for the day, and so on). Science coaches appear to be a sustainable and effective way to provide elementary teachers with the immediate and individualized professional development they require. However, there remains much to learn about what effective coaches do and how they impact what teachers do (Vandenburg & Stephens, 2010; Walpole & Blarney, 2008), particularly considering the apparent lack of due attention in the literature. To contribute to the research on science coaches and how they can best support elementary teachers at various stages of their careers, this study identifies and explores the dilemmas perceived by a novice teacher (i.e., less than 3 years of teaching experience), a teacher just emerging from the induction stage (i.e., three years of teaching experience), and a veteran teacher (i.e., more than 10 years of teaching experience). Moreover, it investigates how each teacher reconciled dilemmas related to teaching elementary school science.

Literature Review

Coaching as Professional Development in the Elementary Science Classroom

The elementary school is a unique context for the teaching and learning of science (Mensah, 2010). Unlike high school and middle school teachers, elementary teachers are responsible for teaching all the core subjects, have limited instructional time allotted to science, tend to lack an adequate background in science (Fulp, 2002; Shulman, 1986), and, consequently, many elementary teachers have low confidence in teaching science (Cochran & Jones, 1998). To cope, elementary teachers avoid teaching science, teach only the topics with which they are most comfortable, or focus on expository teaching rather than discussion and questioning (Harlen, 1997). Even when elementary teachers do not shy away from teaching science, their pre-existing belief systems may filter new pedagogical ideas in complex ways impacting their practice (Pajares, 1992; Richardson, 1996; Tilgner, 1990).

Teaching science in reform-oriented ways offers another layer of complexity. While there have been many cycles of reform over the years, several ideas have remained constant—although the wording may have changed. The most recent era of reform, referred to as the standards-based reform movement, began with the publication of Benchmarks for Scientific Literacy (American Association for the Advancement of science [AAAS], 1993) and a number of other documents have followed since (National Research Council [NRC], 1996, 2000, 2007, 2011). These documents advocate several reform-oriented strategies teachers of science should implement in their classrooms, although it is understood that teaching science in reform-oriented ways is a much more complex and interrelated process than enumerating strategies implies. Keeping this in mind, some examples of reform-oriented science instructional approaches include: teaching unifying themes (NRC, 1996) or crosscutting concepts, such as patterns, cause and effect, and systems (NRC, 2011); implementing inquiry-based lessons that engage students in the practices of science and engineering (AAAS, 1993; NRC, 1996, 2011); focusing on depth over breadth in terms of content; alignment of lessons with students' interests and prior experiences (Tal, Krajcik, & Blumenfeld, 2006); teaching about the nature of science (NOS) (e.g., McComas, Clough, & Almazroa, 2002); integrating science and the other core disciplines (e.g., Howes, Lim, & Campos, 2009); and engaging students in argument to develop their ability to make evidence-based claims (e.g., Bricker & Bell, 2008, NRC 2011). The newest science education reform, the Next Generation Science Standards (Achieve, Inc., 2013), highlights all of these reform-oriented practices and overlays engineering design, which offers an additional consideration in teaching elementary science. Thus, studies have shown that even if teachers possess reform-oriented beliefs this is not a sufficient condition for ensuring that their beliefs align with their practices (Brickhouse & Bodner, 1992; King, Shumow & Lietz, 2001). For example, teachers may believe that studying less material in more depth is ideal for students to build robust understandings. However, their practice may not reflect their belief when being held accountable to state-mandated tests that cover a broad range of material superficially. In some cases, this can lead teachers to suppress their commitment to a constructivist approach, where instruction is focused on learners building their own understanding through social interaction and independent reflection (Smith & Southerland, 2007).

Science curricula also play a role in influencing teacher practice. Kit-based materials have become increasingly widespread in the elementary grades as a means of enhancing the inclusion of science in the classroom. Full-Option Science System (FOSS) is a curriculum developed at the Lawrence Hall of Science at the University of California at Berkeley. It has been widely adopted by districts across the United States. The activities in these kits have been designed to align with students' cognitive levels and what we know about how students learn. The FOSS kits aim to promote active learning, multisensory methods, peer interaction, discussion, reflective thinking, and interdisciplinary connections (Delta Education, 2011), yet teachers may enact them in such a manner that they do not promote rich learning for students (NRC, 2000). Therefore, teachers require professional development, such as coaching or other supportive programs to learn how to implement curricula in reform-oriented ways.

Commonly used one-shot workshops and short courses have been shown repeatedly that they do not improve teacher practices (Yoon, Duncan, Lee, Scarloss & Shapley, 2007). When teachers return to their school, they are typically on their own to figure out how to take their new learning and implement it in practice. Coaching provides the potential for situated and content-based learning. Although the most effective means of coaching for teachers is not well-defined (Walpole & Blarney, 2008), several roles have been delineated. These include "change coaches," who work primarily with the principal and concentrate their efforts at the school-level, and "content coaches," who work with and support teachers in a particular subject area (Neufeld & Roper, 2003). Researchers have also differentiated between coaching as a supervisory approach versus a side-by-side method. In the former approach, the coach provides only feedback; in the latter, the coach may teach a lesson in order to show the teacher how a new strategy or change can be enacted (Kretlow & Bartholomew, 2010). While coaching is increasingly being used by schools for professional development in the areas of literacy and mathematics (Antsey & Clarke, 2010), science coaches are much less common.

This research study aims to uncover elementary teachers' thinking about teaching and learning science as they work with science educators in the role of science coach to implement a new curriculum. Since the FOSS kit-based curriculum was adopted district wide, it is crucial to uncover teachers' perceived dilemmas related to implementing the kits and how teachers go about reconciling these tensions. The conceptual framework of the study focuses on the dilemmas of teaching and the professional learning continuum of teaching. Specifically, this study identifies and examines how three teachers at various career stages navigate the tensions they experience in teaching elementary school science using a kit-based elementary science curriculum.

Conceptual Framework

Teacher or Teaching Dilemmas

Teachers encounter dilemmas on a daily basis that impact how they translate their knowledge and skills into practice. However, "we seldom examine these below-the-surface conflicts even though [teachers] cope with them continually in [their] work" (Cuban, 1992, p. 6). How teachers address dilemmas is an area of research that requires further investigation, in order to deepen our understanding of the complexities of teaching and learning (Gort & Glenn, 2010). This is particularly relevant for this study as we look at elementary science teaching.

A dilemma is a situation presenting a minimum of two alternative courses of action, neither of which is optimal. While Berlak and Berlak (1981) viewed dilemmas as solvable, most other researchers believe dilemmas can only be managed or addressed through compromise (Cuban, 1992; Katz & Raths, 1992). Taking the latter stance, Lampert (1985) contended that instead of focusing on solving problems, teachers assume the role of active negotiator. The teacher has a host of interests that must be balanced in the classroom, and in doing so, "She debates with herself about what to do, and instead of screening out responsibilities that contradict one another, she acknowledges them, embraces the conflict, and finds a way to manage" (p. 190). Dilemmas characterize the internal struggles teachers go through with regards to the external problems they perceive (Gort & Glenn, 2010). Focusing solely on external barriers or constraints does not provide the whole picture, since "much of the difficulty is internal to the teacher, including beliefs and values related to students, teaching, and the purposes of education" (Anderson, 2002, p. 7).

Professional Learning Continuum

Researchers commonly categorize and account for differences among teachers based on their years of experience when discussing the challenges and successes of learning to teach (e.g., Davis, Petish & Smithey, 2006). Although teachers encounter unique challenges based on their individual dispositions, experiences, and contexts, there are some general stages that teachers tend to go through as they gain experience and knowledge related to teaching. At the same time, it is important to note that teachers do not necessarily progress through these stages linearly, nor do they necessarily advance through all stages.

Researchers have proposed different, yet overlapping models for the stages of the teaching career. For example, Feiman-Nemser (2001) described a professional learning continuum that begins with pre-service education, extends through the induction period (the first three years in the classroom), and continues until retirement. Ryan (1986) delineated four stages: (1) pre-service teachers envision themselves being like their most effective teachers (*fantasy* stage); (2) upon assuming the role of classroom teacher they realize the challenges of fulfilling their responsibilities and working within the confines of their school context (*survival* mode); (3) with experience teachers develop a repertoire of knowledge and strategies (*mastery* stage); and (4) some eventually reach a level of proficiency where they can share their wisdom with their colleagues (*impact* phase). While teachers may be in the mastery stage in some aspects of their practice, they may not have attained mastery in other respects.

Huberman's (1989) model is more detailed and consists of several stages. He described new teachers as in a stage of *survival and discovery*, characterized on the one hand by "continuous trial and error…wide discrepancies between instructional goals and what one is actually able to do in the classroom…[and] concerns with discipline and management that eat away at instructional time" (p. 349). On the other hand, the challenge of learning to teach can be perceived as exciting due to "the sharp learning curve [and] the headiness of having at last one's own pupils" (p. 349). Teachers may enter the *stabilization* phase as successes with their instructional practices begin to accrue and their concerns shift from issues of survival to the quality of their instruction, after which some teachers enter an *experimentation and diversification* phase where they seek out new knowledge and ideas to try out in their classroom. Beyond this point, teachers may enter a phase where they question themselves as teachers. If they have tried to diversify their practice unsuccessfully (*stock-taking*), some pass through a "self-accepting" period where they exert less effort on improving their practice and take on a mechanical approach perceived as successful (*serenity*). Still, others may go through a time where they become more prudent in their practice and more dubious of reforms (*conservativism*). The final stage in Huberman's model is *disengagement*, which involves a gradual process of withdrawal and a refocusing of one's efforts outside of the classroom and school.

Research Questions

This research study aims to uncover elementary teachers' thinking about teaching and learning science as they work with researchers in the role of science coach to implement a new kit-based curriculum. The research questions are:

1. What dilemmas did three teachers at various stages of the professional learning continuum perceive related to teaching and learning science?
2. How did the teachers reconcile the dilemmas they perceived related to science teaching?
   a) What were the differences and similarities in how the teachers at different stages of their careers reconciled the dilemmas they perceived related to teaching science?
   b) What impact, if any, did the researchers—in the role of science coach—have on the teachers' reconciliation of their dilemmas?

Method

In order to provide "a complex, detailed understanding of the issue" (Creswell, 2007, p. 40), this research study employed a case study approach. Rich, thick descriptions (Merriam, 1998) were developed to describe how three first-grade teachers addressed the dilemmas they perceived related to teaching science.

Context and Participants

This study took place over the course of a school year (August 2010-June 2011) at Morningview Elementary (all proper names in the study are pseudonyms). This pre-kindergarten through eighth grade school is located in a large urban district in the northeast and served approximately 600, primarily African American (75%) and Latin@ (24%) students, with 75%

qualifying for free or reduced lunch.[1] The school district had recently changed their science program and the teachers at Morningview received their new FOSS kits mid-way through the year prior to the commencement of this study.

Monita, Jenny, and Angela were on the first-grade team in the school and served as the participants for this study. None of the teachers on the first-grade team had a science degree; however, they were certified K-6 teachers and had completed a graduate-level elementary science methods course at the time of their certification. Monita is an Indian woman in her mid-twenties who possessed one year of teaching experience when this research began. Monita had no prior experience with the FOSS curriculum before this school year. Jenny is a White woman in her mid-twenties, with three years of teaching experience. Jenny had used the FOSS kits when she student taught in college and had tried out nine lessons from the Solids and Liquids kit the year before this study. Angela is an African American woman in her sixties and had 25 years of teaching experience. Angela had taught two lessons from the Solids and Liquids kit the year prior to this study. She had gained some additional experience with the FOSS lessons by attending a five-day science institute that took place the summer before this study began. Angela was one of 36 teachers who attended this professional development opportunity and one of 6 teachers (of different grade levels) who attended from her school. The second author (Felicia) coordinated the summer science institute which was led by a team of FOSS PD providers. The institute aimed to familiarize teachers with their FOSS kits. Both authors attended the full institute and participated alongside the teachers.

Researchers as Participant Observers

This research was the result of a school-university partnership. Neither researcher was a staff member hired by the school or school district and neither worked for FOSS. At the time of the study, the first author (Alissa) was a doctoral student in science education. She completed her undergraduate degree in chemistry and her master's degree in secondary science education. She is a former high school chemistry teacher. Alissa served a dual role, working both as science coach and participant observer. By integrating these roles, a participant observer "become[s] capable of understanding the program as an insider while describing the program for outsiders" (Patton, 1990, p. 128). As the science coach, Alissa facilitated meetings with the first-grade teachers, helped out in their classrooms as a co-teacher, and offered constructive feedback and support with respect to lesson planning and instruction. This enabled her to live through the reality of teaching first-grade science at Morningview (Marshall & Rossman, 1999). In addition, she collected video recordings of the teachers' science lessons and was present at regular grade-team planning meetings.

To ensure that data analysis remained as objective as possible, the second author (Felicia) maintained a role of non-participant observer during the data collection (Merriam, 1998). At the same time, Felicia had a deep understanding of the school and its context through her longstanding relationship with Morningview and several years of prior work with other groups of teachers on the school's science team. Felicia is an assistant professor of science education and a former high school biology, physics, and earth science teacher. As part of her role as professor, she teaches the science methods courses to elementary and secondary preservice teachers and conducts monthly professional development workshops with teachers. At Morningview, Felicia served as a science coach for other teachers in the school, working mainly with the science cluster teacher, Ms. Warren, but did not work with the first-grade team during the study period. Guba and Lincoln (1981) explained that when acting as an observer, one is "responsible to persons outside the milieu being observed" (p. 190). At the same time, they state that when acting as a participant, one "has a stake in

[1] Data obtained from the school's Quality Review Report for the 2007-2008 academic year.

the group's activity and the outcomes of that activity" (p. 190). Both researchers were invested in assisting to develop a strong elementary science program across all grade levels at the school.

In working with the first-grade teachers at Morningview, a supervisory coaching role was used to gain insight into their practices and needs. In addition, a side-by-side role was employed to model how new strategies could be implemented. Coaching took many forms, including stepping-in during lessons to demonstrate certain strategies or helping to respond to students' questions when the teachers requested assistance with the content. The authors created documents to support the teachers in carrying out new strategies in context (Appendix A). These included discussion prompts to assist the teachers in probing student thinking and templates with sentence stems to assist the children in designing and carrying out investigations, analyzing their data, and reporting conclusions grounded in evidence. Various modes of feedback were employed, including providing immediate suggestions during enactment of a lesson, as well as providing support prior to and after teaching lessons.

Data Collection

Multiple forms of data were collected and used to construct the cases of Monita, Jenny, and Angela. Two interviews each were conducted with the three participants. The questions aimed at elucidating their dilemmas in teaching science and the reasons they ascribed to instructional changes (Appendix B). The principal and assistant principal participated in an interview to establish information about the school context and to assist in triangulation of the data. Monita, Jenny, and Angela's science lessons were observed and videotaped 3, 5, and 25 times, respectively. The number of observations and co-planning meetings varied due to the voluntary nature of this study and the regularity with which each teacher taught science. Co-planning meetings took place twice with Monita (both were recorded and transcribed), four times with Jenny (two were recorded and transcribed), and 18 occasions with Angela (four were recorded and transcribed). Debriefing sessions took place after observed lessons (at the teacher's discretion). A semi-structured approach was used during these meetings to illuminate how the teacher felt the lesson went and what if anything she would change moving forward (Appendix C). Monita participated in one (which was recorded and transcribed), Jenny participated in three (one was recorded and transcribed), and Angela participated in 12 of these meetings (10 were recorded and transcribed).

In addition, 12 science-focused teacher meetings were held over the course of the school year. Attendance at these meetings varied due to outside commitments, and the format of the teacher meetings varied based on teacher needs. Meetings took place during a planning period, afterschool, or during lunch. These 30-45 minute meetings served as opportunities to cultivate collaborative, trusting relationships among all the teachers and researchers. Teachers shared how their lessons were going, suggestions for their colleagues, and what they planned to teach next. At times, Alissa in the role as coach worked with the teachers to setup equipment or discuss the sequencing of lessons. The 12 science-focused teacher meetings were audio recorded and transcribed. For the purpose of triangulation, a research journal was used to record field notes regarding classroom observations, interviews, teacher meetings, and the summer institute.

Data Analysis

Constructivist grounded theory (Charmaz, 2006), an inductive, multistage approach, was used to analyze the data. Transcripts of lessons, teacher meetings, and one-on-one discussions and interviews with teachers were entered into ATLAS.ti (Muhr, 1997/2005). During initial coding, transcripts and field notes were coded line-by-line, while remaining open to ideas that surfaced from the data. A more selective approach, called "focused coding" (Charmaz, 2006), was taken during a second pass through the data. This time the lens of teacher dilemmas was used to write interpretive memos and codes. Codes were compared to codes to identify relationships, and codes were eventually condensed into themes. From this process, three overarching teaching dilemmas emerged (see Figure 1). Specifically, the teachers struggled with whether to spend time and effort on science or the other core subjects, how to go about teaching science with the lack of a background in science, and whether to use the curriculum materials as a script, starting point, supplement, or not at all. The data was examined a third time to focus on how each teacher reconciled these tensions, paying specific attention to the impact of coaching as a form of professional development and the impact of the teachers' levels of teaching experience, or career stage. Through memo-writing, the researchers were able to "synthesize and explain larger segments of data" with our attention on career stages, reconciliation of dilemmas, and the role of coaching to support elementary science teaching (Charmaz, 2006, p. 57).

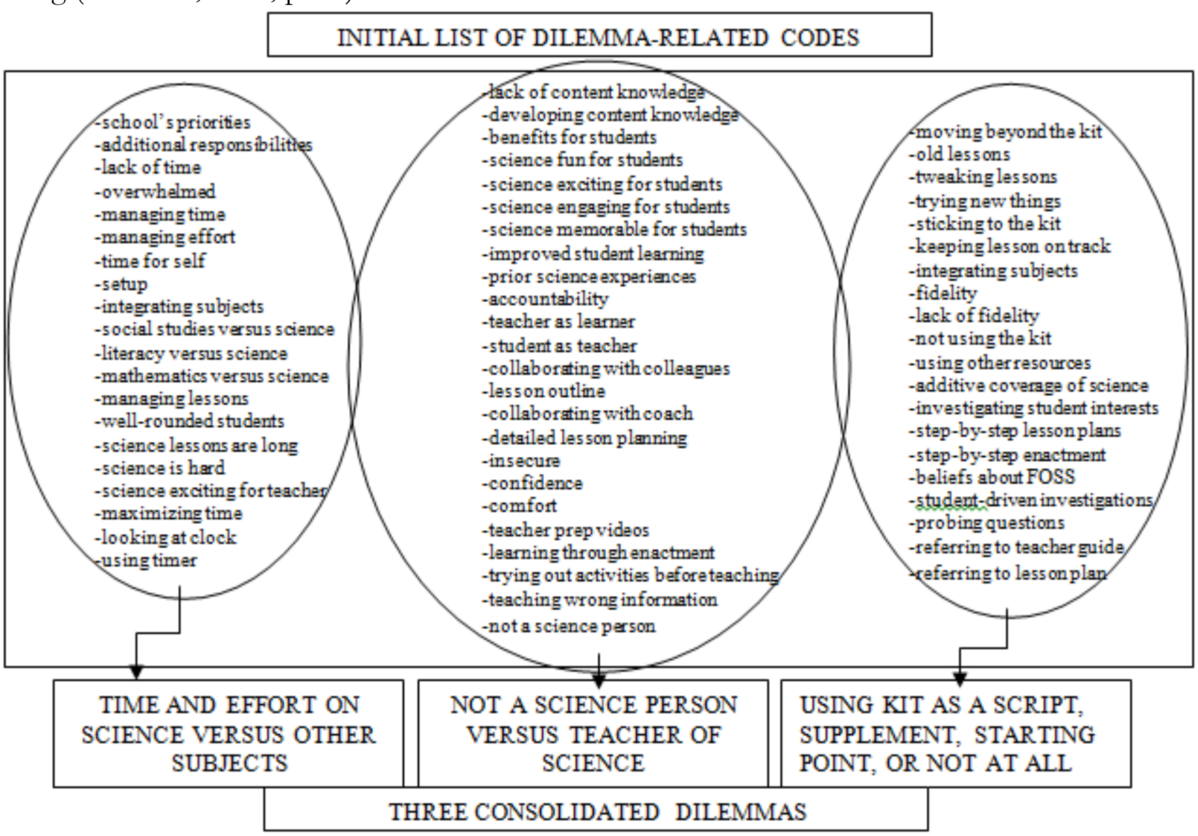

Figure 1. Emergence of three dilemmas related to science teaching.

While bias is a concern for both qualitative and quantitative approaches alike, Creswell (2007) and others (e.g., Guba & Lincoln, 1989) make several suggestions for addressing this potential issue. Through prolonged engagement with the participants in their school context, we worked to enhance the reliability of our study. Moreover, we collected and analyzed multiple sources of data. Triangulation enabled us to view the participants' beliefs and practices from multiple angles (Yin, 2003) and allowed for fine-grained, rich, thick descriptions to substantiate our findings. From these detailed descriptions, readers can evaluate the findings for themselves and determine transferability. Brickhouse and Bodner (1992) declared, "The degree to which these or any other research findings are generalizable to other situations is dependent on the similarities between the two contexts" (p. 474). Peer review (Creswell, 2007; Guba & Lincoln, 1989) throughout the stages of this research study provided an additional layer of reliability.

Findings

Due to the fact that this study was voluntary and the teachers had the option to participate in coaching sessions and meetings as often or infrequently as they liked, the results achieved in this study are likely to be less powerful than if the teachers had been required by their administrators to work with a science coach with a similar approach and level of expertise. Nonetheless, the findings revealed pertinent information regarding dilemmas, career stage, and the use of the coaching model for elementary science education.

Dilemma #1: Spending Time and Effort on Science or Other Subjects

All three teachers found time to be their biggest constraint in terms of teaching science as a result of a number of school-wide initiatives, such as Talent Tuesday[2] and Studio in the School[3]; monthly assessments of each student's reading levels; regular meetings with the literacy and mathematics coaches; field trips; and afterschool literacy PD. All three teachers articulated that when time was lacking, science was the first subject to go. Angela asserted, "There are so many things … that are demanded of us like reading number one, math number two … we're observed in those areas." None of the teachers were required to be observed teaching science. While student promotion was tied to students' reading levels, and progress in mathematics and literacy was carefully monitored, there was no such accountability for science. Jenny explained, "Since first-grade is the big year for reading…a lot of time is spent ... planning my reading lessons, my small groups, making intervention groups. …I won't have a job if they don't advance in their reading levels."

The teachers stated that as long as their students were progressing in reading, they felt their administrators would not take issue with them going several weeks without teaching science. In an interview, the Assistant Principal (AP) admitted she did not focus her efforts on observing and developing teachers' science teaching practices as she did not feel she had the knowledge and skills to "speak to it in depth." Science made her feel "uncomfortable" and, consequently, it "has gone pretty much unrecognized" at Morningview. The AP's background was in literacy and that was where she felt she could best support her teachers. For instance, since Monita was new to first grade, the principal and AP told her to focus her efforts on developing her knowledge and skills related to teaching literacy:

Everyone says that if I were to focus on one thing and get really good at one thing this year it's reading…So, even if we don't teach anything else, it doesn't matter. And it stinks that it's like that. We're not building a whole child like that.

Monita felt conflicted about not teaching science because of her desire to develop "well-rounded" students who would "grow up and want to pursue science." She felt that all subjects should receive the same level of emphasis in elementary school, as they do in high school. In an effort to partially reconcile this tension, Monita relied on the science cluster teacher, Ms. Warren, as her students' main source of science instruction: "I have no time. That's why I'm using Ms. Warren as my savior for science." Neither Jenny nor Angela viewed the cluster teacher in this way, since Ms. Warren only saw their students for 40 minutes per week.

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[2] Talent Tuesday is a (one afternoon a week) project-based enrichment program where each teacher teaches a cluster of mixed-grade students who elect to join a particular group based on their interests. For example, one group collected food and books for a local food bank.

[3] Studio in the School is a 20-week visual arts program for students and teachers. The artist spends one afternoon a week in the classroom and works with the teacher to connect art experiences to literacy.

Monita made time to teach five FOSS lessons over the course of the year, including two in the fall, when there were more regular team meetings. This approach to coaching, such as holding regular team meetings served as a form of accountability for Monita to teach science:

To see how far the other teachers have gotten in their experiments, it makes me feel the pressure of like I have to catch up. I have to do it…'cause if we didn't have those meetings, we would never talk about science and I would never know and I wouldn't care to try to incorporate it.

Monita also taught two FOSS lessons for her administrative observations (January 2011). She explained her motivation: "I want to be able to show [the principal] that we do science in here. Not just for show, for the fact that these kids still need that." After these two lessons, Monita did not teach a FOSS lesson again until the insects arrived for her third and final unit later in the year (April 2011). She explained:

I do feel like I taught more towards the end [of the school year], especially with the insects because we had to go with the process of the way things were happening and I feel like that was very good. It made us have to do it.

Monita expressed the desire to teach more science; however, she felt this would only come with experience. She stated, "I know that next year I'm not going to do the same thing…I'm not going to be learning everything for the first time. I'll know how to balance things." In the interim, Monita employed an additive approach to teaching science by slipping it in when she felt she could. She would relate her morning meeting to science, point out connections to science while on field trips, and bring out science books during reading centers. Monita explained: "I'd rather have that than not anything," even though this was not her preference. She believed, "Science isn't just talking about it, it's doing." However, she was unable to enact her beliefs due to limited time to plan for science, her lack of experience, and science not being a priority, as messaged to her by the administrators to put literacy first.

Jenny and Angela also found science to require more effort and time to teach than any of the other subjects. If Jenny felt like she was running behind schedule, she would say to herself:

I know the science lesson is long…once in a while, I'm like, oh my god, maybe we shouldn't do this. I don't want to [split and teach science over] two days and then we're going to have to skip a read aloud…So, it's about managing everything.

Both Monita and Jenny carefully planned and monitored how much time they spent on activities during the day. In planning for science, they each carefully read through the FOSS teacher's guide and wrote outlines, in their own words, to guide their enactment. As a more experienced teacher, Jenny felt ready to commit to taking on science: "I'm more comfortable in first grade…I'm not as overwhelmed with all the other subjects…I can put more time and effort into science." Jenny felt motivated to teach science from meeting with the Alissa and felt that the team meetings allowed her "to realize that we need to put more time into [science]." As a result of the meetings, Jenny commented, "It's important for them [students] and we're all feeling more comfortable and confident and feeling more secure to just try it out."

On days where Angela taught science, she was comfortable dedicating as much of the afternoon as needed to the lesson. Her feeling was, "You have to spend that time for quality." While Angela spent more time than her colleagues teaching science each week, she did not spend as much time as they did planning and preparing for each lesson. As a veteran teacher, Angela felt comfortable teaching off the cuff in subjects in which she felt skilled and knowledgeable. Angela claimed, "Reading, writing—I can just do it with my eyes closed." Despite admitting it was not ideal, this approach carried over into science. Angela reflected, "[my students] were missing out…when I don't know what I should know before going into [the science lesson]." To reconcile this tension, Angela met with Alissa during lunch to plan. She also began referring to the FOSS teacher's guide during her lessons to ensure she did not miss key aspects of the lesson.

Over the course of the year, Monita taught five FOSS lessons. Angela and Jenny each taught 20 FOSS investigations, plus several lessons that extended beyond the kits during the FOSS Insects unit, although Angela's lessons were significantly lengthier. Angela attributed her consistency in teaching science to working with Alissa on a regular, weekly basis, which "motivated" her and created a sense of accountability to teach science. Angela also developed a passion for teaching science as she found herself as engaged in the FOSS lessons as her students. She believed that teachers prioritize the things they care about: "You know time is so limited around here…but I find if your heart is in something you will find the time." However, she acknowledged, "I do have to push something else to the side to get that science in and…social studies is suffering."

Engaging with the science coach in the meetings, both Jenny and Angela began integrating literacy and mathematics into their science teaching as one means of reconciling their dilemma of time and science teaching. For example, they practiced literacy skills by pointing out text features, such as headings and table of contents when using science texts. While carrying out an investigation into whether a mealworm or beetle is faster, Jenny reviewed the mathematics concept of doubles (the beetle had traveled approximately twice as far as the mealworm in the same amount of time). At the end of the year Angela's students were learning about poetry in their reading and writing lessons. Thus, while studying insects in science, Angela had her students to write a song about the life cycle of a beetle using the information and vocabulary they learned during their investigations.

Dilemma #2: Teaching Science without a Science Background

All three teachers had concerns about teaching science, given their limited knowledge of the discipline. Monita stated, "I do feel like I'm the least confident teaching science because there's so [much to teach]… am I going to be wrong?" Jenny found that "sometimes science is hard." Angela expressed, "I'm afraid of giving wrong information…because these kids are like sponges and I don't want them going home [with the wrong information]." To address this dilemma of limited science knowledge, the teachers positioned themselves as learners. Monita stated: "I like showing the kids that I don't know everything, that I'm learning with them." Angela made the comment, "I'm learning along with my students."

The teachers also encouraged their students to assume the role of teacher. During observations in Monita's class, she prompted students to describe their personal experiences related to the lesson to the class. With her students, Jenny explained, "I'm having them learn that we all don't know everything…Your parents might not know clouds. You can go home and teach them." During investigations, Angela invited students to come to the front of the class to share their findings. Leveraging the role of student-as-teacher, Monita, Jenny, and Angela addressed their insecurities related to content knowledge and science teaching by sharing with students the role of teacher and learner.

Another way Monita and Jenny worked around their lack of knowledge about science and science teaching was to carefully read through the FOSS teacher's guide and write their own lesson outlines to follow during enactment. At the beginning of the spring semester, Monita met with Jenny to plan a lesson, which she felt increased her confidence and knowledge of science. Monita shared the following in an interview:

We're both the same way where we have to write it on paper to say like okay bring the kids to the rug, like a step-by-step thing…so to have a clear outline…I feel like it calmed my nerves to be like, after this they're going to do this.

While writing out lesson plans, notes, and questions helped Monita, it was not enough to erase her nerves, as the following dialogue illustrates. This excerpt was from a lesson on the three states of matter:

Monita:	Who can tell me what this bag is [Ziploc bag containing a wooden block in the shape of a cube]?
Student 1:	A cube.
Monita:	A cube. [Teacher refers to her outline.] We call this a solid. It doesn't… [Teacher looks toward the researcher.] … it doesn't change its shape? I don't want to say the wrong thing.
Researcher:	[Motions to continue.]
Monita:	[Looks back toward the students:] Okay the solid doesn't change the shape. (…)
Monita:	Raise your hand if you don't know what one of these words [on your handout] means. Just say the word and I'll explain.
Student 3:	Rigid.
Monita:	Rigid is like … [addresses the researcher:] hard? Is that…how could I describe?

From the excerpt and observations of Monita, she was noticeably unsure and did not feel comfortable trying to explain the concept of solids to her first-graders.

Similarly, Jenny explained how writing her own lesson plans from the FOSS teacher's guide was helpful: "Just making my own routine this year has helped me feel more comfortable [teaching science]…So, now I'm like I know what I'm doing each time. I have this down pat. I can just do it." To deepen her science content knowledge, Jenny researched topics on the internet. As suggested by the science coach, Jenny watched the FOSS teacher preparation videos as needed. She explained:

Definitely looking at the videos has been so helpful because I'm a visual person. So, getting to see it, I'm like, oh my gosh, I could definitely do this…I feel like[it] gives me a good model, even though I have my own style of questioning and everything.

Jenny articulated that the more FOSS lessons she taught, the more comfortable she felt teaching science: "Now I feel pretty confident, especially because [the lessons] are building on each other and we're always reviewing. I actually learned through this [teaching the consecutive lessons] also."

In addition, Jenny found discussing the lessons with her colleagues and the science coach during meetings to be helpful. Consequently, she began to seek them out informally to receive the immediate support she needed as she prepared for upcoming lessons. She shared, "If I know Angela already did the lesson, I'll run into her room…I definitely try to communicate with my colleagues about how their lessons went or how they're planning on implementing it." Knowing what the enacted curriculum might look like and how students might respond, Jenny felt more prepared to teach the unfamiliar content and scientific practices.

Angela was usually ahead of her colleagues in teaching science lessons and addressed her lack of science content knowledge by committing to work with the science coach on a weekly basis. When she had the opportunity to co-plan a lesson on clouds with Jenny, Angela found that the process also boosted her confidence and content knowledge:

I felt a little bit more confident doing it with someone or talking to someone about what I was going to do, because you really don't know what you're doing if you don't talk to someone. And that's what was great about having you [the science coach] also because you are a science person.

While Angela did not feel like she became a science person, stating "I am the farthest from being a science person", she felt trying out the lessons and reflecting with the science coach and her colleagues made her feel more prepared to teach the FOSS science lessons. Having the FOSS lessons to guide her practice and discussing the lessons and content ahead of time improved her confidence and enjoyment in teaching science: "I'm happy about science… It's not one of those things I'm dreading like, oh what are we going to do now? And, I don't know that much about that."

Akin to Jenny, Angela believed the FOSS teacher preparation videos led to increased content knowledge and science pedagogical knowledge: "I have more knowledge about the content area. That's for sure! Ha! You know, just from watching the films, and reading a little bit about it, and then listening to the things that you [the science coach] have to say." She was comfortable with the idea that improving her practice would take time, and it was okay to get things wrong because such experiences were beneficial in helping to move her practice forward:

I always like to be laid-back. I don't like to be tense and really nervous about it because it's just the lesson and I could always do it again and that's the benefit of learning from this…And each time that I tweak it I should be able to get a little bit better…If I can learn from whatever mistakes I make, then I think I'll get better and better as the years go on.

Therefore, being a veteran teacher, Angela had a more organic approach to instruction and was comfortable with taking risks, trying new things, and re-teaching a lesson or concept if the first attempt did not achieve the desired learning outcomes.

Dilemma #3: Using the FOSS Kits as a Script, a Supplement, a Starting Point, or Not at All

The three teachers started off the academic school year teaching the lessons the first-grade team had designed and used in previous years. Jenny stated that she enjoyed these lessons and felt comfortable enacting them. Being new to the first-grade team, Monita followed her team's lead. Angela had less of an attachment to the old lessons. She felt that they were "getting kind of boring." Angela described one of the lessons from the unit on the seasons, explaining students would fold a sheet of paper in four and draw pictures to illustrate the appropriate clothing for each time of year. Angela, however, described herself and her students as more engaged in the FOSS lessons and felt they led to deeper learning:

[The students] really feel like scientists. I know. I've taught science for many years…and I never had children really feel like scientists…It's a good thing when I can ask a child what is a cloud and they can say it's made of drops of water.

Once the science coach began working with Angela on a more consistent basis and scheduling meetings with the first-grade team, Jenny and Monita began teaching from the FOSS curriculum as well. However, Jenny took breaks from the kit from time to time to teach old lessons she enjoyed or ones she felt addressed standards that the FOSS lessons did not. Swapping between the FOSS curriculum and the first-grade team lessons in this manner was a source of tension for Monita. She was a novice teacher and wanted to stick with the team, but she felt it was challenging to move back and forth between the two sets of lessons. Monita was unfamiliar with both curricula; therefore, she was not aware of how they could be used to connect and build on each other. Still, Monita's initial experiences with FOSS were positive:

I did my lesson with the parachutes last week…they got it…They're like the air is pushing the parachute up…I was like gosh that's perfect. So, they were really into it and…they enjoyed it.

Despite her students' engagement in and learning from the investigations in the FOSS kit, this was the second and final FOSS lesson Monita taught during the fall semester. She felt overwhelmed with teaching first grade for the first time and regularly referred to being held accountable in reading, writing, and mathematics, as mentioned earlier. Consequently, Monita generally resorted to an additive approach to teaching science, rather than investing her time in the FOSS kits. At her end of the fall semester interview, Monita maintained her favorable perception of the FOSS curriculum. "I love it…It's child-friendly and they seem to enjoy it." Moreover, she expressed a desire to catch up with her colleagues:

I especially want [to teach more FOSS lessons] because in the older grades they're so clueless…. I want to create memorable lessons, things that they'll remember. 'In first grade we did this,' or 'I remember talking about this.'

In January, Monita taught two more FOSS lessons, which she planned and implemented following the teacher's guide. In debriefing sessions with the science coach, she began to articulate areas where there was room for improvement with the FOSS lessons. After teaching a lesson on the properties of solids, Monita explained:

I wish they had sandpaper as one of the [items], something that shows a good example of [the property] *rough*…if there was something that was definitely each of these properties it would be easier for them to understand these properties.

Despite only teaching a few FOSS lessons, Monita had a new conception of the FOSS curriculum, describing it as "almost like a one-dimensional way of thinking." Monita's impressions of the kit-based curriculum continued to transform as she pursued and eventually secured a teaching position at another school for the following year. She stated, "At my new school, I know they use FOSS, but they just use it as a guideline. Not so much like we have to do this lesson."

Jenny, who had two years of experience implementing the old lessons that the first-grade tam developed, felt that using these lessons as a supplement complemented the FOSS curriculum. Similar to Monita, Jenny described her approach to using the kits as following the teacher guide step-by-step. The materials were there, and Monita and Angela wanted to make sure they were enacting lessons with fidelity. Jenny believed that FOSS was written by experts in the field and they knew best. However, with the experience that came with implementing lessons over the course of the year and reflecting with her team and the science coach, Jenny began to see room to improve the FOSS curriculum. Reflecting with the science coach, Jenny stated:

I think once we spoke about that, the time when you came in [to observe]…I was like-- Why didn't I do this? Why didn't I do that? I need to learn that it's okay to use my own ideas and not just stick with FOSS.

Jenny's belief that she could effectively modify the lessons slowly increased over the course of the year; however, she stuck to the script much, like Monita. In the following example, Jenny showed the students the inside cover of a book with different bridges and discussed with students the role of an engineer and the types of information engineers need to know to build a bridge:

Jenny: I hear a lot of you saying that an engineer is someone who's going to build something like a bridge using all of their thoughts and knowledge that they have about solids, and they're thinking about all the properties like…shape and the size and if it's bumpy or smooth, the texture.

Student: Also, how do they build a bridge if they can't get over there [across the water]?

Jenny: So, maybe they'd have to take a boat. [Looks at clock.] Okay, so today you are all going to be engineers and you're going to get to use what you know about solids especially the solids at your seats to build a tower. ….

Student: Also, how would they get down to the bottom of the ocean [to build the bridge]?

Jenny: Oh that's definitely for another lesson.

Student: For that, sometimes they might use a submarine.

Jenny: Exactly. Alright signals up, I'm going to set the timer for about 15 minutes and you're going to get to make your tower.

Therefore, adhering to the curriculum so tightly and not knowing how to address the students' inquiries, Jenny missed opportunities to engage her students in a very relevant discussion of engineering and bridges, the topic of her lesson.

Angela, the veteran, was comfortable veering off from the first-grade team's plans and moving ahead with the FOSS lessons. Angela, similar to Jenny, stated the kits were better than what she could come up with on her own in terms of science lessons and thus trusted the curriculum. She stated, "You know they've tested this stuff. You know it's going to be somewhat better than what you could do." Angela followed the FOSS lessons in order, explaining "this way I'll know which ones to pick and choose from because if you don't do them all then you don't know." However, she did not always use the teacher's guide like a script, even though she stated this was the best way to enact new material. Sometimes, Angela relied on the teacher's guide to structure the conversation with her students. Other times she would leave the guide aside and delve into students' ideas or her own questions, where "a lot of my questions come from what they say, so a lot of my questions come from the direction the lesson is going."

In her interview, the assistant principal (AP) commented she thought Angela had reached a plateau when it came to her instructional practice. The AP explained that despite providing Angela with feedback around increasing the level of critical thinking and student-centered instruction, she had not seen any change. The AP explained that after Angela spent time with the science coach teaching the FOSS lessons, not only was there a change in the depth of conversation in teaching science, but there was also a change in Angela's practice. For example, during science investigations and discussions, Angela elicited more conversations and interactions from her students, and these practices permeated the other subjects that Angela taught as well.

While Angela's lessons were more student-centered than her colleagues', her lack of planning and her experience teaching off the cuff led sometimes led to missed opportunities to bring students' attention to key learning goals. For example, when the students made parachutes, she omitted the part of the FOSS lesson where students were to compare releasing parachutes with one versus two "passengers," which were represented by paperclips. After meeting with the science coach to reflect on how the lesson went, like Jenny, Angela realized the missed opportunities in her science teaching for further student engagement and learning. After a few such instances, she began referring to the teacher's guide more frequently while enacting her science lessons.

Jenny and Angela engaged their classes in two student-driven lessons using the handouts created by the science coach to scaffold the process. Students designed and conducted their own experiments to answer questions they were interested in regarding the FOSS insect lessons. Some questions were: "Do beetles climb better on bumpy or smooth paper?" "Do mealworms like pretzels, Pirate's Booty snack, or cereal better?" And, "which is faster a beetle or a mealworm?" After this experience, Jenny saw the FOSS lessons in a new light: "Everything is kind of setup for [the students]…whereas the last [student-driven] investigation they got to choose what they wanted to do." In response, Jenny setup a permanent interest center in her classroom where students worked in pairs to plan and conduct investigations related to any other questions they had about the insects. Jenny explained that the purpose of these interest stations was to "leave it open-ended and [students] could go around the room to get what they need and kind of just letting them figure it out for themselves."

Angela also took the experience of student-driven investigations a step further. During an Olympic themed school day, she had her students plan and carry out an investigation to determine how to increase the speed of their beetles during a race (i.e., by narrowing the track, by providing a trail of food). Both Angela and Jenny expressed a desire to incorporate student-driven investigations into other FOSS units moving forward.

Discussion

In order to contribute to the literature on defining the work of coaches and how they support teachers (Vandenburg & Stephens, 2010), this study identifies and explores three elementary teachers' perceptions of the impact of their relationship with the science coach on their ability to address their dilemmas and enact reform-oriented science teaching practices. Three common dilemmas emerge from this study. First, elementary teachers feel a tension between spending their time and energy on science or on the other core subjects. Second, they struggle to manage their lack of science knowledge and skills with their responsibility to teach the subject. Third, elementary teachers grapple with whether to use their kit-based curriculum as a script, a starting point, a supplement to their previous curriculum, or not at all. The results of this study support the viewpoint that dilemmas are not solved, but rather addressed through compromise. Therefore, Lampert's (1985) vision of teachers as dilemma managers seems apt, noting that teaching is an inherently uncertain task (Lortie, 1975). Teachers encounter a plethora of uncertainties throughout their daily practice "due to the complex nature of their work, which is centered on human relationships and involves predicting, interpreting and assessing others' thoughts, emotions, and behavior" (Helsing, 2007, p. 1317). How teachers navigate their uncertainties appears to be related to their career stage, their sense of accountability to teach science, and opportunities to collaborate with reform-minded colleagues and coaches.

Non-linear Pathways for Science Teaching

Ryan (1986) points out teachers progress through a non-linear pathway as they move through their careers. In some respects, the participants in this study can be considered to be in the novice stage. At the outset of this research, the science content and the FOSS kits are relatively unfamiliar to them. They may be in the mastery stage in some aspects of their practice (literacy and mathematics teaching), while they may not have attained mastery in other respects (science teaching). Monita, Jenny, and Angela show signs of being in Huberman's (1989) initial *survival* and *discovery stages*, as they are acclimating themselves to their new science curriculum. None of the teachers have a catalog of strategies built up for teaching science. However, Jenny and Angela have a repertoire of general pedagogical knowledge and skills that help them with their classroom management and enable them to focus on the *discovery* aspect of this phase. Monita, on the other hand, is in *survival* mode. Compared to her colleagues, Monita spends much less time and energy exploring and discovering the FOSS curriculum and developing her science teaching practices. In addition to learning to teach science, Monita has the task of familiarizing herself with teaching first-grade more broadly. Therefore, teaching the FOSS investigations requires a commitment in time and effort that Monita, at her early stage, is not ready to make. This is reasonable in light of the fact that Jenny had not been ready to make this commitment until she had three years of experience under her belt.

In the current elementary school culture, mastery in the areas of literacy and mathematics teaching appears to open the door for teachers to focus on improving other areas of their teaching practice, such as science. As Jenny moves out of the induction phase, she feels more comfortable. She is confident in aspects of her instructional practice she deems a priority, and her concerns shift from issues of day-to-day survival to the quality of her instruction. Jenny is ready to tackle her science teaching practice as she sees it impacting the quality of her instructional practice as a whole. While Jenny is moving into the *experimentation* stage, she is *conservative* in trying out new things and feels a need to stick closely to the teacher's guide that accompanies the kit. Since she has not gone through the self-accepting *serenity phase*, Jenny is more preoccupied with keeping to a schedule.

Angela has been ready for a change for a while, but she did not have the capacity and support she needs to move her science teaching practice forward. At the outset of this study, she is in the serenity phase—her practice being routine and mechanical. The assistant principal (AP) has noticed very little change in Angela's practice over several years, despite her feedback encouraging Angela to enact more student-centered approaches to instruction. After originally believing that Angela's practice hit a plateau, the AP reports seeing drastic improvement in the quality of discussion Angela is able to elicit from her students toward the end of this study, which she attributes to Angela working with the science coach. It is evident that Angela feels re-invigorated to improve her practice through a combination of supports, including participating in the summer institute which sparks initial interest in science, looking at the science curriculum as a usable model to guide her change, and working with the science coach who creates a sense of accountability for her to change. Instead of refocusing her efforts outside of school, which is typical of teachers nearing the end of their career (the *disengagement* phase), Angela refocuses her efforts at the classroom level and gives more attention and time for science instruction. In terms of teaching science, she moves back to the more productive stage of *experimentation*. Angela is more inclined to allow the lesson to follow the students' lead. The findings of this study support Ryan's (1986) claim that teacher development is a complicated and nonlinear journey.

Science Coach for Accountability

In addition, this study highlights the positive impact a science coach can have on how teachers manage their dilemmas; nevertheless, teachers may not make the most of their access to this more-knowledgeable other without a strong sense of accountability to do so. What elementary teachers want from a science coach and how intrinsically motivated they are to accept support from a science coach may depend on teachers' comfort levels in literacy and mathematics, which, in turn, may be tied to their career stage. Experienced teachers—who have had time to build up their knowledge, pedagogy, and management skills in the core subject areas deemed most crucial by the elementary school culture (i.e., mathematics and literacy)—appear to be more open to focus their efforts on science. When science is not a priority in elementary school settings, administration and teachers, who are under tremendous pressure to maintain and improve students' reading, writing, and mathematics skills, science is "ripped out of the curriculum in terms of time, access and quality" (Mensah, 2010, p. 981). When there are so many aspects of one's practice that require attention, science instruction risks being relegated to the margins. However, from this study there is evidence that accountability for science from administrators, fellow grade-level teachers, and a science coach can lead to greater efforts on the part of the elementary teacher to improve her science instructional practice at all stages along the professional learning continuum. The overall findings suggest that having a coach regularly on-site can create a sense of accountability for teachers to improve their science teaching practice. Science cannot so easily be swept under the rug. Opportunities for teachers to talk about and consider ways to address their challenges with teaching science are highly recommended and supports need to be put in place to ensure effectiveness.

If educational policy continues to make literacy and mathematics a priority, science will continue to suffer. In New York State, yearly testing begins in the third grade, although teachers are expected to keep annual progress records of students in the lower grades as well. In elementary schools, emphasis in the core testing subjects, namely mathematics and literacy, has adversely affected instructional time in science. The Center on Educational Policy (2008) reports that 28% of U.S. districts in a representative sample noted a decrease in science instructional time as a result of NCLB, from an average of 226 scheduled minutes per week to 152 scheduled minutes per week. Similarly, Marx and Harris (2006) found that science instructional time was only 6% of the total instructional time for third grade classes. This "narrowing of the curriculum" is indicative of urban and low-performing schools and is mainly a consequence of intense pressure to boost test scores (Crocco & Castigan, 2007; Spillane & Callahan, 2000; Upadhyay, 2009); unfortunately, in many states, science test scores are not part of the accountability equation. However, in states that include science in their accountability measures, National Assessment of Educational Progress (NAEP) data reveals that fourth-grade students perform significantly higher in science without detriment to their performance in mathematics and reading (Judson, 2012). We agree with Judson (2013) who contends that, "while including science in accountability formulas appears to be a step toward gaining more classroom attention for the subject, a great deal more consideration must be paid to developing the habits of mind promoted by the NGSS; allocation of classroom time is but one important step in this direction" (p.635).

As our study shows, there are other sources of accountability that support science teaching and learning. Working with a science coach may lead teachers to feel a stronger sense of responsibility (to their colleagues and students) to make science a more substantial part of their efforts and to engage their students in the practices representative of the work of scientists, as outlined in the NGSS (e.g., designing and carrying out investigations). Clearly, there is a need for empowering policies that support elementary science teaching, both in terms of time for science instruction, quality of science instruction, and professional development for teachers in science (Judson, 2013; Mensah, 2010).

State accountability measures may be the impetus for schools to carve out increased time for science, while science coaches may be the ticket to ensuring quality instruction through facilitating team meetings, co-planning, and following up with individualized, one-on-one support. Working with a more-knowledgeable other, such as a science coach, can bring teachers' attention to reasons why they should or should not omit lessons in their curriculum, modify them, or follow them more closely. With minimal prior experience in science teaching, elementary teachers need support to develop and facilitate authentic science learning experiences. A science coach can problematize teachers' practices in productive ways and support them in effectively navigating teaching dilemmas. Without reflecting on their practice with a more-knowledgeable other, Kretlow and Bartholomew (2010) state, "teachers may not be aware they are implementing a strategy incorrectly and may continue doing it because they or their students like it" (p. 281). Alternatively, it could be that "teachers may not have success with a strategy and discontinue it because they do not feel it works or do not have access to help" (p. 281). To move to more reform-oriented teaching practices, teachers need to know these practices exist and what they involve, see a need for them, and learn how to incorporate them into their classroom (Berg, 2012). Science coaches can serve not only to create new dilemmas or uncertainties, but also to provide teachers with tools to assist them in moving from viewing dilemmas as immobilizing their science teaching practice to viewing them as opportunities to enhance their instruction. As Helsing (2007) asserts, identifying and describing the conditions that move teachers from the former to the latter form of uncertainty has crucial implications for those who educate and provide PD for teachers, as well as administrators.

Coaching Teachers at Various Stages of Their Careers

Approaches to coaching teachers who are in different stages of their careers need to look different. This connects to Moore's (2008) argument for teacher-centered professional development models that are designed to meet the personal and professional needs of individual teachers at different phases of their careers. Novice teachers, like Monita, are often in survival mode, so it is especially crucial for coaches to be cognizant of their time constraints and feelings of anxiety. These teachers have everything to learn about teaching in a classroom of their own. Novices not only have to build up their content knowledge and management skills in teaching science, but also have to do so in other subjects. The more coordinated the coach's efforts are with the vision of the school and supports in other subjects areas, the more helpful the coach can be. Scaffolding from the science coach may need to be greater at this stage. This may entail spending more time on building teacher confidence to teach science, for example, through direct modeling in the classroom followed by the teacher trying out the skills on her own. Furthermore, coaches need to work closely with administrators to ensure a clear and unified vision for the novice's development that prioritizes the most crucial aspects of her practice. The particular area of support will depend on the teacher. While a coherent plan for PD is helpful for all teachers, regardless of their stage, it may be most crucial for those just embarking on their teaching careers.

Teachers who are just exiting the induction phase, like Jenny, may be more intrinsically motivated to try new things than either novices or veterans. At this stage, teachers may be more comfortable with their daily routines and thus feel ready to begin expanding their repertoire and refining it. These teachers, however, need to learn how to loosen the reins they held so tightly in their novice years. Coaches may need to focus their efforts on supporting these teachers to take risks and learn strategies that will help them relinquish some of their control, allowing students to guide the direction of the lesson to a greater extent. Co-planning and co-teaching may work quite well with teachers at this career stage.

Veterans, like Angela, who are nearing the end of their careers, may be more comfortable with their practice and less inclined to put in the effort to change than teachers earlier in their careers. In order to move from the *serenity* or *disengagement* stages back to the more active stages of *diversification* and *experimentation*, veteran teachers may need to have their interest and motivation sparked. Coaching veterans may involve showing them how teaching in more-reform oriented ways can breathe life back into their practice and give them a renewed sense of excitement for teaching. Veterans may be more comfortable and confident in their general teaching practice and teaching off the cuff. These teachers may be open to veering off course from the curriculum and more confident trying new things with less scaffolding than those with less teaching experience. It may be beneficial for coaches to focus their efforts with veteran teachers on how to diverge from the curriculum in ways that align with learning goals for students and reform-oriented practices. Again, co-planning and co-teaching may work well with this group, in addition to encouraging them to take more risks and to teach science with more rigor, such as "high-leverage practices", which are teaching practices that "lead to comparatively large advances in student learning" and "when done well, give teachers a lot of capacity in their work" (Ball, Sleep, Boerst, & Bass, 2009, pp. 460-461). From this study, it is evident that "one-size fits all" professional development will not meet the needs of teachers at different career stages.

Conclusion

A key finding of this study is that the dilemmas and constraints that teachers view as priorities, such as those related to literacy and mathematics, may need to be addressed before teachers are ready to focus on other aspects of their practice, such as science. However, with effective support and accountability it may be possible to speed up the readiness process by instilling in teachers the need and motivation to expand their efforts, and arming them with the tools to do so. Creating a culture in schools where avoidance is not possible (i.e., through open and candid discourse with the support of a science coach) may be a viable means of de-marginalizing science in elementary classrooms.

Having access to and support from a "science person" (as Angela puts it), who is regularly on-site at the school, has an education background, is knowledgeable of reform-oriented science teaching, and possesses deep pedagogical and content knowledge, has the potential to impact teachers' abilities to reconcile the dilemmas they perceive in ways that are more consistent with reform-oriented teaching. Working with a science coach can positively impact teachers' content knowledge and pedagogical knowledge for science teaching (Shulman, 1986), their sense of accountability to teach science, their ability to manage their time and efforts, and their capacity to use curricula in productive ways. At the same time, we must keep in mind that teachers may experience these benefits to a greater or lesser extent depending on their prior knowledge and experiences, their comfort levels in other areas of teaching, their career stage, and the culture of their school. Research that investigates the applicability of these findings to larger pools of teachers to determine their generalizability is suggested.

The purpose of this research is not to place the blame on teachers for the lack of science instruction in elementary classrooms, but to inform teacher educators, administrators, education researchers, and policymakers of the encumbering tensions educational policies may place on teachers and how teachers at different stages in their careers may reconcile these tensions with support from a science coach. If we are serious about our nation's vision of moving to the top of the heap in science, then schools need to be equipped in science through the same policies and resources that are in place for literacy and mathematics (Mensah, 2010). The fact that so many elementary schools do not employ a single person with a science background is inexcusable. Providing schools with a science coach, who possesses both a science background and expertise in science education, has the potential to be a scalable form of much needed support. Literacy coaches have become ubiquitous, thus hiring science coaches might be a feasible and effective approach of ensuring ongoing, job-embedded support for elementary science teaching and learning.

References

Achieve, Inc. (2013). Next Generation Science Standards. Washington DC: Achieve Inc. Retrieved from www.nextgenerationsciencestandards.org

American Association for the Advancement of Science. (1993). Benchmarks for science literacy: A project 2061 report. New York: Oxford University Press.

Anderson, R.D. (2002). Reforming science teaching: What research says about inquiry. Journal of Science Teacher Education, 13(1), 10.

Antsey, L., & Clarke, B. (2010). Leading and supporting mathematics teacher change: The case of teaching and learning coaches. Mathematics Teacher Education & Development, 12(2), 5-31.

Appleton, K. (2007). Elementary science teaching. In S. K. Abell & N. G. Lederman, Handbook of Research on Science Education (pp. 493-535). Mahwah: Lawrence Erlbaum Associates.

Ball, D. L., Sleep, L., Boerst, T. A., & Bass, H. (2009). Combining the development of practice and the practice of development in teacher education. The Elementary School Journal, 109(5), 458-474.

Berg, A. (2012). De-marginalizing science in the early elementary classroom: Fostering reform-based teacher change through professional development, accountability, and addressing teachers' dilemmas (Doctoral dissertation). Available from ProQuest Dissertations and Theses database. (UMI No. 3507600)

Berlak, A., & Berlak, H. (1981). Dilemmas of schooling: Teaching and social change. London: Methuen.

Bricker, L.A., & Bell, P. (2008). Conceptualizations of argumentation from science studies and the learning sciences and their implications for the practices of science education. Science Education, 92(3), 473–498.

Brickhouse, N.W., & Bodner, G.M. (1992). The beginning science teacher: Classroom narratives of convictions and constraints. Journal of Research in Science Teaching, 29(5), 471-485.
Center on Educational Policy. (2008). Instructional time in elementary schools: A closer look at changes for specific subjects. Washington, DC: Center on Educational Policy.
Charmaz, K. (2006). Constructing grounded theory: A practical guide through qualitative analysis. London: Sage Publications Ltd.
Cochran, K., & Jones, L. (1998). The subject matter knowledge of preservice science teachers. In B. J. Fraser & K. G. Tobin (Eds.), International handbook of science education (pp. 707–718). Dordrecht, The Netherlands: Kluwer Academic Publishers.
Creswell, J.W. (2007). Qualitative inquiry & research design: Choosing among five approaches (2nd Ed.). Thousand Oaks, CA: Sage Publications, Inc.
Crocco, M. S., & Costigan, A. T. (2007). The narrowing of curriculum and pedagogy in the age of accountability: Urban educators speak out. Urban Education, 42(6), 512-535.
Cuban, L. (1992). Managing dilemmas while building professional communities. Educational Researcher, 21(1), 4–11.
Davis, E., Petish, D., & Smithey, J. (2006). Challenges new teachers face. Review of Educational Research, 76(4), 607-651.
Davis, K.S. (2003). Change is hard: What science teachers are telling us about reform and teacher learning on innovative practices? Science Education, 87(1), 3–30.
Delta Education. (2011). What is FOSS? Retrieved from: http://www.deltaeducation.com/science/foss/whatisfoss.shtml
Feiman-Nemser, S. (2001). From preparation to practice: Designing a continuum to strengthen and sustain teaching. Teachers College Record, 103(6), 1013-1055.
Fulp, S.L. (2002). Status of elementary school science teaching. Chapel Hill, NC: Horizon Research, Inc.
Gort, M., & Glenn, W.J. (2010). Navigating tensions in the process of change: An English educator's dilemma management in the revision and implementation of a diversity-infused methods course. Research in the Teaching of English, 45(1), 59-86.
Guba, E. G., & Lincoln, Y. S. (1989). Fourth generation evaluation. Newbury Park, CA: Sage.
Guba, E.G., & Lincoln, Y.S. (1981). Effective evaluation. San Francisco: Jossey-Bass Publishers.
Gunning, A.M., & Mensah, F.M. (2010). One pre-service elementary teacher's development of self-efficacy and confidence to teach science: A case study. Journal of Science Teacher Education, 22(2), 171-185.
Harlen, W. (1997). Primary teachers' understanding in science and its impact in the classroom. Research in Science Education, 27(3), 323-337.
Helsing, D. (2007). Regarding uncertainty in teachers and teaching. Teaching and Teacher Education, 23(8), 1317–1333.
Howes, E.V., Lim, M., & Campos, J. (2009). Journeys into inquiry-based elementary science: Literacy practices, questioning, and empirical study. Science Education, 93(2), 189–217.
Huberman, M. (1989). On teachers' careers: Once over lightly, with a broad brush. International Journal of Educational Research, 13(4), 347-362.
Judson, E. (2012). When science counts as much as reading and mathematics: An examination of differing state accountability policies. Education Policy Analysis Archives, 20(26). Retrieved from http://epaa.asu.edu/ojs/article/view/987.
Judson, E. (2013). The relationship between time allocated for science in elementary schools and state accountability policies. Science Education, 97(4), 621-636.

Katz, L.G., & Raths, J. (1992). Six dilemmas in teacher education. Journal of Teacher Education, 43(5), 376-385.
King, K., Shumow, L., & Lietz, S. (2001). Science education in an urban elementary school: Case studies of teacher beliefs and classroom practices. Science Education, 85(2), 89-110.
Kretlow, A.G., & Bartholomew, C.C. (2010). Using coaching to improve the fidelity of evidence-based practices: A review of studies. Teacher Education and Special Education, 33(4), 279–299.
Lampert, M. (1985). How do teachers manage to teach? Perspectives on problems in practice. Harvard Educational Review, 55(2), 178–194.
Lortie, D.C. (1975). Schoolteacher: A sociological study. Chicago: University of Chicago Press.
Loucks-Horsley, S., Stiles, K. E., Mundry, S., Love, N., & Hewson, P.W. (2010). Professional development for teachers of science and mathematics (3rd Ed.). Corwin Press.
Marshall, C., & Rossman, G.B (1999). Designing qualitative research. Thousand Oaks, CA: Sage Publications.
Marx, R. W., & Harris, C. J. (2006). No Child Left Behind and science education: Opportunities, challenges, and risks. The Elementary School Journal, 106(5), 467-478.
McComas, W.F., Clough, M.P., & Almazroa, H. (2002). The role and character of the nature of science in science education. In W.F. McComas (Ed.), The nature of science in science education: Contemporary trends and issues in science education (pp. 3–39). Dordrecht, The Netherlands: Kluwer.
Mensah, F.M. (2010). Toward the mark of empowering policies in elementary school science programs and teacher professional development. Cultural Studies of Science Education, 5(4), 977-983.
Merriam, S.B. (1998). Qualitative research and case study applications in education. San Francisco: Jossey-Bass.
Moore, F.M. (2008). Positional identity and science teacher professional development. Journal of Research in Science Teaching, 45(6), 684-710.
Muhr, T. (1997/2005). Atlas.ti (Version 5.2 for Windows). Berlin: Atlas.ti Scientific Software Development GmBh.
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 Academy Press.
National Research Council. (2007). Taking science to school: Learning and teaching science in grades K-8. Washington, DC: The National Academy Press.
National Research Council. (2011). A framework for K-12 science education: Practices, crosscutting concepts, and core ideas. Washington, DC: National Academy Press.
Neufeld, B., & Roper, D. (2003). Coaching: A strategy for developing instructional capacity—promises and practicalities. Washington, DC: Aspen Institute Program on Education and the Annenberg Institute for School Reform.
Pajares, M.F. (1992). Teachers' beliefs and educational research: Cleaning up a messy construct. Review of Educational Research, 62(3), 307-332.
Patton, M.Q. (1990). Qualitative evaluation and research methods (2nd Ed.). Newbury, CA: Sage Publications.
Putnam, R.T., & Borko, H. (2000). What do new views of knowledge and thinking have to say about research on teacher learning? American Educational Research Association, 29(1), 4-15.
Richardson, V. (1996). The role of attitudes and beliefs in learning to teach. In J. Sikula, Handbook of research on teacher education (pp. 102-119). New York: Macmillan.

Ryan, K. (1986). The induction of new teachers. Bloomington, IN: Phi Delta Kappa Educational Foundation.

Shulman, L. (1986). Those who understand: Knowledge growth in teaching. Educational Researcher, 15(2), 4-21.

Smith, L. K., & Southerland, S.A. (2007). Reforming practice or modifying reforms?: Elementary teachers' response to the tools of reform. Journal of Research in Science Teaching, 44(3), 396–423.

Spillane, J. P., & Callahan, K. A. (2000). Implementing state standards for science education: What district policy makers make of the hoopla. Journal of Research in Science Teaching, 37(5), 401-425.

Tal, T., Krajcik, J.S., & Blumenfeld, P.C. (2006). Urban schools' teachers enacting project-based science. Journal of Research in Science Teaching, 43(7), 722 – 745.

Tilgner, P. (1990). Avoiding science in the elementary school. Science Education, 74(4), 421-431.

Upadhyay, B. (2009). Negotiating identity and science teaching in a high-stakes testing environment: An elementary teacher's perceptions. Cultural Studies of Science Education, 4(3), 569-586.

Vandenburg, M., & Stephens, D. (2010). The impact of literacy coaches. What teachers value and how teachers change. The Elementary School Journal, 111(1), 141–163.

Walpole, S., & Blamey, K. (2008). Elementary literacy coaches: The reality of dual roles. The Reading Teacher, 62(3), 222–231.

Yoon, K.S., Duncan, T., Lee, S.W., Scarloss, B., & Shapley, K.L. (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. Retrieved from http://ies.ed.gov/ncee/edlabs/regions/southwest/pdf/REL_2007033.pdf

APPENDIX A

Discussion Prompts

Like scientists, students should…	**Possible Guiding Prompts:**
Become aware of their prior conceptions	- What do you already know about ________? (record students' ideas on chart paper)
Propose and design investigations that are meaningful to them	- What do you want to know about ________? - How could you find out?
Carefully collect and organize data	-How will you keep track of your observations/data?
Develop logical explanations (justify their claims with evidence)	- What did you find out about ________? - How do you know?
Welcome constructive feedback from peers and engage in debate based on strength of evidence	- Who agrees/disagrees with that? Why? - Does anyone want to add on to that? - Why do you think that? - How can we find out? - Is that a fair test? (controlling variables)
Reflect on their practice (consider how prior ideas fit with newly generated ideas)	(revise students' original ideas on chart paper) - Any lingering questions? - Can anyone answer that? - What could we do to find out?

Student-Driven Investigations (Teacher Handout)

(1) Before the investigation:

(a) What do you know about ______________________?

"I think that…"

(b) What do you want to know about ______________________?

"I want to know…"

(c) How can you find out?

"I can find out by…"

*some types of questions can be answered with reading materials, some with observations, and some with collecting experimental data
*for the purposes of this activity students should investigate testable questions where they collect experimental data as evidence for findings

(d) What do you predict will happen during your experiment?

"I predict that…"

(2) After the investigation:

(a) Title:

(b) What do I want to find out?

"I want to find out…" or

Question: **"Who/Which/What/When/Where/Why/How…"**

(c) How did I find out? [list the steps in the procedure or write a paragraph]

(d) Data collected: [table, chart, and/or diagram]

(e) What did I find out?

"I found out that…"

"I think this because…"

[use data collected as evidence]

(f) Discussion and debate as a class:

Who agrees/disagrees with this student's findings? Why?

"I agree with _____. I also think that… I think this because…"

"I respectfully disagree with _____. I think that… I think this because…"

Was this a fair test? Why or why not?

What problems did you have during the investigation?

How would you improve this investigation next time?

Any lingering questions?

Can anyone answer that?

Student-Driven Investigations (Student Handout)

Before the science investigation:

1. What do I want to find out? (Underline your prediction.)

_*I want to find out…*____

____

2. What steps will I take to find out?

_*First I will…*____

____

____

____

During the investigation:

3. Data: What am I seeing or measuring?
(Example: Draw a diagram and/or make a chart with measurements or tally marks)

After the science investigation:

4. What did I find out?

_*I found out that…*____

____

____

____

5. How do I know? (Look back at your data to explain your findings.)

_*I think this because…*____

____

____

APPENDIX B

Teacher Interview Protocol

(I) Teachers' perceptions of their views and practices:

1. How would you describe your approach to teaching science? Examples?

2. How do you think your students learn best? How do you maximize student learning?

3. How often did you teach science at the beginning of the school year? Why?

4. How often have you been teaching science throughout the current unit? Why?

5. How comfortable do you think you are with the science content you are currently teaching?

6. How often do you teach lessons from your FOSS kit? What other science resources do you or have you used?
    -How closely have you been sticking to the FOSS curriculum?
    -How have you been deciding which FOSS lessons to teach and not to teach?
    -What do you find to be the pros and cons of FOSS? What are your impressions of this curriculum?
    -What are your impressions of the student-driven investigations? (Second interview only)
    -What changes would you like to make to your science teaching practice?
    -What is your plan for teaching science next year? (Second interview only)

(II) Professional Development and Support

7. Who do you talk to about science?

    Prompts: Who do you turn to for advice? Who has influenced your thinking about science instruction? Who has influenced your science teaching practice? How often do you interact with these people?
    -Why do you talk to some people and not others about science instruction?

8. Do you find it beneficial to interact/collaborate with your colleagues? Why or why not?

    -What factors facilitate/hinder your ability to interact/collaborate with your colleagues?

9. Do you have any desire to receive science PD or support?

    -What kind of support would you like to receive for science, if any?
    -Have you sought out any support for science?

10. Are you currently registered for any upcoming PD (any of the content areas)?

(III) Challenges & Dilemmas

11. What constraints do you think inhibit your science instructional practice? Examples?

> Prompts: What do you think are your biggest concerns/challenges when it comes to teaching science?

12. How do you think these constraints can be addressed?

(IV) Working with Colleagues and Coach

13. How have your discussions about science during your teacher planning meeting changed over the course of the year, if at all? Changed from last year? In what ways? Whether I am there or not?

14. What do you think you have gained/learned from working with me? With your colleagues this year?

15. What aspects of working together this year have been most beneficial to you, if any?

16. In what ways do you think our time together would be more beneficial?

17. Do you think the teachers on your grade-level team have a shared vision of effective science instruction? Explain.

18. Since you have been participating in this research study, has there been any change in your patterns of interaction with other teachers and colleagues at your school?

> (e.g., Do you interact more/less often? Have the types of things you talk about changed over time? If so, in what ways?)

APPENDIX C

Post-Lesson Reflection Prompts

1. How did you feel the lesson went?

2. What do you think the students got out of the lesson? What don't you think the students got out of the lesson?

3. What was your purpose or goal for the lesson (what did you really want the students to come away with)?

4. What, if anything, would you do differently next time?

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