Science Specialists in Urban Elementary Schools: An Ethnography Examining Science Teaching Identity, Motivation and Hierarchy in a High-Stakes Testing Climate

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ABSTRACT

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There are few studies exploring the impact and effectiveness of the science specialist model or its implementation specifically in urban schools. This ethnography explores the roles and responsibilities of science specialists in urban elementary schools, drawing upon interviews with the science specialists, classroom teachers, and building administrators to portray the science-teaching identity and characteristics of the science specialists according to Social Identity Theory (Gee, 2000-2001) as well as classroom teacher science-teaching motivation, according to Expectancy Theory (Vroom, 1964). In this role, specialists provide science instruction, curriculum coordination and communication, and support of classroom teachers. The expectations and limits of leadership from the science specialist are also discussed. The use of science specialists to provide pull-out instruction, wherein a classroom teacher drops off her class for instruction by the specialist, results in a decreased sense of classroom teacher instrumentality. This model of science specialist instruction can also undercut other science-teaching motivation components like expectancy of success, science-teaching identity, self-efficacy and valence for science teaching. Science specialist instruction in a pull-out model can result in teacher disengagement from science instruction. Additionally, hierarchies flowing from school and district-level policy and practice are described and analyzed according to how they mediate and are mediated by a science specialist model.

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I would like to dedicate this dissertation to all of the teachers who have touched my life and, thereby, this work. I share this achievement with you: To my first teachers, my parents, Mary and Steven Roberts, who valued education and set me on a path of opportunity. To those teachers whose passion, enthusiasm, and grace made me want to be a teacher, especially Lesa Milas, who made me love science. To the teachers I am honored to call friends, colleagues, and mentors, especially Robert Lockhart, who gave me the space and the advice to grow as a teacher. To my teacher and guide through this dissertation process, Felicia Mensah, who pushed my thinking at every juncture. And to the teachers who invited me into their classrooms and shared their stories for this study, especially "Mr. Davis" and "Ms. Brown", it has been an honor to teach alongside you.

Lastly, it takes a village for the mother of a small child to write a dissertation. I want to thank my family for all of their support, encouragement, and many hours of babysitting. To my husband, Steve and my son, Eddie, for your patience and love, thank you. All my love, always.

CHAPTER I

INTRODUCTION

Purpose and Rationale

The purpose of this study is to shed light on a widely and variably used but rarely studied instructional model—the science specialist—by describing and analyzing its implementation, specifically in urban elementary schools in a high-stakes testing climate. Thus, this study investigates the role of science specialists in instruction and leadership and analyzes their role and interactions at the school site. While there is theoretical support for science specialists in the literature, there is only one study empirically examining their effectiveness (Schwartz, Lederman, & Abd-el-Khalick, 2000) and none in an urban context. Like any intervention, this model may have intended and unintended consequences for teachers and students. This study focuses on the relationship of the science specialist role with science-teaching identity and motivation among the faculty.

There is no more fundamental and pertinent question in elementary science today than, "Who teaches it?" In response to the constraints of classroom teachers in achieving the vision of elementary science reform, scholars have proposed the use of science-specialists who have a particular expertise in science content and pedagogical content knowledge (Abell, 1990; Gerretson, Bosnick, & Schofield, 2008; Hounshell, 1987; Nelson & Landel, 2006; Wiliams, 1990). In response, school leaders have mobilized funding to support this model, such that 27% of elementary students in the year 2000 received some or all of their science instruction from a specialist (Schwartz & Gess-Newsome, 2008). In practice, these professionals provide a range of services: teaching and co-teaching students, organizing materials, providing professional development, and other responsibilities. There are few studies exploring the impact and effectiveness of the science specialist model or its implementation specifically in urban schools (Berg, 2012; King, Shumow & Lietz, 2001; Schwartz et al., 2000). The current climate of high-stakes testing (Marx & Harris, 2006) and scripted curricula (Barab & Luehmann, 2003) provide additional context and confounding effects in urban schools (Crocco & Costigan, 2007). This study explores science-teaching identity and motivation in urban elementary schools implementing a science specialist model. Specifically, how are the science-teaching attitudes and orientations of the educators, (classroom generalists, science-specialist, and principals) developed as a result of the specific components of the science specialist model implemented at a school site?

Factors that Determined the Origin of this Study

My own interest in elementary science specialists began as an undergraduate student-teacher in Boston pursuing my elementary education certificate. While matched with classroom teachers, I encountered science specialists who taught my students to "cover" classroom teacher preparation periods. In this system, I felt science was marginalized, relegated to a particular box in the schedule and put on equal footing with other "enrichment" subjects like art, music, and physical education. The distribution of science-teaching responsibility between the specialist and classroom teacher was not clear, nor was there any mechanism for collaboration, such common planning time or a pacing calendar of lessons. Similar themes and questions arose from my work with the elementary teachers of the Harlem Schools Partnership. This University Partnership paired neighborhood public schools with STEM education faculty members and doctoral students. As a doctoral research fellow, I provided professional development to in-service elementary teachers in the area of science through instructional coaching and co-teaching. I also attended and led grade-level curriculum planning meetings with the purpose of familiarizing elementary teachers with the kit-based inquiry-oriented science curriculum the district had recently adopted. Teachers from the Partnership schools attended summer professional development workshops on the university campus, led by STEM education faculty. Principals from the Partnership schools met regularly for conversations about supporting STEM activities in their schools. Lastly, pre-service teachers from the university visited the Partnership schools for a clinical science-teaching experience. I served as coordinator and supervisor of these students at my assigned school sites. This Partnership provided researcher access to the schools and teachers who became the sites and participants for this study.

Between Boston and New York, I have known eight specialists across six schools, each slightly varied in job responsibilities and qualifications despite employing the same basic "enrichment" staffing model. Some viewed the position as a desired step away from the self-contained classroom while others viewed it as a pathway to get into a classroom assignment. Some specialists considered themselves curriculum leaders among the faculty, others maintained science as a separate domain. Many lamented the lack of science in the elementary school, providing an assortment of explanations based on their experience and observations.

Initially, I thought that my doctoral career might be occupied with the documentation of the barriers and constraints to elementary science but found that these factors are already well-documented (Abell & Roth, 1992; Greenwood & Scribner-MacLean, 1997; Tilgner, 1990; King et al., 2001). Recognizing that any curriculum's effectiveness ultimately resides with teachers making individual decisions to enact desired practices (Abell & Roth, 1992; National Research Council [NRC], 2012), I have turned instead to a critical analysis of the position of the science specialists, as it is implemented in urban elementary schools, to elucidate its intended and unintended consequences.

Research Questions

The questions that guide this research study are listed below.

1. What are the roles, responsibilities, and identities of science specialists in urban elementary schools, as perceived by the specialist, classroom teachers, and administrators?
2. How do the uses of science specialists influence the science-teaching motivation of classroom teachers according to Expectancy Theory?
3. How do school-level structures and district-level factors establish, reinforce, or work against hierarchies and thereby impact science-teaching culture in urban elementary schools with science specialists?

Organizational Overview of the Chapters

In the following section (Chapter II) I provide an overview of the literature about elementary science. This includes studies about the structural and organizational challenges of elementary science teaching, difficulties cited by elementary teachers, and deficiencies found within elementary teachers in the area of science. The literature survey also supplies the articles that comprise the scholarly description, justification, and evaluation regarding science specialists at the elementary level. Lastly, Chapter II provides a description and integration of the theoretical frameworks utilized in this study, namely Social Identity Theory (Gee, 2000-2001), Self-Efficacy Theory (Bandura, 1977, 1982, 1997), and Expectancy Theory of Motivation (Vroom, 1964).

Chapter III presents the design and methodology of this study - a critical ethnography. I provide a rationale for this research methodology and describe the setting and participants, data sources, analysis techniques, and measures taken to support confidentiality, reliability, validity, and rigor.

The findings chapters for the dissertation are written as separate papers in the format of a manuscript. Chapter IV is the first of the findings chapters. It focuses on the first research question regarding the roles and responsibilities of the science specialist. This chapter draws on the theoretical framework of Social Identity Theory to explore how science specialists see themselves and also how they are seen by their teacher colleagues and building administrators.

Chapter V is the next findings chapter and focuses on the second research question, looking at how various uses of the science specialist are associated with classroom teacher science-teaching identity. This chapter draws on the theoretical framework of Expectancy Theory of Motivation and Self-Efficacy Theory to analyze classroom teachers' science-teaching motivation according to the dimensions of expectancy, instrumentality, and valence.

Chapter VI is the final findings chapter, in which I look at school, district, and state-level factors affecting elementary science teaching in an urban, high-stakes accountability environment. These factors include testing, curriculum materials, budgets, contracts, staffing, and leadership. Interconnections among these factors and unintended consequences of the science specialist model are discussed.

The dissertation concludes with Chapter VII, which provides a summary of the major findings across Chapters IV – VI and a synthesis of the findings across all of the research questions. The implications of the science specialist model on elementary science are presented, and recommendations and considerations are presented.

CHAPTER II

LITERATURE REVIEW

Elementary Science and the Classroom Teacher

The landscape of elementary science is complex and dynamic. While elementary grades have traditionally emphasized reading, writing, and mathematics, there is increasing demand for high-quality science instruction at the elementary level. Reforms in K-12 science have been inspired by America's persistent low and inequitable achievement in science (Hill, Corbett, & St. Rose, 2010; National Center for Educational Statistics, 2007; NRC, 2011) and resulting concern about future global competitiveness and prosperity (Achieve Inc., 2004; Muller & Beatty, 2008). A sequence of national standards documents (Achieve Inc., 2012; American Association for the Advancement of Science [AAAS], 1993, 2007; NRC, 1996, 2012) have shaped the science education reform movement for the past two decades, including and expanding expectations for elementary science programs. The existence and adoption of such national and state standards are a first step towards establishing the expectation that elementary students will be engaged in science.

The most recent documents (Achieve Inc., 2012; NRC, 2012) envision a rigorous elementary science program encompassing and integrating various scientific disciplines with key science and engineering practices as well as crosscutting concepts. As a result, teachers should "have a strong understanding of the scientific ideas and practices they are expected to teach, including an appreciation of how scientists collaborate to develop new theories, models, and explanations of natural phenomena" (NRC, 2012, p. 256). Unfortunately, this characterization is not widely true of elementary classroom teachers. Numerous studies have found elementary teachers to be wanting in various domains of science-teaching knowledge, including science content and pedagogical knowledge, knowledge about instructional practices, and knowledge about the nature and practices of science (Greenwood & Scribner-MacLean, 1997; Howes, 2002; King et al., 2001; Nelson & Landel, 2006; Tilgner, 1990). Similar deficiencies have also been found among those with more science background, such as secondary teachers (Abd-El-Khalick & Boujaoude, 1997; Bianchini, Johnston, Oram & Cavazos, 2003; Brickhouse, 1990). The gap between teacher capacities and desired practices is a critical matter for the next generation of education reform.

Gaps and deficiencies in elementary teacher knowledge are often attributed to their role as generalists, teaching a variety of subject areas as well as a range of scientific disciplines (Abell, 1990; Gerretson et al., 2008; Hounshell, 1987; Miller, 1992), a fundamental consequence of the self-contained classroom. Others have cited elementary teachers' lack of interest or confidence in science (Abell & Roth, 1992; Hounshell, 1987; Williams, 1990) or deficiencies in reasoning ability (Tilgner, 1990). With these teacher-centered factors, it is worth noting that the lack of science knowledge, interest, and reasoning abilities among a non-specialist population of adults, such as elementary teachers, is an indictment of the K-12 science education system and further evidence of the need for reform (Mensah, 2012). Teacher preparation is also an issue, with only 25% of classroom generalists in one large-scale survey classifying themselves as well-prepared to teach science (Marx & Harris, 2006).

In addition to teacher-centered factors, a number of school-level factors constrain elementary science, as reform or lack thereof, does not depend only on the actions of individual teachers (Carlone, Haun-Frank, & Kimmel, 2010). These include a lack of instructional time allotted for science, insufficient materials, equipment, funds, space, and facilities (Carlone et al., 2010; Century, Rudnick & Freeman, 2008; Levy, Pasquale, & Marco, 2008; Marx & Harris, 2006; Tilgner, 1990). Teachers in urban schools additionally cite lack of sufficient adult supervision and presence of behavioral problems (King et al., 2001). These barriers have been consistently reported for two decades and speak to the very nature of inquiry-oriented science instruction as loud, messy, and materials-intensive. Professional development and alternative staffing models may address some of the conventional barriers to elementary science.

Professional development for elementary science suffers from some of the same constraints as elementary science in general, namely that professional development time must be distributed among several content and administrative areas (Hounshell, 1987), and that priority is often given to literacy and mathematics (Crocco & Costigan, 2007; Greenwood & Scribner-MacLean, 1997; Jacobson, 2004; Levy et al., 2008). Successful professional development in elementary science may take place through induction, mentoring, modeling, and in-service workshops and should include rich content and pedagogical knowledge coherently linked with the anticipated needs of the teacher during implementation (Cooke-Nieves, 2011; Koch & Appleton, 2007; NRC, 2012; Penuel, Fishman, Yamaguchi & Gallagher, 2007). Professional development in science is often closely linked to curriculum materials, likely because elementary teachers rely heavily upon curriculum materials to teach science (Abell, 1990; Abell & Roth, 1992). The goals of such professional development are often to familiarize teachers with the intended reform by providing content and pedagogical knowledge around a relevant teaching topic. Forbes and Davis (2008) share how pre-service teachers developed a curricular role identity as a result of working, adapting and enacting curriculum materials, alongside more experienced science teachers. In-service teachers will benefit from similarly crafted professional development opportunities.

Elementary Science and Science Specialists

A different potential remedy to the barriers and challenges of elementary science is a transformation in the staffing model used in elementary schools towards a "specialist" model. The basic rationale is that a science specialist will be a relative expert in matters of science content and pedagogy and therefore better suited to teach elementary science (Abell, 1990; Gerretson et al., 2008; Hounshell, 1987; Jacobson, 2004; Mangiante, 2006; Miller, 1992; Williams, 1990). What qualifications might such a teacher possess? Both Hounshell (1987) and Abell (1990) offer descriptions. Such a teacher should have "a strong background in biology…chemistry, physics, astronomy, and geology" according to Hounshell (1987, p. 157), while Abell prefers the depth of a "major in science at the undergraduate level…and concomitant professional training for teaching elementary science" (1990, p. 293). The specialists should be a confident and enthusiastic science teacher, and an effective collaborator with other teachers. Employing such a teacher could, in theory, guarantee more regular exposure to science and provide for higher quality instruction, due to the specialist's ability to focus on appropriate pedagogy for science.

Within this general rationale, numerous "specialist" models have been proposed and implemented. Abell (1990) and Schwartz and Gess-Newsome (2008) each outline four potential models. Schwartz & Gess-Newsome describe a pull-out model where the classroom teacher is not present for the science instruction, such as in Abell's physical education teacher model. Both authors describe a departmentalized model, wherein grade-level colleagues specialize in different disciplines and students rotate among them. Other models position the science specialist to primarily develop classroom teachers rather than deliver instruction themselves, like Abell's school-within-a-school and Schwartz and Gess-Newsome's resource/coaching model. Students may receive science lessons co-taught or team-taught by the specialist and classroom teacher, as in Schwartz and Gess-Newsome's support team model or Abell's media center model. Gerretson et al. (2008) and Miller (1992) advocate specialist instruction for both mathematics and science, proposing team teaching and mentor teaching as solutions. Jacobson (2004) favorably describes a science resource teacher who conducts hands-on lessons as a supplement to the regular instruction of the classroom teacher. Nelson and Landel (2006) advocates for departmentalizing the upper elementary grades to allow teachers to specialize in areas of demonstrated effectiveness. Another variation on departmentalization entails assigning one teacher to primarily plan and develop science lessons with all teachers enacting science curriculum. Mangiante (2006) addresses some critics of the specialist model, insisting that her schools specialists are not "itinerant teachers" (p. 50), simply providing free periods to classroom teachers. Rather, specialists and classroom teachers collaborate, meeting regularly to plan lessons, co-teaching, and offering ideas of integration with other subjects. Figure 1 provides an overview of various science specialist models.

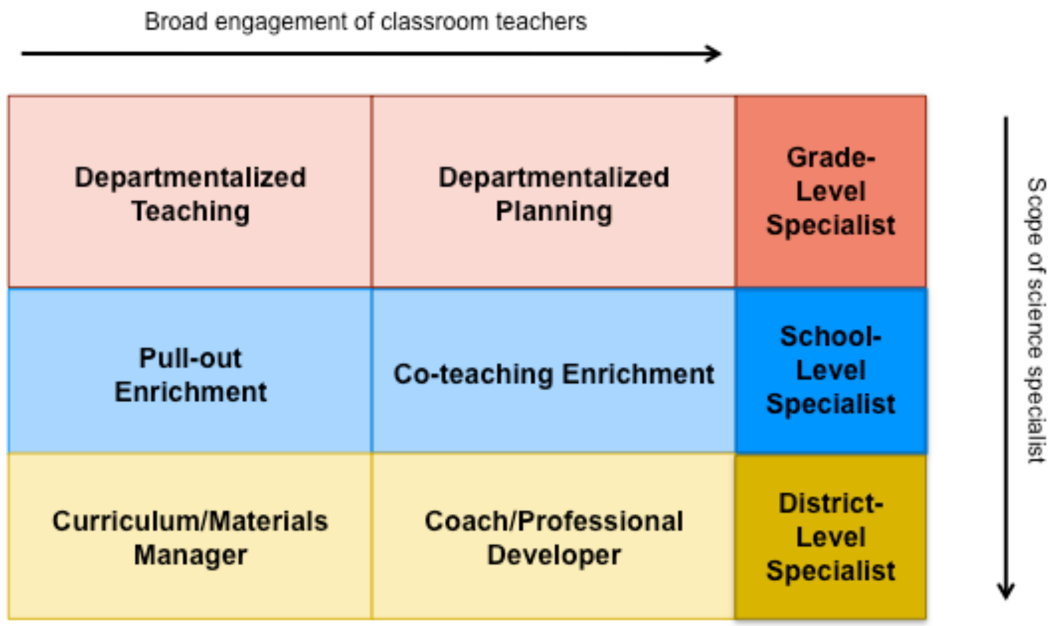

Figure 1. Schematic of various science specialist roles described in the literature.

Amidst this diversity of imagined roles, a key factor to consider in comparing the different models is the role and presence of the classroom teacher during science instruction. A defining characteristic of the "pull-out" models is that the classroom teacher and specialist do not teach simultaneously. Collaboration during non-instructional time is a variant of this model. The "Departmentalized" model similarly concentrates science teaching in one individual, though this teacher is likely one member of a grade level team rather than an enrichment teacher for the school. "Resource" and "co-teaching" models position the specialist to primarily develop the science-teaching capacity of classroom teachers (i.e. coach), while providing support in a challenging instructional area. Potential roles of a school-level specialist are described further in Figure 2.

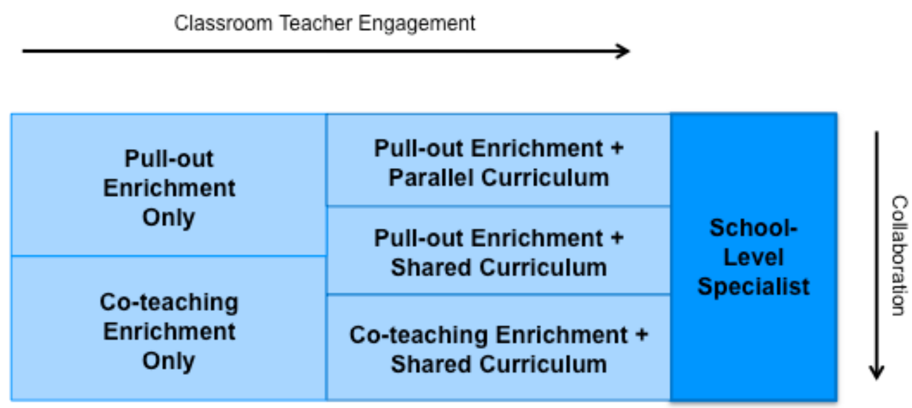

Figure 2. Schematic representation of science instruction arrangements using school-level specialists.

As these selections from the literature illustrate, the precise job descriptions and functions of the science specialist vary greatly across contexts. The financial impact also varies, as co-teaching and resource models incur greater costs due to the presence of two teachers for a single lesson. Science specialists expected to provide professional development or leadership in the area of science may also command higher salaries. The diversity of science specialist roles complicates research efforts to determine the effectiveness of science specialists. To productively move forward describing the effectiveness of various models for elementary science, a common language within the research community is required (Century et al., 2008). Without a common framework for describing particular roles, any successes or failures are a product of the specific model implemented and cannot be generalized to other specialists.

Not all scholars joined the push for science specialists, as some argue that the separation of science from the self-contained classroom would place numerous desired outcomes at risk. Opportunities for interdisciplinary connections and teachable moments may be lost (Swartz, 1987) as the classroom teacher loses touch with science instruction and the specialist is unavailable for the remainder of the school day. In a pull-out model of science instruction, it is likely that both students and teachers will consider science to be a separate and perhaps disconnected portion of the curriculum (Century et al., 2008; Olsen, 1992). Science may be reinforced as an exclusive activity, suitable for only some adults (Olsen, 1992). This would be at odds with current efforts to include all children in science and provide many role models of adults engaged in science.

Arguing for specialists, Abell adds some irony on this point, "Would it not make more sense to concentrate teacher education efforts on a select group of attentives rather than continually trying (however unsuccessfully) to affect every teacher?" (1990, p. 295). The same argument could, of course, be used to exclude students from science in the interest of efficiency or excellence. Assigning someone else within the school to teach science may result in the classroom teacher pulling away or disengaging from science instruction and involvement, resulting in a "centralization of science enthusiasm in a small number of individuals rather than across a dispersed leadership capacity" (Schwartz & Gess-Newsome, 2008, p. 26). This arrangement would make science culture and practice at a school particularly susceptible to changes in personnel and inherently less stable. The extent of these negative impacts depends greatly on the specific model involved and the extent to which science-teaching responsibility is concentrated in the specialist.

Implementing and Evaluating Science Specialists

While there are several theoretical and opinion pieces, there is a dearth of published empirical studies specifically examining the effectiveness of a science specialist program at the elementary level. From this piece it is possible to examine the impact of a science specialist program on the classroom teacher and the students. Schwartz, Adb-El-Khalick and Lederman (2000) compared two suburban school districts, one specialist-led district and other with traditional classroom generalists. In this model, science specialists developed lesson plans and co-taught science with classroom teachers. While science took place in a different room, it did not take place during the teacher's preparation period, assuring her presence for the lesson. Classroom teachers were expected to meet with the specialist, conduct follow-up activities and review homework assignments.

Based on standardized exam scores and student work, the science specialist model was deemed effective. Additionally, specialists' lesson plans exhibited greater alignment with national standards than those of classroom generalists in either district. When comparing the lesson plans of the two groups of generalists, the authors found that classroom generalist lessons from the specialist-led district showed the least alignment to national standards for inquiry-oriented lessons. This suggests that with science lesson planning no longer a primary responsibility, teachers' skills in this area may have atrophied or failed to develop as they did in the classroom generalist-led district. In this study there was minimal differential effect on students, as they had similar test scores to the comparison district. This was considered an accomplishment, since the factual knowledge emphasized on the exam was thought to be less emphasized in the specialist-led district. Lesson plan comparisons suggest that students in the specialist-led district were exposed to more inquiry-oriented practices during their time with the science teacher.

The specific roles provided by the specialist must be kept in mind when evaluating this study as these features differ significantly. Differences in science-teaching ability between classroom generalists and science specialists will depend on the qualifications and aptitudes of individual teachers. In a large urban district, science specialists with differing roles may be employed within a single school (Cooke-Nieves, 2011). Since urban science specialists may be under-qualified (King et al., 2001), they may not possess considerably greater skills in science instruction. Staffing models should also be considered in the context of urban schools, including the climate of high-stakes testing and the impact of scripted curriculum materials.

High-stakes testing is a significant component of school culture in the era of accountability ushered in by the No Child Left Behind Act (NCLB) of 2001 (2003). This is especially true in historically underperforming urban school districts. In the first wave of NCLB, states implemented standards and testing in the areas of literacy and mathematics. In New York State such yearly testing begins in the third grade. In elementary schools, emphasis on these testing subjects has adversely affected instructional time in science, with 28% of U.S. districts in a representative sample reporting decreasing instructional time in science as a result of NCLB, from an average of 226 scheduled minutes per week to 152 scheduled minutes per week (Center on Educational Policy [CEP], 2008). Similarly, one survey of third grade classes (Marx & Harris, 2006) found that science comprised just 6% of total instructional time. This "narrowing of the curriculum" is particularly acute in urban and low-performing schools as a result of intense pressure to boost test scores (Crocco & Castigan, 2007; Spillane & Callahan, 2000; Upadhyay, 2009). One possible avenue to include more science within the constraints of testing would be to integrate science with literacy and mathematics. Unfortunately, teachers' aspirations and efforts in this area are often trumped by highly structured and scripted "proven" curricula in mathematics and literacy, adopted whole-cloth to increase test scores (Carlone et al., 2010; Demko, 2010; Ede, 2006; Reeves, 2010; Smagorinsky, Lakly, & Johnson, 2002).

The marginalization of science is somewhat mitigated by the second wave of NCLB, which requires testing in science (NCLB, 2003). The presence of high-stakes assessments has been positively correlated with instruction time allotments (Marx & Harris, 2006). Still, science test scores are not required to count towards Adequate Yearly Progress (NCLB, 2003), meaning science scores may not carry the same weight as literacy and mathematics scores. Conversely, there may be benefits in retaining a low-profile status for science at the elementary school; as Carlone et al. (2010) write, "...there is a certain amount of freedom that accompanies the teaching of a 'non-tested' subject…no narrowly prescribed, oppressive meanings of 'elementary science teaching' for teachers to be forced to take up" (p. 959). With priority comes accountability, as often measured through reductive and narrow means. A single New York City elementary school is driven by different accountability measures at different grade levels, creating interesting sub-groups for analysis.

New York has developed a science test for 4th graders, in addition to annual testing in literacy and mathematics beginning in the third grade. Thus, teachers in grades K, 1, and 2 operate outside of the state testing system. As such, they would be expected to be the least affected by the high-stakes testing culture. Teachers of grades 3 and 5 prepare students for testing in literacy and mathematics only and may feel pressure to pull away from science. Teachers in grade 4 must prepare their students for testing in literacy, mathematics, and science. The tensions among these disciplines reveal teachers' perceptions about what curriculum is important and how assessment data is evaluated.

To prepare students for the 4th grade state assessment, the New York City Department of Education (NYC DOE) has adopted an official curriculum for elementary science K-5, consisting of 3-4 modular science "kits" for each grade level, available from FOSS™ and DSM™ (NYC DOE, 2012a). Such highly scripted curriculum materials may serve an educative purpose for ill-prepared elementary teachers or they promote rote instruction by attempting to "teacher-proof" the curriculum (Ball & Cohen, 1996; Barab & Luehmann, 2008; Forbes & Davis, 2007). The structured nature of the curriculum may affect how science specialists and classroom teachers work together. On one hand, pre-formed lessons may be easier to coordinate (e.g., specialist teaches even-numbered lessons and classroom teachers teach odd-numbered lessons). However, it may also be that scripted curricula enable or promote further disengagement from science teaching on the part of the classroom teacher.

Another contributor to the science culture of an elementary school is the leadership provided by the building administration. While the tasks of an urban principal are manifold, one important area is curricular leadership. Elementary principals, being generalists themselves, may not be well-equipped to provide instructional leadership and supervision in the area of science (Barish, 2008; Finnigan, 2010; Lanier, 2009). Though this challenge is not unique to the urban setting, principals of low-performing and/or high-poverty schools face additional challenges related to student needs, test scores, and funding that may further distance them from real leadership in science.

In this challenging climate, what does a successful elementary science program look like in New York City? It should satisfy instructional time requirements by including science three to four periods per week. It should involve the city-designated curriculum, meaning that kits should be distributed to appropriate classrooms and regularly replenished. Instruction in a successful science program should be relevant to the needs and backgrounds of students, adapting curriculum materials as needed (Barab & Luehmann, 2003; Ladson-Billings, 1995). If instructional responsibility is to be shared among specialists and classroom teachers, it is critical for a successful program to involve collaboration or coordinated effort between the science specialists and the classroom teachers. Both the specialist and classroom teacher must take responsibility for science instruction. Enthusiasm and agency towards science ought not to be concentrated in only one person; rather, both parties should consider themselves to be capable science teachers. In a school with a successful specialist model, classroom teachers should consider the specialist to be *a* science teacher rather than *the* science teacher.

Conceptual Framework

For the conceptual framework of this study, I use Identity Theory (Gee, 2000-2001), Social Learning Theory (Bandura, 1977, 1982, 1997), the Expectancy Theory of Motivation (Vroom, 1964) and Hierarchy Theory (Carlone & Webb, 2006). Chapter IV contains a detailed description of self-efficacy and identity theory. Chapter V contains a detailed description of Expectancy Theory. Chapter VI contains a detailed description of hierarchy. A brief overview of each conceptual framework is provided below.

Identity Theory

Gee (2000-2001) positions identity as a self-concept that relates to one's actions in society and what others recognize you to be. Identities are then internalized and used by individuals to define themselves, inviting acceptance or resistance. Gee identifies four sources of identity that contribute to a person's sense of self. These are nature-based (based on inborn characteristics), institutionally-based (derived from an assigned role), discursive (understood through interactions with others), and affinity-based (shown by allegiance to an interest group). Since identity is related to activities that occur in a range of contexts, a single person has many overlapping identities.

Social Learning Theory

Bandura (1977, 1982, 1997) describes self-efficacy within his social learning theory and argues that self-efficacy has a great deal of power in determining how individuals approach tasks. Self-efficacy is "the conviction that one can successfully execute the behavior required to produce the outcomes" (p. 193). When an individual has greater self-efficacy, task performance is enhanced while stress is diminished (Bandura, 1982). Sources of self-efficacy include mastery experience, vicarious experience, verbal persuasion, and affective and physiological states (1977, 1997).

Expectancy Theory of Motivation

Expectancy Theory (Vroom, 1964) is a well-established theory of motivation that takes into account the interplay of individual and organizational factors that affect an individual's motivation to engage in some task. Vroom (1964) characterizes motivation as a product of three factors: Expectancy, Instrumentality, and Valence. Expectancy is the belief that effort leads to good performance. This is a product of the individual's agency, confidence and self-efficacy regarding the work task as well as the availability of resources and the lack of constraints. Instrumentality is the belief that good performance will result in favorable outcomes. In other words, it is the belief that the individual's performance will contribute meaningfully to attaining the desired outcome. Lastly, valence is the individual's evaluation of the value of the outcomes of performance, including rewards and incentives. In Vroom's model there is a multiplicative relationship of these three components leading to overall motivation.

Hierarchy Theory

Carlone and Webb (2006) identify hierarchies as unspoken and rarely challenged aspects of educational culture. Through discourse analysis of a curriculum development workshop they facilitated, the authors examined the ways they replicated or combated the University-School Partnership hierarchy. Through reflection and analysis, they challenge normative, institutional and cultural meanings of professional development, collaboration, facilitation, and leadership and examine how identity is established and mediated by the hierarchy.

Relationship of Conceptual Frameworks

Vroom's (1964) Expectancy Theory and Bandura's (1977) Social Learning Theory both examine the cognitive processes that drive a person's beliefs about a task, their eventual behavior, and outcomes. Both Vroom's expectancy and Bandura's self-efficacy mediate a person's appraisal of whether he or she can be successful at a task. Self-efficacy is one contributor to expectancies, though Vroom also identifies skills, capabilities, adequacy of resources and lack of constraints as components of expectancy. Bandura recognizes other factors drive total motivation but argues for a focus on self-efficacy, " Given appropriate skills and adequate incentives, however, efficacy expectations are a major determinant of people's choice of activities, how much effort they will expend, and how long they will sustain effort in dealing with stressful situations" (p. 194). Since expectancy includes various factors that may cause an individual to believe that effort will lead to performance, the conceptual framework of self-efficacy aligns with expectancy in this study. Self-efficacy impacts confidence and agency and therefore, the perceived relationship of effort and performance. While expectancy and self-efficacy are not synonymous, they are related within the overarching framework of Expectancy Theory.

In addition to self-efficacy, Bandura's (1977, 1982, 1997) social learning theory identifies outcome expectancy as the expectation that certain behaviors will produce desirable outcomes. This outcome expectancy has an analogous definition to Vroom's (1964) description of instrumentality. When considered holistically, the two dimensions of Bandura's social learning theory overlap with Vroom's constructs of expectancy and instrumentality, see Figure 3.

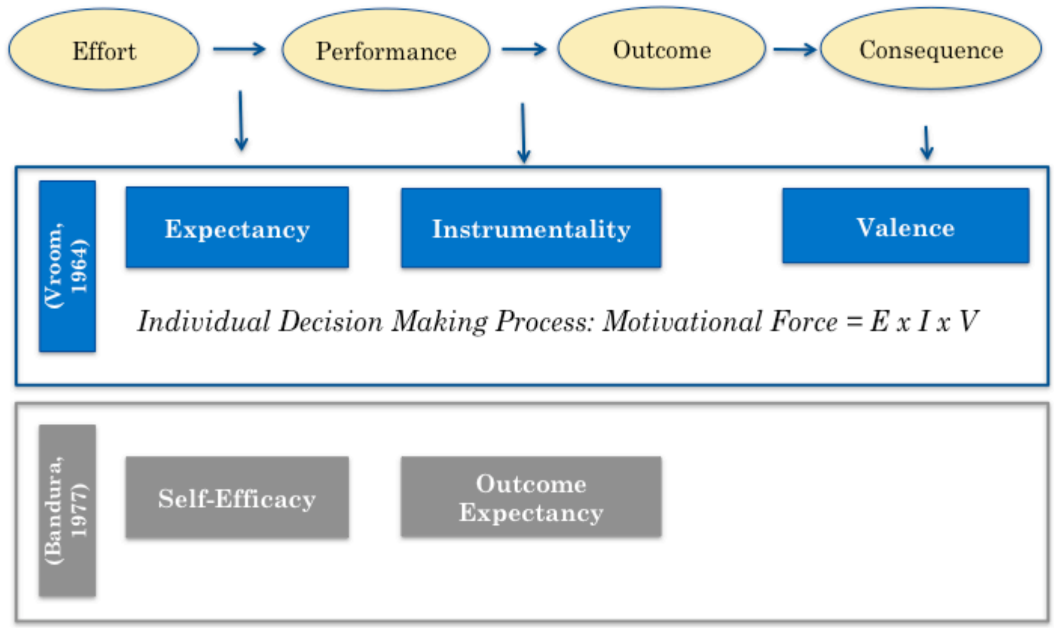

Figure 3. Comparison of terms between Vroom's (1964) Expectancy Theory Model and Bandura's (1977) Social Learning Theory Model.

Vroom's (1964) definition of expectancy is parallel to Bandura's (1977, 1982, 1997) concept of self-efficacy, linking beliefs with behaviors. Vroom's definition of instrumentality corresponds with Bandura's concept of outcome expectancy, as both relate performance/behaviors with outcomes. Instrumentality (Vroom) and outcome expectancy (Bandura) both involve an additional level of analysis by extending beyond individuals' beliefs about themselves to incorporate beliefs about others such as students or coworkers. It should be noted that the term "expectancy" is not used synonymously by both Vroom and Bandura. Since Vroom's model is used as the over-arching theoretical framework for this study, the term expectancy refers to Vroom's definition, unless otherwise noted.

The conceptual framework of Identity (Gee, 2000-2001) relates to the other conceptual frameworks employed in this study. Identity development in the area of science teaching supports teacher self-efficacy and makes a teacher more likely to develop skills and access resources pertinent to science teaching, thereby supporting science-teaching expectancies.

Science-teaching identity is also related to instrumentality, as a teacher with a strong science-teaching identity will be more likely to feel responsible for science outcomes. Lastly, science-teaching identity may also affect a teacher's valence of outcomes, a strong science-teaching identity may drive greater perceived value of science-learning outcomes. These can operate bi-directionally, as students' positive science-learning outcomes (valence), the teacher's sense of responsibility for science (instrumentality) and the teacher's belief that she can deliver effective science instruction each reinforce science-teaching identity.

Hierarchy (Carlone & Webb, 2006) relates to the other conceptual frameworks because hierarchies mediate the priorities and resource allocation in a school. Hierarchies represent implied values that drive accountability systems, mediating the available rewards and consequences for teaching and thereby impacting valence. Hierarchies drive decisions about staffing and instructional models for science that influence teacher instrumentality for science. Lastly, hierarchies determine the allocation instructional time, professional development, and curriculum materials, impacting teacher expectancies in science by influencing the availability of resources and constraints and the level of skill and understanding of teachers.

Chapter III provides an overview of the methodology and methods used in this study including the participants and data sources.

CHAPTER III

METHODOLOGY AND METHODS

Research Design and Rationale

A qualitative approach was most appropriate to address my research questions as I studied science specialists and classroom teachers in their school setting to understand their experiences teaching science and how they interpret them (Merriam, 2009). Qualitative research involves inductive analysis, extensive sharing of participant voices, and a call to action based on complex description (Creswell, 2007). These characteristics were desired in this study. For example, the teachers in this study had unique backgrounds, experiences, insights, and perceptions with regards to teaching science, the richness of which could not be captured through quantitative measures. As described previously, the motivation and identity of teachers regarding science instruction stem from many internal constructs such as identity, self-efficacy, confidence, and the knowledge and perception of rewards and outcomes. To accurately assess these dimensions required in-depth self-disclosure of participants using qualitative measures like interviews.

The questions that guided this research study are listed below.

1. What are the roles and responsibilities of science specialists in urban elementary schools, as perceived by the specialist, classroom teachers, and administrators?

2. What functions do science specialists provide to classroom teachers and how do the uses of science specialists influence the science-teaching motivation of classroom teachers according to Expectancy Theory?
3. What school-level structures and district-level factors impact science-teaching identity and motivation of science specialists and classroom teachers?

Ethnography

Of the many methodologies within qualitative research, I used ethnography in order to paint a vivid portrait of the individual teachers as well as their interactions with one another and the school administration. This method is associated with an in-depth and holistic descriptive of culture. In this qualitative methodology, culture may include "what people do (behaviors), what they say (language), the potential tension between what they do and ought to do, and what they make and use, such as artifacts" (Creswell, 2007, p. 71). I identified patterns in the behavior of teachers and administrators at the schools and thereby characterized the culture of the group (Creswell, 2007). The teachers at these University Partnership sites were a culture-sharing group within the broader group of Harlem-area elementary teachers. They shared several common features such as the demographic profile of students and teachers, administrative guidelines and assessment procedures, and a common science curriculum and instructional time requirements. As members of a University Partnership the teachers shared resources and professional development and principals met regularly to share best practices.

As is the case broadly in qualitative approach, terms oriented towards quantitative methodologies must be redefined. In ethnography "objectivity" is replaced by "critical subjectivity" (Creswell, 2007, p. 212) whereby I constantly evaluated my own biases. This shift acknowledges that no observer is really objective, as we bring our own experiences and ideologies to the research setting. Furthermore, through the act of observing, the researcher affects that which she observes. This acknowledgement requires that the researcher develop and practice a discipline of reflection, self-analysis, and questioning known as critical reflexivity (Anderson, 1989). This reflection is critical to ensure that the patterns that emerge from the data are those truly found therein, rather than those solely based upon my theoretical framework. As guided by Anderson (1989) I reflected on the "relationship between theory and data…the effects of the researcher's presence on the data collected…and …on the dialectical relationship between structural/historic forces and human agency."(p. 254) This meant openly analyzing my data to be open to all themes, revisiting and reevaluating my theoretical framework, keeping broader social and political factors in mind, and understanding that my role as a science instruction resource in the school affected the discourse I had with teachers as well as their behaviors in my presence.

Critical Ethnography

A critical lens and orientation guided this study (e.g. Calabrese Barton, 2001; Carlone et al, 2010). As a critical ethnography, this study of science education in urban schools also addressed questions of power and status quo, equity and access. Merriam explains, "Questions are asked regarding whose interests are being served by the way the educational system is organized, who really has access to particular programs, who has the power to make changes, and what are the outcomes of the way in which education is structured" (2009, p. 35). These questions are relevant to any study of science at the elementary school and any study of urban schools in general.

While the ethnographer aims to address status quo and power, critics argue that the school-based ethnographer may be blind to the broader infrastructure and institutional factors that may be the very source of the status quo (Anderson, 1989). The conceptual framework of hierarchy as well as my research question specifically aimed at school- and district-level factors addressed this criticism and implored me to investigate the sources and rationale for the actions I observed. This ensured that I asked questions and collected data relevant to this contextual layer of science teaching. The themes that emerged bear a practical or ideological resemblance to the i-meanings surfaced by Carlone, et al. (2010).

As a critical ethnographer, it is imperative that I practiced critical reflexivity to avoid using my theoretical framework as a "container into which the data are poured" (Anderson, 1989, p. 254). I continually reflected on the relationship of theory and the data and was open to emergent themes that were outside of or contradictory to my selected conceptual frameworks. Further, my theoretical stance as a critical ethnographer required that I question basic constructs that may have been unconsciously perpetuated within the culture of science instruction. Given my immersion within this culture and first-hand participation in its activities (Merriam, 2009, p. 28) I was at risk of "going native" (Creswell, 2007, p. 72) to the point that I subconsciously accepted these constructs myself and failed to notice them within the data. I guarded against this through peer debriefing and revisiting tenets and works of critical ethnography.

Setting and Participants

While an ethnographic design could be applied to any cultural group, it is especially appropriate when the group is under-represented in the literature or otherwise marginalized. As Creswell (2007, p.70) writes, "Ethnography is appropriate if the needs are to describe how a cultural group works and to explore the beliefs, language behaviors, and issues such as power, resistance, and dominance. The literature may be deficient in actually knowing how the group works because the group is not in the mainstream, people may not be familiar with the group, or its ways are so different that readers may not identify with the group." This description matches well with my participants as there are currently limited studies, qualitative or quantitative, examining the workings or effectiveness of science specialists in urban elementary schools. More broadly, there is very little literature in the area of how science specialists work. Issues of power and dominance are inherent to any study of urban schools, any study of science in elementary schools, or any study of the relationship of science and elementary school teachers. Thus, while the use of science specialists in urban elementary schools is common, the study of science specialists in urban schools is outside of the mainstream.

District Context

The schools in this study were three neighborhood public schools in the Harlem area of New York City. The researcher visited the school sites regularly starting in the fall of 2010 as a doctoral research fellow, spending 1-3 days per week with science specialists and other classroom teachers. The study schools were participants in a University Partnership that provided support and professional development for science instruction. As a result, the researcher provided participants resources and guidance in the area of science instruction for up to three years. This support was not predicated on participation in research.

The schools shared several demographic indicators typical of traditionally defined urban schools - high poverty and high Black and Latino/Hispanic student populations. Demographic characteristics and other descriptive statistics from publicly availably School Progress Reports and School Report Cards from are summarized in Table 1 below.

Table 1
Summary of school characteristics

Metric	Morningside Heights Elementary	Central Harlem Elementary	Washington Heights Elementary
Grade levels served	Pre-K – 5	Pre-K – 8	Pre-K - 5
Approximate enrollment per grade	120	50	140
Average class size	24	25	21

% of students qualifying for free or reduced price lunch	85%	90%	82%
% of Black or Hispanic/Latino students	97%	98%	98%
% of students designated as Limited English Proficiency	15%	8%	51%
% of teachers with fewer than 3 years of teaching experience	4%	3%	3%
% of teachers with Masters + 30 or doctorate	41%	17%	33%

Comparing the schools, Washington Heights Elementary (all proper names in study are pseudonyms) had the highest proportion of Hispanic/Latino students (98%) and a higher proportion of English Language Learners (51%). Central Harlem Elementary was the smallest of the schools, with generally two teachers on each grade level team, in contrast to four or five at Morningside Heights Elementary and six or seven at Washington Heights Elementary. All of these schools had a low proportion of induction- phase teachers and many highly-educated teachers, Morningside Heights Elementary had the greatest percentage of teachers who have attained the Masters +30 level (41%). Both Morningside Heights Elementary and Central Harlem Elementary added grades in recent years. Morningside Heights Elementary grew from a primary school (grades Pre-K to 2) to include grades 3 for the first time in September of 2009 and added forth and fifth grades as that cohort progressed. Likewise, Central Harlem Elementary, which previously served grades Pre-K to 5, added the middle school grades, 6, 7, and 8 in September of 2009, 2010, and 2011 respectively.

Participants

The science specialists in each of the elementary schools functioned as gatekeepers in the “access and rapport” (Creswell, 2007, p. 123) phase of my involvement with the school sites. In three years of work at the school sites, the science specialists were the primary points of contact.

They vary in age, demographic characteristics, science background, and prior teaching experiences, as shown in Table 2 below.

Table 2
Summary of science specialist teacher characteristics

Participant	Sex	Age Range	Race	Role	Prior Experience
Mr. Weiss	M	30s	White	Science Cluster Grades 3-5	• Social Studies Cluster • Classroom Teacher
Mr. Davis	M	50s	African American	Science Specialist Grades 2-5	• Literacy Intervention • Classroom Teacher
Ms. Johnson	F	50s	African American	Science Specialist Grades PreK-6	• Informal Education • Classroom Teacher

In addition, the researcher also worked closely with classroom teachers at each site, both those who collaborated with specialists and those who taught science primarily on their own. Thirteen classroom teachers participated in interviews for this study. Their characteristics are summarized in Table 3 below.

Table 3
Summary of classroom teacher characteristics

Participant	Age Range	Race	School	Teaching Assignment	Other Teaching Assignments
Ms. Ambrose	50s	African American	CHE	Kindergarten	
Ms. Vargas	50s	Latina	CHE	1st grade	2nd grade
Ms. Colon	20s	Mixed Race	CHE	1st grade	
Ms. Evans	20s	African American	CHE	2nd grade	Pre-K
Ms. Alvarez	50s	Latina	CHE	2nd grade	

Mr. McKenny	40s	White	CHE	4th grade	
Ms. Martin	40s	White	MHE	2nd grade	1st grade
Ms. Abreu	40s	Latina	MHE	2nd grade	Mathematics Coach
Ms. Lopez	50s	Latina	MHE	3rd grade, Special Education	Kindergarten, Special Education
Ms. Wilson	50s	African American	MHE	3rd grade	
Ms. Chang	40s	Asian American	MHE	4th grade	3rd grade
Ms. Bryant	30s	African American	MHE	4th grade, Special Education	4th grade, Inclusion
Ms. Forman	30s	African America	MHE	4th grade	5th grade

Building administrators were also interviewed to ascertain their perspectives on the science program in their school. Three principals and two assistant principals were interviewed. Their characteristics are summarized in Table 4 below.

Table 4

Summary of building administrator characteristics

Participant	Sex	Race	School	Role
Mr. Coleman	M	African American	CHE	Principal
Ms. Harris	F	African American	CHE	Assistant Principal, grades Pre-K – 3
Ms. Thomas	F	African American	CHE	Assistant Principal, grades 4 – 8
Ms. Carter	F	African American	MHE	Principal, retired June 2012
Ms. Ducasse	F	African American	MHE	Principal

Data Sources

The sources of data in this study were field notes and observations, semi-structured interviews, a teacher questionnaire, and school artifacts. The primary sources of data, field notes and semi-structured interviews allowed for thick description aligned with the chosen ethnographic method. Qualitative research involves inductive analysis, extensive sharing of participant voices, and a call to action based on complex description (Creswell, 2007). Immersion in the normal day-to-day activities of the school was necessary to observe the desired interactions, since teacher interactions often occur sporadically. Immersion and observation allowed for the development of individualized lines of questioning during semi-structured interviews. This was valuable since relationships and uses of the science specialist were highly variable within and across school settings. Observations and field notes created during the data collection period complemented field notes taken during my three years of ongoing involvement at the field site.

Field Notes and Observations

During the period of immersion at the school sites, I kept detailed field notes describing my observations of teaching practices and school-level factors relevant to science instruction over a three-year period. I observed science specialists engaging in activities that characterize their roles in the schools, during both teaching and non-teaching periods of the day. The method guiding the collection of field notes is described further in Chapter IV.

Semi-structured Interviews

A critical source of data in this ethnography was semi-structured interviews with science specialists and classroom teachers. Semi-structured interviews were conducted and audio-recorded with science specialists (N = 3), classroom teachers (N = 13), and administrators (N = 5). The purpose and context of these interviews is explained further in Chapter IV.

Classroom Teacher Questionnaire

Classroom teachers (N = 37) at the two school sites had the opportunity to complete a questionnaire, with 28 completed questionnaires for a response rate of 76%. The purpose and context of the questionnaire is explained further in Chapter V. Questionnaire responses helped to support the claim that the in-depth comments of interviewed teachers are representative of the school culture at-large, effectively doubling the number of classroom teachers involved in the study.

School Artifacts

School artifacts, such as school schedules, guidelines from school and district administration, administrator- and teacher-created memoranda, professional development offerings, and curriculum and assessment materials were collected. Publicly available documents included artifacts detailing school demographics, prior academic performance, and ratings.

Confidentiality

Participants in this study were assured of the confidentiality of their responses. Classroom teacher questionnaires were anonymous and envelopes were provided to ensure the confidentiality of responses. Questionnaire participants provided written consent at the time of submission. Interview consent, including permission to audio-record, was obtained verbally. Pseudonyms were used for teachers, principals, and schools, and data files were kept in a secure location. The primary risk to participants was a loss of anonymity through disclosure of responses to other teachers or administrators. This was particularly important given the critical lens employed in this study.

Data Analysis

In this study, analysis occurred throughout the data collection phase. This is a suggested strategy in qualitative research (Merriam, 2009) that guides the researcher to review preliminary data sources to note findings, points of interest, and tentative themes with the goal of informing ongoing data collection.

Throughout the data collection phase, researcher field notes were regularly reviewed and commented upon. This preliminary analysis enables more fruitful observation for the future and also lays the groundwork for comparison of themes across data sources. I wrote observer comments and researcher memos (Merriam, 2009) to capture my thoughts about emerging categories and events that I wanted to inquire more about during interviews. Researcher field notes and observations were coded using open, emergent coding in NVivo 10. Those codes were used to form tentative categories and themes via the constant comparison method (Creswell, 2007). Analytic coding (Merriam, 2009) was inductive and comparative and resulted in grouping of codes that had a related meaning. Comparison of data across several sources (separate observations and interviews) allowed the construction of categories that "capture some recurring pattern that cuts across your data" (p. 181).

The same approach was used to derive meaning from teacher and administrator interviews. They were transcribed, regularly reviewed, and coded using open, emergent coding, yielding 89 codes and 1,834 coded segments. Those codes were compared with those from researcher field notes. Comparison resulted in consolidation and revision of codes and tentative categories, in keeping with the constant comparison method (Creswell, 2007). A summary of codes and categories is presented in Appendix A. Preliminary analysis and tentative findings were be used to inform follow-up questions. Teacher and administrator statements were also evaluated in light of the researcher's observations and experiences at the school site, with instances of corroboration noted for purposes of triangulation or, alternatively, instances of conflict between teacher/administrator reports and practices noted for further reflection and exploration.

Data from teacher questionnaires were also analyzed. Teacher comments from open response items in the questionnaire were coded according to the scheme of categories that emerged from the primary data sources. Patterns in teacher responses based on shared demographic characteristics (grade-level, teacher age, years of experience) were also noted. Likert items from part two of each questionnaire were grouped by dimension measured (expectancy, instrumentality, or valence) and results tabulated. Individual teacher scores on these three dimensions were compared with relevant comments from interviews or observations.

The development and naming of categories is a critical step in qualitative research analysis. I developed themes that are responsive, sensitive, exhaustive, mutually exclusive, and conceptually congruent (Merriam, 2009). As an ethnographer, the choice of names for the themes reflects an emic (from the participants) or etic (from the outside) perspective. Merriam identifies three potential sources for the naming of themes: the researcher (as in Chapter VI), the participants (as in Chapter IV), or outside sources such as the literature (as in Chapter V).

As categories emerged and findings from various data sources were reconciled, the process became less inductive and more deductive (Merriam, 2009). Once tentative categories were formed, additional data sources (i.e. additional field notes, interview transcripts, and questionnaire responses) were checked against the categories to see if they adequately interpret the phenomena observed.

Role of the Researcher and Researcher Bias

In my role as a participant-observer I had prior experience that inevitably influenced my observations and analysis of the teachers at the school sites. As a person who identifies as an elementary teacher, I find broad characterizations of teachers as unintelligent or uninterested in science to be offensive. As mentioned earlier, I had experience with science specialists in another large urban district prior to my exposure to the research sites. This experience left me skeptical about the model of specialists employed in a pull-out enrichment context. My general position was to advocate for science as an integral part of the life of the self-contained classroom.

Limitations of the Study

I was limited as a researcher due to my insider-outsider status. While I spent a considerable amount of time at the school sites, I was not a regular employee of the schools. The extent to which teachers viewed me as a colleague vs. an outside resource varied across school sites and individual relationships with teachers. Another limitation of this study was the reality that school environments were constantly changing. Within my time at the schools (Fall 2010 through Fall 2014) there were changes in building administration, teaching assignments, and science-teaching arrangements. These events added to the variation in my sample and the richness of the context. At the same time, they made it difficult to simply describe the effect of science specialists in the urban school setting.

As is typically with a critical orientation, I openly embraced that I brought my own ideology to my observations and analysis as well as the research participants (Anderson, 1989). My ideological perspective affected what I thought about what I saw and heard and also the kinds of questions I asked.

Reliability, Validity, and Rigor

There are a number of factors that contribute to the validity of this study. First, a critical ethnography methodology was both appropriate and possible given my prolonged engagement (Merriam, 2009) at the school sites. This prolonged engagement at the school sites provided a rich context to evaluate teachers' comments. I was able to provide context for teacher comments and use their language, which was critical for the validity of this research methodology. I enjoyed "insider-outsider" status at the school - having formed relationships, meanwhile retaining an outside perspective on school policies and politics.

The methodology selected also emphasizes extensive use of teacher voices. This "thick description" (Merriam, 2009, p. 28) is a hallmark of validity in this area of research and my planned research methods are oriented towards this goal. My experiences enabled me to create a product matching Merriam's standard: "It is…a description of the sort that can emerge only from a lengthy period of intimate study and residence in a given social setting. It calls for the language spoken in that setting, first-hand participation in some of the activities that take place there, and, most critically, a deep reliance on intensive work with a few informants drawn from the setting." (2009, p.28)

My ongoing relationship with the school sites also enabled two other key dimensions of critical ethnography, reciprocity and critical reflexivity. Reciprocity entails giving back to participants (Creswell, 2007) so that participants gain something from being involved with the researcher. Leveraging trust and good will, assuring anonymity, and engaging key informants in the overall purpose of the study were helpful towards the goal of genuine and deep interview responses, especially when they were critical of co-workers and policies or their own practice fell short of district or school guidelines.

Triangulation of data sources was also possible through comparison of teacher responses on questionnaires and interviews as well as comparison of remarks by classroom teachers, the science specialist and the building principal on the same topic. Member checks (Guba & Lincoln, 1989) were another source of validity, with participants reviewing transcripts and providing feedback, to the extent that still ensured their confidentiality. Reliability was enhanced through the inclusion of multiple school sites and science specialists.

The next chapter, Chapter IV explores the first research question, including findings and analysis. The following chapters, Chapters V and VI address the second and third research questions respectively. All three of the findings chapters are in publishable manuscript format.

CHAPTER IV

FINDINGS

THE SCIENCE TEACHER: AN ETHNOGRAPHY EXPLORING IDENTITY AND ROLES OF SCIENCE SPECIALISTS IN URBAN ELEMENTARY SCHOOLS

Abstract

In response to the many well-documented science-teaching deficiencies of classroom generalists, elementary schools may employ a science specialist teacher. These science specialists may have many roles within the school such as delivering science lessons, managing supplies, co-teaching, and supporting or planning with classroom teachers. This ethnography explores the roles and responsibilities of science specialists in three urban elementary schools, drawing upon interviews with the science specialists, classroom teachers, and building administrators to portray the science-teaching identity and characteristics of the science specialists according to Social Identity Theory (Gee, 2000-2001). These science specialists all come from a classroom generalist background and developed science-teaching identity and capacities in the institutionally-sanctioned role of science specialist. In this role, specialists provide science instruction, curriculum coordination and communication, and support of classroom teachers. The expectations and limits of leadership from the science specialist are also discussed.

Introduction

In response to the constraints of classroom teachers in achieving the vision of elementary science reform, scholars have proposed the use of science-specialists whose have a particular expertise in science content and pedagogical content knowledge (Abell, 1990; Gerretson, Bosnick, & Schofield, 2008; Hounshell, 1987; Nelson & Landel, 2006; Wiliams, 1990). In response, school leaders have mobilized funding to support this model, such that 27% of elementary students in the year 2000 received some or all of their science instruction from a specialist (Schwartz & Gess-Newsome, 2008). In practice, these professionals provide a range of services: teaching and co-teaching students, organizing materials, providing professional development, and other responsibilities. There are few studies exploring the impact and effectiveness of the science specialist model or its implementation specifically in urban schools (King, Shumow & Lietz, 2001; Ronan & Mensah, 2013; Schwartz et al., 2000).

This study investigates the role of science specialists in instruction and leadership and analyzes their role and interactions at the school site. The purpose of this study is to shed light on a widely and variably used but rarely studied instructional model by describing and analyzing its implementation, specifically in urban elementary schools in a high-stakes testing climate.

Literature Review

While elementary grades have traditionally emphasized reading, writing, and mathematics, there is increasing demand for high-quality science instruction at the elementary level, inspired by America's persistently low and inequitable achievement in science (Hill, Corbett, & St. Rose, 2010; National Center for Educational Statistics, 2007; National Research Council, 2011). The most recent standards documents (Achieve Inc., 2012; NRC, 2012) envision a rigorous elementary science program; however, numerous studies have found elementary teachers to be wanting in various domains of science-teaching knowledge, including science content and pedagogical knowledge, knowledge about instructional practices, and knowledge about the nature and practices of science (Greenwood & Scribner-MacLean, 1997; Howes, 2002; King et al., 2001; Nelson & Landel, 2006; Tilgner, 1990). Gaps and deficiencies in elementary teacher knowledge are often attributed to their role as generalists, teaching a variety of subject areas as well as a range of scientific disciplines (Abell, 1990; Gerretson et al., 2008; Hounshell, 1987; Miller, 1992), which is a fundamental consequence of the self-contained classroom. Others have cited elementary teachers' lack of interest or confidence in science (Abell & Roth, 1992; Williams, 1990) or deficiencies in reasoning ability (Tilgner, 1990). A number of school-level factors constrain elementary science, including a lack of instructional time allotted for science, insufficient materials, equipment, funds, space, and facilities (e.g. Berg, 2012; Carlone, Haun-Frank, & Kimmel, 2010; Century, Rudnick & Freeman, 2008; Schwartz & Gess-Newsome, 2008). These barriers have been consistently reported for two decades and speak to the very nature of inquiry-oriented science instruction.

A potential remedy to the barriers and challenges of elementary science is a transformation in staffing towards a "specialist" model. By design, the science specialist is a relative expert in matters of science content and pedagogy and therefore better suited to teach elementary science (Gerretson et al., 2008; Miller, 1992; Williams, 1990). Such a teacher should have "a strong background in biology…chemistry, physics, astronomy, and geology" according to Hounshell (1987, p. 157), while Abell prefers the depth of a "major in science at the undergraduate level" (1990, p. 293). Employing such a teacher could, in theory, guarantee more regular exposure to science and provide for higher quality instruction.

Within this general rationale, numerous “specialist” models have been proposed and implemented. Abell (1990) outlines four potential models: the physical education teacher, the media center, the departmentalized, and the school-within-a-school. Schwartz and Gess-Newsome also identify four models: departmentalized, pull-out, resource/coaching, and support team (2008). Gerretson et al. (2008) and Miller (1992) advocate specialist instruction for both mathematics and science, proposing team teaching and mentor teaching as solutions. In addition, Jacobson (2004) favorably describes a science resource teacher who conducts hands-on lessons as a supplement to the regular instruction of the classroom teacher. Nelson and Landel (2006) advocates for departmentalizing the upper elementary grades to allow teachers to specialize in areas of demonstrated effectiveness. Finally, Mangiante (2006) describes a model where specialists and classroom teachers collaborate, meeting regularly to plan lessons, co-teaching, and offering ideas of integration with other subjects. Figure 4 provides an overview of various science specialist models.

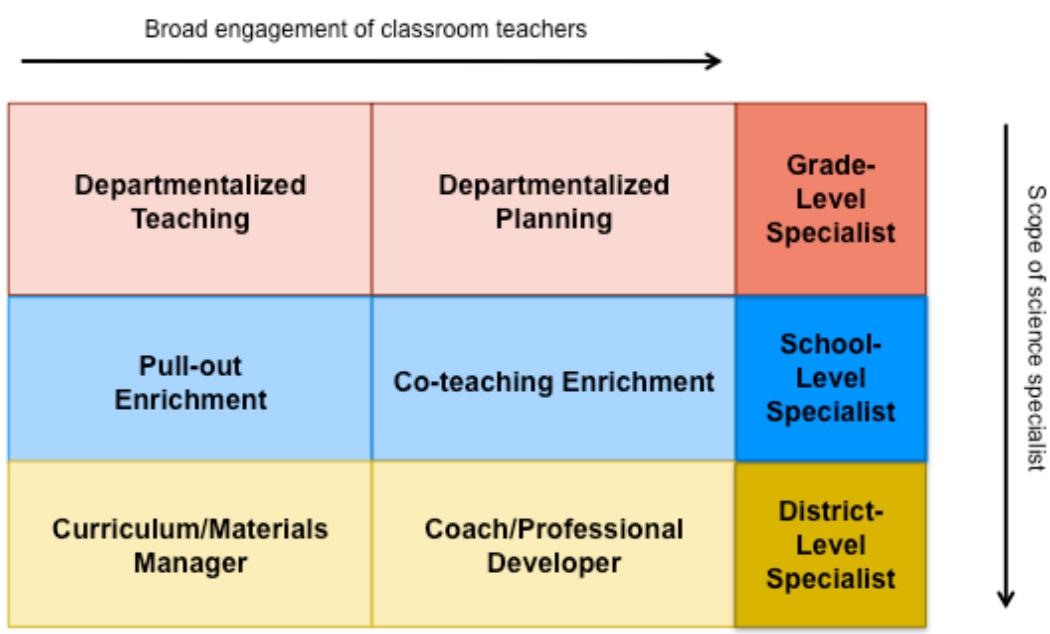

Figure 4. Schematic of various science specialist roles described in the literature.

Not all scholars joined the push for science specialists. In a pull-out model of science instruction, where the science instruction taught by the science specialist occurs without the classroom teacher present, it is likely that both students and teachers will consider science to be a separate and perhaps disconnected portion of the curriculum (Century et al., 2008; Olsen, 1992). Science may be reinforced as an exclusive activity, suitable for only some adults (Olsen, 1992), and opportunities for interdisciplinary connections and teachable moments may be lost (Swartz, 1987). Assigning someone else within the school to teach science may result in a "centralization of science enthusiasm in a small number of individuals rather than across a dispersed leadership capacity" (Schwartz & Gess-Newsome, 2008, p. 26). This arrangement would make science culture and practice at a school particularly susceptible to changes in personnel and inherently less stable.

As these selections from the literature illustrate, the precise job descriptions and functions of the science specialist vary greatly across contexts. The diversity of science specialist roles complicates research efforts to determine the effectiveness of science specialists. To effectively move forward describing the effectiveness of various models for elementary science, a common language within the research community is required (Century et al., 2008). Without a common framework for describing particular roles, any successes or failures are a product of the specific model implemented and cannot be generalized to other specialists.

Conceptual Framework

The conceptual framework used in this study is identity, specifically science-teaching identity according to Social Identity Theory (Gee, 2000-2001). Gee positions identity as a self-concept that relates to one's actions in society, what others recognize you to be and how you define yourself. Institutions and societies determine what attributes of an individual or group are important. These identities are then internalized and used by an individual to define himself or herself, inviting acceptance or resistance. Gee (2000-2001) identifies four sources of identity that contribute to a person's sense of self. These are nature-based (based on inborn characteristics), institutionally-based (derived from an assigned role), discursive (understood through interactions with others), and affinity-based (shown by allegiance to an interest group). Since identity is related to activities that occur in a range of contexts, a single person has many overlapping identities.

For instance, Gee's (2000-2001) concept of identity can be applied to elementary school teachers and the activities of science teaching. First, an elementary teacher may consider herself to be a "science person" or "not a science person" as a matter of nature, a nature-identity. This may conflict with the institutional identity of being assigned to teach science curriculum as a science specialist. A science specialist has a specifically designated institutionally-based identity. This teacher is recognized by others to be a science teacher, supporting a discursive identity. This teacher will likely internalize this self-concept and may even develop an affinity-based identity by choosing to engage in activities with other science teachers or science enthusiasts. It is also important to recognize that teachers bring to the classroom a range of positional identities, those "directly related to an individual's life experiences, which are lived in culturally constructed worlds, such as gender, class, race, ethnicity, age, and religion, to name a few" (Moore, 2008a, p. 685). These various identities may be advantaged or disadvantaged, represented or underrepresented, in traditional science discourse.

Development of science-teaching identity is a major goal of pre-service and in-service science teacher education (Forbes & Davis, 2008; Moore, 2008a, 2008b). In their work with pre-service classroom teachers, Forbes and Davis (2008) found that teachers developed a curricular-role identity in science instruction through engagement in teaching practices as well as critiquing and implementing curricula. Moore (2008b) documents the development of identity as science teachers and agents of change among pre-service teachers in an urban context. Pre-service teachers developed their science-teaching identities along with their overall development as teachers, and as teachers of other content areas. Moore (2008b) also points out that a science-teacher identity is "actively constructed" and "constantly negotiated" (p. 590). This active process is also noted by Carlone et al. (2010) in interviews with in-service elementary science educators. Among the themes of their critical ethnography is the idea of "becoming" (p. 955) a science person or a science teacher. This notion of identity as evolving and responsive to changes in the social or institutional environment meshes well with Gee's concept of identity. Therefore, the two research questions for this study are:

1. What are the roles, responsibilities, and identities of science specialists in urban elementary schools, as perceived by the specialist, classroom teachers, and administrators
2. What functions do science specialists provide to classroom teachers?

Method

Research Design and Rationale

A qualitative approach was used in order to understand the experiences of science specialists and how they interpret them (Merriam, 2009). The teachers in this study have unique backgrounds, experiences, insights, and perceptions with regards to teaching science, the richness of which requires in-depth qualitative measures. An ethnographic method was used in this study in order to paint a vivid, in-depth and holistic portrait of the science specialists as well as their interactions with other teachers and the school administration. In this qualitative methodology, culture includes "what people do (behaviors), what they say (language), the potential tension between what they do and ought to do, and what they make and use, such as artifacts" (Creswell, 2007, p. 71). For a multi-site study to be fairly considered an ethnography, the participants must be part of the same culture-sharing group. In this study, the participating schools were members of a larger culture sharing group - the broader population of teachers in non-charter elementary schools in Harlem. These teachers shared a similar demographic profile among themselves and the students they served. They were also bound by the same contract, standardized testing program, science curriculum, and district-level policies, such as instructional time requirements. The participant schools also share another layer of commonality, as members of a University Partnership with the researcher's institution. Through this partnership, the teachers shared resources and professional development and principals met regularly to share best practices.

District Context

The schools in this study are neighborhood public schools in the Harlem area of New York City. The schools share several demographic indicators typical of traditionally defined urban schools- high poverty and high Black and Latino/Hispanic student populations.

In these three urban schools, science specialists are generally employed in a pull-out model. Classroom teachers bring their classes to the science teacher one or two periods per week for science instruction. During this time the classroom teacher attends meetings and conducts other professional responsibilities. The same pattern is followed for other "enrichment" subjects like art and music. This would be considered a "physical education teacher model" though contact time falls significantly short of the three to five sessions per week that Abell (1990) proposes. With one to two periods of instruction by the specialist, all classroom teachers should be supplementing specialist instruction to reach the recommended instructional time for science, 135-180 minutes per week, depending on grade level (New York City Department of Education, 2012b).

Participants

Entering the schools as a science-specific resource, the researcher made initial contact with the science specialists at each school. The researcher's relationships with the science specialists have entailed three years of ongoing professional support, coaching, and advocacy for science at the school level. In addition to being researcher I have also become a confidant, colleague, co-teacher, and friend in their classrooms. The specialists vary in age, demographic characteristics, science background, and prior teaching experiences, as shown in Table 5 below. All names are pseudonyms.

Table 5
Summary of science specialist teacher characteristics

Participant	Age Range	Race	Role and School	Prior Experience
Mr. Weiss	30s	White	Science Cluster 3-5 Washington Heights Elementary	Social Studies Cluster, Classroom Teacher
Mr. Davis	50s	African American	Science Specialist 2-5 Morningside Heights Elementary	Literacy Intervention, Classroom Teacher
Ms. Johnson	50s	African American	Science Specialist preK-6 Central Harlem Elementary	Informal Education, Classroom Teacher

Beginning with the science specialists, the researcher also branched out to provide science-specific support to classroom generalists and administrators. These contacts provided additional prospective research participants. To add additional context to science specialist reports, thirteen classroom teachers and five building administrators were also interviewed. The classroom teachers interviewed represent a range of uses of the science specialist. The selection of classroom teachers was purposeful but also convenient, in drawing upon the researcher's established relationships. Administrator characteristics are summarized below in Table 6.

Table 6
Summary of building administrator characteristics

Participant	Sex	Race	School	Role
Mr. Coleman	M	African American	CHE	Principal
Ms. Harris	F	African American	CHE	Assistant Principal, grades Pre-K – 3
Ms. Thomas	F	African American	CHE	Assistant Principal, grades 4 – 8
Ms. Carter	F	African American	MHE	Principal, retired June 2012
Ms. Ducasse	F	African American	MHE	Principal

Due to a change in leadership during the study period, Washington Heights Elementary did not participate in the phase of this research study that involved building administrator or classroom teacher interviews.

Data Sources

Data sources for this study included field notes and observations and semi-structured interviews, with school artifacts serving in a supportive role.

Field Notes and Observations

While providing instructional support, I also observed science specialists to see the activities that characterize their roles in the schools, during both teaching and non-teaching periods of the day. Throughout the period of immersion at the field site I kept detailed field notes, cataloguing observations and questions about practices, norms, and structures that impacted science instruction. I used the Reformed Teaching Observation Protocol (RTOP) (Sawada et al., 2002) and Science Management Observation Protocol (SMOP) (Sampson, 2004) to guide my observations of science specialist teaching practices. However, it should be noted that describing and evaluating their teaching practices was not the primary goal of observation. I focused on teacher activities, transitions and interactions as well as teacher comments about science-teaching practices, challenges, and barriers. While specialists and classroom teachers did not typically have scheduled meetings, they did interact during the normal course of school. These interactions often occurred sporadically, such as when the classroom teacher dropped off her class with the science specialists, or happened to walk by the science specialist's classroom, so immersion in the normal day-to-day activities of the school was necessary to observe the desired interactions.

Semi-structured Interviews

A critical source of data in this ethnography was semi-structured interviews with science specialists and classroom teachers. Semi-structured interviews were conducted and audio-recorded with three science specialists, thirteen classroom teachers and five administrators. Science specialists were asked about their beliefs and attitudes about science instruction, their experiences and identity as science teachers, and the role they fulfill in the school. Classroom teachers were asked about their beliefs and attitudes about science teaching and interactions with the science specialists. Teacher interviews were conducted during preparation or lunch periods in the teachers' classrooms. Interviews with principals or other school leaders broached topics such as the role of science in the elementary school and the role of the administrator and specialist in leading an elementary science program. Participants in this study were assured of the confidentiality of their responses. Interviews lasted 10 to 55 minutes, with follow-up through member checking.

School Artifacts

To determine official policies and verify school-based practices I also collected school artifacts, such as schedules, district guidelines, administrator- and teacher-created memoranda. I also reviewed official curriculum and supporting documents available in the classrooms, as was necessary in my instructional support role. Artifacts detailing school demographics, prior academic performance, school ratings and standardized test results are produced at the district-level and were publicly available.

Data Analysis

The data analysis proceeded according to the constant comparison method (Creswell, 2007). Accordingly, researcher field notes received regular review and comment throughout the research period (Merriam 2009). These comments were used to generate specific lines of questioning and foci of observation for individual teachers. Researcher field notes and observations were coded using open, emergent coding. This preliminary analysis laid the groundwork for emerging categories and comparison of themes across data sources. The same approach was used to derive meaning from teacher and administrator interviews. They were transcribed and coded using open, emergent coding, yielding 609 coded segments and 25 codes in NVivo 10. Those codes were compared with researcher field notes, and the conceptual framework, resulting in consolidation and revision of codes and tentative categories. Preliminary analysis and tentative findings were used to inform follow-up questions. Once tentative categories were formed, additional data sources (i.e. additional field notes, interview transcripts) were checked against the categories to see if they adequately interpret the phenomena observed. In this study, the conceptual framework of Social Identity Theory was used to name themes related to the first research question and participants were used to name themes for the second research question.

Role of the Researcher and Researcher Bias

The researcher was a participant-observer at the school sites with insider-outsider status. While I spent a considerable amount of time at the school sites, I was not a regular employee of the schools. The extent to which teachers viewed me as a colleague vs. an outside resource varied across school sites and individual relationships with teachers. The school environments were constantly changing. As this study took place over multiple academic years, changes in personnel and teaching assignments were inevitable. Two schools experienced changes in building principals, and many teachers changed grade-level assignments at some point during my three years visiting the schools. There were also changes to science specialist schedules, teaching loads and enrichment programs as necessitated by budget shortfalls experienced during the study period. Participants addressed some of these changes in their interview responses. These events added to the variation in my sample and the richness of the context. At the same time, these changes made it difficult to reductively or quantitatively describe how science specialists work with classroom teachers in the urban school setting. The reliability of this study was enhanced through the inclusion of multiple school sites and science specialists. Validity of the findings was enhanced through prolonged engagement with the research sites and subjects, member checking and triangulation of findings across multiple data sources (Guba & Lincoln, 1989; Merriam, 2009).

Findings

Who are the science specialists?

In the State of New York, there was no a specific teaching license or degree required for the science specialist position, beyond a general elementary license. As a result, a principal could appoint a teacher to this position whether she had a background or interest in science or not. The science specialists at each school shared their backgrounds. Ms. Johnson gave a summary of her professional experience,

> I first started out in social work when I was younger. I worked with older girls in girls' groups from the age of 13 to 16 years old… From that situation I went to college. I was an art and psychology major. I minored in elementary school education/special education…In my first position, the first when I came out of college, my first position was computer science, science, and I did art as well. (Ms. Johnson, Science Specialist, Central Harlem Elementary, Interview*)*

Mr. Davis shared his work experience after college,

> I taught in elementary school as a substitute. I taught from kindergarten through 7th grade. As an appointed teacher I've taught 1st grade, 2nd grade, 3rd grade. I taught social studies one year to 6th graders. I was a dean one year of the junior high and I also did academic intervention in the school I work in now for about 4 or 5 years. (Mr. Davis, Science Specialist, Morningside Heights Elementary, Interview)

Mr. Weiss described his indirect path to teaching,

> I wound up deciding to go into education as an undergraduate. Then after college I didn't get a job in teaching right away…When I got my masters I got it in secondary [education], social studies because I guess I thought that was the path that I thought I was going to be on for awhile. (Mr. Weiss, Science Specialist, Washington Heights Elementary, Interview)

Each of the science specialists held various positions in education and within their schools. Each had served for many years as a classroom teacher and more recently in out-of-classroom assignments including teaching science, technology, social studies, academic intervention, and art in the enrichment or cluster model. None of the science specialists, however, had an academic credential that would suggest specific preparation in science or science education. None of them pursued an undergraduate major or minor in a science discipline or specialized in science education at the elementary or secondary levels. In fact, Mr. Davis and Mr. Weiss both specialized in areas other than science—Mr. Davis in literacy and Mr. Weiss in social studies.

While each specialist was appointed by a principal, they transitioned to the science role under different circumstances. Ms. Johnson transitioned to the science specialist role after demonstrating her ability to integrate science with other core academic disciplines in a remedial summer program. Mr. Weiss made a choice to align his professional development program towards science and specifically pursue the specialist position,

> When I got my masters degree [in secondary education and social studies], one of the courses I took was a course on the Renaissance and I wound up doing a lot of research on Galileo…So then my +30 [degree credits] I kind of created my own concentration in science. And then when the social studies thing ended, or when the test was canceled, I had my 30 and above, enough of a background to present myself as a science teacher candidate. (Mr. Weiss, Science Specialist, WHE, Interview)

Mr. Davis, however, was appointed to the position unexpectedly following the retirement of the previous specialist,

> That's where I was strong, working with the kids in academic intervention so of course that's where you want to continue the work, in what you're strong in. I'm thinking the science curriculum, I didn't know anything about, I knew very little, I knew what the boxes looked like, I knew some of the titles but I didn't know the intricacies of the curriculum so I was a bit apprehensive but I said it's a job so I have to do it. (Mr. Davis, Science Specialist, MHE Interview)

These science specialists were veteran teachers who brought many years of education experiences to their roles. The extent to which those experiences specifically entailed science varied, as extensive science-related experience was not necessarily a pre-requisite to assume the position. As a result, in addition to learning the curriculum and pedagogy of science, they also had to establish for themselves an identity as a science teacher.

Specialist Science Identity as Nature-based

Academic credentials are one way to pursue an innate interest in science, but not the only way. The lack of science academic credentials of the science specialists did not preclude them from seeing themselves as "science people". In fact, each of the science specialists professed a natural, innate interest in science that had been with them since their childhoods. Ms. Johnson shared, "I've always loved science…I've always been with nature, through either my ancestors, my parents, through the elementary, all my life I've been in the dirt so I like it." (Ms. Johnson, Science Specialist, CHE, Interview) Mr. Davis reflected on an inspiring experience, from his childhood, doing electrical work alongside his father,

> And then I would also take home scraps from that job, wires, and I took an LED, one time they had LEDs they were throwing away, I took some of them and wires. I took them home and hooked them up to my stereo so it would light up whenever the sound, you know, just little things. I mean I was never a whiz, I was never a true tinkerer with electricity but it sparked my interest. (Mr. Davis, Science Specialist, Morningside Heights Elementary, Interview)

Teachers also carried a number of nature-based identities giving each individual a unique positional identity with regards to science-teaching. Of the three specialists, Ms. Johnson expressed the greatest influence of these positional identities. In her mind, her status as an African American woman necessarily impacts her work teaching science to children of color at Central Harlem Elementary. She shared that she sees herself as a revolutionary in serving this student population traditionally under-represented in the mainstream history of science,

> A revolutionary in the sense that one must fight for the import of science at all cost and that it's essential for children of color to be aware of the import of their scientific contributions to the world and that's only integrating with social studies and the rest. So it's very important that children of color, because this is urban, you're doing urban. They have to. And women [in science] etc. (Ms. Johnson, Science Specialist, CHE, Interview)

Specialist Science Identity as Affinity

Building on interests which they believed to be innate, the science specialists have developed an affinity for science, and specifically, teaching science. For Mr. Davis, this entailed revisiting his childhood love of science, which had waned in adolescence and adulthood. Mr. Davis fondly recalled early science experiences both within and outside of school. After some experience as the science specialist, Mr. Davis came to enjoy teaching science full-time. However, his affinity for science teaching was qualified, he felt he could only speak to his fondness for the curriculum and lessons he currently teaches, rather than science teaching more broadly defined. He shared when he first felt that he enjoyed science teaching,

> The reaction of the kids when they work with the materials. It's heavily hands-on and the kids like doing that. It's a lot of work but when you start to see that the kids get a lot out of it and you just have to hustle to get the stuff out of the boxes out of the kits, all that kind of stuff. Basically, the kids like it. I mean, there are some parts of the curriculum that are not as enjoyable as others to teach but overall it's a pretty good curriculum. (Mr. Davis, Science Specialist, MHE, Interview)

A related source of affinity or enjoyment of science teaching was self-efficacy or the belief that one can be successful at the task. For Mr. Davis and Mr. Weiss, a sense of self-efficacy and confidence was a necessary precondition for enjoyment and affinity for science teaching. Mr. Weiss shares, "I never felt uncomfortable doing [science lessons]. I don't know if that's the norm, but the minute I was in the classroom there was no level of feeling uncomfortable." (Mr. Weiss, Science Specialist, WHE, Interview) The science specialists developed affinity for science by partaking in the excitement of their students and by building a positive confident conception of themselves as science teachers.

Specialist Science Identity as Institutional

While upon reflection, some aspects of their science identity reflected natural curiosities and adulthood interests, these were developed in the context of the institutionally-sanctioned role of science specialist. Being identified by the school leadership as a relative science expert was a stimulus for further science identity development. In fact, for Mr. Davis, the institutional designation of science specialist was the only reason for him to explore his identity as a science teacher,

Interviewer	*Did you see yourself as a science teacher at that time, when you were a classroom teacher?*
Mr. Davis	No I was a classroom teacher teaching science. (laughter) Then I was told that I was going to be the science teacher

	after I had been the academic intervention teacher.
Interviewer	*Told or asked?*
Mr. Davis	Told. She told me in June, prior to the September when I would start doing it that I would be the science teacher. So I tried to check out what the curriculum was and I came maybe a couple of weeks early trying to go through things and figure out what I was going to do.
Interviewer	*In your current role, now, do you see yourself as a science teacher?*
Mr. Davis	Yes.

Principal Carter shared her recollection of appointing Mr. Davis to the science specialist role,

> I could not have selected a better science teacher than Mr. Davis. I am going to tell you a little story about him, too. When I first asked him about this science position he had reservations. And he had reservations because he was an academic intervention teacher for so many years in the area of literacy and he said, "What I know about science, Ms. Carter, is very minimal." (Ms. Carter, Principal, MHE, Interview)

The science specialist, Ms. Brown, also interpreted this institutional identity,

> I would describe my role in the school as a learner. I would describe my role at the school as a partner to my colleagues. I would describe my role as a specialist. I would describe my role as an innovator I would describe my role as a revolutionary. (Ms. Johnson, Science Specialist, CHE, Interview)

One way that the school institution conveys the science-specific role of the science specialist is through a job title. This is designated formally on staff listings and informally within the parlance of the school community. Referring to the science specialist as such shapes the self-perception of the specialist as well as the perception of the science specialist to others. The term "science specialist" has been used in this paper to reflect the nomenclature of the scholarly literature. In fact, a number of different titles can be read and overheard within the school communities. These different titles are included in Table 7 below,

Table 7
Science specialist titles

Title for Science Specialist	Referenced By	School
Cluster teacher for science	Grade 1 Teacher	CHE
Ms. Johnson, the science teacher	Grade K Teacher	CHE
The science teacher/head of science.	Grade 2 Teacher	CHE
There's a science teacher who has, Ms. Johnson, I don't know what her title is, she's the head of the science department I guess	Grade 4 Teacher	CHE
Enrichment teacher	Grade 5 Teacher	CHE
The science specialist	Principal	MHE
Our resident science teacher at MHE	Grade 4 Teacher	MHE
The science teacher role, science cluster, the science expert	Principal	CHE

While distinct, these titles were often used interchangeably to refer to the science specialists by administrators, classroom teachers, students, and the specialists themselves. They were used to provide clarity or even to communicate deference for science specialist colleagues. A special title assigned to the science specialist played a role in determining job responsibilities and how science was perceived within the school. This, in turn, affected the identity development of the science specialist. For all of the specialists, their science-teaching identity was shaped by their institutionally assigned role as science specialist, however that role was defined and enacted in the school community.

However, the administration viewed the science specialist in a different way. For example, a district administrator preferred to keep the title of "science teacher". She explained,

> I would never call them an elementary science specialist that's where I would start. I would call them a teacher, just like we would call- we don't call them math specialists we call them math teachers. I think we have a problem both in this city and nationally that I don't think that everybody recognizes science is a basic skill and I don't think we treat it

> as such. When we start using language like science specialist I think we, it becomes more pervasive. We're not really trying culturally to talk down that language which I think perpetuates the problem. So the first thing is that I wouldn't call them a science specialist I would call them a science teacher. (NYC DOE Administrator, Interview)

This administrator viewed the title of science specialist as a means to marginalize science rather than support the identity development of the science specialist teacher.

Specialist Science Identity as Discursive

A final source of science-teaching identity according to the social identity theory was discursive—the identity constructed through discourse with others. As a result of their institutional designation, science specialists played a particular role within the faculty that affects their interactions with colleagues. These interactions shaped the science-teaching identity of the science specialist, reinforcing their institutional designation. The expectation that the science specialist was a relative expert in matters of science instruction provided a stimulus to develop this expertise. Responding to teachers' requests provided the opportunity to build experience in science that the specialist may not otherwise have amassed. Mr. Davis's colleagues relied on him as a science education expert,

> Without him who is going to teach science? He knows the content front to back. He knows it very well. It's his 3rd year teaching 4th grade compared to me brand new. Each class 4th grade has two prep periods with him. He designed the program. He knows how to get the [students'] attention and make sure everyone follows direction. Like the project for the science fair, he was nice, he gave me some stuff to use. *Grade 4 Teacher, Morningside Heights Elementary, Interview*

More than possessing the title, engaging in the work activities of a specialist supported science-teaching identity, as the teacher was known within the school community as a relative science expert. School leaders echoed the sentiments of classroom teachers and further supported the science identity of the specialist, "Ms. Brown, … she loves science and she advocates for science so that in itself keeps science alive in the K-5 teachers." (Mr. Coleman, Principal, CHE, Interview) This sense of responsibility to the school community associated with the role of the science specialist promoted science-teaching identity within the science specialists, “I’ve been here for awhile and I know I’m relied on.” (Mr. Weiss, Science Specialist, WHE, Interview)

Science Specialists’ Science-teaching Beliefs

As a result of their extensive science teaching responsibilities within the elementary context, science specialists developed robust constructs of science teaching, reflecting their unique beliefs, philosophies and priorities. On the role of the teacher in the science classroom Mr. Weiss shared,

> One of the things I say to them at the beginning of the year when we’re going over discipline and the rules of the class is that we could learn science by reading in a book and taking notes which is a hell of a lot easier for me or we can learn science by doing it. And the doing it is a lot more fun but it becomes more challenging for the teacher to organize things so based on their behavior that’s where I’m going to go with an individual class. I mean it’s almost like an empty threat. They’re going to do science no matter what as opposed to reading in a book. (Mr. Weiss, Science Specialist, WHE, Interview)

Mr. Weiss believed learning science by “doing it” was a critical component of an elementary science program. Further, he believed students have a right to experience science in this way, and they did not have to earn it by their good behavior. Mr. Davis also believed that science is a process. He shared his concept of inquiry,

> Inquiry means to look at something, it can be an idea, it be a rock, it can be a plant, it can be a math problem, but try to take it apart piece by piece seeing what makes it up or try and take different pieces of something and put them together, find out what you can make. I mean George Washington Carver became who he was without any formal science education because as a little boy he went out and played in the grass and the woods and fields and started studying insects and flowers and became I mean one of the most important scientists of the 20th century. People came to see him to learn things from him, big colleges offered him positions and he stayed at his little hut in Tuskegee and he was happy there. The world had to come to him. (Mr. Davis, Science Specialist, Morningside Heights Elementary, Interview)

Mr. Davis believed that careful inquiry can be a powerful tool of discovery, even when unaccompanied by formal education or curricula. It is interesting that Mr. Davis chose to illustrate his concept of science using an African American scientist as a model, someone who reflects his own positional identity as an African American man.

When asked about their favorite kind of lesson, both Mr. Davis and Mr. Weiss used the 4th grade Magnetism & Electricity Unit as an exemplar. Mr. Davis explained the introductory activity wherein students create a circuit to light a bulb,

> The only problem I have is some of them put their hands on the wires when they are supposed to be listening to me but once they see it [light up] it even makes kids who normally don't behave kind of settle down because they feel ownership of this tray and the wires and that circuit becomes theirs. And they're like "Ooh, look!" "Ohh, look!" I mean "No, put yours…" even when they're helping each other, they're arguing "No! don't do it like that, put the wire…why don't you know how to…" so they're arguing but it's within the context of the lesson, they're not just putting each other down. And some of them are more combative kids. So that's why I think I like that. (Mr. Davis, Science Specialist, MHE, Interview)

The science teachers most enjoyed their teaching and feel it most reflects good science-teaching practice when students work collaboratively to investigate something with support and guidance from the teacher.

Student enjoyment of science lessons was an important motivator for the science specialists, and they found it especially rewarding when the students' enjoyment of science spilled over into the rest of their day, especially their home life. For example, Ms. Johnson stated,

> So if I'm teaching a lesson and someone comes back and says, "Ms. Johnson I saw an insect in the schoolyard" or "Here's a leaf I found in the school yard," that means a synthesis happening. So my goal is to move them outside of the room so when somebody comes and says, "I looked this up on the net, here's this animal I did, a human body, oh I can look at this." That is my goal. (Ms. Johnson, Science Specialist, CHE, Interview)

While the science specialists valued hands-on inquiry-oriented experiences for students, they were also highly aware of the external criteria by which the school community and students are evaluated. They modified their curriculum to emphasize literacy and mathematics skills or test-preparation to bring their instructional practice in-line with school-level priorities.

What Do Science Specialists Do?

Science specialists developed robust science-teaching identities as a result of their institutional designation and their responsibility to fulfill the obligations of the role for the sake of the faculty community (i.e. Gee 2000-2001). They also developed science-teaching identity because the work activities of the role provide an opportunity to gain experience, self-efficacy, and affinity for science teaching (Pratt et al., 2006). This raises an important question- what are the responsibilities and activities of the science specialist in these school communities? Many decisions about how to use a science specialist are made at the school level and are, therefore, likely to vary from one community to the next. However, there are several common themes in the enacted activities and responsibilities of the science specialist.

Science Specialist as Science Teacher

The primary role of the science specialist at each school site was to provide science instruction to various groups of students throughout the day. This follows a drop-off model: the classroom teacher brings her class to the science specialist for a 45-minute period during which she attends to other professional responsibilities. The schedule is set by the administration and science periods recur on a weekly basis. During these periods, the science specialist engages students in reform-oriented science instruction consistent with the district's curriculum guidelines. Mr. Davis described his primary role "to deliver the curriculum to the kids, especially the 4th and 5th" and how he worked with the grade-level teachers,

> I'm the primary science teacher for the 4th and 5th grades. And I teach 3rd grade once a week which means that the 3rd grade teachers are supposed to do follow-up lessons or precursory lessons that go along with what I do. I'm responsible for making sure the 4th

> graders are ready, or as ready as they can be, for the 4th grade New York science test. (Mr. Davis, Science Specialist, MHE, Interview)

The principals believed that having a science specialist ensured that all students were exposed to hands-on, inquiry-oriented instruction. They entrusted science instruction to the science specialist. While inquiry experiences were valued, allegiance to the given curriculum was also a priority. Principal Carter of Morningside Heights Elementary explained,

> You know that the 4th graders take a science exam so there is, there is a curriculum that he has to follow in order for those students to pass the test, that's number #1. He has to design different grade activities for each grade. It's not easy. It has to be child-friendly. It has to make sense to each and every child on the grade. It is up to him to make sure that what he's teaching is what the students are learning. It's not easy. Because you're talking about maybe 4-5 classes on a grade. That's a lot of classes. (Ms. Carter, Principal, MHE, Interview)

The existence of the 4th grade science test provided visibility and legitimacy to the elementary science program and the science specialist. In each school, the primary job function of the science specialist was to deliver science instruction, as measured by the proportion of the specialists' schedules devoted to teaching science and the perceptions of the specialists, administrators and colleagues. Depending on the science-teaching involvement of the classroom teacher, the science specialist was the primary science teacher.

Science Specialist as Communicator and Coordinator

As science specialists and classroom teachers often delivered science lessons in tandem, another function of the science specialist was to communicate and thereby coordinate the curriculum. A classroom teacher from Morningside Heights Elementary explained, "He gives us the FOSS you know the plan, the units, where we should be, the pacing calendar. He's excellent about passing that out… He gave us notices to give to the parents to let us know where they were and to see him if they had any questions." (Grade 4 Teacher, MHE, Interview) Mr. Davis communicated with classroom teachers about the science instruction he delivered to their students so that the classroom teacher could effectively deliver her own science curriculum in coordination with his.

Beyond simply reporting back what lessons were accomplished, Mr. Davis went a bit further, he also communicated suggestions for lessons and activities the classroom teacher might attempt in the interval before their next science visit. He shared a typical conversation he would have with a classroom teacher, “I try to encourage them ‘Ok we did this page in the booklet. Maybe you could do this page and let me know before next week. Then when the kids come in [to science] we can do this [activity].’ Some do it some don’t. And that’s the extent of my rapport with them when it comes to what the kids are doing or where we are in the curriculum, etc.” (Mr. Davis, Science Specialist, MHE, Interview) In addition to communication via memos and notices, communication occurred in-person- spontaneously and sporadically. In the absence of regularly recurring common planning periods, communication often occurred as classroom teachers brought their classes to the science specialist, immediately preceding the science specialist’s lesson.

Science specialists also communicated with administrators, most often to keep them abreast of their program and advocate for their needs. Mr. Davis explained, “I just go and I talk to them. Sometimes I’ll give them letters. At the beginning of the year I had a problem. I didn’t have the 5th grade materials, [so] I sent up some desperation letters about what I didn’t have…” (Mr. Davis, Science Specialist, MHE, Interview) The science specialist was a point of contact for various school-wide science matters such as preparation for and implementation of the state science exam for forth graders and the school-wide the science fair. Outside of these once-a-year events, much of the ongoing communication dealt with lesson planning and science materials.

Science Specialist as Keeper of the Kits

One common topic of teacher dialog with the science specialist was materials supply. These were curriculum materials like published teacher resources or scientific equipment and supplies. Mr. Davis explained,

> There were, certain teachers would give me a wish list of things they didn't have that they needed. I would search those things down and bring them to them. Pretty much facilitate the teachers… One teacher, this might have been a second grade teacher, who actually she had a problem with something that was in the kit. It wasn't working right but a lot of them, some of them that come to me, they'll ask me some questions. (Mr. Davis, Science Specialist, MHE, Interview)

Classroom teachers corroborated this role, from their perspective, "He's supportive of what I need. [phone gesture] 'Mr. Davis, I need a tuning fork.' 'Sure I'll send them up.' He listens to what I'm telling him the kids are doing." (Grade 3 Teacher, Morningside Heights Elementary, Interview)

Because the science specialist served a variety of grade levels, they had a reservoir of science curriculum materials at their fingertips. When classroom teachers found that their classroom kits were unexpectedly missing certain supplies, the science specialist was their first point of contact. The science specialist was also the point of contact for science materials at the building level. Each spring when it was time to re-order materials, the science specialist was consulted to provide recommendations based on an inventory. Principal Coleman validated, "She is the keeper of the kits. She is the one who understands what should be in those kits, which items are consumable which ones need to be reordered. I rely on her for the keeping of the inventory." (Mr. Coleman, Principal, CHE, Interview) At Morningside Heights Elementary, Mr. Davis distributed the kits to appropriate grade-level teachers at the start of each school year. The science specialist's classroom was often referred to as a science lab, though from an infrastructure perspective, it was identical to other classrooms. It was the presence of science materials that made the science specialist's room unique.

Science Specialist as Science Resource

In addition to serving as a source of physical materials, the science specialist was also a source of ideas, resources, and advice. Classroom teachers looked to the science specialist as a science and science education expert. As a result, the science specialist also served a consultative and/or conferring role to classroom teachers. The science specialists perceived this as a component of their job responsibilities, "If somebody asks me something then, yeah, I help them out. Mr. Perez is good about that, coming to me and asking me questions. The other teachers will come to me and ask, 'how do we set this up?' and I support them and help them out when I can with that. (Mr. Weiss, Science Specialist, WHE, Interview) As Mr. Weiss indicates, the consulting functions of the science specialist always occurred at the request of the classroom teacher. It was not a function of the science specialist to determine teacher needs in science, either through observation or in consultation with the principal. This support role function was not built into Mr. Davis's day, "I haven't had time to really go and see what they're doing but they know that I am open to questions or whatever they need." (Mr. Davis, Science Specialist, MHE, Interview)

The science specialists' schedules were fully booked with visiting classes. The only periods that the science specialist did not teach directly were the contractually-mandated lunch and preparation periods. This daily preparation period may been seen by administrators as an allocated time for consultation or collaboration with classroom teachers, however, science specialists viewed this time as crucial to prepare for their own classes. Mr. Davis explained,

> I usually set up the room for whatever lesson is going down that day. I put all the materials out; I review what I have to do; I get my essential question and agenda up on

> the board. It's pretty much prepping the room, getting all the stuff out, setting up for the day. Then I feed my critters in the room, all that good stuff. (Mr. Davis, Science Specialist, MHE, Interview)

Science specialists had many of the duties of classroom teachers including preparing lesson plans, setting up materials, communicating with parents, and providing feedback on student work. Specialists almost always used their preparation periods for these tasks.

As judged by how they spent their time, conferring and collaborating with classroom teacher was not a major function of the science specialist. As judged by the faculty community, however, these interactions were viewed as significant. Classroom teachers shared how they rely on science specialists as a resource,

> If I need to find out anything, "what do you have on science that I could use?" "What can I do with this experiment?" or whatnot, kind of like a resource. I'll kind of try to drain her brain on certain things. I wouldn't ask her, "How would you teach this lesson?" I wouldn't do that, I would say, "Where can I get more information on this?" Resource kind of thing because she is supposed to be the expert. So a resource in that sense. (Grade K Teacher, CHE, Interview)

In alignment with the specialist' commentary, these interactions were generally initiated by the classroom teacher. The science specialist provided support related to science content, activities, materials, or suggestions related to the curriculum. While these actions were sometimes pre-planned, they often occurred spontaneously when a classroom teacher had a need and the science specialist was available.

Science Specialist and Support of Classroom Teachers

The science specialist further supported the classroom teachers' science practice by acting as a coach. These interactions moved beyond the resource role with the science specialist reaching out to assist the classroom teacher in developing her science-teaching practice. This role required that the science specialist be accepted as an expert and role model when it comes to science instruction. Coaching occurred through demonstration teaching, such as a push-in or co-taught lessons. This occurred at Morningside Heights Elementary when the new kit-based curriculum was first implemented, "Oh and last year he [Mr. Davis] came in and did demo lessons…He actually came in and did the first lessons so we could see how he did the chart and how you could chart stuff, how he did the lessons and what the structure of the lessons is." (Grade 2 Teacher, MHE, Interview) Rather than delivering all of the science lessons himself, the science specialist jump- started the classroom teachers' practice by starting the unit with a demonstration lesson.

Though these uses of the specialist were well-received at Morningside Heights Elementary, push-in teaching did pose some scheduling challenges. If a specialist is fully booked with classes each day, there are limited times for push-in teaching. With only one preparation period each day, it would take the science specialist several weeks to visit each class in the school. Put another way, if the specialist had an available day for push-in teaching or co-teaching, he could accomplish in one day what would otherwise require a week's worth of preparation periods. This was the case at Morningside Heights Elementary for a time, as Mr. Davis explained, "Last year I was fortunate to have open lab time which gave me time to go around and see different teachers, give lessons in different classrooms, do sort-of like a push-in. This year's schedule I have 1 lab period [per week], that's basically because of budget cuts. So, instead of covering 2 grades, I'm covering 3 grades." (Mr. Davis, Science Specialist, MHE, Interview) The "lab periods" were unscheduled times that the specialist used flexibly in response to teacher requests for push-in or co-teaching. Mr. Davis drew upon his experience as a classroom teacher to empathize with his colleagues and understand what their hesitations and needs were. He initially provided support to all teachers and then engaged in a continuing dialog with those teachers who were responsive to his actions.

Because of their role, science specialists were uniquely positioned to gather information about classroom teacher science-teaching practice. The science specialist knew if students made progress in the curriculum since their last session together. The science specialist knew which teachers were making requests for materials or asking questions. By imperfect inference, the science specialist also knew which classroom teachers were not delivering science instruction in line with school expectations- teaching science poorly, teaching science inaccurately, or, as was the most common concern, not teaching science at all in the classroom. What the science specialist did with this information illuminates the limits of the science specialist's role as leaders within their non-administrative teacher role. On the classroom teachers who were not making progress in the science curriculum:

> The ones who aren't, administration needs to check on them because that's not my job and even if I were told to do that I wouldn't have much time to do it…If I ask them if they've done it they say, "oh, I don't have time." … So I just wait for them to have time to let me know. If I was an administrator I could demand it but no. (Mr. Davis, Science Specialist, MHE, Interview)

Mr. Davis did not feel he had the power to compel teachers to deliver a certain amount or type of science instruction in their classrooms. He also did not feel it was his place to communicate with teachers about their lack of science teaching.

Ultimately, the science specialist was a classroom teacher and not an administrator. They were on the same contract and salary schedule as their classroom teacher colleagues. They did not participate in evaluation or supervision. As such, the science specialists were careful not to overstep their role. Even if they believed they had the leadership capacity to do more with their colleagues in the way of enforcement or evaluation, they did not believe it was their role or job to do so. Principal Coleman agreed, "I think about as much as she can do is have that conversation with one of the administrators. It's an administrative conversation with the classroom teacher. It puts a strain on the relationship and makes it much more difficult for the science teacher to work with the classroom teachers collaboratively if they feel like the teacher is going behind sharing that information." (Mr. Coleman, Principal, CHE, Interview) Principal Coleman believed that a science specialist should preliminarily engage with a classroom teacher to offer support. After that point, however, it should be an administrative matter. Principal Coleman maintained that he has the oversight structure in place to spot teachers who may have deficiencies in science.

Discussion and Implications

In the absence of an official model of elementary science instruction in the New York City schools or any specific guidelines as to how science specialists ought to be used within elementary schools, it is not surprising that a variety of roles and interpretations of the science specialist exist. For example, the various titles used to refer to the science specialist, even within the same building, convey different meanings and some sense of value about the science specialist's role. The science specialist as "enrichment teacher" groups the science teacher with art, music, dance, physical education, technology, etc. This gives the science specialist a group affiliation while reinforcing science as "enrichment" rather than as a core academic subject. "Cluster teacher" is an organizational designation, referring to the science position as an out-of-classroom assignment for which a drop-off instructional model is used. It may also provide a group affiliation (i.e. the cluster teachers) but avoids the hierarchy implied by enrichment versus core subjects. "Science specialist" asserts the core competency of this staff member vs. other classroom teachers but does not specify the actual job activities (i.e. teaching, co-teaching, coaching). Terms like "science expert" and "head of science" convey empowerment, though leadership may or may not be intended. Referring to the science specialist as simply a "science teacher" suggests membership in the general classroom teaching population. However, reference to the science specialist as "a science teacher" often evolves to mean "*the* science teacher", a defining designation and special institutional identity only available to the science specialist.

Various contributors from Social Identity Theory (Gee, 2000-2001) were manifest. Institutional sanction was a powerful force in the establishment of the specialists' science-teaching identity. Reflection on affinity- and nature-based science identities followed. The science specialist's everyday interactions within the school community provide a powerful source of discursive identity and reinforcement for science-teaching identity. That others perceive and expect the specialist to be a science expert shapes the self-perception of the specialist. For the specialists in this study, science-teaching identity was developed within the role of science specialist rather than serving as a pre-requisite to obtaining the role. In this way, being named a science specialist can be a self-fulfilling prophecy.

Though they now each identify as a "science teacher" the science specialists may not be considered highly credentialed to teach science according to expectations in the literature (Abell, 1990; Hounshell 1987). They do not have undergraduate or graduate majors or minors in any scientific discipline. They may have taken graduate courses specific to science education but they do not possess any degrees among them specifically in science or science education. The existence of a science specialist in a school should not be interpreted as the presence of science expertise.

The matter of teacher certification is a driver of this phenomenon; without a separate license for this position, any certified elementary teacher is qualified to be a science teacher or science specialist. Conversely, a teacher with a strong background in science and education with a secondary certificate would be teaching outside of her license area in an elementary science specialist position. The call for science specialists and the implementation of them at the elementary level has not been matched with offering of specific teacher preparation or certification programs. In this climate, principals have shown they will fill science specialist vacancies with teachers already on their faculty, serving in other non-science positions.

The science specialists in this study show how a science-related identity can emerge in adulthood and later in career, even in the absence of specific academic qualifications. This reflects other findings in organizational psychology wherein engagement with the work of a role leads to identity development and refinement specific to that role (Pratt et al., 2006). This bodes well for science-teaching identity development among other elementary generalists. Given sufficient institutional and discursive backing, as well as engagement in science instruction, classroom generalists can come to see themselves as science teachers. Science-specific feedback, coaching or professional development within or beyond their school communities could serve to bolster their qualifications, further develop their identities, and/or provide membership into a community of science educators. Unfortunately, outside of the services of the researcher, science specialists are not provided with many science-specific professional services and are primarily self-taught in science pedagogy. University outreach to science specialist has the potential to have significant impact and fill a void for professional development. In the absence of such partnerships or institutional support, curriculum materials strongly influence practices and may even set boundaries of their science-teaching identity and self-efficacy (Abell & Roth, 1992; Forbes & Davis, 2008). This makes the selection of high quality curriculum materials even more essential.

Judging by their daily and weekly schedules, the primary responsibility of the science specialists in these urban elementary schools is to deliver science instruction in a pull-out model.

At an organizational level, they are simply providing coverage for the classroom teachers' contractually obligated preparation period, the "itinerant teacher" (p. 50) model that Mangiante (2006) warned against. The specialist's science instruction may be considered primary, complimentary, or supplemental depending on the classroom teacher's own engagement with science instruction. Science specialists also serve as communicators, coordinators, and resources in matters of curriculum and materials. Their ability to serve resource or coaching functions is limited by their full teaching schedule. Science specialists may be viewed and used as curriculum leaders within the school, however each of the specialists was clear to define themselves as a teacher rather than administrator. Unlike a coaching model or co-teaching model, wherein science-teaching capability is diffused, the presence of a strong science specialist who serves as the primary science instructor concentrates science-teaching capacity in one individual and is inherently unstable and vulnerable to change.

Conclusion

In the urban elementary schools in this study, potential science specialists were selected from within the classroom generalist population. Some sought out the position because of an established interest in science, and some were assigned to the role. The science specialist role itself is a strong source of science-teaching identity development both because of the institutional identity it provides and also because of the duties and experiences that the position entails. The science specialists at these school sites have embraced their role and developed for themselves a sense of science-teaching identity and self-efficacy. They view themselves as relative science experts within the faculty and therefore a potential source of assistance and leadership for science at their schools. This manifests in their communication, curriculum coordination, and consultation to classroom teachers. The extent to which the science specialist is expected to or able to lead the science-teaching practice of classroom teachers is an important consideration. The science specialists in this study express clear limits to their authority and also to their availability, because of their own science-teaching obligations. The effect of science specialists on the science-teaching identity of classroom teachers and the overall science-teaching culture of the school is an important matter for further investigation.

CHAPTER V

FINDINGS

USING EXPECTANCY THEORY TO EXAMINE SCIENCE-TEACHING MOTIVATION: AN ETHNOGRAPHY OF URBAN ELEMENTARY SCHOOLS IMPLEMENTING A SCIENCE SPECIALIST ENRICHMENT MODEL

Abstract

This ethnography explores the uses of science specialists and classroom teacher science-teaching motivation, according to Expectancy Theory. Classroom teacher science-teaching motivation and its components expectancy, instrumentality, and valence affect and are affected by uses of the science specialist, as dictated by organizational factors like instructional time arrangements. The use of science specialists to provide pull-out instruction, wherein a science specialist provides instruction without the classroom teacher present, results in a decreased sense of instrumentality that can undercut other science-teaching motivation components like expectancy, identity, self-efficacy and valence. Science specialist instruction in a pull-out model can result in teacher dis-engagement from science instruction. This arrangement concentrates science-teaching responsibility, and capacity, within the science specialist.

Introduction

There is no more fundamental and pertinent question in elementary science today than, “Who teaches it?” In response to the constraints of classroom teachers in achieving the vision of elementary science reform, scholars have proposed the use of science-specialists whose have a particular expertise in science content and pedagogical content knowledge (Abell, 1990; Gerretson, Bosnick, & Schofield, 2008; Hounshell, 1987; Nelson & Landel, 2006; Williams, 1990). In response, school leaders have mobilized funding to support this model, such that 27% of elementary students in the year 2000 received some or all of their science instruction from a specialist (Schwartz & Gess-Newsome, 2008). However, there are few studies exploring the impact and effectiveness of the science specialist model or its implementation specifically in urban schools King, Shumow & Lietz, 2001; Schwartz, Lederman, & Abd-El-Khalick, 2000). The current climate of high-stakes testing (Marx & Harris, 2006) and scripted curricula (Barab & Lueuhmann, 2003) provide additional context and confounding effects in urban schools (Crocco & Costigan, 2007).

This study explores science-teaching identity and motivation in urban elementary schools implementing a science specialist model. Specifically, how is the science-teaching motivation of classroom generalists developed in the context of the specific components of the science specialist model implemented at a school site? While there is theoretical support for science specialists in the literature, there is only one study (Schwartz et al., 2000) empirically examining their effect and none in an urban context. Like any intervention, this model may have intended and unintended consequences for teachers and students. This study will focus on the relationship of the science specialist role with science-teaching identity and motivation among the faculty.

Literature Review

Elementary Science and the Classroom Teacher

The most recent standards documents (Achieve Inc., 2012; National Research Council, 2012) envision a rigorous elementary science program encompassing and integrating various scientific disciplines with key science and engineering practices as well as crosscutting concepts. As a result, teachers should "have a strong understanding of the scientific ideas and practices they are expected to teach, including an appreciation of how scientists collaborate to develop new theories, models, and explanations of natural phenomena" (NRC, 2012, p. 256). Unfortunately, this characterization is not widely true of elementary classroom teachers. Numerous studies have found elementary teachers to be wanting in various domains of science-teaching knowledge, including science content and pedagogical knowledge, knowledge about instructional practices, and knowledge about the nature and practices of science (Greenwood & Scribner-MacLean, 1997; Howes, 2002; King et al., 2001; Nelson & Landel, 2006; Tilgner, 1990). The gap between teacher capacities and desired practices is a critical matter for the next generation of education reform.

Gaps and deficiencies in elementary teacher knowledge are often attributed to their role as generalists, teaching a variety of subject areas as well as a range of scientific disciplines (Abell, 1990; Gerretson et al., 2008; Hounshell, 1987; Miller, 1992), a fundamental consequence of the self-contained classroom. Others have cited elementary teachers' lack of interest or confidence in science (Abell & Roth, 1992; Hounshell, 1987; Williams, 1990) or deficiencies in reasoning ability (Tilgner, 1990). Teacher preparation is also an issue, with only 25% of classroom generalists in one large-scale survey classifying themselves as well-prepared to teach science (Marx & Harris, 2006). Professional development for elementary science suffers from some of the same constraints as elementary science in general, namely that professional development time must be distributed among several content and administrative areas (Hounshell, 1987), and that priority is often given to literacy and mathematics (Crocco & Costigan, 2007; Greenwood & Scribner-MacLean, 1997; Jacobson, 2004; Levy, Pasquale & Marco, 2008).

Elementary Science and Science Specialists

A different potential remedy to the barriers and challenges of elementary science is a transformation in the staffing model used in elementary schools towards a "specialist" model (Abell, 1990; Gerretson et al., 2008; Hounshell, 1987; Jacobson, 2004; Mangiante, 2006; Miller, 1992; Williams, 1990). Such a teacher could, in theory, guarantee more regular exposure to science and provide for higher quality instruction, due to the ability to focus on appropriate pedagogy for science. Within this general rationale, numerous "specialist" models have been proposed and implemented (Abell, 1990; Schwartz & Gess-Newsome, 2008). A key factor to consider in comparing the different models is the role and presence retained by the classroom teacher.

Schwartz et al. (2000) compared two suburban school districts, one specialist-led district and other with traditional classroom generalists. In this model, science specialists developed lesson plans and co-taught science with classroom teachers, assuring the presence of the classroom teacher for the lesson. Classroom teachers were expected to meet with the specialist, conduct follow-up activities and review homework assignments. Based on standardized exam scores and student work, the science specialist model was deemed effective. When comparing the lesson plans of the two groups of generalists, the authors found that classroom generalist lessons from the specialist-led district showed less alignment to national standards for inquiry-oriented lessons. This suggests that with science lesson planning no longer a primary responsibility, teachers' skills in this area may have atrophied or failed to develop as they did in the classroom generalist-led district. Lesson plan comparisons suggest that students in the specialist-led district were exposed to more inquiry-oriented practices during their time with the science teacher.   The specific roles provided by the specialist must be kept in mind when evaluating this study as these features differ significantly from a pull-out model.

Conceptual Framework

Expectancy Theory of Motivation

Motivation is a useful construct for evaluating the impact of a science specialist model on teachers' engagement with science instruction. Motivation influences employees', and specifically teachers', engagement with their work. Expectancy Theory (Vroom, 1964) is one well-established theory of motivation that takes into account the interplay of individual and organizational factors that affect an individual's motivation to engage in some task. This theory of motivation has previously been applied in education (Abrami, Poulsen, & Chambers, 2004; Fan, 2011; Finnigin, 2010; Foley, 2011; Green, 2002). Vroom characterizes motivation as a product of three factors: Expectancy, Instrumentality, and Valence. Expectancy is the belief that effort leads to good performance. This is a product of the individual's agency, confidence and self-efficacy regarding the work task as well as the availability of resources and the absence of other constraints. Instrumentality is the belief that good performance will result in favorable outcomes. In other words, it is the belief that the individual's performance will contribute meaningfully to the desired outcomes. Lastly, valence is the individual's evaluation of the value of the outcomes of performance, including rewards and incentives, both positive and negative.

Expectancy Theory can be applied to a school implementing a science specialist model of instruction. The various functions of a specialist may influence the expectancy, instrumentality, and valence of employees (teachers and administrators) within the organization. For example, elementary classroom teachers have traditionally low levels of science-teaching confidence and self-efficacy. Some uses of the science specialist may improve these characteristics of classroom teachers and may increase expectancy, and therefore motivation to teach science. Distribution of science-teaching responsibility between a classroom teacher and science specialist may blur the sense of responsibility of either party for science-education outcomes, thus compromising the instrumentality for science teaching for student learning of both the specialist and the classroom teacher and decreasing motivation. Lastly, teachers and administrators may be influenced by any number of rewards or incentives associated with their teaching decisions. These may be intrinsic, such as the satisfaction in seeing students learn and enjoy science experiences, or extrinsic such as pressure to perform on high-stakes exams in science and other curriculum areas. Depending on how the incentive structures are aligned and how highly teachers value various types of incentives, this may affect a teacher's valence of outcomes towards science teaching. Since Vroom's (1964) model implies a multiplicative relationship of these three components, it is possible for an extreme in one factor to have a great influence on a teacher's overall motivation towards science.

Self-Efficacy

One contributor to expectancy towards a task is self-efficacy. Bandura (1977, 1982, 1997) positions self-efficacy within his social learning theory and argues that self-efficacy has a great deal of power in determining how individuals approach tasks. Self-efficacy is "the conviction that one can successfully execute the behavior required to produce the outcomes" (1977, p. 193). When an individual has greater self-efficacy, task performance is enhanced while stress is diminished (1982). Sources of self-efficacy include mastery experience, vicarious experience, verbal persuasion, and affective and physiological states (1977). Self-efficacy has been widely used in a number of research fields including psychology, education and management. In elementary science education research, self-efficacy has been used to characterize the beliefs and attitudes of teachers towards science, especially pre-service and early career teachers (Cannon & Scharmann, 1996; Enochs, Scharmann & Riggs, 1995; Gunning & Mensah, 2010; Mulholland & Wallace, 2001; Ramey-Gassert, Shroyer, Staver, 1996).

In the context of urban elementary schools, self-efficacy is a powerful lens for analyzing teacher self-reports of science teaching beliefs and attitudes. Considering that elementary teachers report lack of knowledge, preparation and confidence with regards to science teaching, low self-efficacy may be the source of their aversion towards science. Rather than concluding that elementary teachers simply do not like science (i.e., Williams, 1990), this framework provides for a more productive conversation about professional development. Since self-efficacy is positively related to performance, it is reasonable to predict that teachers with greater self-efficacy will be more likely to teach science, to enjoy teaching it, and to teach it well.

Bandura's (1977, 1982, 1997) social learning theory identifies another dimension of beliefs required for enacting desired behavior. In addition to self-efficacy, he identifies outcome expectancy as the expectation that certain behaviors will produce desirable outcomes. When considered holistically, the two dimensions of Bandura's social learning theory overlap with Vroom's constructs of expectancy and instrumentality, see Figure 5.

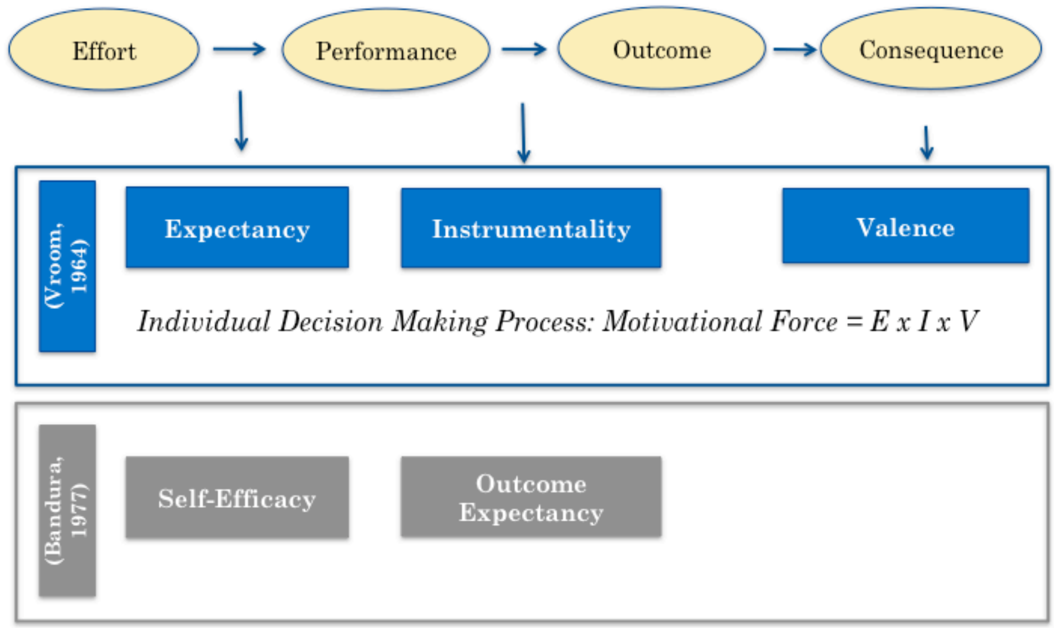

Figure 5. Comparison of terms between Vroom's (1964) Expectancy Theory Model and Bandura's (1977) Social Learning Theory Model.

Vroom's definition of expectancy is parallel to Bandura's concept of self-efficacy, linking beliefs with behaviors. Vroom's definition of instrumentality corresponds with Bandura's concept of outcome expectancy, as both relate performance/behaviors with outcomes. Instrumentality (Vroom) and outcome expectancy (Bandura) both involve an additional level of analysis by extending beyond individuals' beliefs about themselves to incorporate beliefs about others such as students or coworkers. It should be noted that the term "expectancy" is not used synonymously by both Vroom and Bandura. Since Vroom's model was used as the over-arching theoretical framework for this study, the term expectancy will refer to Vroom's definition, unless otherwise noted (i.e. the belief that effort leads to good performance).

Robust scholarly research on Bandura's (1977, 1982, 1997) work in the context of elementary science has yielded the Science Teaching Efficacy Belief Instrument (STEBI), a validated and widely-used research instrument for measuring the efficacy beliefs of elementary teachers (Riggs & Enochs, 1990). This 25-item Likert instrument measures teacher efficacy and outcome expectancy according to Bandura's conceptual framework. These validated items are used as a launching point for this study. The research question for this study is: What is the relationship between uses of the science specialists and the science-teaching motivation of classroom teachers according to Expectancy Theory?

Method

Research Design and Rationale

Qualitative research involves inductive analysis, extensive sharing of participant voices, and a call to action based on complex description (Creswell, 2007). These characteristics guide this study. The conceptual framework for this study emphasized internal constructs such as motivation, identity, confidence, self-efficacy, manifested in highly individualized ways. It hinged on teachers' perceptions of roles, rewards, and outcomes. As a result, a research method providing for in-depth self- disclosure and introspection was required. Given the richness desired, the ethnography method was chosen for its in-depth and holistic description of culture. This methodology allowed analysis of both individuals and interactions. For example, science specialists maintain individual relationships with each classroom teacher, classroom teachers work with grade-level colleagues, and all are overseen by building administrators. Ultimately, an ethnography characterizes the culture of a group (Creswell, 2007). The culture-sharing group of this study was Harlem-area teachers at neighborhood public schools as they shared similar students, instructional guidelines, science-teaching structures, and assessment and accountability systems. Further, the research site schools were members of the same University Partnership, a factor that determined their engagement with the researcher and provided access to shared resources and professional development.

My ongoing relationship with the school sites also enabled two other key dimensions of ethnography, reciprocity and critical reflexivity (Creswell, 2007). Participants in the University Partnership received ongoing science support and professional development from the researcher for three years, not predicated on participation in research. As a result of long-term immersion and relationship-building, I had to develop a practice of critical reflexivity. Rather than aiming to be objective the researcher develops and practices a discipline of reflection, self-analysis, and questioning (Anderson, 1989). This reflection was critical to ensure that the patterns that emerge from the data were those truly found therein, rather than those solely based upon the theoretical framework.

Ethnographic methods are especially appropriate when the studied group suffers from historical under-representation in the literature or has been otherwise marginalized. The literature review uncovered limited studies, qualitative or quantitative, examining the workings or effectiveness of science specialists in urban elementary schools. Thus, while the use of science specialists in urban elementary schools was common, the study of science specialists in urban schools was outside of the mainstream.

Setting and Participants

District Context

The two schools in this study are neighborhood public schools in the Harlem area of New York City. As a result of a University Partnership, the researcher visited the school sites 1-3 days per week for three years as a doctoral research fellow. The participating schools share several demographic indicators typical of traditionally defined urban schools- high poverty and high Black and Latino/Hispanic student populations.

At the studied schools, science was part of the schools' enrichment program, with instruction provided on a pull-out basis. Classroom teachers received their contractually obligated daily 45-minute "preparation period" while students were instructed by specialists in a variety of disciplines including music, art, dance, physical education, technology and science. This would be considered a "physical education teacher model" though contact time falls significantly short of the three to five sessions per week that Abell (1990) proposes. With only one or two periods per week scheduled with the science specialist, all classroom teachers should have been supplementing specialist instruction to reach the recommended instruction time for science, 135-180 minutes per week, depending on grade (New York City Department of Education, 2012b).

Participants

Science specialists, classroom teachers and building administrators of Central Harlem and Morningside Heights Elementary schools participated in this study. Science specialists were initial contacts and served as gatekeepers in the "access and rapport" (Creswell, 2007, p. 123) phase of my involvement with the school sites. The researcher provided occasional consultation to building administrators, who were also participants in this study. The researcher also worked closely with classroom teachers at each site, both those who collaborated with specialists and those who taught science primarily on their own. These teachers were the main focus of analysis in this study. All participants were assured of the confidentiality of their responses.

Data Sources

The primary sources of data for this study were researcher field notes/observations and semi-structured interviews with school personnel. A teacher questionnaire and school artifacts served a supportive role

Field Notes

During the three-year period of immersion at the school sites, I kept detailed field notes describing my observations of teaching practices and school-level factors relevant to science instruction. I observed and participated in the science-teaching preparation and practices of classroom teachers and science specialists, focusing on teacher activities, transitions and interactions as well as teacher comments about science teaching practices, challenges, and barriers. Immersion in the normal day-to-day activities of the school was necessary to observe the desired interactions.

Semi-structured Interviews

Interviews with science specialists and classroom teachers were a critical source of data in this ethnography. Science specialists, classroom teachers and administrators participated in semi-structured interviews that were audio-recorded and transcribed. Three science specialists were asked about their beliefs and attitudes about science instruction, their experiences and identity as science teachers, the role they fulfill in the school, and the role of science in the urban elementary school. Thirteen classroom teachers were asked about their beliefs and attitudes about science teaching and interactions with the science specialists. The interviewed teachers were selected to represent a range of grade levels, years of experience, and self-expressed confidence with science teaching. Interviews were conducted in the teachers' classrooms, lasting 10 to 55 minutes. Three principals and two assistant principals were also interviewed in their respective offices, lasting 15 to 45 minutes. Both teachers and administrators participated in follow-up clarification through member-checking. Ultimately, the selection was purposeful but also convenient, in drawing upon teachers with whom I have established relationships.

Classroom Teacher Questionnaire

All K-5 classroom generalist teachers at the school sites had the opportunity to complete a questionnaire during a faculty conference. 28 responses were collected from a total of 37 eligible teachers for a 76% response rate. The questionnaire elicited classroom teachers' demographic characteristics, teaching background, familiarity with the science curriculum, and self-reports of science teaching practices and science-teaching identity using forced-choice and open-response items.

The questionnaire included targeted items for each component of the theoretical framework of Expectancy Theory. Because expectancy, instrumentality, and valence were theorized to exist in a multiplicative relationship, it is possible that a teacher may be so strongly affected by one dimension that her comments on science teaching would not address each dimension. While I could have specifically probed interview responses to clarify the nuances among expectancy and instrumentality and valence, I believed such pointed questions would be counter to the naturalistic climate I wanted to establish during interview sessions. To address these dimensions, the questionnaire included Likert items modified from the Science Teaching Efficacy Beliefs Instrument (STEBI) to separately measure teachers' expectancy, instrumentality and valence. Vroom's (1964) concept of expectancy was gauged through a selection of the STEBI's self-efficacy scale items. Vroom's concept of instrumentality was gauged through a selection of the STEBI's outcome expectancy scale items. Vroom's valence dimension was gauged by new items created in the style of the STEBI. Questionnaire items, listed by STEBI source and dimension measured, are included in Appendix B. The teacher questionnaire is included in Appendix C. Science specialists completed a modified version of the classroom teacher questionnaire, as shown in Appendix D. This provided an important source of triangulation for the classroom teacher's reports of science specialist roles.

School Artifacts

School artifacts, such as school schedules, guidelines from school and district administration, administrator- and teacher-created memoranda, professional development offerings, and curriculum and assessment materials were collected to ascertain official policies and verify teacher reports. Publicly available documents included artifacts detailing school demographics, prior academic performance, and ratings.

Data Analysis

Throughout the study period, the researcher created observer comments and researcher memos (Merriam 2009), noting findings, points of interest, and tentative themes with the goal of informing ongoing data collection. Researcher field notes and observations were coded using open, emergent coding. Those codes were used to form tentative categories and themes via the constant comparison method (Creswell, 2007).

Teacher and administrator interviews were also coded according to this method using NVivo 10, yielding 676 coded segments across 47 codes. Comparison of codes across data sources resulted in consolidation and revision of codes and tentative categories. Category naming reflected an etic perspective, using Vroom's (1964) Expectancy Theory of Motivation. Teacher and administrator statements were also evaluated in light of the researcher's observations and experiences at the school site. Analytic coding (Merriam, 2009) was inductive and comparative and resulted in grouping of codes that had a related meaning. Comparison of data across several sources (separate observations and interviews) allowed the construction of categories. Representative quotations from these categories are presented in the findings.

Data from teacher questionnaires was also analyzed. Quantitative items were grouped by dimension measured (expectancy, instrumentality, or valence) and results tabulated. When compared with relevant comments from interviews, these provided a basis for triangulation of teacher reports. Teacher comments from open response items in the questionnaire were coded according to the scheme of categories that emerged from the primary data sources, with patterns in teacher responses noted. Questionnaire responses from non-interviewed teachers provide a basis for generalizing findings as characteristic of the school's culture. Statistical analysis of teacher grade-level sub-groups was not expected to yield significant results due to both the small number of teachers at each grade level and changes in teaching assignments.

Reliability, Validity, and Rigor

My prolonged engagement at the school sites provided a rich context to evaluate teachers' comments and formed the basis of validity in this study (Merriam 2009). The methodology selected also emphasized thick description of the research area, including the extensive use of teacher voices. Triangulation of data sources was possible through comparison of teacher responses on questionnaires and interviews as well as comparison of remarks by classroom teachers, the science specialist and the building principal on the same topic. Member checks were another source of validity (Guba & Lincoln, 1989). Reliability was enhanced through the inclusion of multiple school sites. A limitation of this study was the many changes that occurred within the school during the study period, including changes in building administration, teaching assignments, and science-teaching arrangements. Thus the object of the study was dynamic and inherently complex. These events added to the variation in my sample and the richness of the context and heightened the need for intimate knowledge of the research setting.

Findings

Expectancy

One component of classroom teacher motivation to teach science according to Expectancy Theory is Expectancy, the belief that one's efforts will lead to desired performances. A teacher with a high expectancy towards science believes her efforts to prepare science lessons will result in effective delivery of science instruction. High expectancy is supported by high self-efficacy, agency, and identity regarding science teaching, as well as the availability of relevant resources and the absence of constraints.

One way for teachers to manifest their agency in science-teaching was to adapt, modify, and supplement the given curriculum, thereby asserting that they knew their students best and they have the skills, capacity, and authority to make changes which benefited their students. "You know your students and you know the best approach to teach them. Kids don't all learn the same way and there's really no differentiation in the FOSS Science so you have to find those different stations where this kid could work here, you could work here, you could work here and we all come back to report your findings." (Ms. Ambrose, Grade K, CHE, Interview) Teachers who took this approach saw curriculum materials as a starting point rather than a definitive source of authority. A powerful justification for modifying the curriculum was the teachers' belief that the provided lessons were not sufficiently differentiated for their learners. In the interest of differentiation, teachers had license to express their agency. Special education teachers felt especially entitled to deviate from the scripted materials, "I'll create my own little lesson that I feel can keep them actively involved and keep their attention because sometimes with some of the topics…you could teach it but they might not get it." (Ms. Bryant, Grade 4, MHE, Interview) Ms. Bryant believed that her experience with her students supersedes the expertise of the curriculum materials.

Classroom teachers envisioned themselves as wearers of many curricular hats, embracing the role of science teacher even if only for part of their day, "I see myself honestly as an everything teacher. But yes, as a science teacher, when it's time to do reading I'm that reading specialist. When it's time to do math I have to become the specialist and the same with science. When it's time to do science I do jump right into that role and I become that science specialist." (Ms. Evans, Grade 2, CHE, Interview). Other teachers, while implementing science instruction, identified more as a generalist, "I teach science but no, in the fourth grade I'm a general ed [education] teacher. I teach science; I teach math; I teach ELA...But yeah, I teach science. I'm not a science teacher." (Mr. McKenny, Grade 4, CHE, Interview) Teaching science does not equate to being a science teacher.

For Ms. Martin, science identity is related to science-teaching expectancy. She does not believe she is effective enough as a science teacher to consider herself a science person, "I'm not a science person. That's how I view myself still...No. it's not my thing. I feel if I were I would have to stop everything else that I'm doing because I can't possibly be proficient in everything." (Ms. Martin, Grade 2, MHE, Interview). A classroom teacher's science identity may be formed when the classroom teacher evaluates their relationship to science, science-teaching and the science curriculum relative to her other teaching responsibilities.

Classroom teachers also weighed their relative science-teaching position within the faculty. The presence of a science specialist among the faculty affected the development of science-teaching identity among classroom teachers. Because the science specialist only teaches science, that person was often considered *the* science teacher, making classroom teachers reluctant to identify as science teachers themselves, “I think that would be more for someone, like Ms. Johnson would be a science teacher because that’s what she does all day long.” (Mr. McKenny, Grade 4, CHE, Interview) To Mr. McKenny being a science teacher meant having a special expertise in science instruction, not something attainable for the classroom generalist teacher. Other teachers express similar categorical exclusions from considering themselves science teachers, such as a Grade 2 CHE teacher stating on the questionnaire, “No, I do not have science certification.” The teachers believed that only such a license would endow them with the skills necessary to consider themselves a science teacher. These teachers had enough expectancy to believe they could deliver science instruction, but they believed embracing a “science teacher” identity required a higher level of skill and credential that they did not possess. Interestingly, no separate certification was necessary for an elementary teacher to occupy the role of science specialist. While she may not have considered herself qualified to be a science teacher, certification would not have impeded any Central Harlem Elementary teacher from being a science specialist.

Even among science enthusiasts, science-teaching identity was limited to the science specialist. When asked, “Do you see yourself as a science teacher?”, one teacher responded,

> Yeah I thought about it one year. Every year they ask us what grades do you want to teach and then outside of those core grades, what enrichment do we want to teach and I actually did put science one year when I was really super interested in science. I could see myself as a science teacher. I know I would be good at it because I am a hands-on person and I do like to do activities so I really wouldn’t mind. I could see myself doing that. (Ms. Evans, Grade 2, CHE, Interview)

Ms. Evans expressed a positive conception of herself as a science teacher in terms of confidence and self-efficacy, however she expressed this in the conditional future, not the present- she *would be* a good science teacher, rather than she *is* a good science teacher. To these classroom teachers, science-teacher identity is only available to the science specialist.

The existence of a science specialist also affected students' conceptions of what it means to be a science teacher and who occupies that role within their school. These student perceptions can then affect how the classroom teachers view themselves, relative to science. Ms. Martin recounted a conversation she had with students at the beginning of the school year,

> At first [the students] said 'Well Ms. Martin, Mr. Davis is the science teacher, why do you have science on the schedule?' …I said, 'I'm teaching science too' and they said, 'Oh you are?' I said, 'Yes, we're going to be doing science in the classroom' and they said, 'Oh, ok.' They got right in with it but at first they said, 'Oh we go to Mr. Davis for science. Oh you're going to be teaching science also? Yes!' (Ms. Martin, Grade 2, MHE, Interview).

If students went to a teacher specifically for science, it was logical that students would see that teacher as *the* science teacher, much like they would see other enrichment teachers as *the* art teacher or *the* music teacher. At the beginning of a science lesson by a classroom teacher, students may have exclaimed, "but you're not the science teacher!" Rather than an act of resistance, this was simply a moment of cognitive dissonance for the students. As Ms. Martin reported, students quickly assimilated the idea of having two science teachers, their classroom teacher as well as the science specialist. However, the idea that your students do not see you as a science teacher and instead defer to the science specialist as the science teacher may have served to deflate the science-teaching expectancy of the classroom teacher, especially if it was fledgling.

At Morningside Heights Elementary, not all classes visited the science specialist. Some classroom teachers were the only science teachers for their students. In the absence of competition from the science specialist, the students viewed the classroom teacher as their science teacher, as perceived by the teachers' responses to the question, do you think your students see you as a science teacher? "Yes, I teach them science - no one else does" (Grade 1, MHE, Questionnaire). In the absence of a science specialist, students' perceptions of what it means to be a science teacher were informed by what they saw—their classroom teacher delivering science instruction.

Instrumentality

The influence of the science specialist on classroom teacher science-teaching instrumentality depended on how the science specialist was used and if a shared teaching arrangement was expected. In Expectancy Theory, instrumentality is the belief that enacted performances will lead to desired results. In the context of science teaching, it is the extent to which a teacher believes that their personal science instruction is instrumental to the students' science learning.

Even when the science specialist's schedule followed the same pull-out enrichment schedule, there were many interpretations of the science specialist/classroom teacher relationship. The science specialist could deliver a separate but related curriculum supplemental to what the classroom teachers would teach. The science specialist could be providing nearly all of the science instruction with the classroom teacher providing curriculum integration and support. The science specialist may be driving instruction and making requests of the classroom teachers or vice versa. Each of these impacted the science-teaching instrumentality of classroom teachers. In addition to being highly variable, overall classroom teacher instrumentality was low relative to expectancy, as measured on the classroom teacher questionnaire (N = 28) and summarized in Table 8 below. The mean and standard deviation for each questionnaire item are listed in Table 10 in Appendix E.

Table 8
Summary data from classroom teacher questionnaire- expectancy and instrumentality

Dimension Measured	Mean	Standard Deviation
Expectancy	3.83	0.97
Instrumentality	2.71	1.27

When a science specialist delivers some science instruction, the classroom teacher's sense of instrumentality was reduced. This is frequently the case at Morningside Heights Elementary, "I know they're going [to science] twice a week [so] I kind of fall back a little bit with doing it. You know last year they only went once [per week] and I was teaching it more, and that's not a good thing. I mean it's a good thing that they go to [science] but they still need the teaching from the classroom teacher. With all this other stuff…I taught it more last year but this year, honestly, I haven't taught it like I did last year." (Ms. Bryant, Grade 4, MHE, Interview) The more instruction the students received from the science specialist, the less ownership the classroom teacher felt. Instrumentality was not an all-or-nothing proposition; rather, it appeared to be incremental. When the second grade team went from having zero periods with the science specialist each week to one period each week the following year, there was a concurrent decrease in classroom teacher engagement with science instruction,

Ms. Martin: Do you want the truth? Last year when I was in 2nd grade everybody was doing science because we were talking about it after school in meetings we were organizing, getting the materials because last year was the first year that I used it [FOSS kits] and some of the other people used it so the kit wasn't set up…This year when I mentioned it no one was doing it in second grade…

Interviewer: *That grade level conversation didn't happen this year among you as second grade teachers?*

Ms. Martin: No. I just basically said what I was doing. Other people

> said ‘I’m overwhelmed. I can’t do this. I’m back in the classroom. I’m learning the curriculum.’…The people that were on 2nd grade half of them moved [to other grades]…I guess they decided not to do [science]. I don’t know but they told me they weren’t doing it. (Ms. Martin, Grade 2, MHE, Interview)

One reason for change in classroom teacher science practice, as cited by Ms. Martin was the turnover within the teacher team, resulting in a new team relatively inexperienced with the second grade science curriculum. Ms. Martin’s recollections of their concerns suggested low expectancies- low self-efficacy for science-teaching and the presence of constraints imposed by other instructional demands. Another variable was the introduction of one science enrichment period each week to the second grade schedule. The shift of instructional time to the science specialist was associated with a drop in instrumentality of the classroom teachers.

Whether or not it was the principal’s intention, teachers viewed any instructional time with the science specialist to mean less science responsibility for them. Some classroom teachers viewed this as a guarantee in instructional time with the specialist and thereby a justification to lower the rank of science within their instructional priorities. They came to rely on the science specialist not only direct the science program but to fully implement it. Amidst other pressing priorities, some completely disengaged from the science program. Thus, having a science specialist did not add or enrich science instructional time. It simply shifted it to the specialist. In fact, in some cases it resulted in *less* time for science, as the introduction of just one period each week from the specialist could result in classroom teacher disengagement from science.

On the other hand, if a science specialist’s program was structured as supplemental or “enrichment” then the classroom teacher retained instrumentality and ownership of the science program. This was frequently the case at Central Harlem Elementary, “Even though they see Ms. Johnson I still feel responsible for the material that they’re learning. So pretty much how it’s worked is I've worked with the other grade teachers and we still cover what we need, you know, the things that we need to cover, the most important ideas, sometimes if we don't have time for everything else." (Ms. Colon, Grade 1, CHE, Interview)

The relationship of instrumentality and curricular roles was self-perpetuating. The conception of the science specialist's program as "enrichment" drove the development of classroom teacher instrumentality. Meanwhile, high levels of classroom teacher instrumentality relegated the specialist's program to "enrichment" status. When classroom teachers maintained a high level of instrumentality, the science was in a more supportive and less directive role, Ms. Johnson, the science specialist at CHE explained, "Basically classroom teachers they tell me where they are and then I compliment what they do." (Ms. Johnston, Science Specialist, CHE, Interview)

At Central Harlem Elementary, classroom teachers relied less on the science specialist to be the primary science teacher. Specifically, teachers of the early childhood grades, K-3 maintained a high level of instrumentality towards science-teaching. These teachers share an assistant principal who maintains oversight of science along with other subjects, "Not in science, in *everything*. She's making sure we are following the curriculum, where are you in this unit. Month by month, she comes she asks, 'Where are you in science? Where are you in social studies? Where are you in math? Where are you in literacy?' That's the only person." (Ms. Ambrose, Grade K, CHE, Interview) This level of administrative oversight was not found in the upper grades at Central Harlem Elementary or at Morningside Heights Elementary. Thus, expectations of leadership were also an important contributor to classroom teacher instrumentality.

Instrumentality is not necessarily a zero-sum game. It is possible for both classroom teachers and science specialists to have high instrumentality, for example, if each party is clear about their respective responsibilities and role there can be a shared sense of ownership for science instruction. At Morningside Heights, there was a sliding scale of responsibilities between the classroom teacher and science specialist that roughly coincided with grade level. The youngest students, grades K and 1, did not receive science instruction directly from the science specialist. These teachers implemented the science curriculum themselves and Mr. Davis provided support and consultation as requested. Students in grades 2 - 5 generally received one to two periods each week with Mr. Davis, with some expectation of additional instruction by the classroom teacher. There was some alignment of expectations among the principal, science specialist and classroom teachers:

> Then whatever research and activities that Mr. Davis is doing in science is extended in the classroom…So far the schools I've worked at we've had science as enrichment or as part of the content area but I also always emphasize that the teachers continue it so the children are not just getting science when they go to Mr. Davis, it is collaboration between both teachers because it is one of the major content areas. (Ms. Ducasse, Principal, MHE, Interview)

> I only see them once a week, which means that the 3rd grade teachers are supposed to do follow-up lessons or precursory lessons that go along with what I do. (Mr. Davis, Science Specialist, MHE, Interview)

> I do read-aloud to kind of supplement the FOSS kits...Usually I just do read-alouds usually our new stuff-- introducing new concepts like a food chain ecosystem. (Ms. Chang, Grade 4, MHE, Interview)

Owing to their position as classroom generalists, classroom teachers considered themselves as was well positioned to provide content literacy support and interdisciplinary curriculum integration.

Principal Coleman explained how he envisions the distribution of responsibility at Central Harlem Elementary,

> There are certain lessons within the scope of the curriculum that are being taught by the classroom and planning should allow for some of those hands-on lessons to also be delivered by the science enrichment teacher …If I'm doing a unit that requires that I fill some containers up and you know I have some papers out and water splashing, the science lab and the tables they are using are set-up to handle that type of experiment in a much better way. (Mr. Coleman, Principal, CHE, Interview)

According to Principal Coleman, the science specialist's program should include the more hands-on portions of each unit. In this model the classroom teacher would serve a supportive role- laying the groundwork for an investigation by teaching content and then, after the investigation, providing an opportunity to share, discuss and perhaps write about their results. The science specialist's room becomes the "lab" where key investigations happen. In this model, deliberate planning and close communication between the specialist and classroom teachers would be essential for a well-integrated experience. Principal Coleman showed an awareness of the level of collaboration required by this model and suggested a process for determining who should teach what,

> I think it's a joint decision once the teachers have an understanding of the entire spectrum of what they're trying to teach over the course of the year, which of them are going to be a little messier and could probably be handled better in the science lab…It should work in that whenever the teachers sit down to do their planning, their curriculum maps, the science enrichment teacher should be involved. (Mr. Coleman, Principal, CHE, Interview)

The existence of shared responsibility for the same curricular goals necessitated some level of collaboration and coordination between the specialist and classroom teachers. Principal Coleman spoke of thoughtful planning and curriculum mapping in which the science specialist played in integral role and all parties were accountable to the agreed distribution. How and how well do the schools implement this vision?

Collaboration and coordination were important contributors to implementing the designed distribution of responsibilities,

> We're working on being on the same curriculum. Because we do the same things like plants, we all do plants, but we're not doing the exact same things. We're not teaching the same concepts within the plant unit so a lot of the times when she [the science specialist] grades them it's based on things that they're doing with her and it does align with what I'm doing but it may not be the exact same thing so I have to give them a grade based on what I'm doing. (Ms. Evans, Grade 2, CHE, Interview)

The fact that the schools adopted a scripted kit-based curriculum provided an interesting context for collaboration. If both the classroom teacher and the science specialist adhered, more or less, to the scripted curriculum it could be relatively easy to coordinate who is delivering which lessons while maintaining a coherent unit. At the same time, without a coordinated approach, the potential to repeat lessons is high. The consensus among lower-grades classroom teachers at Central Harlem Elementary was that they would proceed with the lessons of the scripted curriculum program. They assumed that none of these lessons was being taught by Ms. Johnson and they found this assumption was validated by the students' lack of specific experience with the scripted curriculum. In the absence of coordination, the science specialist deferred to the classroom teachers to deliver the scripted curriculum and she provided related lessons of her own design. High classroom teacher instrumentality may not delivery any value-add to students without coordination.

At Morningside Heights Elementary, low classroom teacher instrumentality, ironically, provided some protection against the challenges of coordination. Mr. Davis proceeded with the scripted curriculum with minimal concern of lesson overlap because he knew most teachers were not implementing the lessons of the scripted curriculum. Those teachers who did deliver science lessons outside of his program communicated with Mr. Davis about their progress:

> Like I would let him know beforehand what lessons I had done, like say Pebbles Sand and Silt I would do lessons 1, 2, 3 [and] he would do an extension from that unit so he wasn't repeating the same thing I was doing...I would call him on the phone and let him know or I would put a note in his mailbox this is a lesson I just did. This is the unit I'm in and these are the lessons I'm doing so I try not to have an overlap because that seemed to

> be counterproductive. If they already put rocks in water in my room for 45 minutes why would they want to go in there and do it again? I mean they would do it but it seems he would be able to do something else. (Ms. Martin, Grade 2, MHE, Interview)

Mr. Davis and Ms. Martin had a well-functioning collaborative relationship, resulting in a shared science-teaching responsibility between them. Unfortunately, the same cannot be said of Ms. Martin's grade-level colleagues. Because only Ms. Martin delivered science lessons her class ended up ahead of other classes in the curriculum. Already preparing curriculum for four different grade levels, Mr. Davis had an interest in limiting the number of different lessons he delivers each day. As a result, Mr. Davis generally stalled Ms. Martin's class with provided enrichment and integration worksheets when they got ahead of other classes. Thus, Ms. Martin's efforts in science had limited value-added for her students, despite her high instrumentality, because of her colleagues.

Ms. Wilson was in a similar position and shared her feelings when asked about being discouraged in coordinating and collaborating science teaching. She responded,

> Not at all. I'll keep going. I'll stay where my kids are. I'll do what I need to do for my students. I understand where he's going to have to back track because certain classes may not be using science or have very specific science instruction. I don't let that slow me down. I'm going to keep going. Even if he has to slow his pace because he's trying to keep all together, that's still not going to slow me down. I'm going to keep going. (Ms. Wilson, Grade 3, MHE, Interview)

Structural barriers also inhibited effective collaboration and negatively affected shared responsibility. First, because of the drop-off model, classroom teachers had minimal knowledge of what the science specialist did during her/his instructional periods. Mr. McKenny shared, "Sometimes you know with her [the science specialist] setting and the lab, I don't really know what they do in there because I'm not there. (Grade 4, CHE, Interview). Unlike a co-teaching model, in a pull-out enrichment model the classroom teacher, by definition was not involved in the science specialist's instruction. The pull-out model might not have been an impediment to coordinated instruction if teachers collaborated in the development of their curriculum; however, the science specialists did not meet with the grade-level team at any regular interval. The science specialists' schedules did not include designated time to meet with each grade-level team.

The classroom teachers did meet regularly with their grade-level colleagues but science was only one of the many matters for them to discuss. In the lower grades at both Central Harlem Elementary and Morningside Heights Elementary, classroom teachers delivered science instruction themselves and they planned collaboratively together without the building specialist. They discussed science along with other subjects at their meetings, "We say, 'Where are you in science? What are you doing this week in science?' We all have the same lesson plan so science comes up on our lesson plan." (Ms. Ambrose, Grade K, CHE, Interview) Low teacher instrumentality, in contrast, was evidenced by a lack of conversation about science within the grade level team, "Science is most definitely not one of the topics of discussion. It's usually centered around literacy and then math is like, 'ok let's get some math discussion in', but mostly it's literacy." (Ms. Wilson, Grade 3, MHE, Interview)

While they expressed expectations upon interview, principals did not seem to be aware of the enacted practices of collaboration pertaining to science, including some of its structural challenges. "There are meetings that are held between Mr. Davis and the classroom teachers. He reviews with them, you know, the different topics that he's teaching." (Ms. Carter, Principal, MHE, Interview) For a common planning time to occur, each class at that grade level had a preparation period simultaneously, courtesy of the enrichment teachers. Depending on the number of classes per grade and the number of enrichment teachers, the science specialist may be categorically unavailable during common preparation periods.

Principals accurately reported that classroom teachers and science specialists often conversed as the teacher drops her class off to the science specialist. The brief nature of these interactions limited their depth. Ms. Wilson, a classroom teacher with high science-teaching instrumentality describes how she and Mr. Davis coordinated their efforts,

> Well, we kind of work in tandem. This year we were less in sync than we have been, than we were last year. It's not always possible for us to have that dialog and it's usually a drive by- ok what lesson are you on? Ok this is what I'm doing. So that we don't overlap but this year we kind of overlapped more lessons. So he and I are kind of working the same side of the street but we may not be exactly in sync though, sometimes yes and sometimes no… So we're talking as I'm picking the kids up or giving them to him, it's like a 1 or 2 minute conversation. (Ms. Wilson, Grade 3, MHE, Interview)

In addition to chatting when the class is being dropped off, classroom teachers also caught up with the science specialist during other spontaneous moments throughout the day. The science specialists used other methods of communication that did not require in-person interaction such as notices and student work:

> Some of the classroom teachers take the booklets. They keep the booklets in their room so they are kept abreast of what's going on. I always let them know, if you want to, you can do a follow-up. I try to encourage the teachers to do a follow-up lesson on the one that I've done and try to do it in tandem. Some of them do it and some of them don't. I can tell when the booklets come back to me who's doing. (Mr. Davis, Science Specialist, MHE, Interview)

In theory, the unit booklet provided teachers and administration with information, reducing the need for communication at the time of drop-off. Students are also relied upon as a means of sharing information and coordinating lessons, "When they return after science I usually ask them questions, what they've done and how they've done it...That's when they'll say, 'no it's this way. This is what we did' and I'll see that they're able to explain it and give me feedback." (Ms. Bryant, Grade 4, MHE, Interview) What follows is a lesson planning exchange that occurred as a third grade classroom teacher dropped off her class to the science specialist:

> After reading what was written on the chalkboard, one student tells Mr. Davis that the classroom teacher was planning to do the activity Mr. Davis had planned the next day. Mr. Davis asks the classroom teacher (still in the hallway outside the classroom) to verify. They confer and plan out who will do what which day. Mr. Davis offers to do a different lesson than the one he had planned.

This exchange resulted in the successful avoidance of a lesson duplication. If the exchange had not occurred, the classroom teacher would have likely prepared and launched a hands-on science investigation the students had already completed. While this exchange was successful in that end, it was particularly haphazard, as it relied upon a number of coincidental factors. These factors include that the classroom teacher happened to describe her science plans to her students in advance, that the student happened to remember and decide to report those plans, that the classroom teacher was still in the hallway as class began, and that Mr. Davis was willing and able to shift his plans at the last minute. The haphazard communication patterns between the science specialist and classroom teachers made genuine collaboration difficult. When the curriculum is not well-coordinated between the science specialist and classroom teacher it is difficult to promote a sense of shared responsibility and science-teaching instrumentality.

Valence

The final component of science-teaching motivation according to Expectancy Theory is valence, the extent to which an individual values the rewards and consequences that stem from various outcomes. How do teachers value students' science learning in a complex landscape of incentives and accountability metrics? Do teachers view their students' science learning as inherently important? Science learning may be part of a test-based evaluation system that provides external motivation for classroom teachers to be engaged in science instruction. Other subjects like literacy and mathematics may also be part of that evaluation system and may effectively crowd out concern for science in the classroom teachers' mind.

In accordance with No Child Left Behind (2003) New York, students took yearly tests in literacy and mathematics starting in third grade. These tests were high-stakes for students in terms of their promotion and for the school in terms of its rating and standing. Standardized tests also existed for science K-8, but these were only implemented at the 4^{th} and 8^{th} grade levels. The official relative value of the science test compared to the literacy and mathematics tests was a complex matter. Principal Ducasse shared how she viewed the tests, "Even though they are doing the 4th grade test, but everything, their scores are based on those ELA and math scores." (Ms. Ducasse, Principal, MHE, Interview) The potential impact on literacy and mathematics scores was a justification for science instruction, more so than the results of the fourth grade science test itself.

Classroom teachers had their own sense of their priorities and obligations regarding test preparation, "Classroom teacher always worry about state test reading and math first that's why we have Mr. Davis to deal with science. If they did well [on the science test] it's Mr. Davis. He did a great job because he had them twice a week. If they did bad I would blame myself, I should have done more." (Ms. Chang, Grade 4, MHE, Interview) To Ms. Chang, tests were an important motivator and driver of instructional priorities. She viewed preparation for reading and mathematics tests as her foremost job priority. Even though she was a fourth grade teacher, meaning her students would also be tested in science, she did not view science as a high priority. Not all classroom teachers felt very driven by standardized testing. However, those that did feel the pressure to perform on the literacy and mathematics tests more than science. As such, the testing structure provided a strong valence to engage in literacy and mathematics instruction. The valence for science was less and, in fact, the testing structure could serve as a disincentive to engage in science instruction.

Another potential source of valence is the teachers' own job performance evaluation system. To what extent was classroom teachers' science-teaching performance valued by building administrators and, more broadly, the teacher evaluation system? Principal Coleman explained the new teacher evaluation system which included student test scores,

> They look at the growth of children in ELA and math and that is how they determine how you did as a teacher. They are not looking at how you did in social studies or science. Those are the only 2 content and subject areas that they're weighing…I think it's just going to be one of the consequences of trying to measure teachers' growth and value by student test scores in ELA and math. They're not using science test scores at all to determine the teachers' value. (Mr. Coleman, Principal, CHE, Interview)

There were rewards and consequences, however indirect, for performance in literacy and mathematics at the student, teacher, and school levels. Science did not figure prominently in this accountability structure. In a world of competing demands, it is logical to commit ones efforts more so to an area with greater anticipated rewards, or fewer negative consequences. The classroom teachers' ratings of various contributors to valence for science-teaching are summarized in Table 9 below. In fact, teachers perceive greater valence associated with the ELA exam, versus the science exam.

Table 9
Summary data from classroom teacher questionnaire- valence

Dimension Measured	Mean	Standard Deviation
Valence- intrinsic for science teaching	4.48	0.51
Valence- English/Language Arts state exam	3.32	1.42
Valence- science state exam	2.79	1.42
Valence- teacher rating by principal based on science	2.29	1.15
Valence- teacher compensation based on test performance	3.11	1.31

Fortunately, formal accountability systems are only one source of potential reward or consequence. Intrinsic motivation and students' enjoyment of science also contributed to the teachers' valence for science teaching. "I like teaching science… once we had a snow storm, lots of snow outside, took the kids outside; let's predict how much snow you think fell, in terms of inches... I would go out, say put your coat on let's go out and play in the snow. I just love for the kids to experience the weather, understand it." (Ms. Ambrose, Grade K, CHE, Interview) For teachers who engage in science, seeing the students' enjoyment was a reward that made the teachers' efforts to prepare worthwhile. This was the highest rated source of valence identified in the teacher questionnaire. The sense of meeting students' needs and assisting in their scientific development was a reward that may not be a part of the accountability system but was still of value to the teachers.

Discussion & Implications

Classroom teachers vary in each of the three components of Expectancy Theory (Vroom, 1964) and therefore exhibit a wide range of science-teaching motivations. A classroom teacher's science-teaching motivation influences and was influenced by her interactions with the science specialist. Science specialists influence classroom teacher science-teaching expectancies. Science specialists can support classroom teacher science-teaching expectancies by acting as a resource or coach to classroom teachers and by ensuring access to curriculum materials. In the current model, these functions of the science specialist are limited by the science specialists' full teaching schedule, as supporting classroom teacher science-teaching expectancy is not a focus of the role. Meanwhile, the existence of a science specialist served as a barrier to classroom teacher science-teaching identity because only the science specialist possesses the institutionally-sanctioned role of science teacher. Some teachers may associate science-teaching identity only with the science specialist role. Expectancy of success in science teaching also influences how classroom teachers utilize the science specialist. Teachers with low science-teaching self-confidence and self-efficacy use the science specialist as a resource to support their instruction.

The presence of a science specialist strongly influences classroom teacher instrumentality for science-teaching. Specifically, the use of the science specialist in a pull-out model to teach science lessons to students blurs the sense of instrumentality of the classroom teacher. This was especially evident at Morningside Heights Elementary in the upper grades. Just one scheduled lesson with Mr. Davis each week was enough to trigger a release of science-teaching instrumentality and bring classroom teacher science-teaching motivation and practice to nearly zero. Under this arrangement, the presence of science specialists may accelerate the narrowing of the curriculum with regards to science (Crocco & Castigan, 2007). Central Harlem Elementary managed to somewhat insulate against the drop in instrumentality associated with a pull-out specialist model, as a result of strong administrator oversight in science.

Instrumentality also affects how classroom teachers collaborate with the science specialist. Teachers with almost no instrumentality for science are not engaged in science instruction and do not have much about which to communicate or collaborate with the science specialist. Teachers with some instrumentality engage in a discourse with the science specialist about their progress within each curriculum unit and may follow the science specialists' suggestions about follow-up activities. Teachers with high instrumentality, in contrast, consider themselves the primary science teacher, responsible for addressing the entire science curriculum. In this case, the science specialists' instruction may become supplemental, enrichment, or even irrelevant to the goals of the curriculum unit. Teachers with high instrumentality engage in science instruction, built self-efficacy and expectancy and are therefore less likely to defer to the science specialist as expert or seek counsel. Cultivating greater classroom teacher instrumentality is one path towards a sense of shared responsibility for teaching science. However, in the absence of a detailed pacing guide, clear expectations about the desired distribution of duties, or any mechanism for regular collaboration, the ability of a classroom teacher and science specialist to execute shared responsibility for science is severely compromised.

There are both intrinsic and extrinsic components of valence that affect science teaching in urban elementary schools. Intrinsic benefits of teaching science generally center on student enjoyment of reform-oriented science curricula and are shared by all teachers. Teachers correctly perceive greater extrinsic rewards and consequences for student performance in other areas, namely literacy and mathematics. This is a consequence of the local interpretation of national reforms like No Child Left Behind (2003) and, more recently, the Common Core. The existence of a science specialist enables classroom generalists to minimize their sense of responsibility for science exam outcomes.

As theorized, the components of Expectancy Theory (Vroom, 1964) contribute to an overall sense of science-teaching motivation. Low expectancy can negate the intrinsic valence associated with science teaching. If the classroom teacher believes such benefits of science instruction exist but does not believe she can deliver reform-oriented science instruction effectively, she is less motivated to teach science. High instrumentality supports the development of expectancy and valence, as a teacher engages in reform-oriented curricula she can gain a sense of self-efficacy for science and observe and feel responsible for student enjoyment of science. In contrast, low instrumentality reduces the initiative and incentive to engage in science instruction, affecting those with all levels of expectancy but especially detrimental to those with already low self-efficacy and science-teaching identity for whom the task of teaching science seems nearly insurmountable.

In the context of urban elementary schools implementing a science specialist model there are conditions that are associated with relatively high science-teaching motivation. These include teaching a non-testing grade, strong administrative expectations and oversight in the area of science, view of curriculum materials as a starting point, self-efficacy in science, delivery of all science lessons by the classroom teacher, or view of science specialist's instruction as supplemental. Conversely, there are conditions associated with relatively low science-teaching motivation of classroom teachers such as teaching a testing grade, view of curriculum materials as overwhelming, low self-efficacy, delivery of one or more lessons each week by the science specialist, and the view that the science specialist's instruction is primary.

However desirable, science-teaching motivation of classroom teachers is necessary but not sufficient for students to have a well-coordinated science experience in a science specialist model. To effectively leverage the shared teaching arrangement inherent in the pull-out science specialist model, there must be a shared sense of science-teaching responsibility. Each party must have instrumentality, must acknowledge the other party's instrumentality, and must display some initiative to communicate and coordinate even when no formal mechanisms for collaboration exist. It is rare indeed for science-teaching responsibility to be truly shared and for an effectively collaborative relationship to exist. There were several common factors associated with these successful instances.

First, these teachers adhere to the scope and organization of the scripted curriculum. They do not rely on the scripted lessons themselves, but for matters of coordination, the structured lessons provide shorthand for lesson-related communication. Next, the classroom teachers have moderate expectancy and self-efficacy regarding science such that they plan and execute science lessons while still valuing the science expertise of the science specialist. Similarly, these teachers have a moderate sense of instrumentality. They have enough to be involved but not so much that the specialist is relegated to a support role. Finally, these classroom teachers were not overwhelmed by testing in other subjects by reasons of their grade assignment, personal philosophy about standardized tests, or their confidence in student performance levels.

Conclusion

Classroom teacher science-teaching motivation affects and is affected by uses of science specialist in an urban elementary school, as dictated by organizational factors like instructional time arrangements. The use of science specialists to provide pull-out instruction results in a decreased sense of instrumentality that can undercut other science-teaching motivation components like expectancy and valence. Science specialist instruction in a pull-out model can result in teacher dis-engagement from science instruction, even with just one period per week provided by the specialist. This arrangement concentrates science-teaching responsibility, and capacity, in one teacher within the school, leaving science particularly susceptible to changes in personnel.

On the other hand, strong leadership can create a valence for science-teaching at the building level, even when the state accountability system does not prioritize science learning. In the absence of a clear distribution of responsibilities, a classroom teacher may take ownership of the science curriculum, relegating the science specialist's instruction to a supplementary role. This arrangement supports diffuse science-teaching responsibility and capacity, while limiting the value added by employing a science specialist. While it may be possible to create clear expectations, cultivate shared responsibility, and arrange for seamless integration of classroom teacher and science specialist science instruction, this was not the case at the studied elementary schools. The science education community should be aware of the unintended consequences associated with implementing a pull-out science specialist model.

CHAPTER VI

FINDINGS

MEDIATING HIERARCHIES IN A SCIENCE SPECIALIST MODEL: THE CONTRIBUTION OF SCHOOL AND DISTRICT-LEVEL FACTORS TO THE SCIENCE CULTURE OF URBAN ELEMENTARY SCHOOLS

Abstract

The purpose of this study is to shed light on a widely and variably used but rarely studied instructional model by describing and analyzing its implementation, specifically in urban elementary schools in a high-stakes testing climate. School and district factors that affect the enacted science specialist model are identified and critically analyzed. School and district factors establish, perpetuate and/or work against the unquestioned institutional hierarchies of core over enrichment, tested over untested, and literacy and mathematics over science. District level inputs analyzed include teacher contracts, student enrollments and budgets, instructional time requirements, curriculum materials, standardized tests, teacher accountability systems, and school accountability metrics. School-level factors analyzed include the faculty, school organizational structure, University Partnerships, school culture, and building leadership. While science specialists may be intended to promote science and guarantee exposure to high-quality science instruction, they may effectively marginalize science.

Introduction

The purpose of this study is to shed light on a widely and variably used but rarely studied instructional model—the science specialist—by describing and analyzing its implementation in urban elementary schools in a high-stakes testing climate. This study specifically investigates school and district-level factors that influence the culture of science instruction in urban elementary schools implementing a science-specialist model. While there is theoretical support for science specialists in the literature (e.g. Abell, 1990; Hounshell, 1987; Miller, 1992; Williams, 1990), their implementation in urban contexts has not been examined. Like any intervention, this model may have intended and unintended consequences for teachers and students. Intended to promote the role of science from its historically marginalized position in the elementary school, the real-world enactment of various science specialist models may reveal different truths and meanings of science at the elementary school. This study will focus on how the science specialist role and culture of specialist-led schools mediates school and district level factors like contracts, schedules, curriculum materials, state testing, and leadership.

Literature Review

A number of school-level factors have been described in the literature as limiters of elementary science. These include a lack of instructional time allotted for science, insufficient materials, equipment, funds, space, and facilities (Berg, 2012; Jacobson, 2004; Marx & Harris, 2006; Tilgner, 1990). Teachers in urban schools additionally cite lack of sufficient adult supervision and presence of behavioral problems (King, Shumow, & Lietz, 2001). Researchers identify elementary teachers as lacking in various domains of science-teaching knowledge, including science content and pedagogical knowledge, knowledge about instructional practices, and knowledge about the nature and practices of science (Greenwood, Scribner-MacLean, 1997;

Howes, 2002; King et al., 2001; Nelson & Landel, 2006; Tilgner, 1990). Professional development of classroom generalists must be distributed among several content areas (Hounshell, 1987), and priority is often given to literacy and mathematics, (Crocco & Costigan, 2007; Greenwood & Scribner-MacLean, 1997; Jacobson, 2004; Levy et al., 2008). Science curricular leadership at the building level is also a challenge, with many principals ill-equipped to provide instructional leadership and supervision in the area of science, owing to their own background as generalists (Barish, 2008; Finnigan, 2010; Lanier, 2009). Though this challenge is not unique to the urban setting, principals of low-performing and/or high-poverty schools face additional challenges related to student needs, test scores, and funding that may further distance them from real leadership in science.

These barriers have been consistently reported for two decades and speak to the very nature of inquiry-oriented science instruction as messy, and materials-intensive. These issues also reflect the perennial struggle to advance the position of science within the elementary school, made even more challenging in the era of accountability ushered in by the No Child Left Behind Act (NCLB) of 2001 (2003). In elementary schools, emphasis on the tested subjects of literacy and mathematics has adversely affected instructional time in science, with 28% of U.S. districts in a representative sample reporting decreasing instructional time in science as a result of NCLB, from an average of 226 scheduled minutes per week to 152 scheduled minutes per week (Center on Educational Policy [CEP], 2008). This "narrowing of the curriculum" is particularly acute in urban and low-performing schools as a result of intense pressure to boost test scores (Crocco & Castigan, 2007; Spillane & Callahan, 2000; Upadhyay, 2009). Positioning science within the tested realm bears positive and negative repercussions. The presence of high-stakes assessments has been positively correlated with instruction time allotments (Marx &

Harris, 2006) suggesting a rebound in devotion to science. Still, science test scores are not required to count towards Adequate Yearly Progress (NCLB, 2003) meaning that science scores may not carry the same weight as literacy and mathematics scores. On the other hand, there may also be benefits in retaining a low-profile status for science at the elementary school, namely curricular freedom (Carlone et al., 2010).

Science specialists may be seen as a remedy to some of the barriers and challenges of elementary science (Abell, 1990; Gerretson et al., 2008; Hounshell, 1987; Jacobson, 2004; Mangiante, 2006; Miller, 1992; Williams, 1990). While the precise job descriptions and functions of the science specialist vary greatly across contexts, science specialists are conceptualized as relative experts who provide instruction and/or support in this challenging curricular area. In one of the only studies of science specialist effectiveness, Schwartz, Adb-El-Khalick and Lederman (2000) compared two suburban school districts, one specialist-led district and other with traditional classroom generalists. In this model, science specialists developed lesson plans and co-taught science with classroom teachers. Classroom teachers were expected to meet with the specialist, conduct follow-up activities and review homework assignments. Comparing the districts, the specialists' lesson plans exhibited greater alignment with national standards than those of classroom generalists in either district. Based on standardized exam scores and student work, the science specialist model was deemed effective. This study, however did not attempt to characterize the systemic effects of the specialist model on the school science culture or investigate mediating factors.

Conceptual Framework

A critical lens guides both the conceptual framework and design of this study (e.g. Calabrese Barton, 2001; Carlone et al., 2010). I rely on critical theory to "critique and challenge, to transform and empower" (Merriam, 2009, p. 34) unquestioned assumptions and current practices. Specifically, two notions from critical studies within elementary science education frame this research—hierarchy and i-meanings. Hierarchies involve assumed and unquestioned power relationships whereas i-meanings describe the institutional meanings of key terms that govern allowable practices.

Carlone and Webb (2006) examine hierarchy as an unspoken and rarely challenged dimension of University-School partnerships. They examine the ways they replicated or combated this hierarchy as the facilitators of a curriculum development collaboration for in-service elementary school teachers. They identify historical meanings that affect current practices and apply critical analysis to their observations. In doing so they challenge normative, institutional and cultural meanings of professional development, collaboration, facilitation, and leadership and examine how identity is established and mediated by the hierarchy. They examine discourses at the linguistic level to address questions about who is privileged and whose needs are being served.

In a related study, Carlone et al. (2010) employ a critical ethnography method to examine the experiences of teachers implementing standards-based science in a variety of elementary school settings. In doing so, they question and problematize notions of the "traditional schooling discourse" (p. 943) such as curriculum, instructional time, resources, and assessment. The authors acknowledge the powerful role that the status-quo can have in a school setting and that its assumptions can proceed with little questioning, even from teachers who recognize that their practices go "against the grain" (p. 946). From interviews they identify a number of institutional-level factors that affect teachers and shape their identities and conviction to teach science, naming these as i-meanings. They find these i-meanings "so powerful because they authorize or sanction allowable practices and meanings" (p. 944).

Building from these two studies on hierarchy and i-meanings, this current study uses a critical stance to reveal new meanings with regards to the dilemmas of elementary science instruction in a high-stakes accountability culture. Furthermore, I challenge the literature's prevailing notion that a teacher-centered deficit is an impasse for reform-oriented science instruction. In this study, I address the following research question, How do school-level structures and district-level factors establish, reinforce, or work against hierarchies and thereby impact science-teaching culture in urban elementary schools with science specialists?

Method

Study Design & Rationale

An ethnography aims "to generate insights, to explain events, and to seek understanding" (Anderson, 1989, p. 253). Power and the status quo are typically questioned in critical ethnography. Merriam's questions for critical research in education provided guidance, "Questions are asked regarding whose interests are being served by the way the educational system is organized, who really has access to particular programs, who has the power to make changes, and what are the outcomes of the way in which education is structured." (2009, p. 35) These questions were at the core of the science specialist issue as it played out in urban elementary schools: Who had access to high quality science instruction? Whose interests did the science specialist serve? What were the intended and unintended consequences of the school and district structures and priorities? What unquestioned hierarchies were at play? While these questions did not supplant the research question, they percolated throughout the research process.

A critical ethnography methodology was both appropriate and possible given my prolonged immersion at two urban elementary school sites. I was able to provide context for teacher comments and use their language (Merriam, 2009) which was critical for the validity of this research methodology. I also enjoyed "insider-outsider" status at the school- having formed relationships, meanwhile retaining an outside perspective on school policies and politics. "Thick description" (p. 28) is a hallmark of validity in this area of research and my research methods were oriented towards this goal. My experiences enabled me to create a product matching Merriam's standard, "It is…a description of the sort that can emerge only from a lengthy period of intimate study and residence in a given social setting. It calls for the language spoken in that setting, first-hand participation in some of the activities that take place there, and, most critically, a deep reliance on intensive work with a few informants drawn from the setting." (p. 28) My ongoing relationship with the school sites also enabled two other key dimensions of critical ethnography, critical reflexivity and reciprocity.

As is the case broadly in qualitative approach, terms oriented towards quantitative methodologies were redefined. In this ethnography the notion of "objectivity" was replaced by "critical subjectivity" (Creswell, 2007, p. 212) whereby I constantly evaluated my own biases. As is typical with a critical orientation, I openly embraced that I brought my own ideology to observations and analysis (Anderson, 1989). My ideological perspective affected what I thought about what I saw and heard and also the kinds of questions I asked.

Furthermore, through the act of observing, the researcher affects that which she observes. This acknowledgement requires that the researcher develop and practice a discipline of reflection, self-analysis, and questioning known as critical reflexivity (Anderson, 1989). This reflection was critical to ensure that the patterns that emerge from the data were those truly found therein, rather than those solely based upon my theoretical framework. As guided by Anderson (1989) I reflected on the "relationship between theory and data…the effects of the researcher's presence on the data collected…and …on the dialectical relationship between structural/historic forces and human agency" (p. 254). This meant openly analyzing my data to be open to all themes, revisiting and reevaluating my theoretical framework, keeping broader social and political factors in mind, and understanding that my role as a science resource in the school affected the discourse I had with teachers as well as their actions in my presence.

A danger of school-based critical ethnography identified by critics is that a narrow focus on a school setting can lead the ethnographer to ignore broader infrastructure and institutional factors that may be the source of the very status quo and power that the critical ethnographer desires to challenge (Anderson, 1989). The specific focus of this study on school- and district-level factors minimizes this concern. Currently, there is very little literature in the area of how science specialists work, much less in urban contexts. Issues of power and dominance are inherent to any study of urban schools, any study of science in elementary schools, or any study of the relationship of science and elementary school teachers. Thus, while the use of science specialists in urban elementary schools is common, the study of science specialists in urban schools is outside of the mainstream, lending additional endorsement to the critical ethnographic approach.

Setting and Participants

District Context

This study took place in the Harlem area of New York City at two non-charter, public elementary schools. Both schools serve a predominantly Black and Latino/Hispanic population in a historically high-poverty neighborhood. The research site schools were part of a University partnership in which the researcher served as a fellow, providing instructional support in the area of science. For three years, the researcher visited each school one to two school days each week, meeting with classroom teachers and science specialists.

Participants

The researcher responded to administrator requests and teacher interest in providing professional development to individual teachers and grade-level teams. Much of the researcher's time was spent with the science specialist at each school and, as such, these teachers functioned as gatekeepers to the rest of the faculty. Relationships with classroom teachers provided the basis for research participation, yielding thirteen classroom teacher participants. Three principals and two assistant principals also participated in this study. Because the research question sought to address matters beyond the school level, district-level employees were also contacted. These participants represent a convenience sample of willing participants within the culture-sharing group. All participants were assured of confidentiality, especially important given the critical lens that guided this study.

Role of the Researcher and Researcher Bias

The researcher served in a participant-observer role, simultaneously observing and taking part in the science-teaching activities of the school. As a person who identifies as an elementary teacher, I question the broad characterizations of elementary teachers as unintelligent or uninterested in science, and thus I seek a non-deficit-laded approach. My initial observations in similar settings led me to believe that the use of science specialist for pull-out enrichment often leads to a uncoordinated student science experience, or worse, the disengagement of classroom teachers from science instruction due to a diminished sense of responsibility and authority to deliver science curriculum objectives. My general position is to advocate for science as an integral part of the life of the self-contained classroom. This was especially likely in settings where there was little scheduled time for communication or common planning between classroom teachers and science specialists and/or when there was little administrative oversight in the area of science.

My attention to the particular details of enacting different science specialist models (i.e., existence of common planning time, pull-out vs. co-teaching arrangements) was influenced by my impressions of how education reforms often “trickle down” to urban schools from more fully-resourced suburban settings. Changes may have been made which dramatically change the viability of the reform. As a result, comparison of models or results across contexts is compromised. As an advocate for urban schools, I was skeptical that the effectiveness and viability of a reform had been refereed in only suburban schools (e.g. Schwartz et al., 2000).

My insider-outsider status served as a limitation to this study. I was never a regular employee of the schools and the extent to which teachers viewed me as a colleague varied. Another potential limitation of this study was the reality that school environments are constantly changing. If a controlled environment was sought, numerous changes in teaching assignments, science-teaching arrangements, and even building administration would have been confounding factors. Instead these events added to the variation in my sample and the richness of the context.

Data Sources

Two major sources of data for this study were field notes and semi-structured interviews with each of the research participants.

Field Notes

During the period of immersion at the school sites, I observed the science-teaching activities of science specialists, classroom teachers, and administrators to see the activities that characterize their roles in the schools, and kept detailed field notes of teaching practices, transitions and interactions. I observed and initiated conversations about science teaching practices, challenges, and barriers. Observations and field notes created during the data collection period complement field notes taken during my three years of ongoing involvement at the field site.

Semi-structured Interviews

Interviews were a critical source of data in this ethnography. Semi-structured interviews were conducted and audio-recorded with science specialists (N = 3), classroom teachers (N = 13), building administrators (N = 5), and district administrators (N = 2). Interviews lasted 10-55 minutes and took place in classrooms during lunch and preparation periods. Science specialists were asked about their experience teaching science in a science-specialist model, the role they believe they fulfill in the school, and the general climate of science in the urban elementary school. Classroom teachers were asked about their science-teaching beliefs and attitudes and interactions with the science specialists. Building administrators were asked about the intended functions of their science program, their role in leading an elementary science program and the role of science in an elementary school. Ultimately, the selection of interview participants was purposeful but also convenient, in drawing upon teachers with whom I have established relationships. Administrators and teachers were interviewed once, with follow-up clarification through member checking.

School Artifacts

School artifacts helped to uncover official policies and corroborate and triangulate teacher reports. These artifacts included school schedules, guidelines from school and district administration, administrator- and teacher-created memoranda, professional development offerings, and curriculum and assessment materials. Publicly available documents included artifacts detailing school demographics, prior academic performance, and ratings.

Data Analysis

In accordance with the constant comparison method (Merriam, 2009), analysis occurred throughout the data collection phase. Preliminary reviews noted findings, points of interest, and tentative themes with the goal of informing ongoing data collection. Researcher field notes were annotated with comments and questions, enabling more fruitful and focused observation. I wrote observer comments and researcher memos (Merriam 2009) to capture my thoughts about emerging categories and events that I wanted to inquire more about during interviews.

Open, emergent coding was applied to researcher field notes, observations, and interview transcripts using NVivo 10, yielding 89 codes and 1,834 coded segments. Those codes were used to form tentative categories and themes via the constant comparison method (Creswell, 2007). Comparison of data across several sources (separate observations and interviews) allowed the construction of categories that "capture some recurring pattern that cuts across your data" (Merriam, 2009, p. 181). Teacher and administrator statements were compared with the researcher's observations and experiences at the school site, with instances of corroboration noted for purposes of triangulation or, alternatively, instances of conflict between teacher/administrator reports and practices noted for further reflection and exploration.

Reliability, Validity, and Rigor

There are a number of factors that contribute to the validity of this study. First, my prolonged engagement (Merriam, 2009) at the school sites provides a rich context to evaluate teachers' comments. The methodology selected also emphasizes thick description of the research area, including the extensive use of teacher voices (Merriam, 2009). The critical lens employed in this study necessitates trust, built through prolonged engagement and reciprocity (Creswell, 2007). Triangulation of data sources is also possible through comparison of teacher responses from interviews with observations as well as comparison of remarks by classroom teachers, the science specialist and the building principal on the same topic. Member checks (Guba & Lincoln, 1989) are another source of validity, with participants reviewing transcripts and providing feedback, to the extent that still ensured their confidentiality. Reliability was enhanced through the inclusion of multiple school sites and science specialists.

Findings

Hierarchy 1: Core over Enrichment

The first hierarchy evident at both Central Harlem Elementary (CHE) and Morningside Heights Elementary (MHE) was the relative position of those subject areas considered "core" and those considered "enrichment." In the standard dichotomy, core subjects are primary, academic, and taught by the self-contained classroom teacher. Core subjects are privileged with instructional time, professional development, and strong administrative oversight. Enrichment subjects are secondary, non-academic, and taught by specialists according to a pull-out schedule. Each elementary school's enrichment program consists of a variety of programs, with students experiencing different forms of enrichment on different days of the week. At Morningside Heights Elementary and Central Harlem Elementary these offerings have included Physical Education, Art, Music, Dance, Library, Technology, Social Studies, and Science in various combinations at each site each year. When science is delivered in a pull-out model, a classroom teacher leaves her class with a science specialist for a 45 minute instructional period during which the classroom teacher attends to other professional responsibilities. Science, thereby, becomes part of the school's enrichment program. This creates a dilemma as to the status of science within the core/enrichment dichotomy.

Morningside Heights Elementary

At Morningside Heights Elementary, science struggles to find a position within the core/enrichment hierarchy. The science specialist, Mr. Davis is listed under the heading of "Enrichment Teachers" along with the teachers of art, music, and physical education on the school's staff listing and organizational chart. The science room shared a separate hallway with classrooms dedicated for physical education, art and dance. While the moniker of enrichment is used, the building principal recognizes that this does not fully capture the importance of science as a subject area. She stated, "It's more than an enrichment subject, it's a major content area" (Ms. Ducasse, Principal, MHE, interview). Despite this statement of priority, the practices and customs of Morningside Heights Elementary show than an unspoken hierarchy affects the culture of enrichment subjects, including science. With secondary status, enrichment subjects do not command much attention from school leaders. Ms. Carter explains her leadership philosophy, "I am the type of administrator that will allow my science teacher and my other enrichment teachers as well to fly as far as they can without any restriction, as long as it's going to benefit and be of interest to the students." (Ms. Carter, Principal, MHE, interview) Principal Carter describes herself as an essentially hands-off administrator of Mr. Davis. Note that she groups him with the other enrichment teachers rather than with the classroom teachers or the entire faculty.

There are structural challenges to quality instruction imposed on "enrichment" subjects by the specialist-staffing model. While every teacher must convey high expectations to students, the enrichment teacher must do this for many groups of students, as a person who is not the students' primary teacher. The students perceive it as a different environment. Ms. Bryant explains, "Children tend to act up when they're not around their classroom teacher, you know, because they're with you all day you have, sometimes I can get more out of them than others." (Ms. Bryant, Grade 4, MHE, Interview) Mr. Davis also identifies management challenges related to teaching in the cluster or enrichment model,

> One of the drawbacks, here where I work, when classes and kids come in and they're a little too hyped to calm themselves down and listen to instruction. I have to do discipline and other things like that. A lot of times kids come in unprepared, no pencils. I have kids that come in late... Every now and then the kids come in 15 to 20 minutes late and you cannot learn science that way. You have to be here from beginning to end. So that's one of the most frustrating things, the disciplining I have to do sometimes and the kids coming in late and unprepared. (Mr. Davis, Science Specialist, MHE, Interview)

It's important to note that these are not individual students arriving late, as may occur in a secondary setting with a passing time between classes. Each classroom teacher escorts her class to enrichment. While, classes were sometimes late to science classes because a lesson in their general education class took longer than expected, often they were late following lunch and recess. It was also common for individual students to be scheduled to receive services or complete testing requirements during enrichment classes, in order to minimize academic interference. Given its physical location, it was common for music and activities from neighboring enrichment classes to be overheard in the science specialist's classroom. Despite its recognized academic nature, science was not spared from these disruptions.

In addition to delivering science instruction, Mr. Davis had to convince students to buy into the "core" academic nature of his program. He explains, "Then, you know, some kids they start to realize that I mean business in here and you've even seen one class in particular that used to be rowdy and the kids are doing real science now and they like it." (Mr. Davis, Science Specialist, MHE, Interview) Mr. Davis actively solicited the attention and hard work of students during science instruction, especially his older students. The "one class is particular" he referred to is Ms. Bryant's 4th grade special education class. Mr. Davis and Ms. Bryant had an ongoing dialog about this class. She explains, "I do talk to him about some of the kids who have challenging behaviors and I explain to him that if you have to have them excused then they have to be excused." (Ms. Bryant, Grade 4, MHE, Interview) By "excusing" the students from class Ms. Bryant means dismissing the student prematurely from science class to return to the classroom. Science enrichment is viewed as dispensable—"earned" rather than the students' having a right to it and obligation to complete it.

Central Harlem Elementary

The core/enrichment hierarchy also played out at Central Harlem Elementary. Upon interview, Principal Coleman admitted that the enrichment program was fundamentally secondary and really existed only to serve the needs of the core area (i.e. classroom) teachers, "You realize that the cluster position is pretty much technically just so the teachers can get their preps. You have enrichment because the teachers have to get their prep, their non-duty prep. So whatever ability or expertise you have in the building that is what you sort of make the preps… You can't cut the clusters because teachers contractually are due a prep." (Mr. Coleman, Principal, CHE, Interview) At the most basic level, the pull-out enrichment model was an outgrowth of the principal's need to create a building schedule that satisfies the given constraints of contracts and instructional minutes.

Most noticeably at Central Harlem Elementary, leadership and supervision of enrichment subjects were an afterthought in designing the organizational structure of the school. Mr. Coleman shares, "Last year we had a third assistant principal for the year and she took over the supervision of the enrichment. This year it's being shared between the assistant principals. It's shared. We did that because of the teachers and the children involved. … Now I think sharing is more cohesive and you don't run into the same issues of double punishing kids or not including the supervisor for that particular child's classroom." (Mr. Coleman, Principal, CHE, Interview) As he describes the benefit of bringing the enrichment subjects within the purview of the grade level-appropriate assistant principals, he referenced the ability to respond to student behavior and discipline, rather than a concern about disjointed curriculum leadership. The primary need for administrative action within the enrichment program is dealing with unruly behavior exhibited by students while they are away from their classroom teacher.

While the core/enrichment dichotomy was similarly manifested at Morningside Heights and Central Harlem Elementary schools, the position of science within the hierarchy was different. Whereas at MHE, science struggled to attain academic status within an enrichment model, at CHE, science existed as both a core and enrichment subject. Classroom teachers retained a high degree of ownership of science instruction, supporting its core status within the general education classroom. This core status was reinforced through the administrative oversight of the Assistant Principals and Principal. The lower grades Assistant Principal, Ms. Harris, regularly checked in with classroom teachers to inquire about their progress in various curriculum areas, including science. Ms. Ambrose explains, "She's making sure we are following the curriculum, where are you in this unit month by month. She comes she asks, where are you in science where are you in social studies? Where are you in math? Where are you in literacy? That's the only person." (Ms Ambrose, Grade K, CHE, Interview) The expectation of a conversation with Ms. Harris was a motivator for teachers to deliver the science curriculum. Principal Coleman worked in conjunction with Ms. Harris to supervise progress across the curriculum areas. He described his process for reviewing planned lessons, conducting regular classroom walkthroughs, and observing bulletin board displaying student work,

> If you're teaching electricity over the last 5 weeks and now you're teaching magnetism I don't see evidence of either one of those, you're not teaching it. That's how I use the evidence in the environment to determine the correlation between the lesson plan and what's actually being taught...It is not uncommon [to find a mismatch]. That's a conversation you have to have with teachers when you find that with the curriculum in science and social studies. It doesn't happen as frequently with ELA and math. (Mr. Coleman, Principal, CHE, Interview)

Mr. Coleman looks for topical alignment between lesson plans and student work displayed within or outside of the classroom At Central Harlem Elementary, administration actions supported the classroom teacher's sense of responsibility for the science program.

However, this dual status of science as enrichment and core also had its own challenges, namely, curriculum coordination. The intended relationship of the grade-level "core" assistant principals, the "core" classroom generalists, and the "enrichment" science teacher on matters of curriculum was unclear. Assistant principals did not play an active role in determining which science lessons were delivered by the science specialist. While assistant principals routinely commanded the presence of classroom teachers at curriculum planning meetings, such requests were not made of the science specialist. Outside of matters related to student discipline, the science specialist continues to operate as an "enrichment" teacher outside of the purview of the "core-focused" grade-level assistant principals.

Challenges of "Enrichment"

Organizational challenges of the "enrichment" model contributed to a suboptimal learning environment, as detailed by a district administrator,

> We have to stop asking science teachers to teach like two or three hundred kids over the course of the week. They can't build relationships with those kids. They don't have the efficacy professionally to feel vested as much when you see one student once a week or twice a week and you see 250 of them, that's not an education. And you can't personalize

> that experience for kids. Think about it from the kid's perspective. They have these deep relationships with their 4th grade teacher and then they go see their "science teacher" once a week twice a week, in the same way they have a different teacher who monitors lunch duty twice a week. *Dr. Feeney, District Administrator, interview*

From the students' perspective, filling enrichment periods with academic subjects rather than Art, Music, and Physical Education, changes the nature of the children's day. Couched as "enrichment" students may have expected their "special" for the day to provide a change of pace. This student expectation along with the change in authority figure may have contributed to the behavior issues cited in both schools as a challenge of the science specialist's setting.

The entire enrichment program was both beholden to and somewhat protected by the contract-mediated needs of the "core" faculty at large. Where science did not benefit from the "enrichment" association, other "enrichment" subjects also did not benefit from comparison with science. When budgets tightened, priorities were revealed. When Principal Carter faced cuts at Morningside Heights Elementary, she cut social studies from the enrichment program and assigned classroom teachers to "cover" this area. Ms. Carter did not feel that she could similarly bring science into the "core" instructional responsibilities of classroom teachers and thereby save other enrichment programs. She explains her reasoning,

> *Do you feel that the classroom teachers could take over the science program?* Well frankly Darcy, I wouldn't cut the science program. I would cut dance. Unfortunately I would probably cut music first but I wouldn't cut science. (Ms. Carter, Principal, MHE, Interview)

Following this interview Ms. Carter cut the dance program. Classifying science as an enrichment subject put science in a competitive relationship with the other enrichment programs in terms of time and resources. When principals made difficult decisions about which programs to support with budget resources or instructional time, the academic nature of science within the enrichment environment trumped other offerings.

The matter of appointing a science specialist also shed light on the status of science within the core/enrichment hierarchy. Due to any number of factors, teachers may not consider the science specialist role a desirable position. In the absence of willing candidates, the science specialist position may become a sort of personnel dumping grounds. Dr. Feeney reflected on less successful implementations of the science specialist model she has seen,

> We had some really smart dedicated folks who were really passionate about the work that they were doing, and there was a huge contingent of really disgruntled: My principal doesn't think I'm good enough, and they're making me do this, and I don't know anything about science…They were, from their point of view, they were pulled out of the classroom, and they think of it as pulled out of the classroom, in order to teach science. They see that as a demotion, in some ways. (Dr. Feeney, District Administrator, Interview)

Teachers may not desire the science specialist position because they generally avoided science or they preferred to spend the day as a generalist. The core/enrichment hierarchy adds an additional layer—the science specialist position as demotion. Teacher licensure does not provide a gate-keeping effect for science the way it does for other enrichment areas because anyone with a general classroom-teaching license can assume the position. The purposeful and public appointment of a sub-par educator as a science specialist would send a clear message within the school community about the status of science instruction within the core/enrichment hierarchy.

Hierarchy 2: Tested over Untested

In accordance with No Child Left Behind legislation, New York State implemented a comprehensive program of testing in various academic areas. At the elementary level, students began standardized testing in reading, writing, and mathematics in the 3rd grade and continue annual testing through 8th grade. The state was also required to test students in science, which was done with cumulative tests at the conclusion of 4th and 8th grades. Science held a privileged position within the test/untested hierarchy. At the elementary level, the existence of state testing in science and other subjects was a powerful driver of the school-level science instructional model.

Science Test and Allotment of Instructional Time

The science test provided increased visibility and accountability in the area of science. Morningside Heights Elementary presented an interesting case as it grew from a pre-K to 2 school, with no testing grades, to include grades 3-5. Ms. Carter reflects on how this impacted the science program, "We knew that our 4th graders would soon be taking the New York State science exam and it would become much more intense. We had to have a hands-on science program...You know that the 4th graders take a science exam so there is a curriculum that [Mr. Davis] has to follow in order for those students to pass the test. That's number #1." (Ms. Carter, Principal, MHE, Interview) At Morningside Heights Elementary, the existence of the 4th grade science test did not only drive Mr. Davis's schedule, it was also the raison d'etre for the science specialist model itself. She identified preparation for the 4th grade science test as the science specialist's most important job responsibility.

While many aspects of the science specialist model varied among school sites, it was common for the science specialist's schedule to pay particular focus to 3rd and 4th graders, in anticipation of the 4th grade science test, "And I would have 4th grade for a double period [i.e. 2 each week] because of the state exam... After 2 or 3 years the principal realized that in order to prepare for the 4th grade exam she would give me a double period for some of the third grade. So I would have a double period for some of the third grade classes, and I would have usually a single period for the 5th grade." (Dr. Hall, District Administrator, Interview) Students could spend more time with the science specialist as they progress through the grades to accommodate the increasing complexity of the science investigations or to prepare students for middle school. If these factors were the primary driver of the science specialist's special attention to older students, the trend would have applied or even intensified with 5th grade classes. Instead, 5th grade classes generally received less instruction from the science specialist. The science specialists' schedules reflected the testing-driven priorities of the school.

Relative importance of the science test

Since multiple subject areas and grade levels were assessed through standardized testing, the science test must be interpreted within a complex and rapidly-evolving accountability framework. School leaders described the relative importance of the science test, as they understood it,

> I think you have seen a large amount of schools who have tried to use their science and their social studies periods as an additional period to teach ELA because it's the high stakes test. I don't think it's so much a lack of interest or a lack of concern about teaching those content areas. I think it's just ELA and math has drawn a heavy hand. The reason is because the penalties and the impact on the schools accountability report is much more impacted by those two subject areas. (Mr. Coleman, Principal, CHE, Interview)

Whether Mr. Coleman's perception of the relative weight of the ELA/mathematics and science tests accurately reflects the relevant accountability algorithm is immaterial, these were the perceptions that drove his decision-making. His and other school leaders' perceptions flavored the messages teachers heard about testing and, in turn, their own perceptions about the relative importance of various tests, as Ms. Chang indicates, "Classroom teachers always worry about state test reading and math first. That's why we have Mr. Davis to deal with science... Even though that's equally important because it is a content area and they are going to be tested on that, reading and math come first. Even though it's a fourth grade class." (Ms. Chang, Grade 4, MHE, Interview) English/Language Arts and mathematics tests are more frequent, and they are perceived as being more valuable and important than the science test. The 4th grade test justified the attention paid to science by the science specialist. The more important ELA and mathematics tests provided additional justification for the science specialist model- enabling classroom teachers to continue to focus on other testing areas.

In a further display of hierarchy within the tested subjects, science instruction was sometimes legitimized by its contribution to improvement in literacy skills, "Even though they are doing the 4th grade [science] test, but everything, their scores are based on those ELA and math scores. But what I want my children to understand is that some of those literacy and ELA are science activities or information on science. "(Ms. Ducasse, Principal, MHE, Interview) Instruction in science may benefit students when they come across science-related items on literacy and mathematics exams.

Teachers also picked up messages about the emphasis given to some curriculum areas and testing requirements via the school's efforts to improve student scores. Mr. Weiss gleaned messages about the relative importance of various tests on a regular basis, "There was a meeting for cluster teachers yesterday and this was on my desk today and here are the test scores that we got. Now here are the math scores and the ELA scores. Now here we are the cluster teachers, two of us are science teachers, look at all the important data they give us. The science isn't there... I guess the science test doesn't really count for promotion to the next grade. It's one notch above social studies." (Mr. Weiss, Science Specialist, WHE, Interview) While attempting to foster shared responsibility for test results among all teachers, the administration perpetuates the tested/untested hierarchy by calling all teachers to analyze and address the results of select grade levels in select areas, but not in science.

Another possible contributor to the low sense of urgency for improvement in science was positive student performance on the state exam. Principal Coleman of Central Harlem Elementary weighed in on this point, “The reality is, the science test in 4th grade, students always, historically, do pretty well…It’s not very complicated, so historically most of our children have performed at least at the proficiency level on that test” (Mr. Coleman, Principal, CHE, Interview). Compared to results for English/ Language Arts and mathematics, science test scores for the same students were relatively high. 90% of students from Morningside Heights Elementary scored proficient or higher in the science test compared with 39% and 70% of the same students in ELA and mathematics, respectively. Central Harlem Elementary showed a similar pattern with 64% of students proficient in science versus 11% in ELA and 36% in mathematics. This pattern may reflect strong science programs, the different nature of science testing and/or lower standards for proficiency in science. Despite these varied factors, satisfactory science scores, relative to other areas, were taken as evidence of a satisfactory science program,

> Is the 4th grade science test something you worry about?
>
> No, because Mr. Davis has it together. He’s very thorough. The children enjoy [science and]; the teachers help. I wish more teachers were participating in the science fair but with all of the new initiatives that are coming down, science is still important. So, I’m not worried. (Ms. Ducasse, Principal, MHE, Interview)

With satisfactory science scores at MHE, test preparation responsibility was delegated to the science specialist, “freeing up” classroom teachers and building administrators to keep literacy and mathematics as their primary areas of attention.

The case of the New York State Social Studies exam provided an interesting example of how the tested/untested hierarchy affected attention to academic disciplines, “And after doing the social studies cluster for about four years the state canceled the social studies test. So, there seemed to be no need for a social studies teacher at that point." (Mr. Weiss, Science Specialist, WHE, Interview) Since the cancelation of the test, both Washington Heights Elementary and Morningside Heights Elementary canceled their social studies cluster positions while maintaining their science cluster positions.

Supervision and Evaluation

Another application of the tested/untested hierarchy applies to teachers themselves, who are "tested" through their formal supervision and evaluation system. At the district level, New York City implemented a data-driven framework that attempted, in part, to calculate a teacher's impact using standardized test scores. The inclusion of some scores, and exclusion of others, created a hierarchy of priorities. Principal Coleman explains,

> You can tell a grade 4 and a grade 5 teacher make sure you are covering all of your content areas and make sure you have a strong science and social studies program but whenever, under the new evaluation system and the state-created teacher impact, value-added, they only count ELA and math scores. So they look at the growth of children in ELA and math and that is how they determine how you did as a teacher. They are not looking at how you did in social studies or science. Those are the only 2 content and subject areas that they're weighing. (Mr. Coleman, Principal, CHE, Interview)

For a classroom teacher in the new system, there is less incentive to teach science than literacy and mathematics. The rational teacher would devote instructional time to activities most likely to increase student's literacy and mathematics test scores.

At the school level, principals could insist that instructional time continue to be devoted to science, in accordance with city and state guidelines. One mechanism to ensure this practice would be teacher observations of lessons in these potentially neglected areas. This was not been the case at Morningside Heights Elementary, "[Science is] given a lot more emphasis now but it's still not something administrators are looking for in your instruction. You're still being observed in math and reading. Science and social studies are basically ignored. So of course most teachers are going to gear their instruction towards those." (Ms. Wilson, Grade 3, MHE, Interview) Scheduled teacher observations most often included lessons in reading, writing, and mathematics. The teacher's desire to be observed in an area of relative competence and the principal's desire to observe an "important" subject were mutually reinforcing. Since the majority of the instructional day was devoted to these subjects they were also the subjects most likely to be viewed and assessed in the context of an unannounced observation or walk-through.

Conversely, there was a sense of invisibility regarding administrative oversight of the science specialist, "No one really comes by. *Who might you expect to come by?* Oh, people. We had the quality review no one really came by. Anybody, I mean the principal, parents, anybody can come by and see what we have." (Mr. Davis, Science Specialist, MHE, Interview) During the annual Quality Review, district personnel observed the school, reviewed artifacts from selected teachers and rated the school. This event was met with much anticipation. Many teachers stay late into the night to prepare their classrooms. Whereas Mr. Davis previously received much attention in his literacy intervention role, he found that science was not an area of importance to the reviewers.

Hierarchy 3: Literacy & Mathematics over Science

Science Instructional Time- Planned and Realized

One manifestation of the literacy & mathematics/science hierarchy was the allotment of instructional time for various curriculum areas. Principals and assistant principals shared their expectations around instructional time, both in terms of total minutes, the dispersal of minutes, and the time of the day those instructional minutes occur. Teachers and principals most often allotted morning instructional time towards literacy blocks in reading and writing. When the classroom teacher scheduled science instruction it was often at the end of the day or the end of the week, “Usually I have it in the afternoon. The reason why I usually schedule my science in the afternoon is because by the afternoon sometimes the children get a little antsy after lunch which they need something hands-on and that’s what I like to provide- hands-on lessons.” (Ms. Alvarez, Grade 2, CHE, Interview). Teachers expressed a science pedagogy whose active approach may match well with students’ needs for activity later in the school day. However, when science is positioned at the end of the day, scheduled science instructional time may not be realized, “So often science is bumped and even for me science often is like, oh reading took like an extra hour and a half today or math took this or my prep was changed so science would get bumped.” (Ms. Wilson, Grade 3, MHE, Interview) Relative to the science specialist, the classroom teacher’s schedule was flexible, so one period could run into the next as was necessary to continue a lesson to the desired endpoint.

A further function of the researcher was to act as supervisor and liaison for pre-service teachers enrolled in elementary science methods classes. The very presence of the pre-service teachers provided additional motivation to give science more attention than might otherwise be the case. Ms. Wilson explains, “With the youngsters [pre-service teachers] coming in that kind of helped me to really make an effort. I don’t want them coming in- ok I’m here to watch how you do science and I’m like oh we bumped it. Would you like to watch an extended math lesson? It makes me make a greater effort to pace better so that I can get to science.” (Ms. Wilson, Grade 3, MHE, Interview) While schedule changes were sometimes unavoidable, Ms. Wilson’s comment suggests that science instruction could be retained with more careful planning and pacing and simply making a commitment to do it.

The adoption of the Common Core State Standards and Common Core-aligned curriculum and testing in literacy and mathematics was poised to dramatically affect the literacy

& mathematics/science hierarchy. The full extent of this impact is not yet known, as teachers in New York City were implementing Common Core-aligned curricula for the first time during the last year of this study. However, Mr. Coleman shared his thinking about how the Common Core State Standards may affect the science instructional approach at Central Harlem Elementary,

> There was a time up until recently with the introduction of the Common Core Standards that I would have, I felt that pretty much that 95% of science could be taught hands-on and inquiry program. Based on the Common Core Standards and based on the drive for students to read for understanding and based on the fact that children are not being exposed to textbooks in school perhaps didn't see them until they reached college, we are now sort of decided that it should be more of a 60/40 split or a 55/45 split where they are spending still the greatest amount of the time with the hands-on inquiry work but adding a much higher percentage of textbooks so that children are actually reading for information and finding text-based evidence in that information to support a claim. (Mr. Coleman, Principal, CHE, Interview)

With heightened standards in the Common Core, administrators were contemplating the use of science instructional time to more intensively teach literacy and mathematics skills

The Principal's Role

As a curriculum leader, principals may perpetuate the literacy & mathematics/science hierarchy or actively work against it. There are many factors that may affect the extent to which school administrators are or consider themselves to be capable leaders of the science program at their schools. As former classroom generalists, it should not be surprising they are reluctant to take on science leadership responsibility. When asked, "*Do you consider yourself to be a curriculum leader in science?",* Principal Ducasse stated, "No. No, I'm more of the literacy and the math (Ms. Ducasse, Principal, MHE, Interview). Principal Ducasse abdicated her role as science curriculum leader, "I'm very blessed this year being a first-year principal that with Mr. Davis taking care of science I really have nothing to worry about." (Ms. Ducasse, Principal, MHE, Interview)

School principals who previously served as classroom generalists in a pull-out science specialist model may lack a science-teaching knowledge base. Asked about the most important skills and ideas for students to learn in elementary school science, Principal Carter replied, “Just the basics. Water. You want me to get specific? The body. Hygiene. My son asked me when he was 3 years old, ‘Mommy, why do you wash your hands so often?’ Germs. Diseases…Darcy, science is everything. It’s what you put into your body, the food, the water you drink, the air you breathe. It’s everything.” (Ms. Carter, Principal, MHE, Interview) However important it may be to instill the value of hygienic practices, they were not part of the K-5 science curriculum sequence. Only one grade five unit addressed human health via nutrition. Principal Coleman added a process dimension when he spoke about what he would see during good science instruction, “I would see children with their hands in soil and I would hear conversations about what is in soil. I would see students with cups and waters and tools, electric bulbs, and wires, and batteries to determine what kind of circuit would allow the bulb…I would see hands on. I would see children involved in scientific exploration, and the evidence of that in their science writing in the science content area [of the room].” (Mr. Coleman, Principal, CHE, Interview)
The use of equipment and materials, accompanied by student questioning and observation was evidence of reform-oriented science instruction as understood by the principals.

While they recognized that science instruction was distinct, principals also expected science to be integrated into other subjects. To them science learning was more worthwhile when it was used in service of literacy and mathematics skills. Principal Ducasse shared how she envisioned the role of classroom teachers in the science curriculum, “We have to kind of really make sure that it’s all fitting in. My way of doing it is to integrate it into literacy. A lot of nonfiction texts. A lot of the activities where the children can touch and science is all around.

And science is in the classroom, science is outside, science is the senses. So you can bring it in at all times." (Ms. Ducasse, Principal, MHE, Interview) The classroom teacher had a role in delivering science instruction but her mindset should be towards integration with other curriculum areas.

As supervisors and learning leaders principals should ensure that their expectations are met. Ms. Martin reflected on the culture of accountability for science teaching, "Enforcing meaning telling classroom teachers you have to teach science. Because if you don't say that a lot of people say, 'Oh I don't have time, I'm doing writing; I'm doing reading; I'm doing math.'...That they must teach science because they're teaching everything else. No one's making them do that." (Ms. Martin, Grade 2, MHE, Interview). As a classroom teacher, Ms. Martin noticed a lack of enforcement in the area of science. Teachers concluded that they could "get away with" not doing science. Mr. Davis also attributed the lack of science teaching on the part of classroom teachers to the lack of administrative oversight. Prompted to put himself in an administrative role, he described what he might do differently,

> I would have to really let the classroom teachers know that I'm giving you materials and I want them used. I'm making the rounds going to classrooms, even come here [to the science room]. Go and see what's going on. Make sure I was familiar with the curriculum and the things that's supposed to be taught, *how* it's supposed to be taught. Come into the class say, "look, let me see your science workbooks." Really know what's going on with some of the classes because if you don't do that, some people won't do as much work as others. (Mr. Davis, Science Specialist, MHE, Interview)

Mr. Davis believed science should get more attention from teachers and more oversight from administrators. However, as a rank-and-file teacher, he did not feel it was his role to direct classroom teachers.

Considering the limitations of both building administrators and science specialist teachers, what then was the leadership structure for science beyond the school level? Dr. Feeney explained how her efforts to build science communities shifted with changes to school structure during the NYC Mayor Bloomberg era (2002-2013),

> There were 10 directors of science, one per region. We were helmed by a central office that was staffed just for science and we were building real communities around this work…That whole structure city-wide dissolved in 2007 when we moved away from the regional structure and to full [principal] empowerment. And I'm not saying that empowerment wasn't good. I'm actually a fan of principal empowerment and the model but it did have some tragedies along the way. One of those tragedies, I think, is that we really stalled some momentum in how we think about city-wide change in science instruction. (Dr. Feeney, District Administrator, Interview)

In the model of empowerment, principals had greater latitude to make decisions for their own schools. The levels of "district" and "region" were eliminated in favor of "networks" which provided support resources at the request of their member schools. These networks may have had science-specific staff, but they may not. No principal, classroom teacher, or science specialists identified network-level personnel or resources as an important source of science-related guidance.

Discussion and Implications

The use of a science specialist model to deliver science instruction in an urban elementary school is influenced by, and perpetuates established hierarchies within the elementary school. Science instruction delivered within a specialist model relegates it to "enrichment" status within the already established "core over enrichment" hierarchy. Enrichment classes are characterized by relatively high levels of disruption and low levels of administrative oversight. In the absence of deliberate challenges to the status quo, institutional meanings of "enrichment" are applied to science instruction delivered according to a pull-out enrichment schedule. While science specialists may have been intended to promote science and guarantee exposure to high-quality science instruction (i.e. Abell, 1990) the "core over enrichment" hierarchy mediates this practice and cultivates a culture wherein science was dispensable and secondary, yet paradoxically elitist, as predicted by Olsen (1992). Highly engaging instruction may especially attain "reward" status. Instances of undesired student behavior provide a window into this enrichment mindset, science specialist instruction emerges as a privilege to be earned rather than students having a right to it and an obligation to complete it. The locally defined i-meaning of "enrichment" govern allowable practices at the school level, such as delivery of student services during science periods, the location of the science room, and the establishment of the specialists' teaching schedule. Students' i-meanings of "enrichment" may conflict with the "academic" nature of science specialist instruction.

Delivering science in an enrichment arrangement establishes a new academic/nonacademic hierarchy within the core/enrichment dynamic. Faced with the dilemma of dwindling budgets, i-meanings of "enrichment" and "academic" came into sharp relief at Morningside Heights Elementary, as science trumped other subjects and retained its enrichment funding. At Central Harlem Elementary, science maintained "core" status because of consistent attention from assistant principals and the building principal. Still, administrative attention appeared to be concerned with *whether* science was progressing rather than *how well* science was progressing. This reflects their limited capacity to lead science programs (i.e. Barish, 2008; Finnigan, 2010). While building administrators may implement a hands-off management style as a show of assumed competence, science specialists view this as a sign of their invisibility and low priority. When an enrichment position is strongly or publicly associated with a decrease in responsibility and priority, teachers may interpret appointment to this position as a vote of no-confidence by their administrator.

The tested/untested hierarchy emerges as a sliding scale of priority in this study. In one respect, science occupies a privileged position within this hierarchy because of statewide testing in science. I-meanings of “accountability” mediated by the high-stakes testing culture benefit science instruction in that instruction by the science specialist is viewed as preparatory for the fourth grade science test. Standardized testing is a powerful driver of instructional time allocation in science and a justification for the very existence of the science specialist. Acceptable student performance on this test is used by principals to rationalize the low priority given to science instructional improvement and the continued focus on literacy and mathematics by classroom teachers. Questions about the overall pass rate for this exam and the cut-off scores used to gauge levels of student performance are unasked. The absence of science test scores from the “value-add” calculations for classroom teachers threaten to demote science further within the tested/untested hierarchy, furthering the current perception that the science exam does not really “count” as much as the literacy and mathematics exams. A second set of nested hierarchies emerges - both “counted” and “not counted” categories exist within the “tested” subjects as the narrowing of the curriculum (Crocco & Costigan, 2007) takes effect.

The last historically entrenched hierarchy in the elementary school is that of literacy and mathematics over science. The existence of science specialists is both an outgrowth and perpetuator of this hierarchy. The assumption of instruction by science specialists, however minimal, allows classroom teachers to focus their energies on instruction in literacy and mathematics. When science instruction is scheduled in the general education classroom, it is often at less premium times of the day, if it occurs at all. For a classroom teacher primarily concerned with student performance in literacy and mathematics and for whom science may have been an area of relative discomfort, there is a temptation to let science instructional time slip away at the end of the day. While it was too early in the implementation of the Common Core State Standards to observe, all signs would suggest that the hyper focus on literacy and mathematics would only intensify with the implementation of the Common Core State Standards and evaluation measures thereof. The common reference to them as the "Common Core" rather than the "Common Core State Standards for English/Language Arts and Mathematics" itself reinforces the "literacy & mathematics = core" i-meaning and subverts other elementary academic subjects, including science.

In addition to testing and accountability systems, the expectations and priorities of building administrators are also influenced by their own experiences as educators. School principals who served as classroom generalists in a pull-out science specialist model may lack a science-teaching knowledge base, paving the way for systemic downstream effects. Principals in this study confessed a lack of science expertise whether openly in their interview comments or implicitly through inaccurate descriptions of their own science programs. As seen at Morningside Heights Elementary, the science specialist model enables principal disengagement from science leadership by providing a school-level figure to whom science responsibility can be delegated, extending previous observations of principal limitations in science. This abdication of science leadership allows the principal to focus on instructional leadership in literacy and mathematics, in line with her own expertise and the literacy & mathematics/science hierarchy. Yet, the science specialist is a rank-and-file teacher not explicitly or publicly empowered to act as a leader within the faculty, leaving a vacuum of leadership. The philosophy of principal empowerment requires principals to make decisions for their own school communities, with the thought that knew their community's needs better than a central administrator. Whether principals were well-equipped or well-advised in science decision-making is an important consideration.

When a pull-out model is used that does not involve co-teaching, demonstration teaching, push-in lessons, collaborative planning, or regular in-depth conversation, the vision of specialist instruction to advance the status of science in the elementary school is not realized. Advocacy for science specialists must be tempered with recognition of the risks and unintended consequences entailed in some interpretations of the science specialist model. It should be noted that none of the building principals expressed concerns about their science programs. They believe that the presence of the science specialist alongside favorable state testing results means that their science program is taken care of, not something to worry about. As is typical in a hierarchy, the inherent meanings and consequences of "enrichment" science specialist model are unquestioned and thereby unconsciously perpetuated. Hierarchies may support or privilege the existence and activities of the science specialist in some respects and repress science and science specialists in others.

Positioning classroom teachers to teach science themselves also comes with many risks in this climate, as teachers may be preoccupied with intensive instruction in reading, writing, and mathematics especially as the Common Core is implemented. Already New York City has implemented a revised elementary school progress report system on which science accrues *zero* points. In what is perhaps a sign of things to come, the New York City Department of Education no longer includes science instructional time requirements in its Citywide Instructional Expectations. In a science specialist model, this could have various effects. With the reduced priority given to science, the science specialist role could become further marginalized, Yet, the science specialist could have an insulating effect – guaranteeing all students some exposure to inquiry, hands-on science experiences. Building administrators should weigh merits and consequences of various models in making decisions about how to structure their science programs. Principals would benefit from science-education resources outside of the school building.

Conclusion

The science-teaching culture of a school is mediated by the science specialist structure in place. The particular design and enactment of the science specialist model is influenced by a number of factors and constraints from instructional time requirements and teacher contracts to teacher certification and state testing. These factors operated in a setting characterized by a number of unspoken institutional hierarchies, namely core over enrichment, tested over untested, and literacy & mathematics over science. All of these influenced and were influenced by the components of a science specialist model that were enacted in a given context.

CHAPTER VII

CONCLUSION AND IMPLICATIONS

In this chapter, I summarize the findings across each of the research questions and conceptual frameworks. I also synthesize the results of this study, their implications, and consider questions that may drive future research in this area. The questions that guide this research study are listed below.

1. What are the roles, responsibilities and identities of science specialists in urban elementary schools, as perceived by the specialist, classroom teachers, and administrators?
2. What functions do science specialists provide to classroom teachers and how do the uses of science specialists influence the science-teaching motivation of classroom teachers according to Expectancy Theory?
3. How do school-level structures and district-level factors establish, reinforce, or work against hierarchies and thereby impact science-teaching culture in urban elementary schools with science specialists?

Summary of Major Findings

As explored in Chapter IV, science specialists serve a range of functions in a pull-out enrichment model in urban elementary schools. The primary responsibility of a science specialist in this model is that of science instructor, one who teaches solo science lessons during classroom teacher preparation periods. Science specialists may also function as materials managers, communicators, science resources, and even science curricular leaders. This last finding is significant considering that science specialists often come from a classroom generalist background and gain expertise in science instruction while in the role of science specialist. In addition to providing important efficacy-building experiences, the institutional title and role of science specialist is also a powerful source of identity for science specialists. The participant teachers reflect on some nature- and affinity- based identities for science that are more developed now that they consider themselves a science teacher. Classroom teacher colleagues and building administrators are a powerful source of discursive identity. Science specialists become science experts because others see them as such and expect the specialist to be able to provide consultation and support.

Chapter V uses Expectancy Theory (Vroom, 1964) to analyze classroom teacher science-teaching motivation in a science specialist model. In a pull-out enrichment model, developing science-teaching expectancy among classroom teachers though coaching and resource functions is not the science specialist’s primary job function. However, science specialists do provide support to classroom teachers and foster familiarity with curriculum materials. Curriculum materials themselves can support classroom teacher self-efficacy, though for a novice they may be perceived as overwhelming. Classroom teacher science-teaching identity, a contributor to self-efficacy, may be undermined by the presence of a science specialist. The classroom teacher’s instrumentality, or sense that his or her own science teaching is related to students’ science learning, is reduced when instructional responsibility is shared with the science specialist. This effect can be mitigated by strong administrative oversight for science. Classroom teachers who teach all of their own science lessons, with no pull-out instruction from the specialist, maintain high instrumentality for science. At all grade levels, the school’s culture of valence values achievement and progress in science less than other subject areas; however, teachers cite intrinsic benefits of engaging students in science instruction. In the science specialist model a sense of shared responsibility leading to a well-coordinated curriculum that relies on both the classroom teacher and science specialist's instruction is a rare event.

Chapter VI uses critical theory to explore school- and district-level factors that affect the implementation of the science specialist model in urban elementary schools. District level inputs to this system include teacher contracts, student enrollments and budgets, instructional time requirements, curriculum materials, standardized tests, teacher accountability systems, school accountability metrics, and district organizational structure. School-level factors include the faculty, school organizational structure, school culture, and building leadership. Any and all of these factors influence and are influenced by the specific science specialist model utilized within the elementary school. The specialist model attributes influence and are influenced by unspoken institutional hierarchies of elementary schools, namely core over enrichment, tested over untested, and literacy and mathematics over science. Implementation of science specialist models of instruction for elementary science should be made with awareness of the organizational resources required to enable shared responsibility and a well-coordinated curriculum as well as work against existing hierarchies that may marginalize or mediate the culture of science.

In the urban elementary schools in this study, a pull-out enrichment model was used with minimal provisions for classroom teacher support. This model bears little resemblance to a co-teaching specialist model (i.e. Schwartz et al, 2000; Jacobson, 2004), and should not be expected to share indicators of effectiveness. At a minimal level, science specialists may simply perform the required job function of covering classroom teacher preparation periods. This culture marginalizes science further and relegates science to "enrichment" status, something forewarned by Olsen (1992) and Mangiante (2006). At the other extreme, a science specialist may be the primary science teacher and science leader within the school. This concentration of science-teaching responsibility was identified as a risk of the science specialist model by Schwartz and Gess-Newsome (2008). This ethnography is a starting point in describing the great variety in science specialist models, especially in under-resourced areas.

Synthesis of Findings across Research Questions

While a specialist model may be implemented with the intention of enhancing or building upon classroom teacher science-teaching practice, it can have many unintended consequences. These consequences are a result of the particular components of the science specialist model implemented at these school sites and cannot be generalized to other school contexts employing a different mix of science specialist responsibilities. However, based on commentary from district administrators and my own experience, the pull-out science specialist model variation is common, especially in urban, under-resourced schools.

The first unintended consequence associated with implementing a science specialist model is the demotion of science to "enrichment" status, versus a core academic area. The consequences of this are seen in the titles given to science specialists, the frequency with which students are removed or held back from science instruction, and the relatively low level of administrative concern or involvement in science. Another critical unintended consequence of the science specialist model, as implemented, is the associated decline in classroom teacher science-teaching instrumentality, identity, and engagement. Already overwhelmed with other responsibilities, instruction provided by the science specialist creates the impression that science instruction in "taken care of", and science instruction falls short of instructional time guidelines. It is the student groups whose classes meet with the science specialist once per week that end up faring worst in terms of science curriculum progress. Once a week with the specialist is enough to prompt classroom teacher disengagement, while not guaranteeing the students much time with the science specialist. This unintended consequence may be fairly easy to mitigate by fostering a sense of shared responsibility through clear expectations, a pacing calendar, and opportunities for collaboration and conversation.

Another unintended consequence of the science specialist model is the impact on the school's other enrichment programs. To the extent that one views the Arts, Technology, and other programs as important for students, the arrangement of science as an enrichment subject can be considered a threat. Because science is an academic curriculum area, it can easily trump other programs when time and resources are tight.

A further unintended consequence of the science specialist model is the use of the science specialist role as personnel dumping grounds for underperforming teachers. While this was not observed in this study, factors leading to this case from this study are the lack of specific science background of science specialists, the lack of specific certification required for the position, and the lack of value associated with the standardized test in science.

One pattern which emerged throughout the analysis is the relatively strong science-teaching practice of elementary teachers in the early childhood grades. This can be attributed to a number of factors affecting expectancy, instrumentality, and valence. At Morningside Heights Elementary, teachers of the primary grades deliver science instruction themselves, without any direct instruction provided by the science specialist. The science specialist instead serves a supportive resource role. Since shared teaching responsibility is not sought in this arrangement, the presence of the science specialist does not confuse or diminish classroom teacher instrumentality. At Central Harlem Elementary, where there is instruction by the science specialist in all grades, the classroom teachers' science program benefits from strong administrative oversight from the lower grades assistant principal. Classroom teachers discuss science lessons at their common planning meetings, a source of low-stakes accountability as well as a support to teachers less familiar with the science curriculum. Because of the lack of standardized testing, the effect of the tested/untested hierarchy is minimized. The literacy and mathematics/science hierarchy is present, as teachers feel pressure to move students along primarily in their reading, writing, and math skills however, science instruction is considered less of a threat to these goals. Early childhood educators are adept at integrating literacy and mathematics instructional objectives into their science investigations. In the early childhood context, the curriculum is relatively simple, making it less intimidating to teachers and thereby increasing their sense of self-efficacy. The early childhood teachers are less likely to feel that science detracts attention from other areas and therefore have an easier time allotting time for science lessons.

The perceptions and motives of building administrators were critical in informing this study, as they provide a backdrop to examine teachers' perceptions of their science-teaching responsibilities in context. Building administrators also make decisions that have profound effects on their science programs, whether they intend these effects or not. During the study period, the amount of science instruction provided by the science specialist to a given grade level often changed from one year to the next - from none to some, from some to more, from more to less, to accommodate preparation period requirements at the building level. In addition, teachers often changed grade levels, as the school added upper grades, personnel turned over, and student enrollments fluctuated. All of these factors caused me to prioritize my qualitative findings and reduce any expectations of grade-level differences in my quantitative questionnaire results. For example, if a teacher received coaching from a science specialist and provided all science lessons with her first grade class for many years and is now teaching third grade, is it fair to group her responses will her new upper elementary colleagues? Since self-efficacy is task-specific, how durable is science-teaching self-efficacy when the specific context shifts? This is an interesting question but not one that was explored in this study. This may depend on how one defines the task- delivering a specific unit of curriculum vs. engaging in the general act of science teaching. Teachers more tied to curriculum materials may view their efficacy as more tightly task-specific.

Changes in building leadership also affected access to the school sites. When the principal of Washington Heights Elementary was promoted within the district, the new principal did not carry on with the University Partnership for which I was a doctoral fellow. While I had already spent enough time there to make observations and interview the science specialist, I did not conduct classroom teacher interviews or administer the questionnaire at that site.

The duration of my experience at the school sites was critical to understanding the complex ecosystem of each elementary school and its written and unwritten rules. Because my study examined teacher interactions, coordination, and collaboration (or lack thereof), it was critical to interview both specialists and the classroom teachers they serve. Principal, classroom teacher, and science specialist accounts of roles and responsibilities, or the desired distribution of responsibilities, rarely aligned. If I had only spoken with one of those parties, I would not have had the complete picture. Prolonged engagement was also key in discerning what comments might be wishful thinking, especially from building administrators. The constant comparison method approach allowed me to corroborate comments and seek clarification casually from other teachers, without divulging any specific information from interviews. Lastly, the most critical research-related benefit of my prolonged engagement at the school sites was the opportunity to gain the trust of teachers such as to honestly capture their science-teaching experiences in their own words, on the record. While some teachers moderated their criticism, the level of candor I captured in recorded interviews matched and sometimes exceeded what I had heard before in conversations with teachers.

While building administrators supported my research and were giving of their own time for interviews, the matter of scheduling the teacher questionnaire was a challenge. Considering my long-established role as a science instructional resource at the schools, principals may not have seen me as a "researcher" *per se*. While the questionnaire was ultimately administered in the desired window, the administrative endorsement could have been stronger.

Discussion and Implications

This study provides one window into the variety of science specialist roles noted previously (Schwartz & Gess-Newsome, 2008) and explores the unintended consequences hypothesized in early discussions from the literature (Olsen, 1992; Swartz, 1987). Social Identity Theory (Gee, 2000-2001) provides a framework for examining science specialist science teaching identity. Whereas previous descriptions of science specialist focused on academic qualifications (Abell, 1990; Hounshell,1987), this study shows that a lack of specific academic qualifications does not prevent science specialists from developing a science-teaching identity. For these teachers, Gee's institutional and discursive identity sources were especially powerful. With similar priority, institutional endorsement and supportive discourse, it is reasonable to believe that many classroom generalists can develop a science-teaching identity.

While generalists can develop socially-mediated science-teaching identity in the science specialist role, the presence of a science specialist can have a dampening effect on the science-teaching identity of other classroom generalists. Social Identity Theory (Gee, 2000-2001) and Social Learning Theory (Bandura, 1977, 1982, 1997) explain how individual self-concepts like identity and self-efficacy are influenced by social contexts. The influence of these factors on science teachers has already been thoroughly explored in the literature (e.g. Cannon & Scharmann, 1996; Enochs, Scharmann & Riggs, 1995; Gunning & Mensah, 2010; Moore, 2008b; Mulholland & Wallace, 2001; Ramey-Gassert, Shroyer, Staver, 1996). However, elementary teachers work in a complex ecosystem. Their science-teaching experiences are mediated by science specialist models, competing priorities, and accountability structures. Expectancy Theory (Vroom, 1964) provides a conceptual basis to examine the interplay of individual, group, and environmental factors that affect science-teaching motivation at the elementary school. Science-teaching identity and self-efficacy may be impactful, but insufficient to result in classroom generalist science-teaching motivation. Vroom's instrumentality and valence components impact the science-teaching motivation of classroom teachers and are significantly moderated by a pull-out science specialist model.

The science-teaching culture of the elementary school is also mediated by hierarchies and i-meanings (Carlone & Webb, 2006; Carlone et al. 2010), unquestioned and unconsciously replicated. Science-teaching is variably privileged or oppressed as multiple overlapping hierarchies play out. The science specialist model exacerbates the literacy and mathematics over science hierarchy and introduces science to the core over enrichment hierarchy. The tested over untested hierarchy is controlled at the system and state levels, based on testing schedules and accountability calculations. In this context, testing privileged science over social studies and other enrichment subjects yet science was considered less important than literacy and mathematics. In strongly testing-motivated schools where science is already on the fringes of instructional relevance (Crocco & Costigan, 2007), science testing at the same intervals and with the same weight as testing in literacy and mathematics would give science a more privileged position in the tested/untested hierarchy, and would be a measure to actively work against the literacy and mathematics over science hierarchy.

Recommendations for Elementary Science Teaching

Considering the relatively strong showing of science at the early childhood level, the very rationale for implementing a science specialist should be questioned. Perhaps the many categorizations of elementary teachers as ill-equipped to teach science should be qualified by grade level, for perhaps the problem is not as widespread as it seems. Given the relatively simple content and the exploratory nature of the grade-level curriculum, classroom teachers are well-suited to teach science in the early childhood grades, namely pre-kindergarten to grade two. Uses of the science specialist that support classroom teacher practice, like demonstration teaching, serving as a resource, or helping with collaborative planning, support classroom teacher self-efficacy. Using the science specialist to provide pull-out instruction to this age group carries a strong risk of undercutting the classroom teachers' sense of obligation to teach science. This practice should be limited. Instead, science specialists should have more of their time devoted to serving as a coach or resource to early childhood teachers.

The area where the needs of the science curriculum may outstrip the capacities of a classroom generalist, therefore, is a narrow band of grades before students proceed to departmentalized science instruction. In this study this included grades 3 – 5 though in other school organization or standardized testing structures the grades may be different. Thinking about how to support classroom teachers in this narrower context may open up potential solutions with lesser negative unintended consequences than a pull-out science specialist model. That is, of course, if a shared teaching arrangement is even desired. Specialization within the grade-level team alleviates the need for all teachers to deliver science instruction. A regular schedule for switching classes guarantees that science instructional time occurs, addressing the issue of science time not realized that surfaced in self-contained classrooms in this study.

Principals in this study show an interest in expanding the science specialist role to effectively eliminate the need for classroom teachers to be involved in science instruction. These principals do not share in the vision of science as a well-integrated discipline within the self-contained elementary classroom. It may be that in the new era of the Common Core State Standards, continuing with a pull-out enrichment model is a way to guarantee at least some science program, effectively accepting the negative consequences that come along with it. In this scenario, science is perceived as a second-class subject because it is. This should be a distressing notion to the science education community.

Recommendations for Teacher Education and Licensure

Another constituency that should take an interest in exploring science specialist models is pre-service teacher education programs, especially those in large urban centers where pull-out science instruction is commonplace. Much time and attention is devoted to science identity development within pre-service methods courses (Mensah, 2011; Moore, 2008b). Progress made in developing science identities can be undercut by the presence of a science specialist and instrumentality further compromised by pull-out instruction. A fledgling teacher may be inspired to implement science curricula only to arrive at a grade level planning meeting or mentoring session to hear that there is another teacher who teaches science. Further, there may not be any structures in place for her to be aware what the specialist is doing with her students in order to effectively collaborate. The students may be excited to go see “their science teacher” weekly and, concerned with getting up to speed in other areas, it is foreseeable that the new teacher would let step back from a science-teaching identity. Pre-service teacher programs should introduce students to the idea of working alongside a science specialist in a number of different capacities that may be present in area schools including demonstration teaching, co-teaching, coaching, or pull-out enrichment. Prospective teachers should see science specialists as collaborators and resources, like special education professionals, and not as competition or justification for not providing their own instruction.

Institutions of teacher education should also consider whether they ought to provide specific programs for science specialists. These could be offered to pre-service students in the hopes of creating well-qualified individuals whom principals could appoint. However, given the propensity of principals in this study to appoint someone already on their faculty to this role, programs targeted to in-service teachers may better address the need for professional development. At a policy level, states should consider whether to require an additional license or endorsement in the area of elementary science. An elementary education candidate could achieve a cross-endorsement by taking additional science, science pedagogy, and pedagogical content knowledge courses. A secondary education candidate could achieve a cross-endorsement by taking additional courses in child development and elementary science methods. While entrenching science as “separate”, an elementary science licensure requirement would serve a gate-keeping function. The existence of specialized licensure requirements in art and music prevents principals from using these positions as dumping grounds, provides greater stability for these roles, increases the professionalism of these positions, and provides some guarantee of qualifications.

Future Research

Overall, it is clear that the science specialist model implemented in this study’s setting bears little resemblance to the suburban co-teaching model described in Schwartz et al. (2000).

In that model, science specialists developed lesson plans and co-taught science with classroom teachers. While science took place in a different room, it did not take place during the teacher's preparation period, assuring her presence for the lesson. Classroom teachers were expected to meet with the specialist, conduct follow-up activities and review homework assignments. The science specialist model implemented in the current study falls short of the literature's call for science specialists in terms of the qualifications of the specialists (Abell, 1990; Hounshell, 1987) and the role of the classroom teacher (Mangiante, 2006). The literature suffers from a lack of descriptions of science specialist models in practice, considerations and evaluations of their effectiveness, and a re-examination of their justification. While this study does not exhaust these needs by any means, it provides a window into the implementation of science specialists in one urban context.

The literature would benefit from additional ethnographic descriptions of science specialists in other contexts as well as the effect of science specialists on classroom teacher science-teaching identity and motivation. Similar findings in other urban contexts would help to establish the unintended consequences of science specialists implemented as a pull-out enrichment teacher. Descriptions of science specialists in suburban contexts may surface additional functions of the specialist and structures for collaboration that occur in more highly resourced settings. In addition to rich descriptions, large scale surveys at the district level could provide a sample to further delineate the science specialist functions present in a variety of school settings as well as the rationales, if any, that district administrators provide for their model.

The status of science in the elementary school should be closely monitored as the Common Core State Standards-aligned curricula and assessments thereof are implanted in schools. This will be a general matter of concern to the elementary science education community. The results of this study suggest that particular attention should be paid to how these tensions and relative priorities are mediated in specific ways by the science specialist structure. Instrumentality of classroom teachers for science should be further and more broadly examined; its mediation by science specialist structures and effect on classroom teacher science-teaching identity and motivation should be targeted, measured, and quantified. More generally, scholarly work using elementary classroom teachers as participants should make note of any science specialist structure that may be present at the school sites. Given their prevalence and their impact on classroom teacher identity and motivation to teach science, it is likely that science specialists present a significant underexplored variable in elementary science education.

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APPENDICES

Appendix A: Summary of Codes and Categories

Research Question 1	Research Question 2	Research Question 3
Who are the science specialists?	*Expectancy*	*Core over Enrichment*
Specialist background	Classroom Teacher (CT) agency and teaching identity	Science as enrichment
Specialist identity	CT self-efficacy	Management in enrichment
Specialist self-efficacy	CT science teacher identity	Administration schedule changes
Specialist personal experience with science	CT identity relative to SS	Budget cuts
Specialist construct of science teaching	CT personal experience with science /fear of science	Challenges
Students' enjoyment of science	CT autonomy- instructional time decisions	
Specialist construct of nature of science	CT construct of science teaching	*Tested over Untested*
Social relevance of science curriculum	CT preparation for science teaching	Test preparation- science
	CT construct of inquiry	Testing/NYC government
Roles and responsibilities of a science specialist	Classroom management	No Child Left Behind
Specialist job activities- enacted	Math in Science	Administration attitudes about 4th grade science test
Communication	Literacy in Science	
Specialist knowledge of classroom teachers' practice	Art in science	*Literacy & Mathematics over Science*
Science materials		Science instructional time
Science instructional time with specialist	*Instrumentality*	FOSS scripted materials
Specialist job title	Collaboration	NYC DOE PD in science
Specialist position as promotion or demotion	CT/CT collaboration in science	Staff and Schedules
Out of classroom teaching placements	Specialist vs. CT schedules	University Partnerships
History of specialists	Lesson redundant/overlap	Pre-service teachers
Specialist job responsibilities	CT knowledge of specialist curriculum	Science status, not a priority
Leadership for science	Specialist vs. CT duties	Science status, is a priority
	Specialist vs. CT relative instructional time	Leadership for Science
	Grades in science CT perseverance	Principal conception of science teaching
	Specialist vs. CT accountability	
	Valence	
	CT attitudes about 4th grade test	
	CT enjoyment of teaching science	

Appendix B: Questionnaire Items (Classroom Teacher Version)

* Item from STEBI, numbered as shown
**Item modified from STEBI

Expectancy

2 I am continually finding better ways to teach science.*

3 Even when I try very hard, I don't teach science as well as I do most subjects.*

11 I understand science concepts well enough to be effective in teaching elementary science.*

14 I find it difficult to explain to students why science experiments work. *

15 I am typically able to answer students' science questions.*

Instrumentality

4 When the science grades of my students improve it is most often due to me as the classroom teacher having found a more effective teaching approach.**

7 If students are underachieving in science, it is most likely due to my ineffective science teaching.**

10 The low science achievement of some of my students cannot generally be blamed on me as their classroom teacher.**

12 As the classroom teacher, I am generally responsible for the achievement of my students in science.*

1 Students' achievement in science is directly related to the science specialist's effectiveness in science teaching.**

Valence

9 I anticipate negative consequences for the school if my students don't perform well on the state science test.

5 I anticipate negative consequences for the school if my students don't perform well on the state ELA tests.

6 Seeing my students enjoy science makes my effort to prepare them in science worthwhile.

8 My principal uses my science-teaching performance to determine my teacher rating.

13 Teacher ratings and student test scores now may be used to determine my pay in the future.

Appendix C: Classroom Teacher Questionnaire

Dear Classroom Teachers,

Please complete this voluntary questionnaire about science instruction for my dissertation study. Your response will remain confidential and anonymous. The goal of my study is to better understand how science instruction works at your school, specifically how both classroom teachers and science specialists work to enhance science understandings of your students. If you are interested in knowing more about this research or have any questions, please contact me.

Thank you! ~Darcy Ronan, Teachers College

Part One

1. What grade level do you currently teach? *Circle one*

K 1 2 3 4 5 6

2. How many years of teaching experience do you have? *Circle one*

0-2 3-5 6-10 10+

3. What is your age? *Circle one*

20-29 30-39 40-49 50+

4. How many class periods per week does your class receive instruction from the science specialist?

0 1 2 3 4 5

5. In an *IDEAL* week, how many periods of science instruction does your class receive from you, the classroom teacher?

0 1 2 3 4 5

6. In a *TYPICAL* week, how many periods of science instruction does your class receive from you, the classroom teacher?

0 1 2 3 4 5

7. How often do you…

Co-teach with the science specialist	Never	Rarely	Occasionally	Often	Regularly
Plan science lessons or activities with the science specialist	Never	Rarely	Occasionally	Often	Regularly
Communicate with the science specialist about the progress of a unit or specific student in science	Never	Rarely	Occasionally	Often	Regularly
Seek guidance or information about science instruction techniques from the science specialist	Never	Rarely	Occasionally	Often	Regularly
Seek guidance or information about the science curriculum from the science specialist	Never	Rarely	Occasionally	Often	Regularly
Seek equipment or materials from the science specialist	Never	Rarely	Occasionally	Often	Regularly

8. How would you describe the science specialist's role in the school?

9. What are the science topics and skills that students learn in your specific grade level? (i.e. third grade)

10. Finish the sentence. "In a good science lesson…"

11. Do you consider yourself a science teacher? Please explain.

12. Do you think your students consider you to be a science teacher? Please explain.

13. Finish the sentence. "When I think about an upcoming science lesson I feel…"

14. Would you be willing to be interviewed for my study? Yes No

Part Two: Please indicate the degree to which you agree or disagree with each statement below by circling the appropriate letters to the right of each statement
SA = Strongly Agree
A = Agree
UN = Uncertain
D = Disagree
SD = Strongly Disagree

1. Students' achievement in science is directly related to the science specialist's effectiveness in science teaching.	SA	A	UN	D	SD
2. I am continually finding better ways to teach science.	SA	A	UN	D	SD
3. Even why I try very hard, I don't teach science as well as I do most subjects.	SA	A	UN	D	SD
4. When the science grades of my students improve it is most often due to me as the classroom teacher having found a more effective teaching approach.	SA	A	UN	D	SD
5. I anticipate negative consequences for the school if my students don't perform well on the state ELA tests.	SA	A	UN	D	SD
6. Seeing my students enjoy science makes my effort to prepare them in science worthwhile.	SA	A	UN	D	SD
7. If students are underachieving in science, it is most likely due to my ineffective science teaching.	SA	A	UN	D	SD
8. My principal uses my science-teaching performance to determine my teacher rating.	SA	A	UN	D	SD
9. I anticipate negative consequences for the school if my students don't perform well on the state science test.	SA	A	UN	D	SD
10. The low science achievement of some students cannot generally be blamed on me as their classroom teacher.	SA	A	UN	D	SD
11. I understand science concepts well enough to be effective in teaching elementary science.	SA	A	UN	D	SD
12. As the classroom teacher, I am generally responsible for the achievement of my students in science.	SA	A	UN	D	SD
13. Teacher ratings and student test scores now may be used to determine my pay in the future.	SA	A	UN	D	SD
14. I find it difficult to explain to students why science experiments work.	SA	A	UN	D	SD
15. I am typically able to answer students' science questions.	SA	A	UN	D	SD

Appendix D: Science Specialist Questionnaire

Dear Science Specialists,

Please complete this voluntary questionnaire about science instruction for my dissertation study. Your response will remain confidential and anonymous. The goal of my study is to better understand how science instruction works at your school, specifically how both classroom teachers and science specialists work to enhance science understandings of your students. If you are interested in knowing more about this research or have any questions, please contact me. Thank you!

~Darcy Ronan, Teachers College

Part One

1. How many years of teaching experience do you have? *Circle one*

0-2 3-5 6-10 10+

2. For how many years have you been serving in the role of science specialist? *Circle one*

0-2 3-5 6-10 10+

3. What is your age? *Circle one*

20-29 30-39 40-49 50+

4. How would you describe your role in the school as you see it?

5. How do you think others (classroom teachers, administrators) would describe your role in the school?

6. How often do you…

Co-teach with classroom teachers	Never	Rarely	Occasionally	Often	Regularly
Plan science lessons or activities with classroom teachers	Never	Rarely	Occasionally	Often	Regularly
Communicate with classroom teachers about the progress of a unit or specific student in science	Never	Rarely	Occasionally	Often	Regularly
Provide guidance or information about science instruction techniques to classroom teachers	Never	Rarely	Occasionally	Often	Regularly
Provide guidance or information about the science curriculum to classroom teachers	Never	Rarely	Occasionally	Often	Regularly
Provide equipment or materials to classroom teachers	Never	Rarely	Occasionally	Often	Regularly

7. Finish the sentence. "In a good science lesson…"

8. Do you consider yourself a science teacher? Please explain.

9. What do you think are the most important scientific skills and ideas for students to learn in elementary school?

10. Would you be willing to be interviewed for my study? Yes No

Part Two: Please indicate the degree to which you agree or disagree with each statement below by circling the appropriate letters to the right of each statement

SA = Strongly Agree
A = Agree
UN = Uncertain
D = Disagree
SD = Strongly Disagree

1. Students' achievement in science is directly related to the classroom teacher's effectiveness in science teaching.	SA	A	UN	D	SD
2. I am continually finding better ways to teach science.	SA	A	UN	D	SD
3. Even why I try very hard, I don't teach science as well as I do most subjects.	SA	A	UN	D	SD
4. When the science grades of my students improve it is most often due to me as the science specialist having found a more effective teaching approach.	SA	A	UN	D	SD
5. I anticipate negative consequences for the school if my students don't perform well on the state ELA tests.	SA	A	UN	D	SD
6. Seeing my students enjoy science makes my effort to prepare them in science worthwhile.	SA	A	UN	D	SD
7. If students are underachieving in science, it is most likely due to my ineffective science teaching.	SA	A	UN	D	SD
8. My principal uses my science-teaching performance to determine my teacher rating.	SA	A	UN	D	SD
9. I anticipate negative consequences for the school if my students don't perform well on the state science test.	SA	A	UN	D	SD
10. The low science achievement of some students cannot generally be blamed on me as their science specialist.	SA	A	UN	D	SD
11. I understand science concepts well enough to be effective in teaching elementary science.	SA	A	UN	D	SD
12. As the science specialist, I am generally responsible for the achievement of my students in science.	SA	A	UN	D	SD
13. Teacher ratings and student test scores now may be used to determine my pay in the future.	SA	A	UN	D	SD
14. I find it difficult to explain to students why science experiments work.	SA	A	UN	D	SD
15. I am typically able to answer students' science questions.	SA	A	UN	D	SD

Appendix E: Classroom Teacher Questionnaire Results

Table 10

Summary data from classroom teacher questionnaire- mean and SD for each item

Item	Dimension Measured	Mean	Standard Deviation
1. Students' achievement in science is directly related to the science specialist's effectiveness in science teaching. *	Instrumentality	2.33	1.27
2. I am continually finding better ways to teach science.	Expectancy	4.07	0.90
3. Even why I try very hard, I don't teach science as well as I do most subjects. *	Expectancy	3.00	1.27
4. When the science grades of my students improve it is most often due to me as the classroom teacher having found a more effective teaching approach.	Instrumentality	3.18	1.22
5. I anticipate negative consequences for the school if my students don't perform well on the state ELA tests.	Valence	3.32	1.41
6. Seeing my students enjoy science makes my effort to prepare them in science worthwhile.	Valence	4.48	0.51
7. If students are underachieving in science, it is most likely due to my ineffective science teaching.	Instrumentality	2.14	1.08
8. My principal uses my science-teaching performance to determine my teacher rating.	Valence	2.28	1.15
9. I anticipate negative consequences for the school if my students don't perform well on the state science test.	Valence	2.78	1.42
10. The low science achievement of some students cannot generally be blamed on me as their classroom teacher. *	Instrumentality	2.39	1.10
11. I understand science concepts well enough to be effective in teaching elementary science.	Expectancy	3.96	0.74
12. As the classroom teacher, I am generally responsible for the achievement of my students in science.	Instrumentality	3.50	1.17
13. Teacher ratings and student test scores now may be used to determine my pay in the future.	Valence	3.11	1.31
14. I find it difficult to explain to students why science experiments work. *	Expectancy	3.96	0.88
15. I am typically able to answer students' science questions.	Expectancy	4.14	0.45

* Indicates item which was reverse scored