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Jessica Gale   Date

Science Education in Context:

An Exploration of Urban Elementary Teachers' Personal Agency Beliefs

By

Jessica Gale
Master of Arts

Educational Studies

____
Professor George Engelhard Jr.
Advisor

____
Professor Magnia George
Committee Member

____
Professor Robert Jensen
Committee Member

Accepted:

____
Lisa A. Tedesco, Ph.D. Dean of the James
T. Laney School of Graduate Studies

____
Date

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Jessica Gale
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An abstract of
A thesis submitted to the Faculty of the
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Abstract

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Despite decades of science education reform, science education is still neglected in far too many of our nation's elementary schools (Jones et al., 1999; Spillane, Diamond, Walker, Halverson, & Jita, 2001). Because elementary teachers are ultimately responsible for implementing science reform initiatives, revitalizing science education requires a greater understanding of the beliefs elementary school teachers hold regarding their roles as agents of science education reform. At the same time, because elementary science education reform is enacted within complex educational environments comprised of multiple and often competing programs and initiatives, the beliefs of teachers must be considered within the context of state, district, and local school reform activities. The purpose of this study is two-fold. First, an online survey was conducted to identify the personal agency beliefs (Ford, 1992) that exist among elementary teachers (n = 109) in one urban school district. According to Ford's framework, personal agency beliefs consist of teachers' beliefs about their capability (self-efficacy beliefs) and their beliefs about the responsiveness of their school context. Using three scales, this study surveys elementary teachers' self-efficacy beliefs, their beliefs about the environmental factors that would enable them to teach science effectively, and their beliefs about the likelihood that such environmental factors will occur at their school. Second, the study explores patterns in elementary teachers' personal agency beliefs across six comprehensive school reform models. In essence, this is an exploratory study of elementary teacher beliefs in relation to school and district reform context. Implications for research, theory, and practice for policy and elementary science education are discussed.

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Table of Contents

List of Tables

Science Education Reform in Context:

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A recent publication by the National Research Council's Committee on Science Learning in Kindergarten through Eighth Grade begins with the following admonition:

> At no time in history has improving science education been more important than it is today. Major policy debates about such topics as cloning, the potential of alternative fuels, and the use of biometric information to fight terrorism require a scientifically informed citizenry as never before in the nation's history. Yet after 15 years of focused standards-based reform, improvements in U.S. science education are modest at best, and comparisons show that U.S. students fare poorly in comparison with students in other countries. (Duschl et al., 2007, p. 1)

This statement echoes the calls of practitioners, researchers, and policymakers who, for decades, have lobbied for the revitalization of elementary science education. The arguments for investing in elementary science education reflect a broad range of political, economic, and social goals. In addition to the need for a "scientifically informed citizenry" cited above, science education has long been implicated in our nation's pursuit of economic prosperity and global competitiveness (Garrett, 2008; National Commission on Excellence in Education, 1983). Researchers and activists committed to social justice and equity argue that opportunities to achieve scientific literacy represent not only a public good, but also a civil right (Tate, 2001). Further, achievement in science at the secondary and post-secondary levels depends on the interest and foundational knowledge cultivated in elementary classrooms (Logan & Skamp, 2008; Novak, 1992). Finally, research in cognitive development and the learning sciences has enriched our understanding of what children know and how they learn, providing convincing evidence that preschoolers and young elementary students begin formal schooling far better prepared to build scientific understanding than was once thought (Carey, 2000; Duschl et al., 2007).

Yet, in spite of longstanding concern for the state of science education and ongoing discourse around a science education reform agenda advocating "Science for All" (Barton & Osborne, 1995; Frazer, 1986; Hodson & Reid, 1988; Lee & Fradd, 1998; Lynch, 2001; Hoffman & Stage, 1993), science has long been marginalized as a "fringe subject" in American elementary schools (Jones et al., 1999; Spillane, Diamond, Walker, Halverson, & Jita, 2001). In their 1978 study, Stake and Easley concluded that:

> Although a few elementary teachers with strong interest and understanding of science were found, the number was insufficient to suggest even half of the nation's youngsters would have a single elementary year in which their teachers would give science a substantive share of the curriculum and do a good job doing it. (p.19)

Decades later, scholars continue to lament that "science class time, especially in the elementary grades, has been reduced to a vestigial organ whereby science is taught using traditional approaches or, in the worst cases, has been excised from the curricular body"(Goldston, 2005, p. 185). This statement accords with the results of a large-scale study of third-grade classrooms that found that teachers devoted only 6% of class time to science (NICHHD, 2005).

The neglect of science education, while widespread in American elementary schools, is particularly intense in urban public schools (Lynch, 2000; Tate, 2001).

Although the National Science Education Standards "emphatically reject any situation in science education where some people – for example, members of certain populations – are discouraged from pursuing science and excluded from opportunities to learn science" (p. 20), serious inequities persist. Students attending urban schools, and more specifically, students from historically marginalized groups who attend urban schools, face a sort of double jeopardy when it comes to science education. In addition to working against a legacy of oppression that has historically denied people of color and women access to the sciences, students growing up in high-poverty urban communities continue to be more likely than their counterparts in low-poverty communities to have teachers with little preparation to teach science, to attend schools with scarce resources for science teaching, and to have fewer opportunities to take the courses that would prepare them to pursue advanced coursework and careers in science (Lynch, 2000).

The disconnect between the vision of science education imagined by reformers and the realities of science education in urban elementary classrooms presents a puzzle for science education researchers. Given broad consensus on the importance of science education and decades of standards-based reform, how is it possible that the teaching of elementary science has not yet made the transition from passing fad to accepted practice? What will it take for science to finally secure a permanent place in the elementary curriculum? What catalysts and impediments exist to improving science education in urban elementary schools?

Although the undervaluing of science necessarily results from a complex set of interrelated factors, the failures of science education reform may be exacerbated by the systemic school reform agendas that predominate in large urban districts (Apple, 2006;

Hatch, 2002; Pringle & Carrier Martin, 2005; Razze, 2001; Tate, 2001). Knapp & Plecki (2001) identify an array of interdependent policies at the school, district, and state levels that influence science teaching and learning in urban schools. These policies include state standards; teacher recruitment, preparation, and certification policies; professional development and support policies; and assessment and accountability policies. For example, initiatives like the federal No Child Left Behind Act (NCLB) which hold schools accountable for student performance on high-stakes assessments in reading, language arts and mathematics have, as one researcher put it, "accentuated the undervaluing of science education"(Spillane et al., 2001, p. 926). Teachers report scaling back or abandoning science instruction altogether in order to focus on subjects included in state testing and accountability programs. In states where science has been added to assessment programs, there is growing concern that science instruction will be reduced to test preparation (Pringle & Carrier Martin, 2005). Tate (2001) calls for closer examination of possible tensions between the current wave of school reform policy and science education reform, stating that:

> Many have associated the reform of urban schools with accountability models, assessments, and standards. These policy instruments are having an effect on urban schooling. The fundamental question is whether these change mechanisms are producing the desired effect in science education. If they are not, then it is time to challenge them as obstacles to urban school students' opportunity to learn science, and ultimately to their civil rights (p. 1026).

This study takes up Tate's fundamental question by exploring the beliefs of elementary teachers currently implementing science education reform. Each school day elementary teachers make critical decisions about whether to teach science, how to teach science, and what science to teach. Given that "teachers work within policy environments as active agents, interpreting, 'brokering,' and coping with external demands, rather than passively and obediently complying with them" (Knapp & Plecki, 2001, p. 1093), understanding how elementary science education policy unfolds at the local level and how efforts to improve science education interact with other school reform activities will require careful consideration of the special role that elementary teachers play in the implementation process. Unlike secondary science teachers, whose professional development, content knowledge, and instruction typically focus on a single content area, most elementary teachers are generalists charged with teaching across all core subject areas including English/Language Arts, Mathematics, Social Studies, and Science. The work of elementary teachers is further complicated by expectations that initiatives in various subject areas originating at the school, district, and state levels are to be implemented simultaneously at the classroom level. While researchers and policymakers have continually cited the importance of creating coherence through reforms that complement one another, elementary teachers routinely negotiate multiple, often competing or even contradictory reforms implemented at the district, school, and classroom levels (Boum, 2008; Hatch, 2002; Honig & Hatch, 2004; Hatch, 1998; Newmann, Smith, Allensworth, & Bryk, 2001; Rorrer, Skrla, & Scheurich, 2008). Although elementary teachers are considered powerful agents of science education reform (Moore, 2008), prior research fails to appreciate how teachers exercise their agency within complex school reform environments. Therefore, this study advances an empirical understanding of teacher agency through an examination of teacher beliefs –

and specifically, elementary teachers' beliefs about their ability to realize the goals of science education reform.

Rationale

Research in a number of areas including teacher cognition (Spillane, Reiser, & Reimer, 2002), teacher beliefs (Beck, Czerniak, & Lumpe, 2000; Levitt, 2002; Lumpe, Haney, & Czerniak, 2000), and science policy implementation (Haney, Czerniak, & Lumpe, 1996; Knapp, 1997; Shaver, Cuevas, Lee, & Avalos, 2007; Smith & Southerland, 2007; Spillane & Callahan, 2000) confirms that what and how teachers think about science education influences reform initiatives where they matter most – in the classroom. Beliefs, in particular, are thought to have a profound influence on teachers' *approach* to policy implementation. In his exploration of the construct of teachers' beliefs, Pajares (1992) argues that beliefs serve as a filter through which teachers interpret new knowledge and phenomena. According to Pajares (1992), "clusters of beliefs around a particular object or situation form attitudes that become action agendas" (p.319). Haney, Lumpe, Czerniak, & Egan (2002) comment on the centrality of specific beliefs about science education reform, stating that "the beliefs that teachers hold regarding science reform ideas are truly at the core of educational change" (p.171).

Although researchers have begun to examine the relationship between teachers' beliefs and science education reform, this work has typically focused on teachers' responses to specific interventions (Ballone-Duran, Czerniak, & Haney, 2005; Haney, Czerniak, & Lumpe, 1996; Lee, Luykx, Buxton, & Shaver, 2007) or policies (Shaver, et al., 2007). For example, Haney, Czerniak, and Lumpe (1996) investigated factors influencing teachers' intentions to implement one state's competency-based science education reform program. They found that teachers' beliefs regarding teaching behaviors required by the reform significantly predicted their intentions to implement the various strands of the program. While such studies lend critical insight into how teachers interpret and implement particular reform efforts, little is known about how teachers' beliefs influence the implementation of policies that may or may not complement each other. The renewed focus on revitalizing elementary science education provides a critical backdrop against which to explore the beliefs of elementary teachers implementing science education reform within an array of interdependent policies in one urban school district.

Frameworks

Two frameworks provide the conceptual foundation for this study. Knapp and Plecki's framework for the renewal of urban science education guide the examination of the relationship between teachers' beliefs and school and district reform context. Ford's Motivational Systems Theory and, more specifically, his conception of personal agency beliefs, serve as the basis examining teachers' beliefs. Each of these frameworks is described below.

Knapp and Plecki's Framework for the Renewal of Urban Science Teaching

Knapp and Plecki (2001) provide a useful conceptual framework for understanding the specific policy signals at work in science education. Within this framework, Knapp and Plecki identify three sets of forces and conditions thought to drive events in urban science classrooms:

1. Interdependent policies at the school, district, state, and national levels that directly impinge on science teachers' work and careers.
2. Investment of resources at all levels and attempts to actualize these resources.
3. A professional, organizational, and community context that influences resource allocation. (p. 1092)

Knapp and Plecki describe an array of interdependent policies that interact with the conditions in urban schools to constitute what they refer to as the *teaching policy environment*. These policies include: curriculum guidance (formalized as standards, curricular frameworks or materials at the school, district, state, and national levels); assessment and accountability policies; teacher recruitment, preparation, and certification policies; hiring, staffing, and assignment policies, professional development and teacher support policies; compensation, reward, and evaluation policies; workplace redesign and support policies; and, policies aimed at special learning needs. Taken together, these policies combine to "present opportunities and constraints, catalysts and barriers, incentives and disincentives" for teachers ultimately responsible for policy implementation (Knapp & Plecki, 2001, p. 1092). The framework further specifies the aspects of science education influenced by this constellation of policies including: what is being taught, how science is being taught, who is teaching whom, student learning and performance, and teacher learning and colleagueship.

In addition to outlining the components of the teaching policy environment, Knapp and Plecki describe four dimensions that can be used to characterize teaching policy environments: coherence, comprehensiveness, intrusiveness, and stability.

Coherence is defined as the extent to which the different strands of policy offer mutually supportive guidance for science teaching. Comprehensiveness is the degree to which the array of policies touch all aspects of science teachers' work. Intrusiveness has to do with whether policies are designed and enacted in ways that make immediate demands on science teachers versus exerting little or no pressure on teacher practice. Stability refers to the extent to which policies remain constant within the teaching policy environment. For this study, the teaching policy environment, as described by Knapp and Plecki, provides a useful conceptual lens for understanding the context of science education reform at each of the schools in the participating district.

The policy contexts in which elementary teachers are expected to work as agents of science education reform are complex. With layers of interrelated policies being lived out within layers of interrelated contexts (i.e. classroom, school, and district), it is no wonder that science education researchers have so often focused their inquiry on isolated policies and initiatives. Knapp and Plecki's framework, while it is as multidimensional as the arena it seeks to describe, provides a clear starting point for researchers interested in exploring the complex world of elementary science education.

Ford's Motivational Systems Theory

Ford's Motivational Systems Theory (MST) synthesizes a diverse array of existing motivation theories in order to identify factors that can account for individual competence and goal-attainment in a given area (e.g. science teaching). According to MST, motivation is comprised of goals and personal agency beliefs. Ford (1992) defines goals as "thoughts about desired states or outcomes that one would like to achieve" (248) and personal agency beliefs as "anticipatory evaluations about whether one can achieve a goal" (p. 45).

Ford describes two components of personal agency beliefs: capability beliefs and context beliefs. Capability beliefs, which are thought to be synonymous with Bandura's concept of self-efficacy (Haney, et al. , 2000), reflect an individual's expectancies about their own capability to attain certain goals. Context beliefs refer to an individual's expectancies regarding the responsiveness of their environment. Ford argues that, in combination, capability and context beliefs form personal agency beliefs. Drawing on Ford's theory, Lumpe, Haney, and Czerniak (2000) propose that personal agency beliefs can be examined using the Science Teaching Efficacy Beliefs Instrument (STEBI) (Riggs & Enochs, 1990) in conjunction with the Enable (CBATS – E) and Likelihood (CBATS-L) Scales of their Context Beliefs about Teaching Science instrument.

In discussing the interaction between context and capability beliefs, Ford outlines a taxonomy that includes the following ten conceptually distinguishable personal agency belief patterns: Robust, Tenacious, Modest, Fragile, Tenacious, Self-Doubting, Accepting, Antagonistic, Discouraged, and Hopeless. In his discussion of the taxonomy, Ford notes that while the Robust, Tenacious, and Modest patterns may generally be more adaptive, no single pattern is best for all circumstances. For example, a Self-Doubting pattern may be much more suitable than a Robust pattern in situations where individuals are engaged in risky behaviors (i.e. compulsive gambling, drinking and driving).

Ford (1992) suggests that "personal agency beliefs play a particularly crucial role in situations that are of the greatest developmental significance - those involving challenging but attainable goals" and that "they are often key targets of intervention for parents, teachers, counselors, and others interested in promoting effective functioning" (pp. 124-125). If we acknowledge that, for elementary teachers, the goals of science education reform fall into this "challenging but attainable" category, teachers' personal agency beliefs emerge as an important area of inquiry.

For the purposes of this study, personal agency beliefs are conceptualized as elementary teachers' anticipatory evaluations of their own ability to implement the district's current science education reform initiative. More specifically, teachers' personal agency beliefs are viewed in terms of their self-efficacy beliefs, their beliefs about the environmental factors that would support effective science teaching, and the likelihood that such factors would occur within their school context as measured by the STEBI, CBATS-E, and CBATS-L scales, respectively.

Purpose of the Study

The purpose of this study is two-fold. First, the study explores the beliefs related to science education and reform that exist among elementary teachers in one urban school district. Specifically, building on prior research in this area, the study assesses elementary teachers' beliefs about their own capability and their beliefs about whether their school context enables effective science teaching. Second, the study contextualizes teachers beliefs by examining the relationship between elementary teachers' personal agency beliefs and the unique teaching policy environments in which science education reform is enacted. To this end, variations in teacher beliefs are examined across individual various comprehensive school reform models that, in many ways, define the teaching policy environments at individual schools within this district.

Research Questions

The following research questions guide this study:

1. What science self-efficacy beliefs exist among elementary teachers in this urban district?

2. What context beliefs exist among elementary teachers in this urban district?

    a. What environmental factors do elementary teachers believe would enable them to teach science effectively?

    b. What environmental factors do elementary teachers believe are likely to occur at their schools?

    c. To what extent do elementary teachers believe that the environmental factors that would enable effective science teaching are likely to occur at their schools?

3. Do self-efficacy beliefs and/or context beliefs vary across the comprehensive school reform models implemented in the district?

Significance of the Study

The results of this study will be of interest to educators, school leaders, policy-makers, and designers of science curricula and professional development opportunities. The study is the first to focus on personal agency beliefs of a sample of urban elementary teachers and the first to examine personal agency beliefs in relation to school policy contexts. These data could heighten school leaders' awareness of the challenges teachers face and the strategies they employ when integrating reform initiatives at the classroom level. Identifying such school-level strategies could strengthen efforts to implement science reform alongside the variety of initiatives and programs that comprise the teaching policy environments in the participating school district. At the same time, a more complete picture of the ways in which the teaching policy environment may influence teachers' beliefs about science education reform has the potential to enhance efforts to select and implement reform initiatives in ways that complement the science education reform agenda.

At the policy level, this study lends insight into teachers' mindsets about science education reform as they interact with assessment, curriculum, and accountability policy. Such insights have the potential to help policymakers anticipate the challenges educators face when simultaneously implementing strands of education policy that may originate from different sources, have discrepant or even competing goals, and require different modes of teaching and learning. To the extent that teachers report success in meeting the demands of both science education reform and education policy writ large, the current study documents the teacher beliefs and teaching policy environments that may underlie that success.

Finally, this study addresses several methodological limitations evident in previous studies of teachers' beliefs. Most notably, Rasch measurement is utilized to more accurately examine teachers' personal agency beliefs. In previous studies, personal agency belief patterns have been assigned primarily by grouping teachers according to their total scores on measures of capability and context beliefs (Lumpe, Haney, Czerniak, 2000; Haney, Lumpe, Czerniak, 2002). This strategy carries the risk of misrepresenting variation in teachers' reported capability and context beliefs and, consequently, misclassifying teachers' personal agency belief patterns. By using Rasch measurement to examine differential responding among teachers and across comprehensive school reform models, more accurate measurement of personal agency beliefs can be achieved.

Definition of Terms

The following terms are central to the study. For each term, both a general definition and a statement regarding the specific operationalization and use of the term for this study are given.

Context Beliefs

Context beliefs are beliefs about the responsiveness of one's environment regarding the attainment of a specific goal (Ford, 1992). In this study, elementary teachers' context beliefs, which are measured using the Enable and Likelihood Scales of the CBATS instrument, represent teachers beliefs about the aspects of the school context enable effective science teaching and their beliefs about whether these aspects are likely to occur at their schools.

Capability Beliefs

Capability beliefs are beliefs about one's competency in a certain area or capability to attain a specific goal, synonymous with Bandura's self-efficacy construct (Ford, 1992). Using the Science Teaching Efficacy Beliefs Instrument (STEBI), this study examines elementary teachers' beliefs about their capability to teach science.

Personal Agency Beliefs (PAB)

A composite of context and capability beliefs, personal agency beliefs are anticipatory evaluations about one's ability to attain a specific goal. Using the Science Teaching Efficacy Beliefs Instrument (STEBI) instrument and the Enable (CBATS-E) and Likelihood (CBATS-L) Scales of the Context Beliefs about Teaching Science (CBATS) instrument, this study examines both context and capability beliefs in order to profile elementary teachers' personal agency beliefs regarding their ability to effectively teach science within their local school contexts.

Science Education Reform

A broad range of policies, initiatives, and programs intended to improve science teaching and learning. The primary vehicles for science education reform relevant to this study are State Science Standards and a district-wide Math/Science Initiative.

Comprehensive School Reform

A school reform agenda initiated by the district's Superintendent during the 1999-2000 academic year requires all Title 1 schools in the participating district to implement a research-based comprehensive school reform model. This federal legislation defines comprehensive school reform as an approach that:

> integrates a comprehensive design for effective school functioning, including instruction, assessment, classroom management, professional development, parental involvement, and school management, that aligns the school's curriculum, technology, and professional development into a comprehensive school reform plan for school wide change designed to enable all students to meet challenging State content and student academic achievement standards and addresses needs identified through a school needs assessment. (Cross, 2004, p.111)

An array of comprehensive school reform models, most often developed by external agencies, are implemented in urban elementary schools (Cross, 2004). Teachers participating in this study reported that, during the school year in which data were collected, their schools were implementing the following six comprehensive school reform models: Core Knowledge, Direct Instruction (DI), International Baccalaureate (IB), Pearson Learning Solutions, Project Grad, and Success for All.

Teaching Policy Environment

The teaching policy environment is the context in which teachers' work as active, implementing agents. The teaching policy environment is characterized by the conditions that exist in individual schools as they interact with a wide variety of policies including: curriculum guidance (standards, curricular frameworks or materials at the school, district, state, and national levels); assessment and accountability policies; professional development and teacher support policies; and, workplace redesign and support policies. In this study, the teaching policy environment is operationalized by examining differences across the comprehensive school reform models implemented in the district. In the participating district, each school's comprehensive school reform model has implications for many of the polices enacted at the school level (e.g. accountability, assessment, curriculum); therefore, comprehensive school reform models are used as an index of each school's teaching policy environment.

Literature Review

The literature review is organized into two sections. First, guided by the Knapp and Plecki (2001) framework, the review surveys scholarship on the influence of education policy and school and district contexts on elementary science education and reform. After a brief discussion of the nature of teachers' beliefs, the second section of the review describes previous studies examining teachers' personal agency beliefs as conceptualized by Ford's Motivational Systems Theory.

Search Methodology

Literature for this review was initially identified for inclusion by conducting a series of searches of ERIC (US Department of Education) and JSTOR databases. With the goal of locating material on elementary science education policy and reform, the initial search included the key words: *elementary science education reform and elementary science education policy.* Because searches for broad terms like *education reform, standards,* and *accountability* would return an unmanageable number of sources, searches on these terms were cross-referenced with searches for *science education* and *elementary science* to identify articles relating specifically to both elementary science education and major trends in education reform. As Pajares (1992) notes, in the literature teacher beliefs often "travel in disguise" as a number of related constructs including: values, judgments, opinions, perceptions, conceptions, preconceptions, dispositions, practical knowledge, and perspectives (p. 309). Therefore, searches for the key terms *self-efficacy beliefs, capability beliefs,* and *personal agency beliefs* were supplemented with searches using various keywords including: *teacher beliefs, teacher perceptions, teacher practical knowledge, teacher intentions, teacher dispositions, and teacher conceptions.* Again, because searching these terms alone generated too many search results, they were cross-referenced with searches on terms specific to science education and science education reform. After literature was identified for review, I referred to bibliographies of each article to identify additional references.

The subsequent literature review addresses the forces and conditions influencing efforts to improve science teaching and learning and the beliefs of elementary teachers working as agents of science education reform. While this should not be regarded as an exhaustive review, studies that typify the findings, strengths, and limitations of relevant research are included.

Education Policy and Elementary Science Education Reform

This section of the review highlights relevant research on the implementation of science education reform. More specifically, this section presents research on three forces identified in Knapp and Plecki's framework (2001) as key drivers of events in urban science classrooms: interdependent school, district, and state policies; resource allocation; and, professional, organizational, and community context.

Interdependent School, District, and State Policies. Although science education researchers are becoming increasingly interested in the opportunities, challenges, and risks that the current climate of education reform poses for elementary science education, empirical work in this area remains scarce. Appleton (2007) comments on this scarcity in a review of elementary science teaching included in the recent edition of the *Handbook of Research on Science Education*:

> I attend conferences such as AERA and NARST, where teachers recount horrific stories of curriculum limitation, dispirited teachers, and jaded students constrained by so-called reform high-stakes testing regimes; but little of this has actually been published … more research into the consequences of the reform initiatives on elementary science teaching and learning needs to be published. (p.505)

In spite of the paucity of research in this area, the work that does exist lends support to Knapp & Plecki's characterization of the teaching policy environment. There is little doubt that the various policy influences in the framework, from accountability policy to district professional development programs, do indeed "present opportunities and constraints, catalysts and barriers, incentives and disincentives" for science teaching and learning (Knapp & Plecki, 2001, p.1092). The challenge for education researchers is to clarify how policies within the teaching policy environment interact and what these interactions mean for teachers and students as they pursue the goals of science education reform.

The teaching policy environment is hierarchical in nature, with state policies nested within federal policies, district policies nested within state policies, and school policies nested within district policies. This hierarchy means that agents at each level must interpret policy that they themselves did not develop and integrate these policies with their existing goals and practices. In an effort to illuminate how district policy makers interpret state and federal policy, Spillane & Callahan (2000) explored responses to state science standards across nine Michigan school districts. Through interviews with district office administrators, district science specialists, principals, and teachers, the researchers found some interesting disconnects between the intentions of the state policy and the interpretations at the district and local levels. Although all of the districts appeared to attend to state standards, substantive changes in the science content and pedagogy were often lost in translation between the state and district levels. For example, only three of the nine districts made efforts to refocus the K-12 curriculum to reflect the goals of scientific inquiry and intellectually rigorous science at the core of the state's new standards. In describing reform efforts in their districts, participants were much more likely to use familiar terms to articulate their interpretations of the science reforms than they were to discuss the concepts that were central to the reforms. For instance, almost

83% of the participants used the term “hands-on” to describe state and national science reforms. Although the new standards emphasize constructivism and conceptual change approaches to science teaching and learning, only 13% of participants mentioned “constructivist learning” and less than half (45%) discussed improving students’ conceptual understanding.

Other scholars have investigated the specific implications of the recent *No Child Left Behind Act* for science education. Cavanagh (2004) argues that the *No Child Left Behind Act* has prompted teachers to move away from hands-on, inquiry instruction in favor of direct instruction approaches to science teaching. Beginning in 2007, the federal law required districts to administer standardized tests in science and by 2014, to include student performance on science assessments in the calculation of Annual Yearly Progress (AYP). According to Cavanagh, these developments have forced schools to consider cutting back on the in-class science experiments and hands-on activities advocated by reform documents such as the *Benchmarks for Science Literacy* (AAAS, 1993) and the *National Science Education Standards* (NSES) (NRC, 1996). In spite of these potential changes in instruction brought about by the increased emphasis on standardized testing in science, Cavanagh (2007) notes the possibility that with increased accountability and testing, teachers could regain time for science instruction that had been lost due to a narrow focus on mathematics and literacy. Aronson and Miller (2007) further explore the tensions and challenges for science education embedded in the implementation of *No Child Left Behind*, arguing that there exists an imperfect alignment between inquiry-based instruction and the kinds of science learning assessed by the high-stakes assessments. An emphasis on test preparation, Aronson and Miller contend, could reduce instruction to a narrow set of discrete scientific facts that appear on assessments rather than fostering the creative and integrated approach to science teaching that is called for by the NSES.

Although empirical evidence documenting actual changes in science instruction as a result of *No Child Left Behind* and related policies is limited, researchers have investigated teachers' perceptions of the influence of standards, assessment, and accountability policy on science education. A recent study by Shaver, Cuevas, Lee & Avalos (2007) asked elementary school teachers how educational policies affected their science instruction. The study employed a questionnaire followed by focus group interviews with 43 third and fourth grade teachers from six elementary schools in a large urban school district. The results indicated that teachers' opinions concerning all areas of policy evolved as the state enforced stronger measures of accountability during the two-year period of the study. Although the teachers had relatively positive opinions regarding standards, their opinions about the effects of statewide assessment and accountability policies on science became increasingly negative. Shaver and colleagues describe teachers' perceptions of accountability policy, stating that "with one voice they complained about the insistence of their administrators that they teach to the test, emphasizing reading, writing, and mathematics, while reducing or even eliminating instruction in science and other subjects" (p. 734).

These results were consistent with a study by Pringle and Carrier Martin (2005) that explored the potential impact of impending standardized testing on science teaching in one urban district. The study surveyed elementary teachers' concerns about the upcoming high-stakes tests in science asked teachers to comment on what changes, if any, they expected in the approach to science teaching and learning in their classrooms. Teachers' concerns fell into five categories: concerns about the effects of poor reading skills on student performance, time constraints to include science lessons in the school day, too much emphasis being placed on standardized testing, teacher preparedness for science instruction, and lack of familiarity with the test format. The study found that as teachers looked toward increased testing in science, they renewed their commitment to teach science; however, this commitment was generally not based on a belief in the importance of science but rather on the effects of tangible rewards or punishments that accompany high stakes testing. The prediction of one veteran teacher is telling:

> Teachers will lose sight of the wonder and motivation that science can be to students. I am torn between being happy that science is finally being attended to by our district and feeling disappointed that we as educators are being motivated toward change by fear of a test (Pringle & Carrier Martin, 2005, p.8).

In anticipation of the new tests, the teachers participating in this study prepared to align their teaching to science standards while aggressively searching out test preparation materials. Recognizing that their study is limited by its focus on teachers' predictions and intentions regarding future reform, Pringle and Martin call for additional research that highlights how teachers' interpretations of standards are translated into teaching and learning activities.

In addition to widespread concern about individual policies (e.g. NCLB) or types of policy (e.g. accountability) directly impinging on science teaching, researchers have also emphasized the importance of coherence among the many policies that ultimately come to rest in elementary school classrooms (Hatch, 1997, 2002; Knapp, 1997; Marx, Blumenfeld, Krajcik, Fishman, Soloway, Geier, Tal, 2004). Understanding the need for coherence requires an appreciation of just how busy teaching policy environments can be. Hatch (2002) reports that in a 1998-99 survey of school principals in the San Francisco Bay Area, 52% stated that their schools were implementing three or more programs or partnerships created by local groups and nationally known organizations and 15% reported implementing six or more different programs or partnerships. Follow-up surveys with comparison districts in California and Texas indicated that 63% of schools were involved with at least three programs and 27% were involved with six or more. One district reported that 18% of its schools were simultaneously implementing nine or more different programs. Hatch (1998) discusses the consequences of incoherence, asserting that:

> while many new practices, policies, and reform efforts may make sense in their own right, teachers and schools are frequently left to try to integrate and coordinate these varied initiatives when they have neither the resources nor the time to do their work well in the first place. (p. 626)

Knapp and Plecki define coherence within the science teaching policy environment as “the extent to which different strands of policy offer mutually supportive guidance for science teaching” (p. 1092). Given that policies often fail to provide such mutually supportive guidance, Knapp and Plecki contend that “the teaching policy environment often projects mixed messages about the importance of science and how it will be supported” (p.1092). Although the coherence of the teaching policy environment for science teaching has not been a major topic of research, one study investigating the effects of inquiry-based science education in urban elementary schools does illustrate the importance of coherence. Marx and colleagues (2004) report student learning data from a three-year-long science education collaboration with the Detroit Public Schools. The researchers collected student learning data from a district-wide sample of nearly 8,000 students who participated in curriculum units that emphasized inquiry and technology. The findings indicated statistically significant increases in curriculum-based assessments for each year of participation and increasing strength of the effects over the three-year implementation period. The researchers attribute the success of the reform, in large part, to coherence, stating that:

> reform programs that address the range of elements needed for coherence can succeed in urban settings. A combination of carefully designed curriculum materials, learning technologies that are embedded in the materials and serve the needs of learners, quality professional development, and policies that support reform are necessary. (p. 1075)

Comprehensive School Reform. One way that schools have attempted to address the problem of incoherence is through the adoption of “whole-school” reform programs. Specifically, the Comprehensive School Reform Demonstration program, authorized by Congress in 1998, provided $145 million for schools to implement “comprehensive” school reform models. These models, developed either by an external organization or by individual schools, are intended to foster coherence by integrating all aspects of school functioning including instruction, assessment, classroom management, professional development, parental involvement and school management. Although the definition of “comprehensive school reform” included in the federal legislation explicitly states that such programs should include all subject areas, many popular school reform models (e.g.

Direct Instruction, Success For All, Core Knowledge) tend to focus on reading, language arts, and mathematics (Northwest Regional Educational Laboratory, 2006). Further, the extent to which comprehensive school reform models are designed to permit the type of inquiry-based science instruction called by science education reformers remains unclear. To date, there have been no studies examining the specific effects of comprehensive school reform programs on elementary science education. Studies evaluating comprehensive school reform initiatives often focus on outcomes in reading, language arts, and mathematics while paying little attention to achievement in science. For example, in their meta-analysis of studies evaluating 29 nationally implemented comprehensive school reform (CSR) models, Borman, Hewes, Overman, and Brown (2003) rank reform models according to whether they have "strong evidence of effectiveness" and conclude that, overall, the effects of CSR on student achievement are promising (p. 31). However, taken together, the 232 studies compiled for the meta-analysis included far more independent samples for reading (1,017) and math (679) achievement than they did for either science (229) or social studies (138). Additionally, it should be noted that two of the three reform models designated as having "strong evidence of effectiveness," Direct Instruction and Success For All, emphasize reading and, to a lesser extent, mathematics, but generally do not include a science education component.

Perhaps most disconcerting, many of the most widely implemented comprehensive school reform models are grounded in philosophies of teaching and learning that conflict with the modes of teaching and learning advocated by science education reformers (Duschl et al. , 2007). Although a thorough exploration of these conflicts would be beyond the scope of this paper, examples from one popular conservative reform movement, Direct Instruction, begin to illustrate the tensions that can exist between comprehensive school reform models and elementary science education.

Initially developed by Siegfried Engelmann in the 1960s, Direct Instruction applies behaviorist learning theory to classroom instruction. Much like the rats in B.F. Skinner's laboratory, the learning and behavior of students in a D.I. classroom are regulated through a repetitive, teacher-directed stimulus-response cycle. The National Institute for Direct Instruction (NIFDI), which oversees the implementation of direction instruction, describes the program as:

> a model for teaching that emphasizes well-developed and carefully planned lessons designed around small learning increments and clearly defined and prescribed teaching tasks. It is based on the theory that clear instruction eliminating misinterpretations can greatly improve and accelerate learning (http://www.nifdi.org/index.html#what%20is).

In practice, "carefully planned lessons," "clearly defined and prescribed teaching tasks," and "clear instruction eliminating misinterpretations" amount to traditional, teacher-directed instruction. In a typical lesson, the teacher tells students the answer to a question ("This word is cat"), asks a question ("What word"?), gives a verbal signal (often "Get Ready" accompanied by a finger snap, or in some cases the click of a dog-training device), and students repeat the answer back to the teacher in unison ("cat"). At this point, depending on the students' performance, the teacher either offers positive reinforcement ("yes, cat") or a correction ("no. This word is cat.") This sequence is repeated within lessons until all students are “firm” on a particular item and reinforced by review of each item across many lessons.

Although Direct Instruction is not generally prescribed as an instructional program in science, the program’s behaviorist foundation has clear implications for science in the elementary classroom. First, rigid, repetitive instruction is time-consuming, with Direct Instruction lessons in literacy commonly consuming up to three hours of each school day. When instructional time for other core subject areas (mathematics, language arts, writing) along with regular school day activities (lunch, restroom breaks, assemblies) are accounted for, time for science (and social studies) in Direct Instruction schools becomes scarce. This scarcity is only compounded by the fact that the program’s script does not permit any meaningful integration of science and literacy or science and mathematics, a strategy that elementary teachers have found promising as dedicated science time has been stripped from school schedules (Lundstrom, 2005). Second, and perhaps even more problematic for science education, behaviorist instruction has little to offer when it comes to fostering students’ conceptual development in science. Given the recommendations for science teaching and the processes of science learning emphasized in recent science education reform documents (e.g. Duschl et al. , 2007), fostering science learning in a Direct Instruction classroom would require teachers to negotiate discrepant visions of the ways teachers and students ought to engage with each other, their classroom environment, and the curriculum.

Given the prominence of comprehensive school reform programs in elementary schools across the nation, researchers interested in clarifying the relationship between education policy and science education reform should begin to look more closely at whether and how CSR models support the goals of science education reform.

Resource allocation. Knapp and Plecki define resources broadly, stating that "in their daily work teachers and students in conjunction with one another convert temporal, material, intellectual, and social resources into learning" (p. 1093). The resources thought to be of particular importance for science teaching include the allocation of time within the day, the week, and the school year; access to natural phenomena; teachers' intellectual resources (e.g. PCK); and, social resources characterized as "teachers' and learners' attitudes toward learning, science, and each other" (p. 1094).

A common refrain in the literature is that as districts and schools have focused on reform aimed at improving student achievement in reading, language arts, and mathematics, fewer resources have been devoted to elementary science education. Unfortunately, few studies have actually investigated investment in science at the school and district levels. One notable exception is a particularly revealing qualitative study examining the identification and allocation of resources for science education in urban elementary schools (Spillane, Diamond, Walker, Halverson, & Jita, 2001). A qualitative analysis of resource allocation across thirteen Chicago elementary schools revealed that investment in science was consistently limited relative to other subject areas. However, the study also found that it was not merely the presence or absence of resources but whether and how resources were identified and activated that accounted for differences in schools' commitment to science education. Within some schools, the devaluing of science education had come to be expected and was conceptualized by teachers and administrators as a "necessary evil" or simply as the "rules of the game." Not surprisingly, schools where this mindset about science education predominated were not likely to pursue innovation or improvement in science instruction in any serious way. On the other hand, in schools where teachers were invested in improving science education, limited resources were parlayed into substantive efforts to lead change in science education, even when science had not yet made it onto the school administrator's reform agenda.

Similar findings emerged from another study of urban schools' capacity to support change in mathematics and science (Gamoran, Anderson, Quiroz, Secada, Williams, Ashmann, 2003). This study analyzed the availability of resources across six "design collaboratives" comprised of urban schools in which teachers worked with researchers to improve their ability to teach for understanding in math and science. Similar to Knapp and Plecki and Spillane et al. (2001), the authors of this study define resources broadly to include material resources (e.g.: time and curricular materials), human resources (e.g.: expertise), and social resources (e.g.: professional collaboration). Over 60% of the teachers interviewed for the study named time as a valuable resource and the majority of these teachers noted that the best use of time was planning and learning with other teachers. The relative importance of time is evident in one teachers' comment that "money and verbal support from people around you is important, but I think in the long run if you don't have the time, you can't do it" (p. 68). Human resources found to be particularly important for the six collaboratives included the expertise of researchers who could help teachers build on their limited knowledge of student thinking. Although some schools reported having certain district or school leaders who were instrumental in their growth, the leadership of expert teachers was found to be even more consequential. Acknowledging the importance of coherence among social resources at the school and district levels, the researchers note that" outside expertise can have an impact only if it is perceived to be consistent with, or at least not opposed to, other district initiatives that affect the same teachers" (p. 73). In their analysis of the effect of colleagueship among teachers, the researchers found that professional development was enhanced by the presence of a strong existing colleague group. Interestingly, in addition to showing the many ways in which material, human, and social resources influenced professional development, the researchers also found evidence that professional development influenced the availability of resources. In addition to fostering increases in the expertise and the development of stronger colleagueship among participants, at some sites, the professional development initiative improved the availability of material resources. For example, teachers who participated in the program created curriculum materials that could be circulated among sites. The authors also note that the professional development created incentives for continuing the collaboration, either by generating additional resources or reallocating existing resources.

Professional, organizational, and community context. Knapp and Plecki contend that the actualization of resources is mediated by professional, organizational, and community contexts. Examples of context mediating efforts to improve science education are evident in the previous discussions of interdependent policies and resource allocation. For example, Spillane et al. (2001) and Gamoran et al.'s (2003) studies of resource allocation suggest that teachers' commitment to science teaching and learning was dependent not only on the availability of resources but also on whether schools' had strong professional peer communities dedicated to science education. Indeed, numerous studies have found that teachers' ability to translate policy into practice can be constrained by a number of external contextual factors (Pedretti & Hodson, 1995; Abell & Roth, 1992; Cornbleth, 2001).

Pedretti and Hodson (1995) conducted a study on implementing Science Technology and Society (STS) programs through action research and concluded that working directly with teachers may not be enough to significantly impact the implementation of the STS curriculum. The authors contend that contextual factors such as the structure of the school system including its bureaucracy, administrative procedures, and values can encourage traditional approaches to teaching and, consequently, compromise meaningful science learning. Similarly, Cornbleth (2001) describes how school climate can constrain teachers as they work to implement new curricula or change their teaching practice. More specifically, Cornbleth notes that bureaucratic school climates often foster a "law and order" climate in which following school-wide rules (e.g. attendance, dress codes, grading) and maintaining clean, quiet classrooms take precedence over intellectual risk-taking and inquiry at the heart of science education reform.

In summary, science education reform, like any effort to foster educational change, does not occur in isolation. Interdependent policies, resource allocation, and professional, organizational, and community contexts all have implications for whether and how elementary teachers are empowered and motivated to teach science. Just as these factors help explain teachers' beliefs about science education and reform, teachers' beliefs may also help us better understand the complexities of local policy implementation. This prospect is well articulated by Nespor (1987), who stated that "the contexts and environments within which teachers work, and many of the problems they encounter, are ill-defined and deeply entangled … beliefs are peculiarly suited for making sense of such contexts" (p. 324). Of particular interest for the current study is the relationship between the teaching policy environment and teachers' beliefs about their ability to work as agents of reform.

The Nature of Teachers' Beliefs

In his oft cited review, Pajares (1992) calls teacher beliefs a "messy construct," and for good reason. According to Pajares, the difficulty in studying teacher beliefs stems from "definitional problems, poor conceptualization, and differing understandings of belief structures" (p.307). Science education researchers, having done their part to "mess up" the teacher beliefs construct, are not immune to this difficulty. A survey of the science education literature reveals teacher beliefs as a sort of moving target, continually defying consistent definition or application. Consequently, examining previous research on elementary teachers beliefs about science education and reform requires first considering the nature of beliefs and the variety of definitions in circulation.

Although there is no simple answer to the question "What is a belief?," Pajares reviews the definitions proposed by a number of theorists. Pajares tells us that these definitions include Sigel's assertion that beliefs are "mental constructions of experience - often condensed and integrated into schemata or concepts" (cited in Pajares, 1992, p. 351). Similarly, Nisbett & Ross describe beliefs as "reasonably explicit propositions about the characteristics of objects and object classes" (p. 351). Brown and Cooney (cited in Pajares, 1992) emphasize the relationship between beliefs and action, stating that beliefs are "dispositions to action," which are both time- and context-specific. Rokeach (cited in Pajares, 1992) offers what may be the most encompassing and, as Pajares notes, circular definition of beliefs as “any simple proposition, conscious or unconscious, inferred from what a person says or does, capable of being preceded by the phrase, ‘I believe that …” (p. 352).

In spite of this diversity of definitions, certain elements are shared across the various conceptualizations of teacher beliefs. Common propositions among the various definitions include the notion that beliefs are personal constructs, that they are not always logical, and that they are not consensus driven. According to Pajares, beliefs are differentiated from knowledge because they are based on subjective judgments rather than objective facts. At the same time, Loucks-Horsley et al. (1998) assert that “beliefs are more than opinions: they may be less than ideal truth, but we are committed to them” (p. 27).

Given the elusive nature of teachers’ beliefs, Pajares argues that in order to be useful, the overarching construct of teachers’ beliefs, like all broad psychological constructs, must “come before the reductionist, multidimensional, or hierarchical chopping block to better suit the needs and requirements of research” (p. 315). Accordingly, Pajares advises researchers that “*educational beliefs about* are required” (p.316). That is, when studying teachers’ beliefs, it is necessary to specify the particular type of beliefs under investigation - to note first that the research concerns teachers’ *educational beliefs,* rather than their general belief-systems, and to further designate what the targeted educational beliefs are about. With this advice in mind, the following sections review research focusing on elementary teachers’ beliefs about their ability to achieve the goals of science education reform (i.e. personal agency beliefs).

Personal Agency Beliefs

In their attempts to identify factors that motivate people to achieve particular goals, theorists have reserved a special role for beliefs (Maslow, 1943; Deci & Ryan, 1985; Bandura, 1986). Many researchers have investigated teachers' self-efficacy, defined by Bandura (1986) as "beliefs in one's capabilities to organize and execute the courses of action required to produce given attainments" (p.391) (e.g. Tobin, Tippins, & Gallard, 1994). This line of research has provided strong evidence that self-efficacy is related to successful science teaching (Tobin, Tippins, & Gallard, 1994; Czerniak & Shriver, 1994) and that increasing self-efficacy could empower teachers to work more purposefully toward their goals (Roberts, Henson, Tharp, & Moreno, 2001). For example, Czerniak and Shriver (1994) found that pre-service science teachers with high self-efficacy tended to use a variety of instructional strategies, in contrast to teachers with low-self efficacy, who relied primarily on the textbook. Similarly, through the analysis of teaching videos, Riggs, Enochs, and Posnanski (1991) found that teachers with high self-efficacy and high expectations for their teaching outcomes covered science content and skills more thoroughly, asked more open-ended questions, checked more frequently for student understanding, and connected content to students' lives more often than teachers with low-self efficacy.

In considering factors that may motivate elementary teachers to teach science, it is imperative to recognize that teachers' beliefs, in general, and their self-efficacy beliefs, in particular, do not exist in isolation but in relation to teachers' other belief structures and the real world teaching context. As Pajares (1992) notes, Bandura acknowledged that "self-efficacy, a belief sub-construct, is too broad, vague and context free to be useful" and that "self-beliefs must be context specific and relevant to the behavior under investigation to be useful to researchers and appropriate for empirical study" (p.315). Indeed, studies have demonstrated a relationship between contextual factors and teachers' self-efficacy for science teaching. For example, Ramey-Gassert, Shroyer, and Staver (1996) examined factors associated with elementary teachers' science teaching efficacy. The researchers found that teachers' science teaching self-efficacy was related not only to antecedent factors (previous science experience, teacher preparation, science teaching experiences) and internal factors (attitudes toward and interest in science), but also to a number of external factors including the school workplace environment, student variables, and community variables.

Ford's Motivational Systems Theory (1992) synthesizes existing motivation theories to provide a framework for examining individuals' capability beliefs (synonymous with Bandura's self-efficacy beliefs) in conjunction with their beliefs about their context. Ford argues that capability and context beliefs combine to form personal agency beliefs, defined as anticipatory evaluations about one's ability to attain a specific goal. Ford theorizes that such judgments reflect both our beliefs about our own capability and our beliefs about the responsiveness of our environment. Within this framework, it is possible for individuals to believe very highly of their own capability but doubt their ability to achieve a specific goal because they also believe that their environment is not responsive to their needs. Conversely, an individual with doubts about their own capability may judge that a responsive environment could enable them to realize their goals. Ford's taxonomy theorizes the following ten possible personal agency belief (PAB) patterns: Robust, Modest, Fragile, Tenacious, Vulnerable, Self-doubting, Accepting, Antagonistic, Discouraged, and Hopeless. (See Ford, 1992 for a discussion of each of these personal agency belief patterns).

In my review of the literature, I identified four studies (Lumpe, Haney, Czerniak, 2000; Haney, Lumpe, Czerniak, & Egan, 2002; Andersen, Dragsted, Evans, & Sorensen, 2004, and Bhattacharyya, Volk, & Lumpe, 2009) that examine personal agency beliefs for science teaching. Each of these studies are reviewed below.

In the first study, Lumpe, Haney, and Czerniak (2000) employ Ford's Motivational Systems Theory to develop a measure of teachers' beliefs about their science teaching context. The resulting Context Beliefs about Teaching Science (CBATS) instrument includes 26 items (rated on a five point scale) and is designed to measure a) teachers' beliefs about the degree to which certain environmental factors would enable effective science teaching and b) teachers' beliefs about the likelihood of each factor occurring in their schools. The authors propose that the CBATS could be used in conjunction with existing science teacher self-efficacy measures, such as the Science Teaching Efficacy Belief Instrument (STEBI) (Riggs & Enochs, 1990), to construct profiles of teachers' personal agency belief patterns.

In their efforts to validate the CBATS instrument, Lumpe et al. surveyed a sample of 262 K-12 teachers. In addition to providing evidence for the construct and content validity of the CBATS, the researchers found that most of the teachers they surveyed displayed either robust or tenacious PAB patterns. A robust PAB pattern is, according to Ford, the "most motivationally powerful…because people with strong capability beliefs and positive context beliefs maintain the expectation that their goals will be achieved in the face of obstacles, difficulties, and failures" (pp. 134 - 135). A tenacious pattern, suggested by strong capability beliefs and neutral or variable context beliefs, is indicative of "strength in dealing with obstacles and challenges" (p. 134). Although teachers with a tenacious pattern have confidence in their own capabilities, they may doubt the responsiveness of their environment. Other teachers in the sample exhibited either vulnerable or modest PAB patterns. A teacher with a vulnerable pattern could be "functioning adequately, but may be at risk under conditions of stress" (p. 134). The authors suggest that "vulnerable patterns could be counterproductive to educational change processes" and that "it is likely that teachers who display vulnerable patterns may adopt an accepting/antagonistic or self-doubting pattern if either their capability or context beliefs are further hindered" (Lumpe et al., 2000, p. 287).

Haney, Lumpe, Czerniak, & Egan (2002) subsequently conducted a study that examined the relationship between the personal agency belief patterns and the science teaching practices of six elementary teachers. To assess the effectiveness of the science teaching, the study used a protocol developed by Horizon Research, Inc. for the purpose of evaluating National Science Foundation local systemic change initiatives. The CBATS and STEBI instruments were used to measure context and capability beliefs, respectively. Using the guidelines described in their previous study, the authors used both measures to classify the teachers' personal agency belief patterns. Additional qualitative data, gathered through open-ended interviews, was used to provide further evidence regarding the teachers' personal agency beliefs.

Among the six teachers in the study, two were classified as having a vulnerable personal agency belief pattern, two were classified as having a tenacious pattern, and two were classified as having a robust pattern. The researchers found that three of the four teachers who possessed robust and tenacious personal agency belief patterns exhibited effective science teaching practices. Specifically, the authors note that these teachers tended to deliver science lessons that: illustrated careful planning, incorporated inquiry, drew on students' prior knowledge and experiences, were sensitive to issues of equity, encouraged collaboration, and utilized available resources. One robust teacher, who conveyed extremely strong capability beliefs and positive context beliefs during the interview process, had substantial problems with implementation, content knowledge, and classroom environment. As predicted, each of the teachers with vulnerable personal agency belief patterns scored low on the observation protocol, also exhibiting substantial problems with the implementation and content of their lessons. The authors conclude that their findings provide support for the view that beliefs are valid predictors of teachers' actions. The authors also discuss possible explanations for the discontinuity between one teachers' robust personal agency beliefs and her poor teaching practices. These explanations include the possibility that the teachers' performance was underrated by the observer, the possibility that the teacher dramatically overestimated her capability and the possibility that the teachers' beliefs about what constitutes effective science teaching did not align with the definition of the effective teaching that informed the observation protocol.

Andersen, Dragsted, Evans, & Sorensen, (2004) conducted a similar study looking at the capability and context beliefs of a cohort of new elementary teachers in Denmark. The researchers used a modified version of the STEBI instrument (the STEBI-DK) to measure self-efficacy three times over the course of the first year of teaching. The survey sample included 66 teachers for the first STEBI-DK administration, dropped to 49 teachers for the second and to 39 for the third. Context beliefs were measured once using the CBATS instrument along with the final administration of the STEBI-DK. The researchers found that the teachers' self-efficacy ratings dropped significantly between the first and second administrations of the STEBI-DK ($p < .02$) but remained stable between the middle and end of the first year of teaching. Examining the relationship between these changes in self-efficacy and teachers' ratings of their school environments, positive changes in self-efficacy were related to higher ratings on both the likelihood ($r = .401$, $p = .011$) and enable ($r = .556$, $p = .00$) scales of the CBATS instrument. The combined likelihood and enable CBATS scores were also significantly related to high self-efficacy changes during the year ($r = .556$, $p = .00$). That is, teachers whose self-efficacy increased tended to believe that the environmental factors on the CBATS would enable them to be effective science teachers and that these factors were likely to occur at their schools.

These findings were further illustrated through three case studies with participants chosen based on their initial self-efficacy scores. The researchers selected two teachers with average self-efficacy scores and one teacher with an initial high self-efficacy score. The teacher with the high initial self-efficacy score had an average score on the CBATS likelihood scale, indicating moderate likelihood that favorable teaching conditions would be present at her school. This teachers' self-efficacy score dropped considerably between the beginning and middle of the school year and again between the middle and end of the school year. Given this falling self-efficacy score and the negative perception of the school environment portrayed in interviews, the authors believed that this teacher would fall into the vulnerable category in Ford's taxonomy of personal agency beliefs. The other two teachers reported relatively high CBATS likelihood scores and either increasing or stable self-efficacies throughout the year. Based on these patterns and qualitative data gathered through interviews, the authors concluded that one of these teachers exemplified Ford's robust personal agency belief pattern and one was on the border between the robust and vulnerable patterns. As in Haney et al.'s study, the authors used the Horizon's observation protocol and found that these three teachers' personal agency belief patterns corresponded to the effectiveness of their science teaching practices. That is, the two teachers with the more robust patterns were rated as more effective than the teacher with the vulnerable personal agency belief pattern.

Bhattacharyya, Volk, and Lumpe (2009) examined the effects of an extensive inquiry-based field experience on pre-service elementary teachers' personal agency beliefs. The study compared changes in personal agency beliefs among 14 elementary teachers who self-selected into two groups: an experimental group that implemented inquiry methods and a control group that used traditional teaching methods. As in Haney et al. (2002) and Andersen et al. (2004) studies, the participants completed the CBATS and a version of the STEBI (STEBI-B for preservice teachers). The researchers found that, in general, the PAB patterns of the control group declined and the PAB patterns of the experimental group increased. This difference between the experimental and control groups' PAB patterns was attributed to the possibility that the inquiry method could have boosted the teachers' capability beliefs; however, the authors caution that the result could also reflect the fact that the experimental group happened to have slightly higher capability beliefs at the beginning of the study.

In order to gain further insight into the relationship between PAB patterns and inquiry teaching practices, the researchers conducted interviews and used the Horizon observation protocol to observe seven participants in the experimental group. As in previous studies (Haney et al. , 2002; Andersen et al. , 2004), the researchers found that, in general, there were consistent relationships between the elementary teachers' personal agency beliefs and their implementation of inquiry teaching methods. Two of the seven teachers were exceptions to this general pattern. Although both teachers reported a high level of confidence in their science teaching and were therefore classified as having a robust personal agency belief pattern, observations revealed substantial problems with their implementation of inquiry teaching methods.

Although this preliminary research on teachers' personal agency beliefs provides some insight on the factors that motivate teachers' to pursue science education reform, the limitations of these first studies suggest important questions for future research. First, although existing studies consider context an important determinant of teachers' decision-making and behavior, as evidenced by their investigation of teachers' context beliefs, researchers have yet to explore how personal agency belief patterns may cluster or vary according to school context. Given the complexity of the teaching policy environment and the impact of policy on science education reform, determining how personal agency beliefs patterns vary across and within schools and school reform programs can inform the implementation of science reform initiatives. For example, in developing professional learning opportunities, district staff may approach schools where teachers' tend to have robust personal agency belief patterns much differently than schools where teachers are more likely to exhibit antagonistic personal agency beliefs. A second related area for future research concerns sample size. The majority of previous studies have profiled the personal agency beliefs of relatively small samples of teachers. In addition to being the first to look at personal agency beliefs across school reform models, this study is the first to attempt to classify the personal agency beliefs of elementary teachers in a large urban school district. Finally, this study applies new data analysis techniques to the study of personal agency beliefs. In previous studies, teachers have been assigned to personal agency belief patterns according to whether their scores on the self-efficacy and context belief measures fell in the upper, middle, or lower third of the possible range of scores. As described above, several studies have also used qualitative interview data to inform their classification of personal agency beliefs. Using item response theory (the Rasch model) to triangulate survey data, this study illustrates another method for measuring teachers' personal agency beliefs.

Methodology

Recall that this study investigates the following questions:

1. What science self-efficacy beliefs exist among elementary teachers in this urban district?

2. What context beliefs exist among elementary teachers in this urban district?

    a. What environmental factors do elementary teachers believe would enable them to teach science effectively?

    b. What environmental factors do elementary teachers believe are likely to occur at their schools?

    c. To what extent do elementary teachers believe that the environmental factors that would enable effective science teaching are likely to occur at their schools?

3. Do self-efficacy beliefs and/or context beliefs vary across the comprehensive school reform models implemented in the district?

Participants and Setting

This study took place in a large urban school district in the southeastern United States. The district includes 57 elementary schools, 17 middle schools, 19 high schools, two single-gender academies (6-12th grade), and seven charter schools. The district served approximately 57,000 students during the 2009-2010 academic year. The ethnic makeup of the district's student population is 86% percent African American, 8% Caucasian, 4% percent Hispanic, and less than one percent Multi-racial, Asian, or American Indian. Seventy-six percent of the district's students are eligible for free and reduced priced meals and eighty-seven percent of the district's schools are designated as Title I schools. Of the 2,084 elementary teachers working in the district during the 2009-2010 academic year, 71% identify as African American, 25% identify as Caucasian, 3% identify as Hispanic, 1% identify as Asian, and less than one percent identify as Multi-racial, American Indian or Pacific Islander. Eighty-five percent of the district's K-5 teachers are female.

This original sample for this study included data from 121 K-5 elementary teachers. Two participants were excluded because they completed only a small portion of the online survey. In order to facilitate comparison of teacher responses across the most prevalent comprehensive school reform models in the district, four teachers were excluded from the sample because they did not identify their school's CSR model and six were excluded from the sample because fewer than three teachers reported working at a school with their reform model. Demographic, teaching background, CSR Model distribution for the final sample of 109 teachers is included Table 1.

The participating district requested that, in order to avoid the appearance of coercion, school level administrators should not be involved in recruitment. Instead, a snowball sampling procedure was used to recruit teachers for participation in the study in two waves. During the first wave of recruitment, K-5 teachers received study information included in materials distributed at a district-wide professional development program. During the second wave of recruitment, teachers were sent a link to the survey through email addresses posted on individual school web sites. Teachers were encouraged to complete the survey themselves and to share the link with colleagues at their school sites. Given this snowball sampling procedure, it is impossible to calculate an accurate participation rate; however, the final sample equates to approximately 12% of the respondents who received email invitations. Because of limitations on funding and restrictions set by the Institutional Review Board, no incentives were offered for completing the survey.

Policy context. Teachers' perceptions of their teaching policy environments are cultivated within a set of nested federal, state, district, and school level policy contexts (Knapp & Plecki, 2001). Among the policy influences at work within the participating district are the federal No Child Left Behind Act, Comprehensive School Reform, State Standards, High Stakes Testing, and a recent district-wide Math-Science Initiative. See Appendix A for an overview of the implementation of these policy influences within the district.

Instruments

Participating teachers responded to items from two previously developed surveys: the Context Beliefs about Teaching Science (CBATS) survey (Lumpe, Haney, Czerniak, 2000) and the Science Teaching Efficacy Belief Instrument (STEBI) (Riggs & Enochs, 1990). Both the surveys were administered in a single session using *FluidSurveys*, an online application that allows researchers to administer online surveys and compile data. Teachers were not timed, and all teachers completed the survey within twenty minutes. All teachers completed an informed consent form (Appendix B) approved by the Emory University Institutional Review Board. Table 2 summarizes the data sources and analyses of these data sources for each research question. Each of the instruments used in the study is described below.

The Context Beliefs About Teaching Science Survey. The Context Beliefs about Teaching Science (CBATS) survey (Appendix C) was developed by Lumpe, Haney, and Czerniak (2000) to assess teachers' beliefs about their science teaching environment. The CBATS instrument includes two scales: the enable scale (CBATS-E), which assesses teachers' beliefs regarding the extent to which twenty-six environmental factors enable effective science teaching (strongly agree – strongly disagree) and the likelihood scale (CBATS-L) that asks teachers to rate the likelihood that each of the factors would occur at their school (very likely – very unlikely). Examples of environmental factors included in the scale include professional development, team planning, funding, planning time, parent involvement, and class size. Lumpe and colleagues provide partial evidence for the construct validity of the CBATS through a factor analysis resulting in the two scales and twenty-six items on the final scale.

Additional evidence for construct validity was provided by demonstrating both a modest correlation between CBATS scores and Bandura's similar, but more narrow, outcome expectancy beliefs construct and a slight correlation between CBATS scores and science self-efficacy beliefs. Lumpe et al. conclude that the CBATS can be used in conjunction with current science teacher self-efficacy measures (i.e. the STEBI) to approximate teachers' personal agency belief patterns. According to the authors, other potential uses of the CBATS include determining factors that predict specific personal agency belief patterns, assessing teachers' perceptions of school science programs, and planning and monitoring professional development experiences.

The Science Teaching Efficacy Belief Instrument. Riggs and Enochs (1990) developed the now widely used Science Teaching Efficacy Belief Instrument (STEBI) (Appendix D) to measure the self-efficacy and outcome expectancy beliefs of in-service elementary teachers. The 25-item STEBI asks teachers to respond using a 5 point Likert scale (strongly agree – strongly disagree) to items belonging to two subscales, self-efficacy and outcome expectancy. Self-efficacy items are designed to assess teachers' beliefs regarding their capability to teach science. Outcome expectancy items are designed to assess teachers' beliefs regarding any educators' ability to affect science learning. Sample self-efficacy items include statements such as, "I know the steps necessary to teach science effectively." Outcome expectancy items include statements such as, "the teacher is generally responsible for the achievement of students in science." The STEBI has been shown to have internal consistency with Cronbach's alpha coefficients of .85 for the self efficacy sub-scale and .81 for the outcome expectancy sub-scale. Test/retest reliability for the STEBI was demonstrated with Pearson Correlation coefficients of .87 for the self-efficacy sub-scale and .77 for outcome expectancy sub-scale. Because Ford's framework implicates self-efficacy (capability beliefs) as a component of personal agency beliefs but does not include outcome-expectancy beliefs, only data from the self-efficacy belief subscale of the STEBI were analyzed in this study.

Teacher Questionnaire. All teachers completed a short questionnaire in which they provided demographic information and information about their teaching experience (years teaching in district/school, grades taught, comprehensive school reform model) and education (number of science courses taught). This survey also asked teachers to estimate the time (in minutes) allocated to science in their classrooms each week.

Results

The following section discusses the results of the exploratory data analyses. Each research question was addressed using both traditional exploratory data analyses (graphical displays, descriptive statistics, ANOVA, correlations) and Rasch Analysis.

Research Question 1: What science self-efficacy beliefs exist among elementary teachers in this urban district?

A summary of teachers' responses on the Science Teaching Efficacy Beliefs Instrument (STEBI) are presented in Table 3. Although teachers' responses on certain STEBI items are indicative of high self-efficacy for science teaching, the survey results also highlight potential negative beliefs that many teachers hold about their ability to effectively teach science. For example, 97.2% of teachers surveyed reported that they welcome student questions in science and 77.9% agreed that they are able to answer students' science questions. At the same time, 48.6% of teachers reported that they generally teach science ineffectively and 72.4% of teachers reported that even when they try very hard, they do not teach science as well as they teach other subject areas.

Figure 1 presents the variable map for the STEBI. The first column of the variable map indicates the logit scale. The second column labeled "Teachers" represents the individual teachers who participated in the study, with teachers scoring higher on the measure appearing near the top of each item map. The third column represents the items on the STEBI scale. The fourth column indicates the relative locations of teachers' belonging to each of the Comprehensive School Reform models (discussed in research question 3 below) represented in the study on the logit scale. Consistent with the descriptive analysis, the variable map shows that this group of teachers believes they welcome student questions (item 12) and, at the other end of the logit scale, also believes that they do not teach science as well as other subjects (item 2). The remaining 11 items were spread across approximately 2 logits.

Table 4 summarizes the measurement reports and summary statistics for the STEBI scale. For teachers, this table presents information on the distribution of teachers across the logit scale and the fit of the teacher participants. The significant separation reliability for persons of .82 ($\chi^2 = 480.9$, $p < .001$), indicates that teachers tended to vary in their self-efficacy for science teaching. Fit statistics provide an indication of the degree to which response patterns show more or less variability than would be expected if the data were completely compatible with the model. Although both infit and outfit statistics can be used to evaluate model-data fit, here outfit statistics are reported because they are more sensitive to outlying or unexpected values (Bond & Fox, 2001). The outfit mean square of 1.03 indicates that, overall, teachers' responses on the STEBI instrument demonstrated a good fit with the model; however, the high standard deviation of .60 for the teacher facet suggests more variation in teachers' responses than would be expected. Using a commonly accepted interpretation of outfit values, teachers' response patterns were categorized as noisy (Outfit MnSq >1.2), muted (Outfit MnSq<.8), or typical (Outfit MnSq between .8 and 1.2). Of the 109 teachers who participated in the study, 27 exhibited significantly more variation (a "noisy response pattern) and 34 exhibited significantly less variation (a "muted response pattern") than would be predicted by the Rasch model.

Research Question 2a: What environmental factors do elementary teachers believe would enable them to teach science effectively?

A summary of teachers' responses on the Context Beliefs about Teaching Science Enable scale (CBATS–E) are presented in Table 5. Overall, teachers' agreed that numerous environmental factors have the potential to enable effective science teaching. Environmental factors that the vast majority of teachers' believed would most enable effective science teaching included: professional staff development, support from other teachers, team planning time with other teachers, hands-on science kits, extended class period length, planning time, permanent science equipment, expendable science supplies, support from administrators, science curriculum materials, a decrease in course teaching load, a reduction in the amount of content, classroom assessment strategies, and teacher input and decision making. Environmental factors that teachers were less likely to endorse as enabling effective science teaching included the involvement of university professors, the involvement of the state board of education, an increase in students' academic abilities, parental involvement, and the adoption of an official school science curriculum.

Figure 2 presents the variable map for the CBATS Enable scale. The first column of the variable map indicates the logit scale. The second column labeled "Teachers" represents the individual teachers who participated in the study, with teachers scoring higher on the measure appearing near the top of each item map. The third column represents the items on the CBATS enable scale. The fourth column indicates the relative locations of teachers' belonging to each of the CSR models represented in the study on the logit scale. Consistent with the descriptive analysis, the variable map shows that teachers tended to agreed that hands-on kits, planning time, teaching input, and support from administrators enabled effective science teaching whereas student ability and the involvement of parents, professors, the state board of education were less likely to be endorsed as environmental factors that enable effective science teaching.

Table 6 summarizes the measurement reports and summary statistics for the CBATS Enable scale. This table presents information on the distribution of teachers across the logit scale and the fit of the teacher participants. The significant separation reliability for persons of .89 ($\chi^2 = 687.8$, $p < .001$), indicates that teachers tended to vary in their beliefs about the factors that enable effective science teaching. Fit statistics provide an indication of the degree to which response patterns show more or less variability than would be expected if the data were completely compatible with the model (Bond & Fox, 2001). The outfit mean square of 1.02 indicates that, overall, teachers' responses on the CBATS Enable Scale demonstrated a good fit with the model; however, the high outfit standard deviation of .53 for the teacher facet suggests more variation in teachers' responses than would be expected. Using a commonly accepted interpretation of outfit values, teachers' response patterns were categorized as noisy (Outfit MnSq >1.2), muted (Outfit MnSq<.8), or typical (Outfit MnSq between .8 and 1.2). Of the 109 teachers who participated in the study, 26 exhibited significantly more variation (a "noisy" response pattern) and 40 exhibited significantly less variation (a "muted" response pattern) than would be predicted by the Rasch model.

Research Question 2b. What environmental factors do elementary teachers believe are likely to occur in their schools?

A summary of teachers' responses on the Context Beliefs about Teaching Science Likelihood scale (CBATS-L) are presented in Table 7. Generally, teachers' believed that many of the environmental factors included in the scale were unlikely to occur in their own schools. Environmental factors teachers believed to be least likely to occur in their schools included community increased funding, extended class period length, a decrease in course teaching load, a reduction in the amount of content, and reduced class size. However, there were factors that a large majority of teachers did believe were likely to occur including: professional staff development, state and national guidelines, support from other teachers, team planning time with other teachers, hands on science kits, science curriculum materials, technology, and classroom assessment strategies.

Figure 3 presents the variable map for the CBATS Likelihood scale. The first column of the variable map indicates the logit scale. The second column labeled "Teachers" represents the individual teachers who participated in the study, with teachers scoring higher on the measure appearing near the top of each item map. The third column represents the items on the CBATS likelihood scale. The fourth column indicates the relative locations of teachers' belonging to each of the Comprehensive School Reform models represented in the study on the logit scale. According to the variable map, teachers were inclined to believe that technology, assessment, curriculum materials, hands-on science kits, and state and national guidelines for science education were likely to occur at their schools. Reduced class size, extended class period, increased funding, and decreases in course load and the amount of content required to be taught were among the environmental factors teachers believed were least likely to occur at their schools.

Table 8 summarizes the measurement reports and summary statistics for the CBATS Likelihood scale. This table presents information on the distribution of teachers across the logit scale and the fit of the teacher participants. The significant separation reliability for persons of .90 ($\chi^2 = 714.8$, $p < .001$), indicates that teachers tended to vary in their beliefs about the likelihood that the environmental factors would occur at their schools. Fit statistics provide an indication of the degree to which response patterns show more or less variability than would be expected if the data were completely compatible with the model (Bond & Fox, 2001). The outfit mean square of 1.00 indicates that, overall, teachers' responses on the CBATS Likelihood Scale demonstrated a good fit with the model; however, as with the STEBI and CBATS Enable scale, the high outfit standard deviation of .45 for the teacher facet suggests more variation in teachers' responses than would be expected. Using a commonly accepted interpretation of outfit values, teachers' response patterns were categorized as noisy (Outfit MnSq >1.2), muted (Outfit MnSq<.8), or typical (Outfit MnSq between .8 and 1.2). Of the 109 teachers who participated in the study, 28 exhibited significantly more variation (a "noisy" response pattern) and 45 exhibited significantly less variation (a “muted” response pattern) than would be predicted by the Rasch model.

Research Question 2c: To what extent do elementary teachers believe that the environmental factors that would enable effective science teaching are likely to occur at their schools?

Comparing teachers responses on each of the CBATS scales (Tables 7 and 10) reveals that several of the factors teachers’ believed would most enable effective science teaching were also believed to be unlikely to occur at the school level. For example, 70.6% of teachers agreed or strongly agreed that a decrease in the amount of content they are required to teach would enable effective science teaching; however, only 10.1% of teachers believed that such a reduction was likely or somewhat likely to occur at their schools. Teachers also reported substantially higher enable than likelihood beliefs for increased funding, extended class period length, planning time, and a reduction in course teaching load. The relationship between mean scores for each of the twenty six environmental factors on the CBATS Enable and Likelihood scales is illustrated in figure 4. Further, scores on the Enable and Likelihood scales were not correlated, $r = .197$, $n = 26$, $p = .33$, indicating that there was not a significant relationship between teachers’ enable and likelihood beliefs.

The variable maps for the enable and likelihood scales provide further evidence of a discrepancy between elementary teachers’ enable and likelihood beliefs. Examining the relative locations of each of the items across the two variable maps confirms that several environmental factors that were thought to enable effective science teaching were not thought to be likely to occur at the school level. For example, item 8 (extended class period length) and item 9 (planning time) are located in the top half of items on the variable map for the enable scale; however, both these items rank near the bottom of items on the variable map for the likelihood scale.

Research Question 3. Do self-efficacy beliefs and/or context beliefs vary across the comprehensive school reform models implemented in the district?

One-way ANOVAs were conducted to explore differences in teacher responding across Comprehensive School Reform (CSR) models (Table 9). Teachers' scores on the Science Teaching Efficacy Beliefs Instrument (STEBI) and Context Beliefs about Teaching Science Enable scale (CBATS-E) did not vary significantly across comprehensive school reform models. However, there was a significant difference in teachers' scores on the Likelihood Scale of the CBATS (CBATS-L), $F(5, 103) = 6.2$, $p < .001$. Post-hoc tests (Tukey's HSD) indicate that teachers in Direct Instruction schools tended to have significantly lower scores on the CBATS Likelihood Scale than teachers in the Core Knowledge ($p < .01$), International Baccalaureate ($p < .01$), and Project GRAD) ($p < .05$) reform models. The relatively low scores of teachers in Direct Instruction schools on the CBATS Likelihood scale are also evidenced by the lower placement of the Direct Instruction reform model on the variable map for the CBATS likelihood scale.

Discussion

As the ultimate agents of science education reform, elementary teachers work within complex teaching contexts to facilitate student learning in science. In doing so, they develop beliefs about themselves as science teachers and about whether their school context is supportive of their science teaching goals. This study documents the self-efficacy and context beliefs of elementary teachers working as agents of science education reform in one urban school district. Teachers' responses on the STEBI instrument suggest that while, overall, elementary teachers who participated in this study are confident in many aspects of their science teaching, doubts remain about their ability to teach science successfully. It is disconcerting, for example, that in a district implementing an extensive (and expensive) science education reform initiative, over 70% of teachers surveyed for this study admit that they do not teach science as well as they do other subject areas. At the same time, responses on the CBATS scales suggest that teachers believe that many of the environmental factors that would enable them to be successful science teachers, such as increased funding or a decrease in the amount of content they are required to teach, are not likely to occur in their schools.

According to Ford's framework, to the extent that teachers both feel that they are incapable of teaching science effectively and believe that their schools are ill equipped to support their science teaching goals, teachers in this study may possess personal agency beliefs that may compromise their ability to successfully implement science education reform. Future research should further explore the ways in which elementary teachers' self-efficacy and context beliefs interact to produce personal agency beliefs related to science education reform. More specifically, qualitative and mixed methods studies that complement the use of the CBATS and STEBI instruments with the analysis of qualitative data regarding elementary teachers' self-efficacy and context beliefs would enable researchers to better classify personal agency beliefs according to Ford's taxonomy. Such classifications could be used to inform professional development programs and future efforts to implement science education reform at the school level.

The Rasch analysis revealed significant variation in teachers' context and self-efficacy beliefs. This variation occurs in spite of the fact that the teachers in this study are implementing a district-wide reform initiative that intends to provide the same professional development experiences and resources to all elementary teachers. Clearly, numerous individual and school-level factors, such as school climate, previous teaching experience, or the actual uneven distribution of resources, could account for variations in teachers' self-efficacy and context beliefs. As researchers continue to examine the role that school context plays in policy implementation, they should work to identify factors that may influence teachers' beliefs about themselves as science teachers or their school context's ability to support their science teaching goals.

When considering the beliefs teachers hold about their school context, researchers tend to differentiate between real versus perceived environmental support factors. However, as noted in previous research on teachers' context beliefs (Lumpe, Haney, & Czerniak, 2000), it is perception, rather than reality, that is likely to guide behavior. If a teacher believes, for example, that her school administration does not support science teaching, she is likely to behave according to this belief regardless of the actual level of support provided by the administration. Therefore, as researchers, policy makers, and school leaders work to improve science education at the school and classroom levels, they should consider both the real conditions of educational support and teachers' perception of this support.

This study also provides preliminary evidence that the teaching policy environments within elementary schools, and specifically, the implementation of comprehensive school reform models, may influence teachers' beliefs about the responsiveness of their science teaching context. Comprehensive school reform models are, by design, intended to shape the school context in ways that, according to Knapp and Plecki's framework (2001), influence science teaching and learning in urban schools. To varying degrees, comprehensive school reform models aim to shape nearly every aspect of the local school context including instruction, assessment, classroom management, professional development, parental involvement and school management. However, researchers have yet to examine the extent to which various comprehensive school reform models are compatible with science education reform initiatives. This is the first study to directly explore the relationship between comprehensive school reform and science education. According to both traditional and Rasch analyses, teachers in Direct Instruction schools tended to score lower on the CBATS Likelihood scale. This result that suggests that teachers in Direct Instruction schools are less likely than teachers in several other reform models, to believe that environmental support factors are likely to occur at their school. Whether this belief reflects an actual lack of support for science teaching in elementary schools implementing the Direct Instruction model is a question for future research. A more in depth examination of elementary teachers' beliefs about science teaching and learning within and across comprehensive school reform models, perhaps through mixed-methods or qualitative research, would further illuminate the potential implications of comprehensive school reform for science education.

In addition to suggesting Comprehensive School Reform as a potentially important dimension of the teaching policy environment, the results of this study validate other aspects of Knapp and Plecki's (2001) framework for the renewal of urban science teaching. As predicted by the Knapp and Plecki framework, teachers' responses indicated that they valued environmental factors related to the investment of resources, including hands-on science kits, permanent science equipment, expendable science supplies, and science curriculum materials. Consistent with Knapp and Plecki's framework, teachers viewed time as a particularly important resource, with the majority of teachers surveyed responding that extended class length and planning time would enable them to be effective science teachers. In addition to resource allocation, Knapp and Plecki propose the professional, organizational, and community context as another important force shaping science teaching and learning in urban classrooms. Although certain environmental factors related to the community context, such as parental involvement and the involvement of university professors, were not seen by the majority of teachers as enabling effective science teaching, teachers' responses on the CBATS Enable Scale did indicate that they valued professional staff development, support from other teachers, support from administrators, and teacher input and decision making.

Limitations

The findings of this study are limited by the self-report survey methodology, sample size, and the use of a non-random sample. As with the use of any self-report survey, without further triangulation or the use of a second validation measure, it is impossible to verify participants' responses. Added to this issue is the notion that beliefs, in particular, are thought to be difficult for individuals to recognize and articulate (Pajares, 1997; Kagan, 1990). For this reason, Kagan (1990) recommends the use of multiple instruments when examining teachers' knowledge and beliefs, arguing that "the use of multi-method approaches appears to be superior, not simply because they allow triangulation of data but because they are more likely to capture the complex, multifaceted aspects of teaching and learning" (p. 459). Sample size, and particularly the number of teachers within each reform model and across grade levels, limits the degree to which conclusions can be drawn about potential differences in teachers' context and self-efficacy beliefs across reform models. Finally, due to constraints on access and conditions put forth by the participating district, random sampling was not possible. Therefore, the results of this study cannot necessarily be generalized to reflect the beliefs that exist among teachers throughout the district or among teachers in similar urban districts.

Implications for Research, Theory and Practice

Although there is a long history of research on self-efficacy beliefs among elementary teachers, few researchers have directly examined the relationship between self-efficacy beliefs and context beliefs (personal agency beliefs) among urban elementary teachers. This study provides new insight into personal agency beliefs for science teaching among urban elementary teachers. As noted above, research on the relationship between comprehensive school reform and science education reform is virtually non-existent. This study represents a first step in what could be a fruitful research agenda examining how comprehensive school reform models interact with the implementation of science education reform programs. Additionally, the study illustrates the use of Rasch measurement theory as a potentially powerful exploratory data analysis tool. The Rasch analysis conducted for this study will inform future qualitative work looking more closely at elementary teachers context and self-efficacy beliefs for science teaching. By examining self-efficacy beliefs in conjunction with context beliefs and in relationship to comprehensive school reform, the study addresses one of the major critiques of previous work on self-efficacy and the rationale behind Ford's conception of personal agency beliefs: "self-efficacy beliefs must be context specific and relevant to the behavior under investigation to be useful to researchers and appropriate for empirical study" (Pajares, 1992, p.315).

This study has clear practical implications for policy implementation and teacher professional development. To the extent that comprehensive school reform models intend to affect the same aspects of teaching and learning targeted by science education reform, district and school leaders should consider how science initiatives and reform models are likely to interact at the school level. Identifying school reform models that either complement or conflict with the goals and processes of science education reform may enable more efficient and effective implementation of science education initiatives. Given that teachers across the district varied substantially in their beliefs about their own science teaching and their school context, a more differentiated approach to professional development and the implementation of science education reform that takes into account potential differences across school and comprehensive school reform models may be warranted.

Conclusion

In summary, this study offers insight into the personal agency beliefs held by elementary teachers in one urban school district. Future research should delve more deeply into urban elementary teachers' beliefs about their science teaching in relation to their school context and, with the ultimate goal of improving student learning in science, examine the relationship between these beliefs and science teaching practices. Because we know that science teaching does not occur in isolation, but rather within a complex teaching policy environment, there is a clear need for future research that will continue to examine the interaction between school level policy context and science education reform.

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Table 1
Demographics, teaching background, CSR Model, and Mean STEBI and CBATS Scores for Study Participants

Characteristics	n (%)	STEBI Mean (SD)	CBATS -E Mean (SD)	CBATS - L Mean (SD)
Gender				
Female	96 (88)	48.79 (7.1)	99.0 (12.1)	83.3 (15.3)
Male	13 (12)	50.0 (4.1)	99.6 (6.6)	78.0 (10.3)
Race/Ethnicity				
African American	85 (78.0)	48.5 (7.0)	97.9 (11.4)	83.1 (15.0)
Caucasian	19 (17.4)	50.9 (5.8)	104.4 (12.5)	81.1 (15.8)
Hispanic	3 (2.8)	50.7 (3.1)	100.6 (2.9)	84.0 (4.4)
Asian	2 (1.8)	44 (5.7)	97.5 (3.5)	76.0 (5.7)
Grade				
Kindergarten	15 (13.8)	47.3 (5.7)	101.3(8.4)	82.7 (11.6)
1st Grade	20 (18.3)	49.4 (5.5)	98.1 (12.5)	78.5 (14.6)
2nd Grade	18 (16.5)	50.1 (8.2)	95.7 (8.7)	85.6 (17.8)
3rd Grade	25 (22.9)	48.0 (7.8)	103.0 (11.8)	75.4 (9.3)
4th Grade	14 (12.8)	46.8 (4.6)	93.3 (12.8)	90.8 (12.5)
5th Grade	17 (15.6)	51.8 (6.9)	100.9 (12.4)	82.5 (16.5)
College science courses completed				
None	23 (21.1)	49.6 (4.2)	97.0 (11.6)	80.2 (12.1)
1 semester	44 (40.4)	47.5 (6.8)	97.3 (6.9)	82.7 (12.4)
2 semesters	22 (20.2)	47.6 (7.4)	100.7 (16.5)	84.5 (15.2)
3 semesters	5 (4.6)	52.8 (5.0)	102.4 (11.3)	90.6 (19.8)
4 semesters	6 (5.5)	53.7 (8.4)	98.0 (12.1)	75.8 (13.1)
5 or more semesters	8 (7.3)	53.9 (7.0)	108.6 (13.7)	83.4 (23.3)
Comprehensive School Reform Model				
Core Knowledge	19 (17)	44.8 (4.6)	98.26 (12.3)	87.1 (8.6)
Direct Instruction (D.I.)	22 (20)	47.6 (7.2)	97.6 (10.2)	71.2 (13.8)
International Baccalaureate (I.B.)	20 (18)	48.0 (5.4)	100.8 (13.6)	93.0 (14.6)
Pearson Achievement Solutions	15 (14)	43.7 (4.1)	96.4 (10.7)	81.5 (15.6)
Project Grad	17 (16)	48.6 (9.3)	104.1 (10.5)	83.4 (16.9)
Success For All (S.F.A.)	16 (15)	45.6 (6.4)	97.0 (11.2)	80.4 (7.5)

STEBI, Science Teaching Efficacy Beliefs Instrument
CBATS, Context Beliefs about Science Teaching Survey – Enable and Likelihood Scales

Table 2
Data Sources and Analyses by Research Question

Research Question	Data Source	Data Analysis
1. What science self-efficacy beliefs exist among elementary teachers in this urban district?	STEBI (Science Teaching Efficacy Beliefs Instrument)	Descriptive Item Analysis (Rasch): variable maps
2. What context beliefs exist among elementary teachers in this urban district? a. What environmental factors do elementary teachers believe would enable them to teach science effectively?	CBATS (Context Beliefs about Teaching Science) – Enable Scale	Descriptive Item Analysis (Rasch): variable maps
b. What environmental factors do elementary teachers believe are likely to occur in their schools?	CBATS (Context Beliefs about Teaching Science) Instrument – Likelihood Scale	
c. To what extent do elementary teachers believe that the environmental factors that would enable effective science teaching are likely to occur at their schools?	CBATS Likelihood and Enable Scales	
3. Do self-efficacy beliefs and/or context beliefs vary across the comprehensive school reform models implemented in the district?	CBATS, STEBI, and personal agency belief profiles Comprehensive School Reform model data self-reported by teachers.	Descriptive Analysis ANOVA: Comparisons across CSR models Rasch Analysis: Variable Maps, fit statistics

Table 3

Science Teaching Efficacy Beliefs Instrument (STEBI) – Average Scores and Proportion of Teacher Responses by Item

		Teacher Response (%)				
Item	Mean	Strongly Agree	Agree	Uncertain	Disagree	Strongly Disagree
12. When teaching science, I usually welcome student questions.	4.4	48.6	48.6	1.8	.9	0
8. I am typically able to answer students' science questions.	3.9	22.9	55	15.6	6.4	0
*2. Even when I try very hard, I do not teach science as well as I do most subjects.	3.8	18.3	54.1	22.0	5.5	0
6. I understand science concepts well enough to be effective in teaching science.	3.4	9.2	44.0	28.4	18.3	0
1. I am continually finding better ways to teach science.	3.3	11.9	35.8	21.1	30.3	0
3. I know the steps necessary to teach science concepts effectively.	3.3	10.1	38.5	25.7	22.9	2.8
*5. I generally teach science ineffectively.	3.3	10.1	38.5	25.7	22.9	2.8
*9. I wonder if I have the necessary skills to teach science.	2.7	3.7	27.5	21.1	31.2	16.5
*10. Given a choice, I would not invite the principal to evaluate my science teaching.	2.6	9.2	10.1	26.6	43.1	11.0
*4. I am not very effective in monitoring science experiments.	2.3	3.7	10.1	12.8	56.0	17.4
*13. I do not know what to do to turn students	2.2	0	5.5	19.3	63.3	11.9

on to science.						
*7. I find it difficult to explain to students why science experiments work.	2.1	.9	9.2	11.0	57.8	21.1
*11. When a student has difficulty understanding a science concept, I am usually at a loss as to how to help the student understand it better.	2.0	.9	5.5	12.8	56.9	23.9

Note: Negatively worded items reverse scored in subsequent analyses per guidelines described by Enochs & Riggs (1990).
Items listed in descending order by mean scores. Mean scores reflect the following values for each response category:
5 = Strongly Agree, 4 = Agree, 3 = Uncertain, 2 = Disagree, 1 = Strongly Disagree.

Figure 1

Variable Map for the Science Teaching Efficacy Beliefs Instrument (STEBI)

```
+-----------------------------------------------------+
|Measr|+Teachers  |+Items      |+Reform Model   |SELF-|
|-----+-----------+------------+----------------+-----|
|   4 +           +            +                + (5) |
|     |           |            |                |     |
|     | .         |            |                |     |
|     | .         |            |                |     |
|     | *         |            |                |     |
|   3 +           +            +                +     |
|     | *         |            |                | --- |
|     |           |            |                |     |
|     |           |            |                |     |
|     | .         |            |                |     |
|   2 + .         +            +                +     |
|     | **.       | 12         |                |     |
|     | **.       |            |                |     |
|     | *******   |            |                |  4  |
|     | *****     |            |                |     |
|   1 + *******.  +            +                +     |
|     | ****      |            |                |     |
|     | *****.    | 11  8      |                | --- |
|     | *****.    | 13  5   7  |                |     |
|     | ***.      | 4          | 4              |     |
*   0 * ****      *            * 2  3   6       *  3  *
|     | .         | 6          | 1  5           |     |
|     | *         | 10  3      |                |     |
|     |           | 1   9      |                | --- |
|     | .         |            |                |     |
|  -1 +           +            +                +     |
|     |           |            |                |     |
|     | .         |            |                |  2  |
|     | .         |            |                |     |
|     |           |            |                |     |
|  -2 +           +            +                +     |
|     |           | 2          |                |     |
|     | .         |            |                |     |
|     |           |            |                |     |
|     |           |            |                | --- |
|  -3 +           +            +                + (1) |
|-----+-----------+------------+----------------+-----|
|Measr| * = 2     |+Items      |+Reform Model   |SELF-|
+-----------------------------------------------------+
```

Note: Refer to Table 3 for items corresponding to item numbers above. For the Reform Model facet, 1 = Core Knowledge, 2 = Direct Instruction (DI), 3 = International Baccalaureate, 4 = Project Grad, 5 = Pearson, and 6 = Success for All (SFA).

Table 4

Measurement Report Summary: Estimated Logits for Teachers, Items, and Comprehensive School Reform (CSR) Model Facets on the Science Teaching Efficacy Beliefs Instrument (STEBI)

	Teachers	Items	CSR Model
Measures			
Mean	.90	.00	.00
SD	.90	.95	.15
N	109	13	6
Infit			
Mean	1.05	.99	1.01
SD	.60	.17	.21
Outfit			
Mean	1.03	1.03	1.02
SD	.60	.24	.21
Reliability of separation	.82	.98	.67
Chi-square statistic	480.9**	551.9**	14.5*

*p < .01

**p < .001

Table 5

Context Beliefs about Teaching Science (CBATS) Instrument - Enable Scale - Average Scores and Proportion of Teacher Responses by Item

Item	Mean	Teacher Responses (%)				
		Strongly Agree	Agree	Uncertain	Disagree	Strongly Disagree
5. Hands-on science kits	4.6	60.6	2.8	2.8	0.0	0.0
3. Support from other teachers	4.4	47.7	3.7	3.7	1.8	0.0
9. Planning time	4.4	56.0	3.7	3.7	2.8	.9
26. Teacher input and decision making	4.4	52.3	8.3	8.3	0.0	0.0
4. Team planning time with other teachers.	4.2	39.4	11.0	11.0	2.8	1.8
14. Support from administrators	4.2	41.3	11.9	11.9	1.8	1.8
10. Permanent science equipment	4.1	32.1	18.3	18.3	0.0	1.8
13. Expendable science supplies	4.1	36.7	6.4	6.4	5.5	1.8
15. Science curriculum materials	4.1	23.9	11.9	11.9	1.8	0.0
1. Professional staff development	4.0	27.5	16.5	16.5	2.8	1.8
8. Extended class period length	4.0	34.9	17.4	17.4	2.8	2.8

25. Classroom assessment strategies	4.0	22.0	14.7	14.7	1.8	0.0
11. Classroom physical environment	3.9	27.5	18.3	18.3	7.3	1.8
20. A decrease in your teaching load	3.9	19.3	12.8	12.8	6.4	1.8
21. Reduction in the amount of content	3.8	26.6	19.3	19.3	5.5	4.6
2. State and national guidelines for science education	3.7	22.9	28.4	28.4	8.3	2.8
23. Involvement of scientists	3.7	18.3	22.0	22.0	11.9	.9
6. Community involvement	3.6	18.3	33.0	33.0	7.3	3.7
7. Increased funding	3.6	21.1	16.5	16.5	13.8	7.3
16. Technology	3.5	10.1	27.5	27.5	14.7	.9
12. Adoption of official school science curriculum.	3.4	22.9	34.9	34.9	19.3	1.8
22. Reduced class size.	3.4	16.5	29.4	29.4	16.5	4.6
24. Involvement of university professors	3.2	8.3	38.5	38.5	18.3	4.6
17. Parental involvement	3.0	17.4	34.9	34.9	22.0	11.9
18. An increase in students' academic abilities	3.0	15.6	27.5	27.5	33.9	7.3
19. Involvement of the state board of education	2.8	9.2	34.9	34.9	32.1	11.0

Note: Items sorted in descending order by mean scores. Mean scores reflect the following values for each response category: 5 = Strongly Agree, 4 = Agree, 3 = Uncertain, 2 = Disagree, 1 = Strongly Disagree

Figure 2

Variable Map for Context Beliefs about Teaching Science Enable Scale (CBATS – E)

```
+----------------------------------------------------------------+
|Measr|+Teachers   |+Items       |+Reform Model           |      |
|-----+------------+-------------+------------------------+------|
|   4 +            +             +                        + (5)  |
|     |            |             |                        |      |
|     | .          |             |                        |      |
|     |            |             |                        |      |
|     | *.         |             |                        |      |
|   3 +            +             +                        +      |
|     | *.         |             |                        |      |
|     | .          |             |                        |      |
|     | *.         |             |                        |      |
|     | *          |             |                        | ---  |
|   2 + *.         +             +                        +      |
|     | *.         |             |                        |      |
|     |            | 5           |                        |      |
|     | ***        |             |                        |      |
|     | *****      | 26  9       |                        |  4   |
|   1 + ********   + 3           +                        +      |
|     | ********.  |             |                        |      |
|     | ********.  | 14  4       |                        |      |
|     | ********   | 10  13  15  |                        | ---  |
|     | **.        | 1   25  8   | 3  4                   |      |
*   0 * .          * 11  20  21  * 1  2   5   6           *      *
|     |            | 2   23      |                        |  3   |
|     |            | 6   7       |                        |      |
|     |            | 12  16  22  |                        | ---  |
|     | .          | 24          |                        |      |
|  -1 + .          + 17          +                        +      |
|     |            | 18          |                        |  2   |
|     |            | 19          |                        |      |
|     |            |             |                        |      |
|     |            |             |                        |      |
|  -2 +            +             +                        + (1)  |
|-----+------------+-------------+------------------------+-------
|Measr| * = 2      |+Items       |+Reform Model           |      |
+----------------------------------------------------------------+
```

Note: Refer to Table 5 for items corresponding to item numbers above. For the Reform Model facet, 1 = Core Knowledge, 2 = Direct Instruction (DI), 3 = International Baccalaureate, 4 = Project Grad, 5 = Pearson, and 6 = Success for All (SFA).

Table 6

Measurement Report Summary: Estimated Logits for Teachers, Items, and Comprehensive School Reform (CSR) Model Facets on the Context Beliefs about Teaching Science Enable Scale (CBATS – E)

	Teachers	Items	CSR Model
Measures			
Mean	1.04	.00	.00
SD	.79	.73	.11
N	109	26	6
Infit			
Mean	1.05	.99	1.01
SD	.57	.21	.17
Outfit			
Mean	1.02	1.02	1.02
SD	.53	.27	.18
Reliability of separation	.89	.97	.74
Chi-square statistic	687.8**	850.5**	17.7*

**$p < .001$
*$p < .01$

Table 7

Context Beliefs about Teaching Science (CBATS) Instrument - Enable Scale - Average Scores and Proportion of Teacher Responses by Item

Item	Mean	Teacher Responses (%) Strongly Agree	Agree	Uncertain	Disagree	Strongly Disagree
5. Hands-on science kits	4.1	27.5	56.9	11.0	4.6	0.0
3. Support from other teachers	3.9	25.7	53.2	9.2	10.1	1.8
9. Planning time	3.8	22.0	51.4	14.7	11.0	.9
26. Teacher input and decision making	3.8	19.3	52.3	16.5	11.0	.9
4. Team planning time with other teachers.	3.8	19.3	56.8	13.8	5.5	4.6
14. Support from administrators	3.7	20.2	54.1	8.3	13.8	3.7
10. Permanent science equipment	3.6	12.8	55.0	11.9	18.3	1.8
13. Expendable science supplies	3.6	25.7	37.6	11.9	16.5	8.3
15. Science curriculum materials	3.5	18.3	43.1	18.3	13.8	6.4
1. Professional staff development	3.4	17.4	36.7	18.3	23.9	3.7

8. Extended class period length	3.3	11.9	44	16.5	18.3	9.2
25. Classroom assessment strategies	3.3	15.6	35.8	14.7	25.7	8.3
11. Classroom physical environment	3.3	11.9	45.0	15.6	18.3	9.2
20. A decrease in your teaching load	3.2	14.7	34.9	14.7	25.7	10.1
21. Reduction in the amount of content	3.2	9.2	34.9	28.4	24.8	2.8
2. State and national guidelines for science education	3.1	7.3	33.9	25.7	25.7	7.3
23. Involvement of scientists	3.0	4.6	17.4	55.0	21.1	1.8
6. Community involvement	3.0	8.3	27.5	25.7	28.4	10.1
7. Increased funding	2.9	6.4	32.1	19.3	29.4	12.8
16. Technology	2.8	8.3	32.1	11.0	31.2	17.4
12. Adoption of official school science curriculum.	2.6	9.2	33.0	11.9	35.8	10.1
22. Reduced class size.	2.4	2.8	13.8	20.2	44.0	19.3
24. Involvement of university professors	2.4	4.6	7.3	27.5	46.8	13.8
17. Parental involvement	2.3	1.8	12.8	27.5	30.3	27.5
18. An increase in students' academic abilities	2.2	3.7	9.2	19.3	37.6	30.3
19. Involvement of the state board of education	2.1	3.7	6.4	12.8	50.5	26.6

Note: Items sorted in descending order by mean scores. Mean scores reflect the following values for each response category: 5 = Strongly Agree, 4 = Agree, 3 = Uncertain, 2 = Disagree, 1 = Strongly Disagree

Figure 3

Variable Map for Context Beliefs about Teaching Science Likelihood Scale (CBATS-L)

```
+-------------------------------------------------------------+
|Measr|+Teachers  |+Items           |+Reform Model     |LIKEL|
|-----+-----------+-----------------+------------------+-----|
|   4 +           +                 |                  + (5) |
|     |           |                 |                  |     |
|     |           |                 |                  |     |
|     |           |                 |                  |     |
|     |           |                 |                  |     |
|   3 + .         +                 +                  +     |
|     | .         |                 |                  |     |
|     |           |                 |                  |     |
|     |           |                 |                  |     |
|     |           |                 |                  | --- |
|   2 +           +                 +                  +     |
|     | .         |                 |                  |     |
|     | .         |                 |                  |     |
|     | *         |                 |                  |     |
|     | .         | 16              |                  |     |
|   1 + .         +                 +                  +  4  |
|     | *         | 15   2    25   5 |                  |     |
|     | *.        | 3               |                  |     |
|     | *****.    | 1    14   4      |                  | --- |
|     | ********* | 11   12   26     | 3                |     |
*   0 * *****.    * 13   17   18     * 1    5    4    6  *  3  *
|     | ***       | 10   19   23   6 |                  |     |
|     | **.       | 24   9           | 2                |     |
|     | ***       |                 |                  | --- |
|     | .         | 22              |                  |     |
|  -1 + .         + 7    8           +                  +     |
|     | .         | 20   21          |                  |  2  |
|     | .         |                 |                  |     |
|     | .         |                 |                  |     |
|     |           |                 |                  |     |
|  -2 +           +                 +                  + (1) |
|-----+-----------+-----------------+------------------+-----|
|Measr| * = 3     |+Items           |+Reform Mode      |LIKEL|
+-------------------------------------------------------------+
```

Note: Refer to Table 7 for items corresponding to item numbers above.
For the Reform Model facet, 1 = Core Knowledge, 2 = Direct Instruction (DI), 3 = International Baccalaureate, 4 = Project Grad, 5 = Pearson, and 6 = Success for All (SFA).

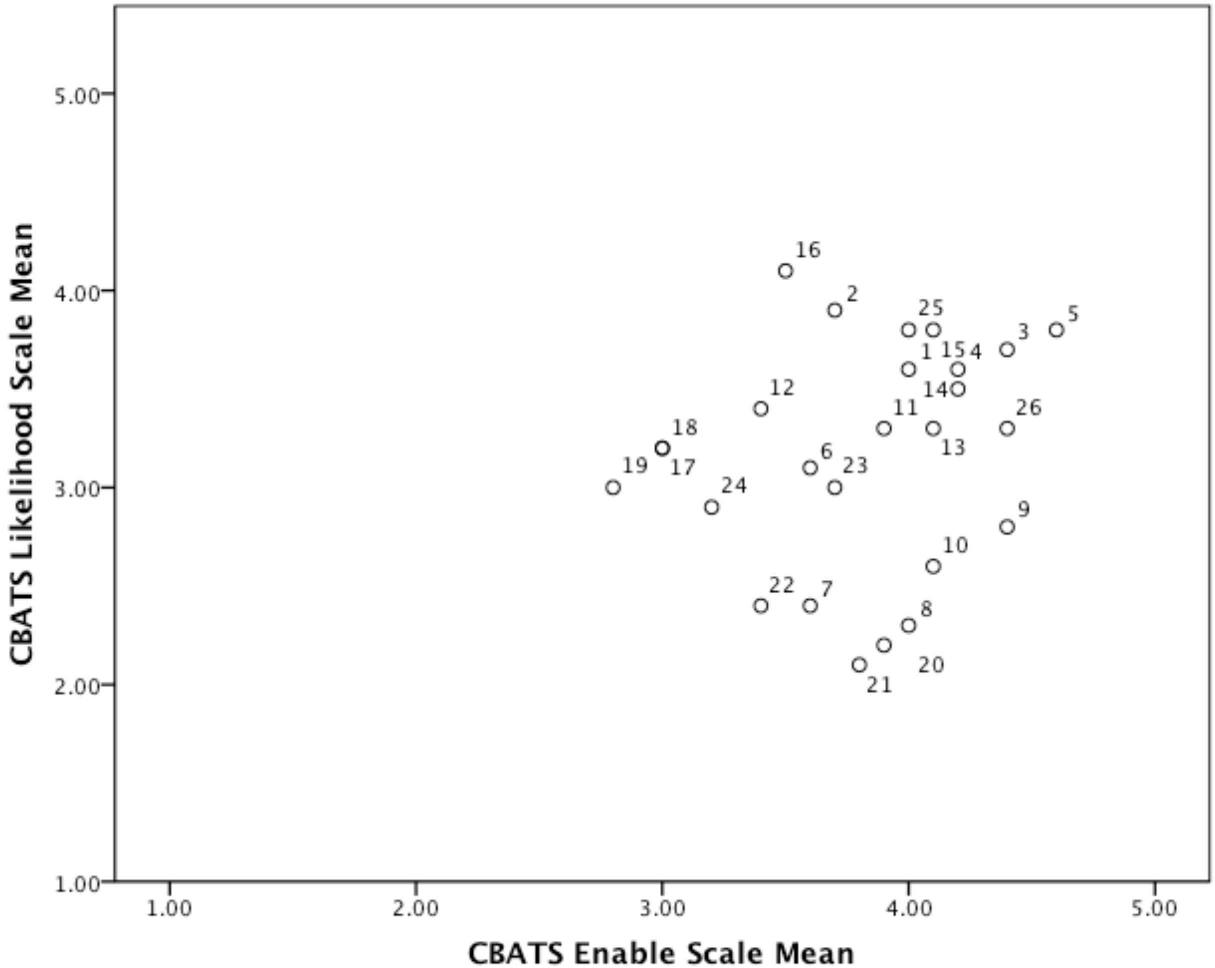
Table 8

Measurement Report Summary: Estimated Logits for Teachers, Items, and Comprehensive School Reform (CSR) Model Facets on the Context Beliefs about Teaching Science Likelihood Scale (CBATS- L)

	Teachers	Items	CSR Model
Measures			
Mean	.18	.00	.00
SD	.71	.65	.19
N	109	26	6
Infit			
Mean	1.02	1.00	1.00
SD	.46	.16	.15
Outfit			
Mean	1.00	1.00	1.00
SD	.45	.17	.16
Reliability of separation	.90	.97	.93
Chi-square statistic	714.8**	858.8**	81.4**

**$p < .001$

Figure 4.
Relationship between Context Beliefs about Teaching Science Enable (CBATS – E) and Likelihood (CBATS-L) Scores by Item



Note: For the CBATS – E Scale, mean scores reflect the following values for each response category: 5 = Strongly Agree, 4 = Agree, 3 = Uncertain, 2 = Disagree, 1 = Strongly Disagree. For the CBATS – L Scale, mean scores reflect the following values for each response category: 5 = Very Likely, 4 = Somewhat Likely, 3 = Neither Likely Nor Unlikely, 2 = Somewhat Unlikely, 1 = Very Unlikely.

Table 9

One –Way ANOVA - Science Teaching Efficacy Beliefs Instrument (STEBI) and Context Beliefs about Teaching Science Enable (CBATS-E) and Likelihood (CBATS-L) Scores by Comprehensive School Reform (CSR) Model

		Measure		
CSR Model	n	STEBI	CBATS – E	CBATS – L
Core Knowledge	19	44.8 (4.1)	98.3 (12.3)	87.1_b (8.6)
Direct Instruction	22	47.6 (7.2)	97.6 (10.2)	71.2_a (13.8)
International Baccalaureate	20	48.0 (5.4)	100.8 (13.6	93.0_b(14.6)
Pearson	15	43.7 (9.3)	96.4 (10.7)	81.5 (15.6)
Project GRAD	17	48.6 (9.3)	104.1 (10.5)	83.4_b (16.9)
Success for All	16	45.6 (6.4)	97.0 (11.2)	80.4 (7.5)
F		1.7	1.1	6.2*
η^2		.07	.05	.23

Note: Standard deviations appear in parentheses.
*p < .001
Means with differing subscripts across columns are significantly different based on Tukey's HSD post hoc tests.

Appendix A: Policy Context Overview

While a thorough analysis of relevant education policy would be far beyond the scope of the current study, understanding the setting in which data were collected does require a brief overview of the major policy influences exerting themselves within the district's elementary schools. Because the intent here is not to evaluate or analyze but to describe features of major policies as they relate to the elementary teachers participating in this study, the following summaries are drawn primarily from the policies themselves rather than from scholarship on the implementation or evaluation of those policies.

No Child Left Behind. The No Child Left Behind Act of 2001 calls for all states to establish academic standards and an assessment program with the goal of ensuring that all students reach 100% proficiency on state assessments by 2014. Adequate Yearly Progress (AYP) refers to the intermediate goals that the state, its school districts, and schools must achieve on annual standardized tests. Schools that have not achieved state-defined AYP in the same subject for two consecutive years are identified as needing improvement and must provide parents with the option to transfer their child to a higher performing school within the district. If a school fails to make AYP in the same subject for three or more consecutive years, low-performing students are eligible for free tutoring or supplemental educational services provided by the school or an outside provider. Under the State accountability program, schools that fail to make AYP for more than two consecutive years also face a series of escalating consequences ranging from the implementation of school improvement plans to corrective action and school restructuring.

The stated goal of No Child Left Behind during the period from its signing through the 2006-07 academic year was to close achievement gaps in the core subjects of reading and mathematics. No Child Left Behind requires states to develop science assessments to be administered at the elementary, middle, and high school levels beginning in the 2007-08 academic year, although it does not require student performance on these science assessments to be included in the calculation of AYP. In the school district where this study was conducted, individual principals are permitted but not required to include student performance on the state science assessment as a secondary factor in determining AYP.

Six of the fifty-seven elementary schools in the participating district did not make AYP during the 2008-2009 update academic year. Nearly ninety percent of the elementary schools in the district have made AYP for at least three consecutive years prior to the 2009-2010 academic year.

Comprehensive School Reform. A school reform agenda initiated by the district's Superintendent during the 1999-2000 academic year requires all Title 1 schools in the district to implement a research-based comprehensive school reform model. Reform model implementation in the district has been supported in large part through the Comprehensive School Reform Demonstration Program passed by Congress in 1997 and ultimately expanded with the passage of NCLB in 2001(Cross, 2004). This federal legislation defines comprehensive school reform as an approach that:

> integrates a comprehensive design for effective school functioning, including instruction, assessment, classroom management, professional development, parental involvement, and school management, that aligns the school's

> curriculum, technology, and professional development into a comprehensive school reform plan for school wide change designed to enable all students to meet challenging State content and student academic achievement standards and addresses needs identified through a school needs assessment. (Cross, 2004, p.111)

Under this program, grants for reform model implementation were made to state education agencies and subsequently administered as competitive sub-grants to local education agencies and schools. Between 1999 and 2005, individual schools in the participating district applied for and received these sub-grants to support the adoption of comprehensive school reform models.

Although federal funding for the Comprehensive School Reform Program expired in 2005, all Title 1 schools in the district continue to implement comprehensive school reform models. The variety of reform models adopted across the district has resulted in a range of approaches to instruction, assessment, classroom management, professional development, parental involvement, and school management. See Appendix B for the school district's descriptions of the thirteen comprehensive school reform models currently being implemented in the district.

State Standards. Since 1985, State law has required a standardized core curriculum specifying the skills and knowledge students should gain in each subject area and at each grade level. In 2002 an audit conducted by Phi Delta Kappa found that the State's standards lacked depth, could not be mastered in the instructional time available, were not aligned to standardized tests, and did not meet national subject area standards. Following the recommendations of this audit, the State launched an ambitious effort to revise and strengthen its curriculum, resulting in new standards in English Language Arts, Mathematics, Science, and Social Studies. In contrast to the previous content-based standards, the new performance standards include suggested tasks, sample student work, and examples of teacher commentary. According to the State Department of Education's website, the performance standards "isolate and identify skills needed to use the knowledge and skills to problem-solve, reason, communicate, and make connections with other information."

The new standards were phased in by subject area beginning with English Language Arts during the 2004-05 and 2005-06 academic year and followed in subsequent years by Mathematics, Science, and Social Studies. All grade levels followed the same phase-in sequence and two-year implementation period; however, there was some variation in whether the introduction of new standards overlapped such that some grade levels were in the second year of implementation in one subject area when new standards in another subject area were introduced. Given this implementation plan, the new Performance Standards for Science were introduced in the third through fifth grade in 2005-2006 and in kindergarten through second grade during the 2006-2007 school year. Consequently, all elementary teachers in the district were in either their fourth or fifth year of implementing the new Science standards during the year in which this study took place.

High Stakes Testing. According to the State Department of Education's website, the State's assessment program is intended:

> to measure student achievement of the state mandated curriculum, to identify students failing to achieve mastery of content, to provide teachers with diagnostic

> information, and to assist school systems in identifying strengths and weaknesses in order to establish priorities in planning educational programs.

The assessment program calls for the administration of criterion-referenced tests at the elementary, middle, and high school levels; the *National Assessment of Educational Progress* in grades 4, 8, and 12; and high school graduation tests. All students in grades one through eight are required to take annual criterion-referenced tests in reading, English/Language Arts, and mathematics. Students in grades three through eight are also required to take criterion-referenced tests in science and social studies. Beginning in the 2003-04 academic year, all students in third grade were required to pass the reading exam in order to be promoted to the fourth grade and beginning in the 2004-05 academic year, all fifth grade students were required to pass both the reading and math exams in order to be promoted to the sixth grade. Although schools may elect to have science scores included in the calculation of AYP, scores on standardized tests in science and social studies are not generally considered "high stakes" for students. That is, they are not factored into decisions regarding student promotion and retention.

The Math-Science Initiative. The participating district has made a public commitment to improving student achievement in science. In 2007 the district received a grant from a major corporation for 22 million dollars to support a five-year Math-Science Initiative. According to the district's 2006-07 Annual Report, this 5-year initiative represents the "largest mathematics and science professional development and curriculum program in the nation" and aims to prepare "educators to use project-based, hands-on techniques in order to help prepare students for technical careers that are in demand around the world."

Having focused primarily on improving teaching and learning in mathematics during the first three years of the Math-Science Initiative, the district has committed to pay increased attention to science during the 2009-2010 school year. This renewed commitment to science education includes district-wide professional development and an increased investment in science curriculum and resources. At the beginning of the 2009-2010 school year, all elementary teachers in the district took part in a daylong "Focused Professional Learning" conference. At this conference, teachers participated in a variety of sessions related to the district's efforts to improve science education. All teachers attended grade level content overview sessions in which they reviewed State science standards, explored the district's revised curriculum map and scope and sequence documents, and observed teacher leaders modeling one of the hands-on "Essential Labs" that will now be required in all elementary classrooms. Additional sessions focused on district recommendations regarding lab safety and the district-wide implementation of science notebooks. Additionally, third through fifth grade teachers were introduced to an E-Learning program that makes use of online tools sponsored by the National Science Teachers Association.

Appendix B: Informed Consent

Emory University
Division of Educational Studies
Informed Consent

Title: Elementary Teachers' Practical Knowledge about Science Education and Reform

Principal Investigator: Jessica Gale, Ph.D. student

Sponsor: National Science Foundation

Introduction/Purpose

You are being asked to be in a research study because you are an elementary teacher in Atlanta Public Schools. I am interested in learning about elementary educators' science teaching experiences and their attitudes toward science education. In addition to this survey, we plan to conduct focus groups with teachers at a number of elementary schools in the district. The purpose of this study is to identify trends in elementary teachers' views about science education, to gain insight into elementary teachers' strategies for implementing science education initiatives, and to examine how school context influences science education at the classroom level. This fall, approximately nine hundred elementary teachers in the district will be invited to participate in this study.

Procedures

I am asking elementary teachers to complete a survey through Survey Monkey. The survey will take approximately 30 minutes to fill out. If you agree to participate, you will be asked to check a box stating that you have read and understood this consent form. You will then be provided with a link to the survey and an identification number, which you will enter into Survey Monkey to access the questions. Your name will not be on the survey. Once the survey has been completed, your participation in the survey portion of this study will be over; however, you will be directed to a website where you will have the option to volunteer to participate in a focus group discussion to be held at your school at a later date.

Risks

There is minimal foreseeable risk associated with this study. You have the right to decline to answer any question, for any reason. You have a right to stop the survey or withdraw from the study at any time.

Benefits

While there may be no direct benefit to you from participation in this study, it is hoped that what is learned from this study will have an impact on science education and professional learning in the Atlanta Public Schools district.

Confidentiality

Certain offices and people other than the researcher may look at your study records. Government agencies, Emory employees overseeing proper study conduct may look at your study records. These offices include the Emory Institutional Review Board and the Emory Office of Research Compliance. Study records can also be opened by court order. Emory will keep any research records we produce private to the extent we are required to do so by law. A study number rather than your name will be used on study records. Your name and other facts that might point to you will not appear when I present this study or publish its results.

Compensation

You will not be offered payment for being in this study. There are no anticipated costs to you for participating in this study.

Voluntary Participation and Withdrawal

Your participation in this study is completely voluntary. You have the right to leave a study at any time without penalty.

Questions

If you have any questions about this study you may email Jessica Hammock at jdgale@emory.edu. If you have questions about your rights as a participant in this study, you may contact the Emory Institutional Review Board at 404-712-0720 or 877-503-9797.

If you are interested in the study findings after all the results are analyzed, you may email Jessica Gale at jdgale@emory.edu.

Consent

You may download a copy of this consent form for your records. If you are willing to participate in this research, please check the box below:

___ Yes, I am willing to participate in this study.

Date: ____________________

Appendix C
Contexts Beliefs about Teaching Science Survey

Directions: Suppose your goal is to be the most effective science teacher possible during the next school year. Listed below are a number of school environmental support factors that may have an impact on this goal. In the first column, please indicate the degree to which you believe each factor will enable you to be an effective science teacher. In the second column, indicate the likelihood that these factors will occur (or be available to you) during the next school year. Circle the corresponding descriptor that matches your belief.

	Column 1	Column 2
Environmental Factor	The following factors would **enable** me to be an effective teacher SA= strongly agree A= agree UN = undecided D = disagree SD = strongly disagree	How likely is it that these factors will **occur** in your school? VL = very likely SL = somewhat likely N = neither SU = somewhat unlikely VU = very unlikely
1. Professional staff development on teaching (workshops, conferences, etc.)	SA A UN S SD	VL SL N SU VU
2. State and national guidelines for science education (standards and goals)	SA A UN S SD	VL SL N SU VU
3. Support from other teachers (coaching, advice, mentoring, modeling, informal discussions, etc.)	SA A UN S SD	VL SL N SU VU
4. Team planning time with other teachers	SA A UN S SD	VL SL N SU VU
5. Hands-on science kits (activities and equipment)	SA A UN S SD	VL SL N SU VU
6. Community involvement (civic, business, etc.)	SA A UN S SD	VL SL N SU VU
7. Increased funding	SA A UN S SD	VL SL N SU VU
8. Extended class period length (e.g. block scheduling)	SA A UN S SD	VL SL N SU VU
9. Planning time	SA A UN S SD	VL SL N SU VU
10. Permanent science equipment (microscopes, glassware, etc.)	SA A UN S SD	VL SL N SU VU
11. Classroom physical environment (room size, proper furniture, sinks, etc.)	SA A UN S SD	VL SL N SU VU
12. Adoption of an official school science curriculum (goals, objectives, topics, etc.)	SA A UN S SD	VL SL N SU VU
13. Expendable science supplies (paper, chemicals)	SA A UN S SD	VL SL N SU VU
14. Support from administrators	SA A UN S SD	VL SL N SU VU
15. Science curriculum materials (textbooks, lab manuals, activity books, etc.)	SA A UN S SD	VL SL N SU VU

16. Technology (computers, software, Internet)	SA A UN S SD	VL SL N SU VU
17. Parental Involvement	SA A UN S SD	VL SL N SU VU
18. An increase in students' academic abilities	SA A UN S SD	VL SL N SU VU
19. Involvement of the state board of education	SA A UN S SD	VL SL N SU VU
20. A decrease in your course teaching load	SA A UN S SD	VL SL N SU VU
21. A reduction in the amount of content you are required to teach	SA A UN S SD	VL SL N SU VU
22. Reduced class size (number of pupils)	SA A UN S SD	VL SL N SU VU
23. Involvement of scientists	SA A UN S SD	VL SL N SU VU
24. Involvement of university professors	SA A UN S SD	VL SL N SU VU
25. Classroom assessment strategies	SA A UN S SD	VL SL N SU VU
26. Teacher input and decision making	SA A UN S SD	VL SL N SU VU
27. Comprehensive School Reform Model (SFA, DI, etc.)	SA A UN S SD	VL SL N SU VU
28. State testing (CRCT)	SA A UN S SD	VL SL N SU VU

Appendix D

Science Teaching Efficacy Belief Instrument (STEBI)
(Enochs & Riggs, 1990)

Directions: Please indicate the degree to which you agree or disagree with each statement below by selecting the letters corresponding to your answer.

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

1. When a student does better than usual in science, it is often because the teacher exerted a little extra effort.	SA A UN D SD
2. I am continually finding better ways to teach science.	**SA A UN D SD**
3. Even when I try very hard, I do not teach science as well I do most subjects.	**SA A UN D SD**
4. When the science grades of students improve, it is often due to their teacher having found a more effective teaching approach.	SA A UN D SD
5. I know the steps necessary to teach science concepts effectively.	**SA A UN D SD**
6. I am not very effective in monitoring science experiments.	**SA A UN D SD**
7. If students are underachieving in science, it is most likely due to ineffective science teaching.	SA A UN D SD
8. I generally teach science ineffectively.	**SA A UN D SD**
9. The inadequacy of a student's science background can be overcome by good teaching.	SA A UN D SD
10. The low science achievement of some students cannot generally be blamed on their teachers.	SA A UN D SD
11. When a low-achieving child progresses in science, it is usually due to extra attention given by the teacher.	SA A UN D SD
12. I understand science concepts well enough to be effective in teaching science.	**SA A UN D SD**
13. Increased effort in science teaching produces little change in some students' science achievement.	SA A UN D SD
14. The teacher is generally responsible for the achievement of students in science.	SA A UN D SD
15. Students' achievement in science is directly related to their teacher's effectiveness in science teaching.	SA A UN D SD
16. If parents comment that their child is showing more interest in science at school, it is probably due to the performance	SA A UN D SD

of the child's teacher.	
17. I find it difficult to explain to students why science experiments work.	**SA A UN D SD**
18. I am typically able to answer students' science questions.	**SA A UN D SD**
19. I wonder if I have the necessary skills to teach science.	**SA A UN D SD**
20. Effectiveness in science teaching has little influence on the achievement of students with low motivation.	SA A UN D SD
21. Given a choice, I would not invite the principal to evaluate my science teaching.	**SA A UN D SD**
22. When a student has difficulty understanding a science concept, I am usually at a loss as to how to help the student understand it better.	**SA A UN D SD**
23. When teaching science, I usually welcome student questions.	**SA A UN D SD**
24. I do not know what to do to turn students on to science.	**SA A UN D SD**
25. Even teachers with good science teaching abilities cannot help some kids to learn science.	SA A UN D SD

Note: Self-efficacy items included in online survey are in bold.