Urban Science Teachers' Implementation of Common Core State Standards for ELA within the Context of Interdisciplinary Science Inquiry

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Abstract

The purpose of this study was to explore science teacher beliefs, perceptions and practices surrounding the implementation of the Common Core State Standards (CCSS) for ELA within the context of their Interdisciplinary Science Inquiry (ISI) - based instruction. It was situated within a project called the Engineering and Interdisciplinary Science Partnership (EISP-pseudonym), an NSF-funded teacher professional development program between 12 public schools and 2 public universities in the North Eastern United States. This study utilized a mixed-methods research design to investigate the following research questions: (1) how do science teachers demonstrate knowledge and values of CCSS for ELA curricula when they conduct ISI? and (2) what relationship, if any, exists between teacher beliefs and perceptions of the CCSS for ELA and its implementation in the science classroom? The data sources from this study included three years of teacher interviews, classroom observations, teacher and student artifacts and survey data. The results from this multiple case study demonstrate that (1) science teachers' beliefs related to science teaching have the greatest influence on their implementation of the CCSS for ELA; (2) teachers who approach science teaching using constructivist and reform-based methodologies meet more of the CCSS for ELA student portraits and do so in different ways than their colleagues; and (3) addressing implementation support during professional development is critical to the successful implementation of the CCSS for ELA and ISI/inquiry-based teaching practices. The findings of this study have implications for all stakeholders involved in educational reforms and in-service science teacher professional development.

Key terms: constructivism, curriculum, educational reform, literacy, interdisciplinary science, inquiry, science education, science literacy, teacher beliefs.

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Introduction

Before the introduction of the Next Generation Science Standards (NGSS), the Common Core State (CCSS) for Mathematics and English Language Arts (ELA) (National Governors Association Center for Best Practices & The Council of Chief State School Officers, 2010) were introduced in an effort to improve student achievement. All states were enticed to participate in the adoption of the Common Core Standards by making the adoption of these “internationally benchmarked standards” a prerequisite for their eligibility to vie for Race to the Top grants. The CCSS for ELA (also referred to in this document as “the Standards”) sets clear expectations for the preparation of students to attend colleges and participate in careers as it is commonly accepted that in order for students to participate in the global economy, college attendance is necessary (Hill, 2011). By infusing the entire curriculum with mathematics and literacy skills, the goal is that all teachers will be assisting their students to attain the skills necessary to prepare them to meet this challenge. In particular, science teachers face a unique challenge as they attempt to implement both CCSS for Mathematics and ELA into their teacher practice. Due to the complementary relationship that exists between the math and science disciplines, the incorporation of CCSS for Mathematics may not prove to be very difficult for science teachers. However, science teachers may face unique challenges in incorporating literacy skills into their practice as they attempt to implement the CCSS for ELA.

The CCSS for ELA is multifaceted, focusing on reading, writing, speaking, listening, language, media and technology. This new focus on literacy poses unique challenges to secondary science teachers. Some secondary science teachers have limited training in literacy, as it may not have been a required part of their teacher education programs. In limited cases, science teachers hold additional teacher certifications in elementary education, reading education or special education - all of which prepare teachers to assist students with literacy challenges. Since most secondary science teachers have limited formal training in literacy and are relatively unfamiliar with literacy teaching techniques, a deliberate shift in their classroom teaching would be required for them to incorporate literacy in their practice (Windschitl, Thompson & Braaten, 2011). The challenges that science teachers may encounter while attempting to incorporate literacy skills into their instructional practices may be due to the beliefs and perceptions they have about the CCSS for ELA. These beliefs and perceptions may stem from a myriad of factors including: a lack of formal training in literacy instructional practices, their orientations to teaching science, access to literacy resources and their lack of familiarity with the CCSS for ELA for their particular grade-level and subject area. In order for science teachers to successfully implement the CCSS for ELA, it is imperative that they recognize the significant role that literacy plays in their students’ ability to participate in inquiry-based science as well as the role that literacy skills play in the work of scientists.

The Role of Fundamental Literacy in Scientific Literacy

Scientific literacy in the fundamental sense (reading and writing) is central to scientific literacy in the derived sense (being knowledgeable, learned, and educated in science) (Norris & Phillips, 2003). Although some researchers’ conceptions of science literacy have attempted to include literacy in the fundamental sense (Millar & Osborne, 1998; NRC, 1996; Shortland, 1988), most have conveyed reading and writing in a fundamental relationship to science literacy. Norris and Phillips (2003) however, contend that the relationship between literacy in the fundamental sense and science “is a constitutive one, wherein reading and writing are constitutive parts of science” (p. 226). By constitutive, Norris and Phillips (2003) implicate that literacy in its fundamental sense is a necessary part of science literacy.

The Connection Between Literacy and Science Inquiry

In an effort to improve science education and how it is taught in American classrooms, the Next Generation Science Standards (NGSS) were developed and released in May 2013 (Achieve, Inc., 2013). Already adopted by several states, the NGSS are grounded in the National Research Council's (2012) *Framework for K-12 Science Education.* The NGSS promote the adoption of inquiry-based science instructional practices and articulate a vision for the integration of science and engineering practices with crosscutting concepts and core disciplinary ideas. This new vision of science inquiry maintains the distinctness of the traditional science disciplines while blurring the lines between the disciplines, engineering and technology. The essence of what this integration means can be captured by the term Interdisciplinary Science Inquiry (ISI). Interdisciplinary Science Inquiry is defined as:

> a mode of inquiry that integrates information, data, techniques, tools, perspectives, concepts, and or theories from two or more disciplines or bodies of specialized knowledge to advance fundamental understanding or to solve problems whose solutions are beyond the scope of a single discipline or area of research practice. (NAS, 2004, p. 26)

The emphasis on interdisciplinary science, engineering and technology skills represents a bold shift in how science should be taught within American schools (NRC, 2012). As "literacy skills are critical to building knowledge in science" (Achieve, Inc., 2013, p. 1), the NGSS make direct connections to the CCSS for ELA within its curriculum. The developers of the NGSS worked with the writers of the CCSS in order to align science and literacy standards:

> As the CCSS affirms, reading in science requires an appreciation of the norms and conventions of the discipline of science, including understanding the nature of evidence used, an attention to precision and detail, and the capacity to make and assess intricate arguments, synthesize complex information, and follow detailed procedures and accounts of events and concepts. (Achieve, Inc., 2013, p. 1)

In an attempt to emphasize the critical connection between literacy and science practices, the NGSS Science and Engineering Practices include detailed references to the CCSS Literacy Anchor Standards as well as the CCSS Standards for Science and Technical Subjects. Students are expected to be able to interpret, evaluate, and integrate quantitative and technical content presented in diverse formats. These formats include the interpretation of a wide spectrum of media formats such as: visual (e.g., graphs, tables, diagrams, models and flowcharts), textual (e.g. domain-specific text), mathematical (e.g., equations) and media (i.e., quantitative data and video). The Standards also set clear expectations on students' ability to write and orally defend their positions on scientific arguments by conveying evidence derived through the examination of these media sources as well as data acquired through hands-on experimentation.

"Teaching inquiry-based science for understanding provides a powerful context for promoting literacy" (Magnusson & Palincsar, 2004, p. 316). The use of text in inquiry-based science is authentic to scientific practice and using text in inquiry-based science is a "powerful way to advance the goals of both text comprehension instruction and science instruction" (Magnusson & Palincsar, 2004, p. 316). There is a clear focus on the role of literacy skills in science inquiry as students are expected to be able to pose questions, plan and carry out scientific investigations and research-based enquiries within a collaborative setting, and collect and present relevant data to support their conclusions and claims. Within the domain of engineering practices, students are expected to utilize several elements that are unique to engineers in order to design solutions:

> These elements include specific constraints and criteria for desired qualities of the solution, developing a design plan, producing and testing models or prototypes, selecting among alternative design features to optimize the achievement of design criteria, and refining design ideas based on the performance of a prototype or simulation. (NRC, 2012, p. 68-69)

In order for students to become science literate and to fully engage in science inquiry, they must be able to understand and use domain-specific vocabulary that they encounter through reading, writing, speaking, listening and media use in the science classroom. One of the most important qualities of science, and one of the principal obstacles for students in learning science is to learn its language (Wellington & Osborne, 2001) and to master the complexity of its technical vocabulary. Harmon, Hedrick and Wood (2005) state that content area language presents unique challenges to students as most words in these areas are low in frequency and seldom appear in other contexts. This limits students' multiple exposure to these words, which is essential to the internalization of word meanings. Although each content area has unique vocabulary, the specific vocabulary load in science tends to be larger than in other disciplines. Therefore, students must be able to "expand their vocabulary in the course of studying content" (NGACBP & CCSSO, 2010) in order to fully engage in science and the discourse specific to this domain.

Pilot Study

In order to develop research questions for the current study, a pilot study involving a group of urban public school teachers beginning Summer 2013 and extending through the 2013-2014 school year was conducted. These teachers were participants in the Engineering and Interdisciplinary Science Project (EISP-pseudonym), a NSF-funded professional development program between 12 public schools and two universities in the North Eastern United States. One of the main goals of the EISP project is to improve teachers' abilities in incorporating interdisciplinary science inquiry skills into their science teaching practice. The principle findings from this pilot study can be summarized into two broad categories: (1) teachers' perceptions of the definition and goals of interdisciplinary science inquiry (ISI) play an important role in how they implement literacy skills within their science instruction and (2) teacher beliefs surrounding the goals of the CCSS for ELA and their level of comfort with its implementation within their instruction play a crucial role in how literacy is implemented into their science instruction. It was also noted that the teachers who had more constructivist orientations to teaching science implemented literacy skills in very different ways than their more didactically oriented colleagues. The constructivist teachers tended to include more inquiry-based teaching strategies and focused more on verbal communication. Additional classroom observations would be needed in order to solidify this relationship. Additionally, more data would be needed in order to solidify any relationships that may exist between teacher beliefs and their implementation of the CCSS for ELA into their science instruction.

Purpose of the Study

For the current study, the authors wanted to further investigate the factors that impact science teachers' ability to implement CCSS for ELA within their ISI-based science instruction. The findings in the pilot study provided a starting point for further research and highlighted the need for additional data that may shed more light on any existing relationships between teachers' values, perceptions and beliefs and their implementation of the CCSS for ELA. Since the majority of the teachers who participated would be returning for another year, I wanted to continue to examine their classroom practices and delve deeper into the factors that may influence their ability to implement the Standards. The current study also investigated how the teachers' views on literacy and the CCSS for ELA may have changed since their previous participation in the EISP project and to observe any evidence of changes that they have made to their classroom practices in relation to the incorporation of literacy skills.

The goal of this current study was to investigate how teacher beliefs, attitudes and values about CCSS for ELA influence how science teachers implemented the curriculum within the context of Interdisciplinary Science Inquiry (ISI). Given the demands that NGSS and CCSS for ELA place on science teachers, it is crucial to their success that stakeholders understand the factors that influence the implementation of the Standards and how these factors specifically influence their enactment in the classroom. ISI affords a potential for science teachers to implement CCSS for ELA; during inquiry-based science instruction students are expected to be able to pose questions, plan and carry out science investigations in a collaborative setting and collect and present relevant data to support their conclusions and claims. In order to explore K-12 teachers' beliefs and practices as they attempt to align their teaching of the CCSS for ELA within the ISI framework, the following research questions guided the current study:

1. How do science teachers demonstrate knowledge and values of CCSS for ELA curricula when they conduct ISI?
2. What relationship, if any, exists between teacher beliefs and perceptions of the CCSS for ELA and the implementation of CCSS in the science classroom within the context of ISI?

Theoretical Framework

In this study, constructivism was used as a theoretical lens to (1) evaluate the teachers' knowledge, beliefs and values about science teaching; (2) the students' learning activities and (3) the types of literacy skills that are incorporated into the lessons. Preliminary findings from the aforementioned pilot study yielded some evidence that teachers' knowledge, beliefs and values of science teaching are linked to the way in which they incorporate literacy skills into their teaching practice. It was noted that the teachers in the pilot study who held a guided inquiry orientation (Magnusson, Krajcik & Borko, 1999; Magnusson & Palincsar, 1994) incorporated more oral literacy skills into their science instruction than their more didactic colleagues who tended to focus more on "close reading" of science texts and direct instruction of academic vocabulary. These oral communication skills included verbal collaboration between peers, presenting their findings and participating in argumentation based upon evidence gathered during inquiry-based laboratory activities. Additionally, the teachers with a guided inquiry orientation incorporated literacy techniques that actively engaged their students in their own science literacy development such as using contextual clues during reading to determine unfamiliar science vocabulary meanings, developing operational definitions of science vocabulary terms as a community of learners, asking questions and defining problems, planning and carrying out investigations and analyzing and interpreting data. The tenets of social constructivism were employed to interpret the role of the classroom teacher in their students' learning and the role students play in their construction of their own knowledge.

Social constructivism. In his seminal work, Lev Vygotsky (1978) proposed that learning is socially constructed. Humans use tools that develop from a culture, such as speech and writing, to mediate their social environments. Initially, "children develop these tools to serve solely as social functions, ways to communicate needs" (Kozulin, Gindis, Ageyev & Miller, 2003, p.15). Vygotsky contends that the internalization of these tools leads to higher thinking skills; his answer to this educational challenge lies in his radical reorientation of learning theory from an individualistic to a sociocultural perspective where the key is the use of psychological tools. According to Kozulin et al. (2003), “The essence of cognitive education lies in providing students with these new psychological tools” (p.16). Vygotsky’s social constructivist theory has been the starting point for many discussions on research trends in classroom language research and their relationship to literacy.

Social constructivism and literacy. Social constructivist research on literacy learning focuses on the role of teachers, peers, and family members in mediating learning, on the dynamics of classroom instruction, and on the organization of systems within which children learn or fail to learn (Moll, 1990). Vygotsky’s notion of scaffolds has played a critical role in the development of theory and research on language and literacy learning (Wilkinson & Silliman, 2001). A scaffold is a temporary structure put into place to support students as they learn a new concept or skill and is taken away as the student gains learning independence. Although Vygotsky did not use the term “scaffolding”, Vygotsky’s theory promotes the use of instructional support “by a more knowledgeable other” and should be offered within a student’s ZPD or “zone of proximal development” to maximize student learning. The notion of ZPD takes into account the student’s current understanding and attempts to project where the student’s learning will be with proper support, or scaffolding, by an adult, teacher or more competent peer, such as fellow students.

Silliman and Wilkinson (1994) identified two types of scaffolds: directive and supportive. Directive scaffolds presume that the teacher’s primary job is knowledge transmission and assessment (Cazden, 1988). Directive scaffolds are defined by teacher control mechanisms such as the initiation-response-evaluation (IRE) conversation sequence, which has been the most well-known and studied direct scaffolding technique (Lemke, 1985; Mehan, 1979; Silliman & Wilkinson, 1991). Supportive scaffolding more closely emulates Vygotsky’s ideas of instructional support and comes from the work of Palincsar and Brown (1984). This approach to scaffolding is consistent with current recommendations for learner-centered instruction, values learning as a search for understanding, provides opportunities for responsive feedback, and views the educational process as occurring within a community of learners (Bransford, Brown, & Cocking, 1999). Roehler and Cantlon (1997) identified five types of supportive scaffolding: (a) offering explanations, (b) inviting student participation, (c) verifying and clarifying student understandings, (d) modeling of desired behaviors, and (e) inviting students to contribute clues for reasoning through an issue or problem.

Social constructivism and science instruction. This study took place within an urban school district, which is characterized by high student poverty levels, poor academic performance and a diverse student population. In order to evaluate the types of instructional approaches the teachers in this proposed study employ, sociotransformative constructivism (sTc) will be used. Rodriguez’s (1998; 2002) theory of sTc takes Vygotsky’s theory a step further and applies it to science education to promote social justice within the multicultural classroom context. Sociotransformative constructivism is an orientation to teaching and learning which, like Vygotsky’s theory, affirms that knowledge is socially constructed and mediated by cultural, historical, and institutional contexts (Rodriguez, 1998). As part of this sTc teaching orientation, Rodriguez recommends the inclusion of inquiry-based, constructivist, multicultural and gender-inclusive pedagogical strategies in the science classroom. Rodriguez (2005) suggests several principal strategies that he identifies as being key to enacting sTc in the science classroom: (1) using a variety of student-centered, hands-on and minds-on pedagogical strategies, (2) monitoring student groups for equity (e.g., who is doing the talking and using the equipment), (3) assigning tasks equally, (4) providing opportunities for problem solving, (5) encouraging peer tutoring (scaffolding and mediation), (6) accepting more than one right answer, (7) tapping into students' unique learning styles, (8) praising and encouraging collaborative learning and avoiding promoting a competitive learning environment, (9) making connections to science, technology, engineering, and math (STEM) careers, and (10) focusing on contributions made to STEM fields by individuals from diverse racial and ethnic backgrounds.

The Interdisciplinary Science Inquiry (ISI) framework. For the past three decades, both educators and scientists have supported science inquiry as the best approach for teaching and learning science. This was reflected in numerous reform documents such as the *Benchmarks for Science Literacy* (AAAS, 1993), the *National Science Education Standards* (NRC, 1996) and *Inquiry and the National Science Education Standards* (NRC, 2000). During the past fifteen years, science education research has advanced our understanding about science teaching and learning and has led to the creation of the Next Generation Science Standards (NGSS Lead States, 2013), based upon *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas* (NRC, 2011). NGSS uses a term *Science Practices* instead of inquiry process skills referring to practices being an "evolutionary step to inquiry process skills and expectation of students becoming proficient in what they do and learn" (Nargund-Joshi & Liu, 2013). The *cross-cutting concepts* in the NGSS blur the lines between the traditional science and engineering disciplines thereby highlighting the interdisciplinary nature of science inquiry. This research study took place within the context of the EISP program that focused on teachers' development and implementation of the components of ISI (see Figure 1). The purpose

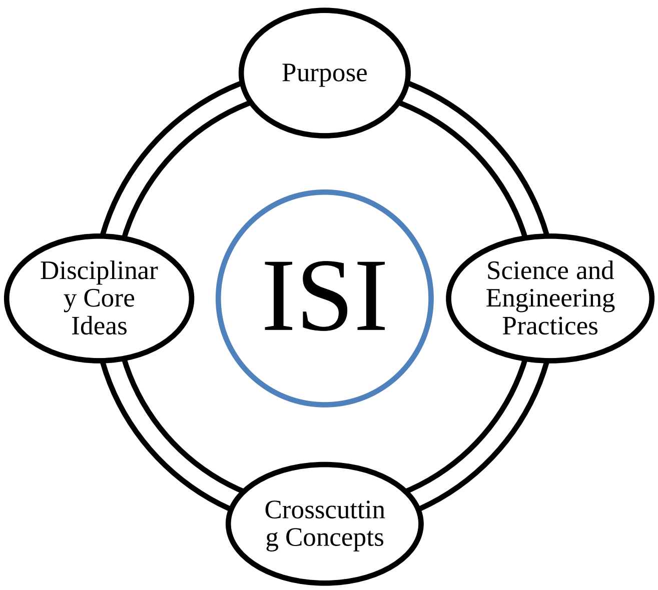

Figure 1. The Interdisciplinary Science Inquiry (ISI) Framework.

of ISI teaching and learning is to make science instruction and learning relevant to students' lives and providing them with more meaningful learning experiences that serve to prepare students to attend to societal needs. ISI is comprised of four key aspects of the NGSS: purpose, science and engineering practices, crosscutting concepts and disciplinary core ideas. ISI serves the following needs: (1) to understand the complex nature and societal needs from multiple disciplinary perspectives; (2) to explore problems and questions that are not confined to a single discipline; (3) to solve societal problems; and (4) to integrate technology and understand its pros and cons.

ISI involves seven science and engineering practices that establish, extend, and refine scientific knowledge; it contains both elements—knowledge and process skills (see Figure 2).

NGSS Science and Engineering Practices
S1. Asking questions (for science) and defining problems (for engineering).
S2. Developing and using models.
S3. Planning and carrying out investigations.
S4. Analyzing and interpreting data.
S5. Using mathematics and computational thinking.
S6. Constructing explanations (for science) and designing solutions (for engineering).
S7. Engaging in argument from evidence.

Figure 2. The NGSS Science and Engineering Practices

Teacher beliefs and professional development. In order to examine the role of addressing teacher beliefs within effective teacher development, Desimone's (2009) conceptual framework of professional development was utilized. Since the participants in this study are a part of EISP, a professional development program, it was critical to explore how their beliefs play a role in the implementation of both ISI and the CCSS for ELA within their classroom instruction. Drawing from recent research, Desimone developed a core conceptual framework for studying the critical features of teachers' professional development (see Figure 3). Each of the characteristics of Desimone's professional development model has been determined to play a role in improving teacher knowledge and skills, improving their classroom instruction and increasing student achievement. The core features of professional development proposed by Desimone include: content focus, active learning, coherence, duration and collective participation. Desimone contends that subject matter *content* focus might be the most important component of teachers' professional development as it has been demonstrated via empirical research that an improvement in teachers' content knowledge has been linked to improved student achievement (Cohen, 1990; Cohen & Hill, 2001; Garet et al., 2008 and Smith, L.K. & Southerland, 2007).

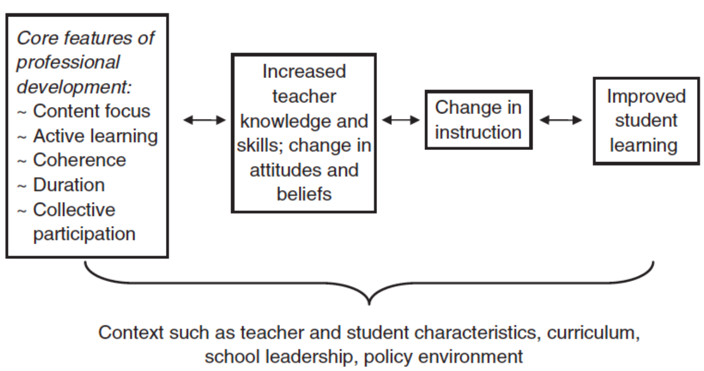

Figure 3. Core conceptual framework for studying the effects of professional development on teachers and students (Desimone, 2009, p. 185).

Teachers' *active learning*, as opposed to passive learning, has been shown to be an important factor in effective professional development (Garet et al., 2001; Loucks-Horsley et al., 1998). Passive learning would include teacher professional development that includes PowerPoint presentations or lectures. Active learning would include such activities as teaching and receiving feedback from peers, observing an expert teacher discussing the lesson with other teachers and reviewing student-created artifacts and having a discussion around it and having opportunities to teach to other teachers and lead discussions with their colleagues. The third component is *coherence*, "the extent to which teacher learning is consistent with teachers' knowledge and beliefs" (Desimone, 2009, p. 184). Coherence can also be related to consistency between educational reforms and teacher professional development (Consortium for Policy Research in Education, 1998; Elmore & Burney, 1997). *Duration* has been shown to play an important role in the effectiveness of professional development (Cohen & Hill, 2001; Fullan, 1993). Research has suggested that in order for professional development to be effective, they must include 20 or more hours of contact time and spread out over a semester. Collective participation, interaction among teachers from the same school, department or grade can lead to powerful teacher professional development (Borko, 2004; Fullan, 1991; Loucks-Horsley et al., 1998).

Literature Review

It is vital in the study of beliefs to consider the nature of beliefs and the models that scholars have developed in order to study them. Pajares (1992) posited that it was important to distinguish between knowledge and beliefs; he suggested that knowledge was based on fact while beliefs are based on evaluation and judgment. Based on research, Mansour (2008) concluded that there was an interaction between knowledge and belief while Nespor (1987) suggested that teachers' beliefs were more powerful than their knowledge when it came to influencing their pedagogical decisions. Pajares (1992) stated that there exists "a strong relationship between teachers' educational beliefs and their planning, instructional decisions and classroom practices"; he theorized that beliefs were "far more influential than knowledge in determining how individuals organize and define tasks and problems and stronger predictors of behavior" (p. 311). Several theories about the meaning of beliefs have been developed, each adding another dimension to this complex notion. Dewey (1938) developed a bipolar model of beliefs where they were categorized as either progressive or traditional, which was criticized as being overly simplistic (Bunting, 1984). Since the 1970s researchers have developed many multidimensional systems to explain this complex concept (Pajares, 1992; Rokeach, 1968; Wehling & Charters, 1969). Kagan (1992) posited that a teacher's knowledge could be better understood through the concept of beliefs and referred to teacher beliefs as a "particularly provocative form of personal knowledge". Over the course of a teacher's professional career their knowledge grows, which materializes into a highly personal pedagogy or belief system that dictates the teacher's behavior. Kagan (1992) states:

> A teacher's knowledge of his or her profession is situated in three important ways: in context (it is related to specific groups of students), in content (it is related to particular academic material to be taught), and in person (it is embedded within the teacher's unique belief system). (p.74)

The Role of Contextual Factors On Teacher Beliefs

Although there are many studies that demonstrate a direct relationship between teacher beliefs and classroom practices, there are several studies that indicate that teacher beliefs and practices are mediated by various contextual factors (Hancock & Gallard, 2004; Mellado, 1998). Context has been described as a "static, residual, surrounding 'container' for social interaction (Lave, 1993, p.22). Most of these contextual factors include the school community, preparing students for standardized exams, covering the prescribed curriculum, administration influences, teachers' learning experiences and teacher education. Contextual factors play a major role in teacher beliefs and these, in turn, have been shown to impact curriculum enactment. Several additional categories of these factors have been identified including: influences from teacher education programs, community factors, cultural myths and school environment stressors.

Socio-cultural context. There is a growing body of research that teacher beliefs should be studied within a “socio-cultural context” due to the fact that no beliefs are context-free (Fang, 1996; Olson, 1988; Pajares, 1992). According to Mansour (2009)

Culture is a screen through which people view their lives and interpret the world around them. It is within this socially constituted nature of culture that beliefs play an integral role in filtering information and determining what is considered important and to be of value in the group. (p. 32)

Teacher beliefs cannot be examined out of context as “beliefs and practices are always situated in a physical setting in which constraints, opportunities or external influences may derive from sources at various levels, such as the individual classroom, the principal, the community or curriculum” (Mansour, 2009, p. 32).

Influence on instructional practice. The transmission of teacher beliefs into the classroom is mediated by many “contextual variables” (Lederman, 1992) including real-life factors (learning behaviors, time, resources, and course contents) (Ajzen, 2002), school policy, the expectations of others (students, parents, fellow teachers and superiors) and the institutionalized curriculum (adopted text or curricular scheme, the system of assessment, and the overall national system of schooling (Ernest, 1988) and personal agency beliefs. Mellado (1998) cites teacher education programs as a contextual factor that influences teachers’ classroom instruction. Mellado (1998) conducted a study on four Spanish student teachers in order to investigate the influence of their conceptions of science teaching and learning on their classroom practices. The data sources from this study (questionnaire, interviews and classroom observations) indicated no clear relationship between their beliefs and classroom practice. The authors posit that this finding was due to their teacher education experiences that may have focused on pedagogical theory and lacked practical classroom applications.

School community beliefs. The beliefs of the school community are important to consider when investigating teacher beliefs. Haney, Lumpe, and Czerniak (2003) conducted a yearlong study on the epistemological beliefs of various community stakeholders: teachers, students, administration, and parents and community members. The participants completed a single sentence that was rated by the authors on a 1-5 point scale for statistical analysis. The findings indicate that the constructivist beliefs of all the study participants were low (Mean = 19.275, based on a possible score of 60). Traditional views of the “teacher as knower” and “student as recipient” were pervasive among the participants. Even more widespread were beliefs relating to teachers’ enthusiasm, care/concern for students and ability to motivate students. These three factors appeared to be highly related to the participants’ beliefs about hallmarks of successful teaching. In contrast, constructivist beliefs related to the curriculum, the use of instruction strategies and assessment techniques were lacking from the participants’ responses. The findings from this study suggest that professional development may play a significant role in teacher and administrator beliefs about constructivist teacher approaches as they demonstrated more positive constructivist beliefs about teacher science than parents/community members.

Cultural myths. Tobin and McRobbie (1996) investigated the factors that impede educational reforms in secondary science classrooms. Using data collected through classroom observations, interviews and a Classroom Environment Survey developed by Tobin, four cultural myths that teacher and students held were identified. These myths impede the enactment of curricula and science reform efforts in the science classroom: transmission of knowledge, being efficient, maintaining the rigor of the curriculum and preparing students to be successful on examinations. The transmission myth views the teacher as the holder and disseminator of knowledge; the efficiency myth is that classroom control and the covering of curriculum is more important than student learning; the rigor myth includes the idea that teachers know the content that needs to be covered and they make decisions regarding the best strategies to implement that result in student learning; the focus on tests and examinations results in an emphasis on low cognitive-level student activities focused on the enacted curriculum. The authors conclude that all of these myths serve as obstacles to reform in science classrooms.

Stressors. Although recent academic research has taken a departure from the study of contextual factors and their influence on teaching practice, its effect is palpable for both teachers and learners (Gahin, 2001; Mansour, 2008). Researchers have identified several "stressors" that impact a teacher's performance including student discipline, student apathy, large class sizes, and rates of student absenteeism. Due to these stressors, teachers may make certain adjustments to their instruction by focusing on more didactic teaching practices and emphasizing rote memorization. Maxion (1996) identified internal and external factors that influence teachers' beliefs and practices. External influences include life experience, education experiences, classroom events, school curriculum requirements, students, administrative demands, theoretical knowledge, educational policy, family and peers. Internal influences include a teacher's culture, internalized external factors (positive school experiences, life experiences and love of the subject), personality, personal practical knowledge, theoretical knowledge, and values.

Personal Agency Beliefs

Ford (1992) states that competence in any given area is a combination of a person's motivation, skill, and environment and that motivation is composed of an individual's goals, emotions, and personal agency beliefs (PAB). PAB are evaluative beliefs comparing a person's goals with the consequences of their pursuit of those goals. Ford (1992) states:

Personal agency beliefs play a particularly crucial role in situations that are of the greatest developmental significance-those involving challenging but attainable goals. Consequently, they are often key targets of intervention for parents, teachers, counselors, and others interested in promoting effective functioning. (p. 124-125)

Capability and context. Ford identifies two types of beliefs that are crucial to an individual's functioning: capability and context. Capability beliefs include an individual's perception of whether he or she possesses the personal skills needed to function effectively (which are synonymous with Bandura's (1986) concept of self-efficacy). Context beliefs include one's perceptions about how responsive the environment (external factors and /or people) will be in supporting effective functioning. Both of these sets of beliefs combine to form personal agency beliefs that regulate the level of motivation a person has in reaching a goal. Ford outlined nine belief patterns that are determined by the strength of capability and context beliefs: robust, modest, tenacious, vulnerable, self-doubting, accepting or antagonistic, discouraged and hopeless.

Personal agency beliefs and science teaching. Utilizing Ford's (1992) Motivational Systems Theory as a theoretical framework, Haney, Lumpe, Czerniak and Egan (2002) examined the relationship between elementary teachers' personal agency beliefs about teaching science and their ability to effectively implement science instruction. Haney et al.'s (2002) study focused on six elementary science teachers who participated in an NSF-funded grant that included a summer institute, and a 2-week long professional development. The data included 10 classroom observations, a questionnaire completed prior to their participation in the summer institute and an 8-question open-ended interview for each teacher. The Context Beliefs About Teaching Science

(CBATS) instrument (Lumpe, Haney, & Czerniak, 2000) and the Science Teacher Efficacy Beliefs (STEBI) instrument (Riggs & Enochs, 1990) were used to identify the teachers' context and capability beliefs. Together the instruments were used to construct personal agency beliefs. Effective science instruction was defined using the criteria established by Horizon Research, Inc. (1998). Haney et al. (2002) concluded that teachers who possessed positive capability and context beliefs score high on effective science teaching domains; these teachers were more likely to include inquiry, careful planning, attend to student prior knowledge and experiences, attend to issues of equity, utilize appropriate and available resources, encourage a collaborative approach, and assess students in a way that was consistent with the intended purpose. Teachers who had high personal agency beliefs were more likely to reach closure or resolution of the lesson's key concepts. The teachers who scored low on the efficacy and context beliefs scored lower on all the effective teaching domains and appeared to struggle with many or all aspects of effective teaching. This study confirms the existence of a relationship between what teachers believe and what they do in the classroom.

Epistemological Beliefs

Several studies have focused on epistemological beliefs and the role these beliefs play in classroom instruction (Benson, 1989; Gallagher, 1991; Hashweh, 1985). Hashweh (1996) conducted a study of 35 Palestinian teachers to identify their epistemological beliefs. These teachers had previously participated in a pilot study conducted by Hashweh in which 91 teachers completed surveys on knowledge and learning. Using the data gathered from this questionnaire, he was able to identify the teachers' epistemological orientations and place them into four groups: Learning Empiricists, Knowledge Empiricists, Learning Constructivists, and Knowledge Constructivists. Some teachers were members of more than one category. They were all asked to participate in another survey to which 49 teachers responded. The second questionnaire consisted of three parts: (1) responses to "critical incidents" or classroom situations involving alternative student conceptions, (2) responses to how they would manage students' alternative conceptions after being presented with a paragraph about research on alternative conceptions, and (3) teachers' ratings of pedagogical strategies. The data analysis revealed several interesting trends: (1) constructivist teachers are more likely to detect student alternative conceptions, (2) constructivist teachers have a richer repertoire of teaching strategies, (3) constructivist teachers use potentially more effective teaching strategies, (4) constructivist teachers report more frequent use of effective teaching strategies and (5) constructivist teachers highly value these teaching strategies compared with teachers who hold empiricist beliefs. Although constructivist teachers were more likely to accept students' alternative conceptions, empiricist teachers were more likely to recognize them. These results are consistent with previous studies (Benson, 1989; Gallagher, 1991). In a previous study, Hashweh (1985) found similar results when conducting teacher interviews. This study demonstrated that teachers who held learning constructivist and knowledge constructivist beliefs are better prepared than empiricist teachers to induce student conceptual change. Also, constructivist teachers tended to have and use more effective strategies they had developed to address conceptual change in their students.

Teacher Beliefs and Educational Reform

Many scholars concur that the implementation of any educational reform depends heavily on teachers (Bybee, 1993; Haney, Cerniak & Lumpe, 1996; Levitt, 2002; Nespor, 1987; Pajares, 1992; Tobin, Tippins, & Gallard, 1994). In order to avoid the pitfalls of previous science education reforms, classroom teachers (as opposed to policy makers) must be the essence of the reform (Duschl, 1990). Teachers are the “change agents” in the implementation process of educational reform and their beliefs must not be ignored (Bybee, 1993); ignoring the role of teachers in the process of change is likely to doom reform efforts to failure (Sarrason, 1996). Although there is research that indicates that some teachers openly embrace new science initiatives others are unwilling or unable to modify their teaching practices to align to reform-oriented practices (Laplante, 1997; Yerrick, Park & Nugent, 1997).

Influence of teacher beliefs on reformed-based curricula. There are several studies that have supported the presence of a strong relationship between teacher beliefs and education reforms and curriculum implementation. Haney, Czerniak and Lumpe’s (1996) study focused on determining the factors that influence science teachers’ intentions to implement an educational reform. Situated within the context of Ohio’s Competency Based Science Model, the authors focused on four strands of learning (science inquiry, scientific knowledge, conditions for science learning, and applications in science learning). Using Ajzen’s Theory of Planned Behavior (1985), the influence of three primary constructs (attitude toward behavior, subjective norm, and perceived behavioral control) on teachers’ intentions to implement the four strands were investigated. The primary data source for Haney et al.’s (1996) study was a random selection of completed mailed questionnaires sent to Ohio science teachers (N = 800). In addition, 13 teachers from this sample were interviewed about their beliefs about the curriculum. Statistical analysis of the survey data was completed utilizing the techniques of backward solution multiple regression and analysis of variance. The statistical findings were organized around the strands of the Ohio Science Model. The results from this analysis indicate that the attitude toward the behavior construct (teachers’ attitudes) held the greatest influence on Ohio science teachers’ intentions to implement the intended curriculum and was the only significant statistical finding. Within this finding, there were interesting differences among the populations of teachers who reported the highest scores in this behavior and were therefore more likely to implement the curriculum as it was intended. The highest scores for the teachers within the behavior construct came from teachers who were female, had the least number of years of teaching experience and taught at the primary level followed by those who taught at the middle-school level. Teachers reporting higher self-efficacy and familiarity with the Ohio Science Model scored higher in the attitude toward behavior domain. Additionally teachers with the least amount of teaching experience reported higher scores than their more experienced colleagues. Haney et al.’s (1996) findings indicate that the greatest predictor of intent to implement an educational reform is teachers’ favorable attitudes and beliefs towards the curriculum outcomes. Another interesting conclusion from this study is that the participants felt that they lacked the ability to bring about educational change and felt that barriers existed (such as lack of staff development opportunities, availability of resources and administrative support) that impeded their ability to implement educational reform.

Change In Teacher Beliefs

Although researchers acknowledge that teacher beliefs can be highly resistant to change, it is possible for teachers to change their beliefs if they are aware of their beliefs and if they are willing to change them (Pajares, 1998). Professional growth in teachers can be encouraged through raising teachers’ awareness of their own beliefs, challenging those beliefs and providing opportunities for teachers to integrate new knowledge into their belief systems (Kagan, 1992). Some studies indicate that teachers can modify their belief structures through classroom learning while others can only change their belief structures when faced with the reality of the classroom (Veenman, 1984; Joram & Gabriele, 1998; Simmons et al., 1999).

Professional development and teacher beliefs. Desimone (2009) discusses the importance of addressing coherence, the role of teachers' knowledge and beliefs, when developing effective teacher professional development. Research has demonstrated that teachers' practical knowledge (an integration of experiential knowledge, formal knowledge and personal beliefs) is action-oriented and person-bound and long-term professional development is required to promote lasting change (van Driel, Beijaard & Verloop, 2001). Luft's (2001) study demonstrated that teacher beliefs and teacher practices are highly entwined. Based upon an inquiry-based professional development program involving experience and beginning science teachers, this study found that the impact varied between the two groups of teachers: the beginning teachers were shown to have changed their beliefs more than their practices while the experienced teachers' practices changed more than their beliefs. This study's findings indicated that in order to promote teacher change in practice, teachers must be provided with opportunities to explore their own behaviors and beliefs and effective professional development must be configured to attend to the diverse beliefs and behaviors of the participants. The results of Luft's study demonstrated that experienced teachers were able to change their practices when the professional development program supported initial changes in their teaching practice that were consistent with their current beliefs. It has also been shown that the changes in teacher beliefs about new curricula come after witnessing successful classroom implementation (Huberman, 1981). As demonstrated in Huberman's study, the focus at the beginning of a professional development program was on improving teachers' cognitive mastery of the individual components of the new curriculum. As the teachers' mastered implementation and they saw positive benefits to their students, their "concern for understanding the structure and rationale of the program grew" (Huberman, 1981, p. 91). The study demonstrates that changes in the teachers' attitudes and beliefs may follow attempts at curriculum implementation and their attitudes may improve after witnessing student improvements (Fullan, 1985).

Conclusion

There has been an ongoing debate about the relationship between teacher beliefs and practice among educational researchers. Many studies on teacher beliefs indicate that the relationship between teachers' beliefs and their classroom practices is complex and is often influenced by varying social contexts (Mansour, 2008), culture (Mansour, 2009), school climate, availability of resources; and mediated by situational variables (Lederman, 1992) such as expectations of others (peers, students and superiors) and the adopted curriculum (Ernest, 1988). Due to its complexity, teacher beliefs have been referred to as a "messy construct" by Pajares (1992) as it:

> travels in disguise and often under an alias of attitudes, values, judgments, axioms, opinions, ideology, perceptions, conceptions, conceptual systems, preconceptions, dispositions, implicit theories, personal theories, internal mental processes, action strategies, rules of practice, practical principles, perspectives, repertories of understanding, and social strategy, to name but a few that can be found in the literature (p. 309).

Although teacher beliefs have been touted as the most valuable psychological construct to teacher education, it has remained a challenge to define what exactly teacher beliefs are. Pajares (1992) posits that the difficulty in understanding and studying teachers' beliefs has stemmed from “definitional problems, poor conceptualization, and differing understandings of belief structures” (p. 307). In order to study teacher beliefs and their effect on classroom practice, it is imperative that a spectrum of influences are acknowledged and identified as contributions to a teacher’s belief structure.

Research Gap

The volume of research conducted on teacher beliefs related to in-service teachers within the classroom setting is relatively sparse. Some of the research to date on teacher beliefs has been heavily dependent on self-reported data such as surveys without classroom observations in order for researchers to draw their conclusions (Haney et al., 1996; Haney et al., 2003; Hashweh, 1996). Fang (1996) criticizes this approach as self-reporting data without classroom observations may reflect what the teacher feels needs to be done rather than what they are doing in their actual practice. Additional studies have been conducted using only two data sources such as interviews and observations (Cronin-Jones, 1991; Roehrig & Kruse, 2005) which also leads the reader to wonder if the teachers answer questions and implement temporary changes that satisfy the expectations of the researchers. Since teacher beliefs are rather static, it would be important to conduct surveys that collected data on teachers’ proclivities to teaching and learning science.

Another deficit with many of the published studies is that they are conducted in isolation of various contextual factors. Education scholars indicate that teachers’ beliefs are complex and multi-faceted; it is therefore reasonable to conclude that the relationship between teacher beliefs and their classroom practices is mediated by many factors as mentioned previously. In order for a study on teacher beliefs and practices to be robust, multiple sources of data such as: interviews, surveys, observations, and artifacts need to be used to provide a genuine picture of this phenomenon. Additionally, the instruments used in the study need to investigate various contextual factors as well as teachers’ perceived roadblocks to their instruction. It is therefore paramount for researchers to employ multiple sources of data as well as using instruments and protocols that probe teachers’ epistemological stances, contextual factors, teacher education influences, self-efficacy beliefs, the role of the educational community, the school context, administrative support and the role of professional development when conducting educational research on the effect of teacher beliefs on reform-based curriculum implementation. Without all of these factors taken into consideration, resulting studies will be unable to provide a true picture of the influence teacher beliefs play in classroom instruction and curriculum implementation. To date, there have been no studies reported on science teachers’ knowledge, beliefs and perceptions of CCSS for ELA as it relates to ISI and how the above factors impact their implementation of CCSS for ELA in ISI teaching.

The current study. This research study aimed to be as multifaceted as the concept of teacher beliefs by examining data from multiple sources including: self-reported teacher data via survey, interviews and multiple classroom observations. Additionally, these instruments explored the myriad of contextual factors that influence teacher beliefs including the students, teacher preparation, teacher values and teachers’ self-efficacy beliefs. This study explored these factors as possible influences to implementing CCSS for ELA within the context of teachers’ ISI-based science instruction. The findings from this study could potentially inform professional development for teachers as they attempt to align their classroom practices with both the NGSS and the CCSS for ELA.

Methodology

This research study utilized a mixed-methods research design to explore the relationship between science teacher beliefs and their implementation of literacy-based teaching strategies within the context of ISI. The mixed methods approach of Dominant - Less Dominant Design was used in a Parallel/Simultaneous Approach (QUAL + quan) (Creswell, 1995; Tashakkori & Teddlie, 1998). In a Dominant – Less Dominant study, the researcher conducts the study "within a single dominant paradigm with a small component of the overall study drawn from an alternative design" (Creswell, 1995, p. 177). For the current study, the dominant data were qualitative (QUAL) and the less dominant data were quantitative (quan). This study employed concurrent, but separate, collection of quantitative and qualitative data so that the researcher could better understand the research problem (see Figure 4). The quantitative data provides an overview of the spectrum of science teachers' knowledge, beliefs and implementation of CCSS for ELA while the qualitative data strengthens and confirms these findings and provides an opportunity for the voices of study participants to be heard.

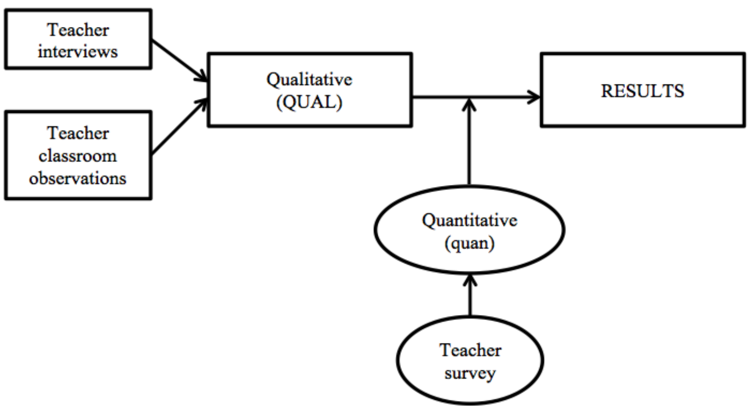

Figure 4. Mixed Methods Design: Parallel/Simultaneous Dominant – Less Dominant (QUAL + quan).

Participants and Site

The participants in this study consisted of a selection of ten in-service K-12 teachers from "Lakeside School District" (LSD), a large urban school district that serves approximately 31,000 students in the Northeastern United States. All of these teachers (N = 10) were participants in the National Science Foundation (NSF) funded Engineering and Interdisciplinary Science Partnership (EISP), a teacher professional development program focusing on interdisciplinary science inquiry (ISI). The EISP is a partnership between two public universities and 12 elementary, middle and high schools in Lakeside School District. As part of their participation with the EISP project, all of the teachers participated in professional development activities during the summer between school years. Most of the science teachers partnered with scholars who are currently conducting research in the science and engineering disciplines. Some of the participants participated in a two-week physics course offered by one of the partner universities. Other participants conducted their own curriculum writing sessions during the summer. Several teachers' summer professional development focused on the engineering design process. In addition to their summer research ISI experiences, the teachers in this study were invited to participate in monthly Professional Learning Community (PLC) workshops. The subjects of these PLC session included: ISI Implementation in the Science Classroom, Engineering Design within ISI, School-wide implementation of ISI, CCSS for ELA within ISI, and ISI and the NGSS Framework.

Participants. A purposive sample of 10 focus teachers, selected from the cohort of the 72 participating LSD school teachers involved in the EISP program, were chosen for this study. All of the teachers have been with the EISP project for three years. In order to study a sample of teachers that represent the spectrum of all the participants in the EISP project, the ten focus teachers were selected based upon the following criteria: (1) grade and subject taught; (2) teaching certifications held; (3) number of years teaching, (4) type of summer professional development experience (university course, curriculum writing, science research, or engineering design); and (5) attendance (low, medium, high) at the monthly PLC sessions held throughout the school year. The criteria used for the selection of teachers was based upon obtaining a cross-section of participants from the EISP grant in which each grade, subject area, summer research experience, level of PLC attendance and teaching certification were accounted for. Within the purposive sample of the study participants, a spectrum and several combinations of these participant characteristics is represented.

Site. All of the focus teachers taught at seven of the twelve EISP-participating schools within the Lakeside School District, a large urban school district in a city located in the Northeastern United States. Overall for the entire Lakeside School District, the New York State accountability report for 2011-2012 (New York State Education Department, 2013) reported that Adequate Yearly Progress (AYP), “which is measured by the percentage of students tested against their performance against defined standards or for graduate rates it is the percentage graduated against defined standards” (p. 2), was not met for elementary and middle-level English Language Arts, Mathematics, Science nor for secondary-level English Language Arts or Mathematics. Even though the school district met the targeted AYP for graduation, in comparison to the State standard of 76%, the district’s graduation rate was low at an overall 53%. During 2014, Lakeside School District’s ELA/Math Aspirational Performance Measures (APM), the percentage of students in the cohort who graduated with a Local, Regents, or Regents with Advanced Designation diploma and earned a 75 or greater on their English Regents examination and earned a 80 or greater on a math Regents examination, was 13% as compared to the statewide average of 38%. Twelve out of the 68 public elementary and middle and high schools in the Lakeside School District were involved in the project. Table 2 provides demographic information on the 12 participating schools.

Data Collection

This mixed methods study strove to understand the impact of teacher beliefs on their ability to implement literacy skills within the context of ISI. To understand this complex process, both qualitative and quantitative data were collected. The collection of the qualitative data occurred through teacher interviews, classroom observations and the analysis of physical artifacts. The quantitative data was collected as part of a 15-question teacher survey (see Appendix C). The items on this survey included teachers’ knowledge of the CCSS for ELA, their perceived values of literacy skills, the appropriateness for their student population, their feelings of self-efficacy in teaching literacy skills and their implementation of various literacy approaches.

Observations. A series of teacher observations took place beginning during summer 2014 and continue through spring 2015. The focus of these observations was to gain an understanding of how the teachers incorporated both interdisciplinary science inquiry and literacy skills into their teaching practice. This new classroom observation data was combined with that collected during years 1 and 2 of the project, during the 2012-2013 and 2013-2014 school years, respectively. During the 2012-2013 school year, informal classroom observations were conducted and included field notes and artifacts collected by the research team members. In some cases, videotape, audio recordings and photographs were taken. During the 2013-2014 school year, formal classroom observations were conducted utilizing an observation protocol that was developed by the EISP research team (see Appendix A). The same protocol was used during the 2014-2015 classroom observations. The observation protocol was composed of three parts: a pre-observation written interview adapted from CoRe: Content Representation Tool (Loughran, Berry & Mulhall; 2012); a field observation form adapted from the Reformed Teaching Observation Protocol (RTOP) (Sawada & Piburn, 2000); and a post-observation rating form that includes components of the ISI summer weekly log sheet and the Inquiry into Science Instruction Observation Protocol (ISIOP) (Minner & DeLisi, 2012) as well as a rating of CCSS for ELA literacy skills that overlap with the NGSS framework.

Interviews. Semi-structured interviews were conducted using a protocol developed by the science education research team (see Appendix B). Each participating teacher was interviewed using this protocol, but additional interviews were conducted to clarify their responses. The topics that the interview protocol included are: (1) teacher background information; (2) teachers' summer professional development experience; (3) teachers' goals and approaches to science teaching; (4) teachers' understanding and use of ISI and inquiry; (5) factors that influence the teachers' ability to implement ISI and inquiry in their classroom; (5) teachers' understanding of CCSS for ELA; (6) teachers' perceptions and values of literacy skills and the CCSS for ELA; (7) teachers' self-efficacy in implementing literacy skills; (8) changes teachers are making to their instructional practices to include literacy skills; and (9) teachers' ability to connect CCSS for ELA with ISI. These responses will be combined with those that were conducted during Years 1 and 2 of the project. During the Year 1 interviews, there was a focus on teaching orientations, summer professional development, understanding of ISI and its implementation during the school year. During Year 2, the questions were the same as those proposed for the current study.

Artifacts. Physical artifacts were collected and coded throughout the duration of the data collection phase of this study. These artifacts included items collected during classroom observations: teachers' classroom instructional materials (student hand-outs: worksheets, lab exercises, readings, etc.), photographs, video and audio recordings of lessons, examples of student work and teacher lesson plans. In addition, teachers' EISP summer research proposals and implementation plans were examined for teachers' professed implementation of their summer research experiences.

Survey. Teacher survey data were collected during the fall 2014. This survey contained 15, 5-point Likert-type items (see Appendix C) that focused on obtaining information about the teachers' perceptions, beliefs and perceived values surrounding the CCSS for ELA. These questions were organized into three major constructs: knowledge, values and integration of CCSS for ELA.

Data Analysis

Qualitative data. The teacher interviews were audio-recorded and transcribed verbatim. The teacher interviews were initially holistically coded (Saldaña, 2009) for general, broad themes. The second cycle of coding utilized a combination of in vivo and open coding (Saldaña, 2009) to create codes that were then categorized by themes. Another researcher coded a selection of teacher interviews in order to promote interrater reliability. The generated themes were used to compare various episodes with the same teacher throughout the project, employed to compare teachers with one another, and to draw attention to patterns within and across the categories and school years.

Classroom observations. Classroom observations were analyzed for both science and literacy practices using an interpretive framework developed by Cheuk (2013) and Stage, Asturias, Cheuk, Daro and Hampton (2013) (See Figure 5).

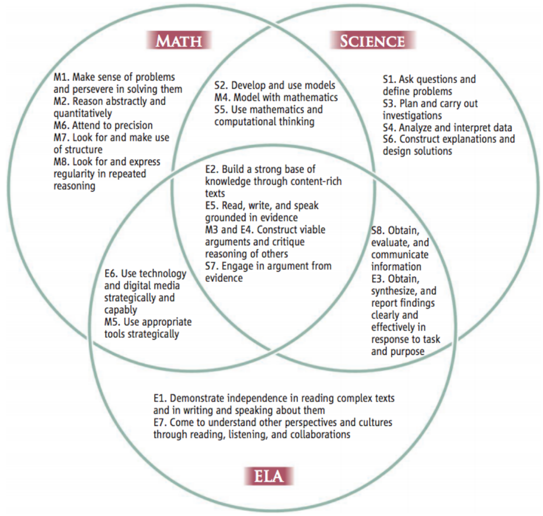

Figure 5. Overlap, Relationships and convergences found in the Common Core State Standards for Mathematics (practices), Common Core State Standards for ELA (student portraits), and the NGSS (science and engineering practices). Adapted from Cheuk (2013) and Stage, Asturias, Cheuk, Daro and Hampton (2013).

Each lesson was coded using the prefixes denoting the *Common Core State Standards for ELA & Literacy in History and Social Studies, Science and Technical Subjects: Portraits of Students* (E1-E7), the *Common Core State Standards for Mathematics: Standards for Mathematical Practice* (M1-M8) and *Next Generation Science Standards (NGSS)* (S1-S8). The letter and number set preceding each phrase in the diagram denotes the discipline and number designated by the content standards. Each of the science lessons was coded using the letter and number set for each student practice (as defined by the NGSS) and portrait (as defined by the CCSS for ELA) that was observed (see Table 4).

Table 4
Student Portraits (CCSS for ELA) and Practices (NGSS)

Common Core State Standards for ELA & Literacy in History/Social Studies, Science, and Technical Subjects Student Portraits	Next Generation Science Standards: Scientific and Engineering Student Practices
E1. [Students] demonstrate independence. E2. They build strong content knowledge. E3. They respond to the varying demands of audience, task, purpose, and discipline. E4. They comprehend as well as critique. E5. They value evidence. E6. They use technology and digital media strategically and capably. E7. They come to understand other	S1. Asking questions (for science) and defining (for engineering). S2. Developing and using models. S3. Planning and carrying out investigations. S4. Analyzing and interpreting data. S5. Using mathematics, information and computer technology, and computational thinking. S6. Constructing explanations (for science) and designing solutions (for engineering).

perspectives and cultures.	S7. Engaging in argumentation from evidence. S8. Obtaining, evaluating, and communication information.

A panel of five science education graduate students coded a sample of teacher classroom observations to promote reliability. Their initial coding was discussed for each lesson and a consensus for final codes was reached through discussion. The final lesson observation codes were used to calculate the frequency with which the focus teachers targeted the student portraits and practices during their lessons. The coding for the lessons was analyzed by year and across all three years to check for any trends or changes to overall teaching practices. The Year 3 lesson code frequencies were examined for three focus teachers that represent different patterns of classroom implementation.

Quantitative data. The quantitative data in this study originated from a 15-item, 5-point Likert-type online teacher survey. The survey provided an overview of the spectrum of the 10 focus teachers in this study and focused upon three aspects of their understandings, beliefs and implementation of the CCSS for ELA within their science teaching practice. The survey data was analyzed using descriptive statistics and used to triangulate the interview and classroom observation data.

Merging of datasets. After separate analysis, the qualitative and quantitative data was merged, overlaid and analyzed. Themes were analyzed through combining, presenting and triangulating both the quantitative and qualitative data. The survey data and interview responses were combined and analyzed within the teacher perceptions, beliefs, values and professed implementation themes; the survey data and observation data were overlaid and analyzed within the classroom implementation theme. The converged data will be presented and explained in the Findings section entitled Case Studies.

Findings

Teachers' Beliefs Related to Science Teaching

The teachers' beliefs related to science teaching were explored during the interview process in an effort to uncover factors that might serve to influence how and in what ways these beliefs might influence the teachers' implementation of the CCSS for ELA and ISI. Teachers were asked about their approach to science teaching, their goals and purposes for teaching science and their expectations for their students' science learning.

Approach to science teaching. When teachers were asked to describe their approach to science teaching, several major themes emerged. These self-proclaimed approaches could be categorized into five main themes: inquiry-based, hands-on, student-centered and student-driven, "layer-cake" and focused on exam preparation. Some of the focus teachers' approaches consisted of overlaps of several of these themes. When asked about their approach to science teaching, the most frequent terms that were referenced in their responses were "inquiry" and "hands-on". Three of the teachers described their approach as a step-by-step process in which inquiry or more student-centered activities only came after direct instruction of science content. Two of the teachers included "Regents" in their response and described their instructional approach as geared towards student preparation to take this year-end assessment.

Goals and purposes for science teaching. To gain a better understanding of what the participants felt their goals were for their science teaching, the teachers were asked to explain what they felt their main purpose was in their science instruction. After data analysis, four themes emerged that helped to categorize their goals and purposes (see Table 7). Two frequent themes emerged during the data analysis of teacher responses, which included the domain of science and real-world application skills. Two less-predominant themes also emerged: exam preparation and student exploration of science phenomena. Half of the participants' responses to the question of what their goals and purposes was for science teaching included references to the domain of science: promoting students' interest, understanding, passion, importance and application of science in their lives. Five of the teachers described their purpose as equipping students with real-world skills. Most of the teachers who taught a Regents course described their goals as getting their students ready to take the Regents Exam. Student discovery was mentioned by two of the teachers as being their primary purpose for science teaching.

Expectations for students' science learning. In order to further understand teachers' motivations in teaching, they were asked about what they expected their students to learn in their classroom. Many of the themes they already mentioned in their approaches and goals were touched upon in their responses to this question (see Table 8). Most of the teachers (seven out of ten) mentioned science skills and abilities as being the primary competency that they wanted their students to gain from their time in their classrooms. These skills and abilities included: skills related to science investigative process, independence in critical thinking and problem solving skills and an understanding of the power behind good collaboration skills. The second expectation that the focus teachers shared was that of their students' progress towards their understanding of the world and applications of their learning to the real world context. Another theme that resurfaced during the data analysis process was that of passing the Regents exam at the end of the school year.

Teachers' beliefs relating to their approaches, goals and expectations for science teaching and learning reveal several overarching themes. To summarize, the data analysis revealed that the teachers' approaches to science teaching could be categorized under five major themes: inquiry-based, hands-on, student-centered and student-driven, "layer-cake" and exam preparation. It also revealed that teachers' purposes for science teaching fell into four main categories: science-related goals, exam preparation, real-world applications and student discovery. The teachers' expectations for student learning could be categorized into three major topics: the development of science skills and abilities, real-life or real-world applications to their science learning and the passing year-end exams, including the Regents. Analyzing these findings across the three themes reveals an interesting conclusion related to teachers' beliefs regarding science learning and teaching: their students' science skills development, beliefs related to students' abilities to apply their science knowledge and skills to real-world and real-life applications and students' preparation and success on the New York State Intermediate Science Exam and Regents Exam are significant influences to their science teaching practice.

According to Anderson and Smith (1987), teachers possess "orientations toward science teaching and learning" which are influenced by their knowledge and beliefs. These beliefs serve as a "conceptual map that guides instructional decisions" (Borko & Putnam, 1996). Science teachers' orientations can be described by the goals they articulate for their instruction and the nature of the characteristics present within their instruction (Magnusson, Krajcik and Borko, 1999). Nine science teacher orientations have been described in the literature: process, academic rigor, didactic, conceptual change, activity-driven, discovery, project-based science, inquiry and guided inquiry. Upon analyzing the participants' interview responses to questions regarding their goals and expectations for science instruction, it becomes clear that the teachers show indications of holding particular orientations, or a combination of orientations, to teaching science. However, without considering their classroom instruction in addition to their stated goals, it would be premature to formally categorize each of the participants into a teaching orientation as typical characteristics of instruction define and differentiate the orientations (Magnusson et al., 1999). It would also be difficult to the participants' interview responses in regard to their approach to science teaching in order to categorize them by orientation (see Table 5) as their conceptions of inquiry are so varied. In order to formally categorize each of the participants into a teaching orientation, additional data would need to be considered.

Teachers' Perceptions and Professed Implementation of ISI

Teachers were asked a series of questions related to Interdisciplinary Science Inquiry (ISI), the foundation of which is the main premise of the EISP professional development project. The participants were asked to explain their understanding of Interdisciplinary Science Inquiry during Year 1, Year 2 and Year 3 interviews. Comparing teachers' responses over three years shows several trends in understandings: there was a shift away from describing ISI as hands-on and a shift towards more Problem-based Learning (PBL). There was also an increase in teacher responses that included inquiry as well as an increase in connecting science to other subjects within and outside of the science disciplines. The greatest global change over the course of the three years with the EISP grant is that all ten of the participants came to understand that ISI incorporates more than just one discipline to help students to deepen their understanding of science.

Perceived overlap between summer EISP experience and ISI with the CCSS for ELA. To get a sense of where teachers connect literacy skills to the work of scientists, they were asked to share their perspective on the overlap between the CCSS for ELA and their summer experience or ISI in general (see Table 11). Seven of the teachers (70%) connected reading as being a necessary component of the standards that the students would need to conduct ISI like they did during their summer professional development experiences. Three of the teachers (30%) included the need to understand scientific vocabulary as a prerequisite to conducting ISI. Three participants (30%) felt that the ability to write was important to conducting ISI. Several teachers (40%) felt that having research skills was important to obtaining background information for scientific experiments. Two of the participants (20%) included "literacy skills" in their responses. In Joy's response to this question, she included the need for literacy skills, vocabulary knowledge and reading ability in her response. She felt that these aspects of the CCSS for ELA were required for participating in research like she did over the summer.

Perceived challenges to inquiry and ISI implementation. Over the three-year timeframe of the EISP project, the teachers expressed the challenges they faced in their classrooms when implementing both literacy skills and ISI. After analyzing the interview responses, the categories of obstacles the teachers conveyed included: student-related factors (100%), curriculum and instruction factors (50%), teacher-related issues (30%), large class sizes (20%) and the lack of instructional resources and materials (20%).

Teachers' professed and observed implementation of ISI and inquiry. Since each teacher had implemented ISI and inquiry so differently over their three-year participation with the EISP grant, it would be difficult to present an organized and coherent written description. Table 13 provides a summary of teachers' professed classroom implementation. The data from teacher implementation plans, summer research proposals and interviews was used to construct this table. A summary of the findings follows the table. An analysis of the implementation data,

Due to the fact that the focus teachers have such diverse understanding of ISI and inquiry, it is no surprise that their implementation of these instructional approaches also varies. Although the majority of the teachers were able to articulate ISI as connecting other subjects to the one they were teaching, there is little evidence in their professed and observed implementation that they are incorporating these other subjects during their teaching practice. It has been stated in the research that the relationship between teachers' orientations and their classroom practice is complex and for various reasons their orientations do not always translate congruently with their instruction (Friedrichsen & Dana, 2003; Volkman & Zgagacz, 2004). A myriad of contextual factors have been identified that contribute to discrepancies between teachers' stated purposes for science teaching and their enacted practice such as: student expectations (Volkman, Abell and Zgagacz, 2005), school resources or requirements (Beck, Czerniak & Lumpe, 2000; Zhang, Krajcik, Wang, Hu, Wu & Qiang, Y., et al.; 2003) and the existence of a "testing" culture (Zhang et al., 2003). All of the participants cited constraints to implementation of ISI such as: student behavioral issues, large class sizes, lack of science materials and the pressure of external assessments. However, it should be noted that although Bryce cited student issues as being a challenge to implementation of ISI, he did not allow this to hinder his reform-based teaching approach that frequently makes interdisciplinary connections. It also needs to be said that Bryce was teaching the same way prior to his involvement with the EISP grant and therefore, has not demonstrated any changes in his instructional style. Bryce will be discussed in depth within his case study in the following chapter.

In Nargund-Joshi and Liu's (2013) study on teacher orientations relating to ISI, a continuum of science teacher orientations was developed. By collapsing the nine teacher orientations mentioned by Magnusson et al. (1999) into four orientations (Inquiry, Conceptual Change, Activity and Traditional) and adding an additional orientation on ISI, Nargundi-Joshi and Liu were able to differentiate their participants' orientations and place them along a continuum of ISI understanding and implementation. Within this framework, teachers can move along this continuum towards an ISI orientation as they hone their understanding and implementation of ISI. Utilizing Nargund-Joshi and Liu's descriptions for their five teaching orientations and using them to analyze the study participants' interview and observation data, it becomes clear where the teachers fall along the orientation continuum. Although all ten of teachers in this study understood that ISI meant connecting their discipline to either other domains of knowledge, their implementation of ISI revealed the depth of their understandings. Five teachers exemplified the Traditional orientation: these teachers' foci included conveying the content knowledge that is demanded by the curriculum set by the school district and the memorization of this knowledge so that the students could pass the year-end exam. Although these teachers have a decent knowledge of what ISI was, they felt that their classroom instruction was constrained by the adopted curriculum and the impending high-stakes testing. Four out of these five teachers implemented some ISI during after-school activities and clubs. Two teachers, Danielle and Graham, fit Nargund-Joshi and Liu's description of Activity orientation: both teachers utilized teacher demonstrations as a vehicle for instruction and incorporated minimal student –center activities that focused on conceptual change. Bryce and Hugh demonstrate the characteristics of both an ISI and Inquiry orientations as they both focused on developing students' science skills and understanding of core science concepts along with science and engineering practices by integrating different disciplines and making discussions relevant to students' lives. Simon demonstrated several science teaching orientations: ISI, Inquiry, Activity and Traditional. During his observed classroom instruction, Simon spent approximately half of his time focused on direct instruction of factual information while the other half of classroom time was dedicated to students developing science skills. He also overlaid several long-term inquiry-based and ISI projects during the school year, both during classroom time and during after-school clubs.

Teachers' Perceptions, Knowledge, Values and Self-efficacy Related to the CCSS for ELA

The main focus of this study was to investigate science teachers' beliefs about the CCSS for ELA and to determine if and how they influenced their implementation within the classroom. Since teacher beliefs are a complex construct, it was important to explore many facets of beliefs that might contribute to or hinder their enactment of the Standards. The facets of teacher beliefs that were investigated include: their perceptions, knowledge, values and self-efficacy related to the CCSS for ELA.

Teachers' perceptions of CCSS for ELA. During the 2012-2013 school year (Year 1) interviews, several teachers were asked about their perceptions about the CCSS for ELA to get a sense of their knowledge before the school district implemented these new expectations. The knowledge gained during this pilot year was used as a baseline for the construction of the interview questions used during the interviews conducted during the 2013-2014 (Year 2) and 2014-2015 (Year 3) school years. The ten focus teachers were asked during the 2013-2014 and the 2014-2015 school years to explain their current understanding of the goals and expectations of the CCSS for ELA. The teachers were asked the same question during the interviews conducted during the consecutive school years to see if there were any changes or growth to their understanding as they implemented the CCSS for ELA into their classroom instruction.

Teachers' knowledge of the CCSS for ELA. One section of the teacher survey focused on teachers' knowledge and familiarity with specific goals and expectations set forth in the CCSS for ELA. The five Likert-type items in this section focused on teacher preparation to teach literacy skills through coursework and district in-services, familiarity with the goals and expectations for the CCSS for ELA and the connection of the CCSS for ELA to Interdisciplinary Science Inquiry (ISI). The survey results that focused on teachers' knowledge of the CCSS for ELA indicated that they felt relatively confident in their knowledge of the goals and expectations for the CCSS for ELA and strategies to implement them in their classrooms (Mean 3.46). However, it is evident that the participants felt that their school district did not prepare them sufficiently to do so (Mean 2.5). Another finding from this survey is that only 50% of the teachers felt they were familiar with specific literacy strategies. Eighty percent of the teachers felt that they understood the overlap of the CCSS for ELA and ISI; within their interview responses they indicated that this overlap was related to reading (70%), science vocabulary (30%), writing (30%) and research skills (40%).

Teachers' values of the CCSS for ELA. The focus teachers were asked to share their values of the CCSS for ELA including their perceived merit of the standards as well as the benefits they might provide to their students. The results from the all five of the survey questions about teacher values of the CCSS for ELA indicated that the participants placed a relatively high value on the CCSS for ELA skills in general (Mean 4.12). This was consistent with their Year 3 interview responses when asked to explain their values of the new Standards. The survey responses indicate that teachers' degree of favorability toward general literacy skills was higher (Mean 4.3) than that towards the CCSS for ELA (3.4). This was also consistent with the Year 3 interview responses: most of the teachers mentioned literacy skills as being important to their students' success, however three teachers (Danielle, Grace and Bryce) commented that they had issues with the CCSS for ELA. Danielle did not feel that they were appropriate for her urban students and Grace and Bryce expressed concern over how the CCSS for ELA was being implemented.

Teachers' self-efficacy in teaching the CCSS for ELA. In order to gauge teachers' level of preparation to teach the CCSS for ELA, one of the interview questions focused on gathering the teachers' opinions on their feelings of readiness to implement the new Standards.

There are responses for six of the focus teachers from the Year 2 interviews that emerged unexpectedly during the interview process, as it was not included in the Year 2 interview protocol. The Year 3 interview protocol incorporated a question about teachers' feelings of preparation as the preliminary data analysis of the Year 2 interview data revealed that teachers' feelings of self-efficacy might play a role in how they implemented the CCSS for ELA.

Summary. After analyzing the quantitative and qualitative data on teachers' perceptions, knowledge, values and self-efficacy in regard to the CCSS for ELA, several overarching trends in their responses emerged (see Table 17). During Year 2, three major themes emerged from the interview responses regarding teacher's perceptions of the goals and expectations of the CCSS for ELA: reading and writing (80%), the creation of specific student artifacts (30%) and student learning goals (30%). During the Year 3 responses, a majority of the teachers mentioned reading and reading strategies (70%), several included science vocabulary in their responses (30%) and 40% mentioned more specific student learning goals as compared to Year 2. The biggest shift between teachers' understanding of the expectation of the CCSS for ELA was from reading and writing in Year 2 to reading and reading strategies and science vocabulary in Year 3. During interviews, the teachers expressed that they held a high value of CCSS for ELA in Year 2 (80%) and in Year 3 (80%). The survey results corroborate this finding: during Year 3, most of the teachers indicated a high level of value associated with the CCSS for ELA (Mean 4.12). During both years, the teachers' interview responses indicated that they thought the CCSS for ELA would benefit their students (Year 2, 90%; Year 3, 80%); their survey results in Year 3 indicate that they felt that the CCSS for ELA was appropriate for their students (Mean 3.4) and would lead to improved student learning (Mean 3.4) In terms of self-efficacy, the teachers who felt the most confident in implementing the CCSS for ELA, held elementary certifications or had a Master's degree in literacy. Many of the teachers (66.6%) reported during Year 2 that they felt relatively confident in implementing the Standards while in Year 3, 70% of the teachers felt at least "adequately" prepared to teach the Standards. In terms of literacy and knowledge of the CCSS for ELA, 90% of teachers revealed that they had taken at least one course in literacy during their teacher training. It is interesting to note that five of the teachers (50%) felt that their school district's training during professional development sessions on the CCSS for ELA was insufficient. Overall, the survey results revealed that the teachers placed a high value of the CCSS for ELA and literacy skills in general (Mean 4.12). All of the teachers felt that literacy skills should be taught by all teachers, they were critical to students' science learning and important to the work of scientists. In relation to their professed self-efficacy, in Year 3, 30% of the teachers expressed that they were not fully prepared to implement the CCSS for ELA while 40% felt they were very confident in their abilities.

Viewing these findings within the context of the available literature, teachers' self-efficacy and values can play a role in implementation of new reforms. According to Ford (1992), there are two types of beliefs that are crucial to an individual's functioning: capability and context. Synonymous with Bandura's (1986) concept of self-efficacy, capability beliefs are an individual's perception of whether he or she possesses the personal skills needed to function effectively. In this study, there was an observed positive shift in professed self-efficacy in implementing the CCSS for ELA between Year 2 (66.6%) and Year 3 (70%). This increase in self-efficacy was also reflected in their teaching practice: there was an increase in the amount of teachers who implemented the CCSS for ELA between Year 2 and Year 3. In terms of context beliefs, which include one's perceptions about how responsive the environment (external factors and/or people), the participants overall felt that the CCSS for ELA would benefit their students (Year 2: 90%; Year 3: 80%). Although Mansour (2008) posited that there was an interaction between teacher knowledge and beliefs, Nespor (1987) suggested that teacher beliefs were more powerful than their knowledge when it came to influencing their pedagogical decisions. According to the findings in this study, teachers' knowledge played an important role on CCSS for ELA implementation. Between Year 2 and Year 3, teachers demonstrated a growth in understanding of the goals and expectations of the CCSS for ELA. During Year 3, the teachers expressed an increased focus in reading and reading strategies as well as an increase focus on science vocabulary, which was reflected in their classroom practice. In terms of their beliefs, most teachers expressed positive values about the CCSS for ELA (Mean 4.12) and with the exception of one teacher, Antonio, no relationships between beliefs and implementation were observed. In this study, teachers' knowledge of the CCSS for ELA may play a more significant role than their beliefs when it comes to implementation of literacy skills within their science teaching practice.

Teachers' Professed and Observed Implementation of the CCSS for ELA

In order to answer the second research question, it was necessary to uncover the ways in which the teachers were implementing the CCSS for ELA. By probing teachers for their professed implementation and combining it with classroom observations, it was possible to construct a "big picture" of their teaching practice. Due to limited opportunities to observe the teachers' classroom instruction it was important to include their professed implementation via interviews, teacher surveys, implementation plans and research proposals.

Teachers' professed implementation of the CCSS for ELA. The last section of the teacher survey focused on how teachers were implementing literacy skills in their science classrooms. The Likert-type items probed the participants' changes that they had made to their classroom practice in light of the adoption of the CCSS for ELA and the types of literacy strategies they were incorporating into their science lessons. One of the intentions of this section was to uncover the specific teaching strategies the teachers are employing that are explicitly mentioned within the CCSS for ELA documents. The findings from all the data collected in this section of the survey indicate that science teachers are making some changes to their teaching practices in light of the CCSS for ELA as well as continuing to practice the literacy strategies that were in place prior to the adoption of the CCSS for ELA (Mean 3.68). It also indicates that students are regularly spending class time focused on mastering academic vocabulary (Mean 3.8), interpreting graphs and tables (Mean 4.2) and sharing their laboratory findings with their peers (Mean 3.7). However, they are not participating in close-reads of scientific texts as often (Mean 3.1). These results also indicate that some teachers were already implementing several of the literacy strategies explicitly stated in the CCSS for ELA documents and some have made additional changes to these practices since the CCSS for ELA were adopted by their school district.

Teachers' observed implementation of the CCSS for ELA. In order to gauge teachers' implementation of the CCSS for ELA, Forty-three classroom observations were conducted over the three-year period of the EISP grant. Three observations were conducted Year 1, twelve during Year 2 and 28 during Year 3.Using Cheuk's (2014) interpretive framework, *Relationships and Convergences among The Mathematics, Science and ELA Practices* (Figure 4), each lesson was coded for the practices and portraits for CCSS for ELA, CCSS for Mathematics and the NGSS (See Appendix D).

Code frequencies and patterns. Frequencies were calculated for each academic year by counting the number of times each code occurred during the classroom observations for that year and dividing by the total number of classroom observations conducted that year (see Table 20).

The results of this data analysis reveal a trend in the amount of time the teachers' implemented literacy, science and math components into their classroom practice. However, it is important to note that while there may be a pattern indicated over the course of the three years, the frequencies are skewed due to the fact that there are an unequal number of classroom observations from year to year and during different years, more classroom observations were conducted with certain teachers. This is attributed to several constraints inherent to the EISP project and each teacher's willingness to allow the research team members to observe their classroom practice. Therefore, it is important that the patterns in frequencies of the lesson elements be contextualized in order to understand any changes over the course of the study.

Year 1. During Year 1, one classroom observation was conducted for three teachers: Simon, Graham and Grace. After coding each of the lessons, it was revealed that overall the teachers incorporated the following practices and portraits in their instruction: S2. Developing and using models (33.3%), S3. Planning and carrying out investigations (66.6%), S4. Analyzing and interpreting data (33.3%), S6. Constructing explanations (for science) and designing solutions (for engineering), (33.3%), S8. Obtaining, evaluating, and communicating information (33.3%), E1. They demonstrate independence (33.3%), E2. They build strong content knowledge (33.3%), E3. They respond to the varying demands of audience, task, purpose, and discipline (33.3%) and E6. They use technology and digital media strategically and capably (33.3%). Using Cheuk's (2013) diagram, 44.4% of the observed student practices and portraits are located within the exclusive domains of Science or ELA, while 33.3% were found where Science and ELA converge in the Venn diagram (see Figure 4). 50% of the practices and portraits were included in the teachers' lessons. While considering these findings, it is important to take into consideration the context of each of the teachers' lessons. Simon's lesson was actually taught by a science researcher and a professor from one of the EISP partner universities. The lesson incorporated a computer program that the students used to count cancer cells and to determine if their patients' samples contained cancer. Graham's lesson was lecture-based in which he used digestive system models to help his students to master domain-specific vocabulary. In Grace's lesson, her students conducted a hair analysis using a highly scaffolded, written laboratory procedure. They collected and recorded their data and answered questions based on their findings.

Year 2. Twelve classroom observations were conducted during Year 2. Danielle, Simon, Graham, Joy, Andrew, Antonio, Bryce, Grace and Hugh allowed the research team to come into their classrooms to watch them teach a science lesson. The following student practices and portraits were observed during the lessons: S1. Asking questions (for science) and defining problems (for engineering) (16.7%), S2. Developing and using models (33.3%), S3. Planning and carrying out investigations (75%), S4. Analyzing and interpreting data (58.3%), S6. Constructing explanations (for science) and designing solutions (for engineering) (58.3%), S7. Engaging in argument from evidence (16.7%), S8. Obtaining, evaluating, and communicating information (50%), E1. They demonstrate independence (8.3%), E2. They build strong content knowledge (58.3%), E3. They respond to the varying demands of audience, task, purpose, and discipline (58.3%), E4. They comprehend as well as critique (16.7%), E5. They value evidence (16.7%), E6. They use technology and digital media strategically and capably (16.7%), and M3. Construct viable arguments and critique the reasoning of others (16.7%). Upon further analysis, it was revealed that out of the thirteen practices and portraits present in the Year 2 teachers' lessons, 30.8% of them fell into the Science domain and 7.7% of them in the ELA domain. 50% of the Practices and Portraits were in the zone of where the Science and ELA domains overlap; 100% of the six practices and portraits in the overlap zone were covered. In order to contextualize these findings, it is first important to note that Bryce was new to the Year 2 observations. The researcher observed two lessons in which his students were involved in low-scaffolded, inquiry-based activities. He was the only teacher in this cohort that incorporated the S7, E4 and E5 practices in his instruction. These three practices are located in the overlap of Science and ELA domains (see Figure 4) as they focus on students to construct arguments and engage in argumentation based upon evidence. 66.7% of the teachers included component E2, which is found in the overlap zone of the Science Practices and ELA Portraits, which focuses on text-based knowledge.

Year 3. During Year 3, 28 classroom observations were conducted in ten teachers' classrooms. Three teachers, Danielle, Simon and Bryce, were observed between 7-10 times, each being observed for five consecutive days at a minimum. The Year 3 observations included the following student Portraits and Practices with their frequencies: S1. Asking questions (for science) and defining problems (for engineering) (24.1%), S2. Developing and using models (41.3%), S3. Planning and carrying out investigations (28%), S4. Analyzing and interpreting data (44.8%), S5. Using mathematics, information and computer technology and computational thinking (13.8%), S6. Constructing explanations (for science) and designing solutions (for engineering) (27.6%), S7. Engaging in argument from evidence (17.2%), S8. Obtaining, evaluating, and communicating information (31.0%), E1. They demonstrate independence (41.4%). E2. They build strong content knowledge (65.5%), E3. They respond to the varying demands of audience, task, purpose, and discipline (48.1%), E4. They comprehend as well as critique (17.2%), E5. They value evidence (17.2%), and E6. They use technology and digital media strategically and capably (3.4%). The classroom observations for Year 3 covered fourteen of the Science Practices and ELA Portraits. Again, 100% of the overlapping Practices and Portraits were included in the lessons. As was the case with the Year 2 observations, Bryce was the only teacher in the cohort that covered all the overlap Practices and Portraits in every lesson. 43% of the Practices and Portraits observed in the Year 3 lessons were within the zone of overlap between the Science and ELA domains.

Teaching profiles. After examining the lesson observation data and frequency patterns, it became apparent that the ten focus teachers could be categorized into five different patterns of implementation: "ELA-centered", "In-the-middle", "Exam-focused", "Reform-based" and "Engineering design".

"ELA-centered". The "ELA-centered" teachers, Danielle and Graham, place an emphasis on literacy skills within their science teaching. According to the coded classroom observation data, both of these teachers dedicated the majority of their class time to students' learning of science academic language (see Figure 6). In the observed classes, both teachers focused on the ELA Portraits E1, E2 and E3. According to the CCSS for ELA, the E1 descriptor includes "[students] acquire and use a wide-ranging vocabulary". This standard attends to the language demands expected from students. 100% of Graham's lessons and 57% of Danielle's observed lessons included a distinct focus on science vocabulary. The E2 descriptor is centered on students "building strong content knowledge" to help students "gain both general knowledge and discipline-specific expertise" through reading, listening, writing and speaking. In 71.4% of Danielle's lessons, there was a focus on student reading, listening and writing while 100% of Graham's lessons focused on close reading, listening to the teacher's explanation science concepts and writing. Portrait E3 focuses on students' ability to "obtain, synthesize, and report findings clearly and effectively". In 85.7% of Danielle's lessons her students reported laboratory findings and 25% of Graham's lessons focused on students reporting on various tissue types. In both of these scenarios, Graham and Andrew's students looked for information and processed it into a form that could be understood by their peers and teacher. In terms of the NGSS student

Practices, Danielle and Graham's students spent less time on these as compared to the ELA Portraits. One of Graham's lessons attended to Practice S2, developing and using models in which a model was used to identify parts of the digestive system. This is the only lesson of Graham's that included a NGSS student Practice. Danielle's lessons focused on S4 (42.9%) and S5 (14.3%). S4 focuses on students analyzing and interpreting data; S5 focuses on computational thinking in science. Danielle's teaching practice will be examined in depth in her case study.

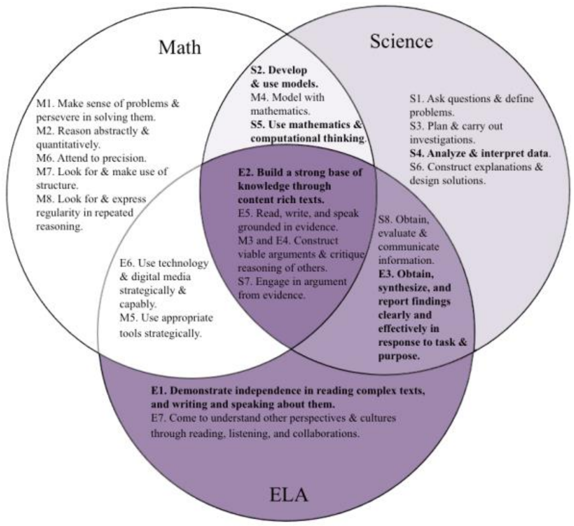

Figure 6. Conceptualization of "ELA-centered" teacher profile implementation.

"In the Middle". There is only one teacher in this category, Simon, a middle school science teacher. As the teaching profile name suggests, Simon teaches middle school and his science teaching practice falls in the middle between the "ELA-centered" and "Exam-focused" teaching profiles. The classroom observation analysis shows that Simon's students spend approximately equal amounts of class time on the ELA Portraits and NGSS Practices (see Figure 7). The ELA Portraits that his lessons focus on are E1 and E2, those that pertain to science vocabulary, reading and writing. Eighty percent of Simon's lessons included the E1 and E2 portraits; 80% of his lessons included one or two NGSS Practices (S1, S2, S3, S4 and S6).

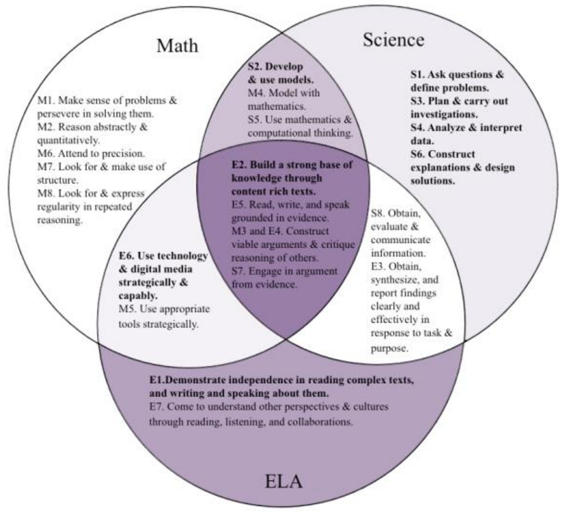

Figure 7. Conceptualization of "In-the-middle" teacher profile implementation.

"Exam-focused". The five teachers in this category, Joy, Juan, Andrew, Antonio and Grace all indicated that one of their primary teaching foci was preparing their students for end-of-year exams. Their patterns of teaching practice show that they place a greater emphasis on science than literacy skills (see Figure 8). The observation data shows that these teachers include a few aspects of the ELA Portraits such as E2 and E3, which were included within highly scaffolded science laboratory activities. Within these laboratory exercises, students focused on reading directions to a laboratory experiment, carrying out the directions with lab materials and writing answers to questions about their findings at the conclusion of the laboratory exercise. The NGSS Practices were the main focus of the observed lessons and all the Practices were included in each lesson with the exception of S7, which focuses on students "engaging in argumentation from evidence". An average of 3.1 NGSS Practices were included in each lesson and 84.6% of the observed lessons included at least one ELA Profile. The average number of ELA Profiles included in these teachers' lessons was 0.85.

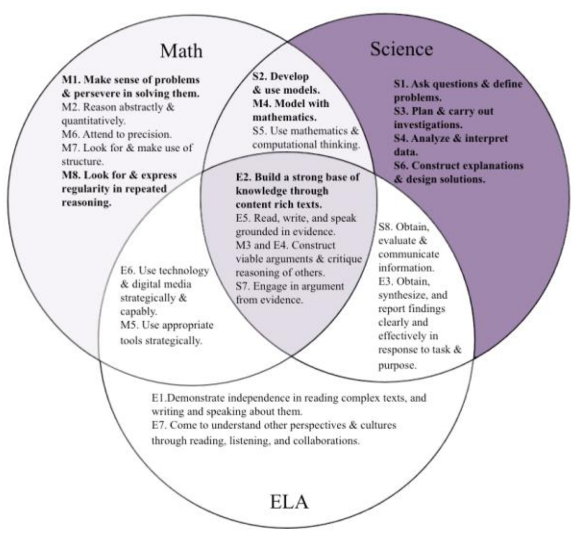

Figure 8. Conceptualization of "Exam-focused" teacher profile implementation.

"Reform-based". Bryce is the only teacher in this category. His profile name refers to the fact that his role in the classroom fits the description of the NRC's description of a teacher that uses collaborative student-learning groups in which they explain and justify what they learned. The teacher's role in the reform-based classroom is that of a facilitator who helps to guide the students' participation and discussion. Due to Bryce's instructional approach, 100% of his lessons include both NGSS Practices and ELA Portraits. 100% of his lessons included seven of the NGSS practices, including S7 and S8 which focus on students' oral presentation and their participation in argumentation based upon their laboratory findings (see Figure 9). All of Bryce's lessons included four (E2, E3, E4 and E5) ELA Portraits. He is the only teacher in this study that incorporated E4 and E5 in his lessons. These two ELA Portraits focus on students' argumentation using evidence. All of his lessons included the portraits and practices found in the intersection section in the middle of Cheuk's (2013) diagram. Bryce will be discussed in depth in his case study.

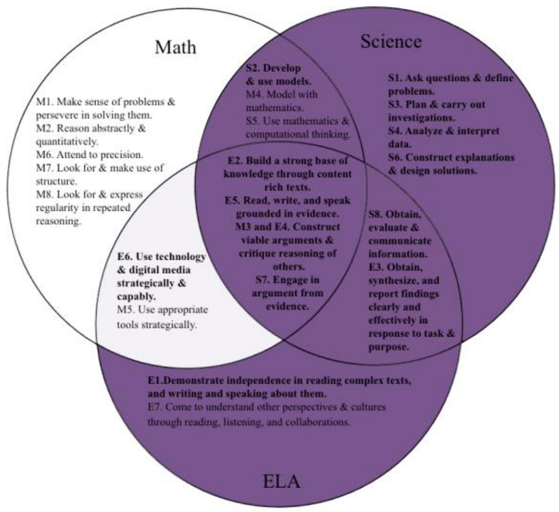

Figure 9. Conceptualization of "Reform-based" teacher profile implementation.

"Engineering design". Hugh, a CTE teacher, is the only teacher in the Engineering design teaching profile. Hugh's lessons focused on the engineering design process in which his students designed and constructed structures. Some of these structures included Boomilevers, Rube Goldberg machines and basketball hoops. The analysis of his three lessons (see Figure 10) show that his students are using computer programs, such as Computer Aided Drawing (CAD) to design their structures (E6) and develop and use models they build (S2), while design solutions for engineering (S6), and planning and carrying out investigations of their designs (S3). He spends 100% of his class time incorporating S2 and S3 (during both the design and construction phases) and 66.6% of his time including E6 and S6 (during the design stage). This trend in Practices and Profiles is different from the others as they are all components of the engineering design process, which is unique to Hugh's discipline.

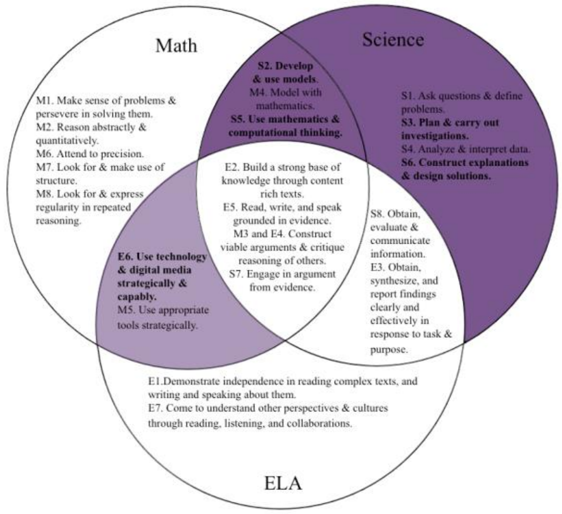

Figure 10. Conceptualization of “Engineering Design” teacher profile implementation.

Discussion

Case Studies

In an effort to gain a better understanding of teachers’ implementation of the Science Practices and ELA Portraits and how this implementation may be influenced by their knowledge, beliefs and values, three teachers were selected to observe in depth during Year 3. The three teachers were selected based upon the following factors: their different professional development pathways in the EISP project, their backgrounds, the grade level they taught and their science teaching practices as observed during the Year 2 pilot study. Danielle, Simon and Bryce were observed for at least one week during the fall 2014. Each teacher’s case study explored their beliefs related to science teaching, their perceptions and values relating to the CCSS for ELA, their professed implementation of the CCSS for ELA, their perceptions of ISI, their professed implementation of ISI, the observed implementation of ISI and the CCSS for ELA and their involvement with the EISP professional development project.

Danielle – “ELA-centered”. The observations conducted in Danielle’s classroom have shown growth in the amount of science that Danielle is doing with her students. She described her approach and goals for her science teaching as being “interactive” and “hands-on” for her students to “explore” new knowledge. This orientation to science teaching is classified as Activity-driven (Magnusson et. al, 1999) or Activity (Nargund-Joshi & Liu, 2013). These orientations are characterized by the inclusion of hands-on science activities or teacher-led demonstrations. Within the context of the EISP project, this orientation is one step on the continuum toward Inquiry and ISI orientations. Danielle’s expectations for her students were to learn the skills of doing experiments such as observing, measuring, interpreting data and make hypotheses. Although she stated that she felt that the CCSS for ELA was “never-ending”, she expressed her confidence in implementing them in her classroom. Danielle’s science teaching can be classified as ELA-centered as her students experience science through ELA practices such as reading, science vocabulary mastery and presenting their findings. The conceptualization of her practice indicates that Danielle’s students are not experiencing science via inquiry practices, but through high-scaffolded ELA strategies using science as the content.

Simon – "In the Middle". Simon's instructional practices demonstrate his stated approach to science teaching – they interweave both science and literacy. He described his goal for science teaching as preparing students to be successful in taking exams and expected his students to pass them. Since he initially felt that he was already incorporating the CCSS for ELA, he didn't make any changes in his teaching practice until Year 2 when he started focusing more on student writing and in Year 3, more presentation skills. Overall, Simon's teaching practice reflects a focus on literacy skills related to reading and vocabulary, science skill building and some low inquiry laboratory exercises. All of these practices are highly scaffolded. Since his students do not participate in any higher-order inquiry, such as guided inquiry, Simon is unable to meet the CCSS for ELA Standards that include argumentation, the development of arguments grounded in evidence, critiquing the reasoning of others and reporting findings. This is demonstrated in the conceptualization of Simon's practice (Figure 10). Simon's science teaching orientation is complex as it includes pieces of three of Nargund-Joshi and Liu's (2013) orientations: Traditional, Activity, and small amounts of Inquiry and ISI. Within the school day, Simon takes a more Traditional/Activity orientation, focusing on science knowledge, vocabulary, and science skills. Occasionally, he overlaid a long-term inquiry or problem-based project with the students. However, most of his Inquiry and ISI were implemented during his after school Science Olympiad and boat building clubs.

Bryce – "Reform-based". Bryce's science teaching practice and his implementation of the CCSS reflects his ideas about science teaching. He described his approach as student-driven whereby the teacher is a facilitator of the students' learning. He stated that his goal for science teaching was to help students develop 21st century skills and to allow his students to learn by exploring and sometimes failing. The expectations that Bryce has for his students are to learn lab skills, group work, critical thinking skills, and above all, that science is a "fluid body of knowledge". Although Bryce conveyed a low level of confidence in implementing literacy skills, his conceptualization of his teaching practice demonstrate that he is incorporating the majority of the CCSS for ELA portraits as well as the majority of the NGSS Standards. This is due to the fact that Bryce employs reform-based science teaching practices that are student-driven and student-centered. He does this by following a curriculum that is predicated upon the guided inquiry method of science teaching. Using Nargund-Joshi and Liu's (1999) continuum of science teaching orientations, Bryce's orientation is located at the highest levels of implementation of ISI/inquiry as he focuses on developing his students' development of science skills as well as core science concepts. He also makes the content relevant to his students' lives while incorporating other disciplines to help his students make interdisciplinary connections. His students are meeting the CCSS for ELA Standards organically as an outcome of this guided inquiry approach.

Discussion of Case Study Findings

The findings from the multiple case study demonstrate that science teachers who incorporate reform-based science teaching practices through low-scaffolded science inquiry are best equipped to meet the demands of the CCSS for ELA as well as the NGSS. The teachers' beliefs in this study about science teaching, not literacy, have been shown to be the biggest determinant of the degree of CCSS for ELA implementation. When science teachers do not incorporate inquiry into their science teaching, the only way they will include the CCSS for ELA is through "add-on" literacy strategies such as doing close reads and science vocabulary activities. This was demonstrated in most of the focus teachers' lesson observations. In order for science teachers to completely implement the CCSS for ELA, a dramatic shift in their science teaching towards inquiry-based instruction will be required. It is also important to note that when asked about the goals and expectations of the CCSS for ELA, none of the teachers connected it to the science inquiry process. Rather, they connected it to reading, writing and science vocabulary mastery. As previously mentioned, teachers' knowledge and beliefs are highly connected to one another (Mansour, 2008). Since it was demonstrated that the focus teachers lacked knowledge about the components of the CCSS for ELA that connected to the NGSS' Science and Engineering Practices, it is difficult to draw conclusions about how their beliefs may influence their implementation of the CCSS for ELA. Instead, the teachers' beliefs about the CCSS for ELA are based upon limited knowledge of the Standards and upon their knowledge about general literacy and ELA skills.

Relationships Between Teachers' Perceptions, Beliefs, Knowledge and Implementation

Analyzing themes across the three cases studies provides insight into the relationships that exist between teachers' perceptions, beliefs, knowledge and implementation of both the CCSS for ELA and ISI.

Implementation of CCSS for ELA Portraits. Cross-case analysis reveals several trends in the relationships that exist between teachers' beliefs, values and knowledge of the CCSS for ELA and the implementation of the Standards within their classroom instruction. Although Bandura (1986) and Ford (1992) suggest that teachers' self-efficacy, or personal agency beliefs, play a significant role in curriculum implementation, the findings from this study do not support this. Bryce, the teacher who conveyed to lowest self-efficacy demonstrated the highest implementation of the CCSS for ELA portraits while Danielle and Simon conveyed higher self-efficacy and fewer student portraits were observed during their instruction. The values that the teachers held in regard to the CCSS for ELA and it's potential benefit to their students also did not demonstrate an influence on the implementation of the Standards. The greatest influence on their implementation of the Standards was teachers' beliefs related to science teaching. Since an overlap between the NGSS practices and the CCSS for ELA portraits exists, it is no surprise that there is a relationship between the implementation of both of these reforms.

Implementation of ISI and NGSS Practices. When examining teachers' level of incorporation of ISI, once will notice that each of the focus teachers did so at varying levels. Danielle incorporated the lowest amount of ISI, while Bryce incorporated the most. Within her interview responses, Danielle and Simon demonstrated a moderate understanding of ISI while Bryce conveyed the highest. Danielle described ISI as being "hands-on" and focused on "student engagement" and "problem solving". Within the EISP's ISI framework, problem solving is located under the Purposes of ISI as "solve[ing] society problems" while "hands-on" would be located under the Science and Engineering Practices as "carrying out investigations" and "using models". However, she did not express any understanding of the ISI framework's Crosscutting Concepts. Simon, demonstrated understanding of both Purposes and Cross-cutting Concepts. When he described ISI as being "problem based", "real-world" and "interdisciplinary" he indicated not only that he understood the purpose of ISI, but also hinted at the Crosscutting Concepts that unify the concepts and processes between disciplines. He also demonstrated this understanding of the interdisciplinary nature of ISI during one of his observed lessons. Bryce described ISI as "Hands-on", "Interdisciplinary" and "Student-centered". These three adjectives fall under the ISI framework's Science and Engineering Practices, Purposes and Crosscutting Concepts. During classroom observations, it was noted that Bryce was meeting the majority of the ISI/NGSS Science and Engineering Practices.

Summary. Looking across the three case studies it becomes clear that there is a significant relationship between teachers' understanding and implementation of ISI and their incorporation of the CCSS for ELA. Teachers' knowledge in this study has been shown to play a significant role influencing their pedagogical decisions (Mansour, 2008) and indicates that their knowledge may play a larger part in their classroom practice that their beliefs. Danielle and Simon both conveyed a similar level of understanding of ISI and demonstrated this understanding at a lower level in their teaching practice as compared to Bryce. Although Danielle's observed implementation indicates a low level of ISI implementation, her professed implementation indicated that she is incorporating more inquiry and ISI than what was observed. Examining the code frequencies for both Danielle and Simon's observed lessons, they both implemented a medium level of the CCSS for ELA portraits, but did so in different ways. Simon implemented more of the CCSS for ELA portraits that overlapped with ISI while Danielle's implementation of the CCSS for ELA reflected more focus on vocabulary and close reading. Bryce demonstrated the most knowledge of ISI and this was reflected in his teaching practice as containing the most Science and Engineering Practices of the three case study teachers. In incorporating these ISI practices, he was also able to include the majority of the CCSS for ELA portraits as they connect directly to the ISI/NGSS Practices.

Conclusions

Science Teachers that Utilize Constructivist Pedagogical Practices are the Most Successful at Implementing the Full Spectrum of the CCSS for ELA

Inquiry and the CCSS for ELA. When the tenets of scientific inquiry are considered (NRC, 1996; 2000) while looking at the expectations for the CCSS for ELA, it becomes clear that many of the expectations set forth in the Standards mirror those within the NRC's definitions of scientific inquiry. Revisiting Cheuk's (2013) diagram and highlighting the portraits and practices that align to the NRC's definitions of scientific inquiry, it becomes apparent that 57.1% of the CCSS for ELA portraits are met through the scientific inquiry process. They are located in the region of the diagram where Science and ELA overlap (see Figure 14). E1 is also met via the inquiry process and is located in the exclusive ELA region. There is much confusion about the definition of inquiry, as exemplified by the teachers in this study. It was observed that all of the teachers in this study, with the exception of Bryce, were implementing their version of inquiry, but not as it was defined by the NRC. They were found to be implementing inquiry at Banchi and Bell's (2008) Level 1 (Confirmation) and Level 2 (Structured) of their inquiry model. In order to meet the expectations of the NRC's definition of inquiry and those set forth within the CCSS for ELA, science teachers will need to be implementing inquiry at Banchi and Bell's (2008) Level 3, Guided Inquiry.

Rodriguez, in his Sociotransformative Constructivism theory, promotes the use of science inquiry as a way of promoting social equity within the multicultural classroom. The scientific inquiry process is also supported by the social constructivist theory in which students participate in the social construction of knowledge and active engagement in the learning process. Inquiry-based learning, or co-operative learning as Vygotsky called it, "is an integral part of creating … a social constructivist classroom" (Powell & Kalina, 2009, p. 244).

Science teachers who hold social constructivist beliefs about science teaching and who teach via scientific inquiry will be meeting the CCSS for ELA more effectively than their more didactic colleagues. The teacher in this study who was the most successful at meeting the demands of the CCSS for ELA was Bryce (see Figure 15). Bryce had a reform-based approach to science teaching and took a social constructivist approach to science instruction. All of the observed lessons in his classroom were taught through the inquiry process. When the observations were coded for the elements of the CCSS for ELA and the NGSS and then highlighted on Cheuk's (2013) diagram, it emphasized the same portraits and practices as shown in Figure 14 which emphasizes the Standards mentioned within the NRC's definitions of scientific inquiry.

The other teachers in this study did not meet nearly as many of the CCSS for ELA portraits as they did not approach teaching from a social constructivist perspective. The other two focus teachers, Danielle and Simon, did not employ reform-based instructional strategies within their instruction. Unlike Bryce, their teaching approaches were high didactic and teacher-centered. Since scientific inquiry was not used during Danielle and Simon's lessons, they were unable to meet the CCSS for ELA portraits located within the center of Cheuk's (2013) diagram. Like most of the teachers in this study, Danielle and Simon's implementation of the CCSS for ELA focused on developing students' reading (E2) and vocabulary skills (E1).

Academic language instructional approaches. When asked about how their instructional practices had changed science the introduction of the CCSS for ELA, many of the participants had either (1) said they were "already doing it" as they were already dedicating class time focusing on science vocabulary and reading or (2) stated that they had increased their focus on science vocabulary and had introduced "close reading" of science text and "text-based evidence". These teachers are meeting some of the expectations of the CCSS for ELA by "bandaging on" general literacy techniques, such as those that related to science vocabulary. Shanahan and Shanahan (2012) refer to this type of instruction of literacy strategies as *content area literacy* as they are general study skills that can be used "to help students learn from subject matter specific texts" (p. 8). In contrast, *disciplinary literacy* "emphasizes the unique tools that the experts in a discipline use to engage in the work of that discipline and the description of unique uses [and] implications of literacy use within the various disciplines" (p. 8).

The three focus teachers were asked to describe their approaches to addressing science vocabulary. Danielle and Simon both described their approaches in ways that reflected Shanahan and Shanahan's (2012) definition of content area literacy. When asked how students would get the definitions to their science vocabulary terms, Danielle said that they would look them up in their textbooks. Simon described his approach as "Identification, discussion, text reading, incorporation into projects, and practice test questions" (Interview, Fall 2014). In Bryce's description, he mentions the approach of using operational definitions to define physics vocabulary. In Bryce's classroom, the students and teacher work together to develop definitions based upon students' conceptual understandings of the science terms and how the terms are measured or used within the science inquiry process. This approach to understanding science vocabulary exemplifies Bryce's social constructivist approach to teaching as he and his students participate as a community of learners to generate meaningful definitions based upon his students' conceptual understanding of scientific phenomenon. Bryce's approach is an example of disciplinary literacy as his approach incorporates "the nature of scientific vocabulary and the specialized tools to construct and analyze vocabulary within the sciences" (Shanahan & Shanahan, 2012, p. 9).

Science teachers who are not employing reform-based practices and including inquiry-based approaches at a sufficient level will not be able to meet the majority of the Standards demanded by the CCSS for ELA without completely changing their approach to science teaching; the majority of the CCSS for ELA can only be met through the inclusion of the scientific inquiry process within science instruction. Although it is vital for all science teachers to address science vocabulary within their instruction, by approaching it from a content area literacy approach, teachers will only be able to meet the expectations of the CCSS for ELA at a minimal level. In contrast, science vocabulary instruction can be approached from a position of scientific inquiry to promote deep conceptual understanding of scientific terminology. In order to incorporate the CCSS for ELA portraits located within the overlap region of Science and ELA, science teachers will need to do more than just bandage on content area literacy approaches to their non-inquiry based instruction; to go beyond a very superficial level of incorporating the CCSS for ELA, science teachers must completely change their instructional approaches to include the inquiry process. Teachers that are not already employing reform-based practices will have to undergo deep, systemic changes in their teaching practice in order to incorporate the CCSS for ELA as it is intended. At the core of this change is the need for strong implementation support both inside and outside of the classroom.

Addressing Implementation Support During Professional Development is Critical to the Successful Implementation of the CCSS for ELA and Inquiry Practices

Desimone's (2009) model (Figure 14) depicts teacher beliefs as both a product of and an influence on the five core features of effective teacher professional development. It also shows that these changes in attitudes and beliefs will lead to changes in instruction. Although this is the adopted model for the EISP project's professional development, it has not been shown to promote significant change in the participants' incorporation of inquiry practices over the course of this three-year study. The goal of the EISP project is to provide professional development opportunities for science teachers to help them to incorporate interdisciplinary science inquiry within their teaching practice. At the core of the EISP project is teachers' summer experiences that may include one of the following: a two-week university physics course, hands-on scientific research, engineering design or curriculum writing. In order to bridge their summer experiences into the classroom, teachers are expected to participate in monthly PLC sessions where the focus is on ISI implementation. Unfortunately, due to a lack in monthly PLC participation, the EISP teachers may miss this important part of the professional development process and experience difficulty translating their summer experiences into classroom practice.

Although Desimone's (2009) model highlights all of the necessary components of high-quality teacher professional development, it is very generalized for all areas of teaching. In the case of the EISP project, it is a professional development opportunity for science teachers and thus, must reflect the unique nature of science teaching. It needs to address the complex process of promoting a dramatic shift from science teachers' current instructional practices and beliefs to an inquiry-based approach. In order for the EISP teachers to implement ISI and inquiry within their classrooms, they will need long-term support, in-classroom instructional coaching and opportunities in the monthly PLC sessions to engage with other teachers in discussing and critiquing science lessons. The monthly professional development activities should be centered on implementing ISI and inquiry-based teaching. As demonstrated in Luft's (2001) study, changes in teacher beliefs may occur after they implement inquiry-based instructional changes and witness success with their students. In his model (see Figure 17), Gusky (2002) also suggested that a change in teacher beliefs tens to occur after teachers gain evidence of improved student learning.

Implications

This study sought to develop an understanding of urban science teachers' beliefs, perceptions and implementation of the CCSS for ELA within the context of interdisciplinary science inquiry. It was demonstrated that the teachers' attitudes and values about the CCSS for ELA did not have a relationship to how they were implementing it. The findings from this study suggest that there is a strong relationship between science teachers' beliefs about science teaching and how they implement literacy skills within their practice. Specifically, the link between science teaching and the implementation of the CCSS for ELA lies within the incorporation of the guided science inquiry process in teachers' instructional practices. Although not explicitly referred to as inquiry, guided science inquiry is a part of the ISI conceptual framework adopted by the EISP project. Inquiry, specifically guided inquiry, is subsumed under the Science and Engineering Practices of ISI and requires science and engineering students to: (1) asking questions; (2) developing and using models; (3) planning and carrying out investigations; (4) analyzing and interpreting data; (5) using mathematics and computational thinking; (6) constructing explanations and designing solutions; and (7) engaging in argument from evidence.

CCSS for ELA and inquiry/ISI. The majority of the CCSS for ELA portraits are part and parcel of the NRC's key components of the inquiry process as well as the ISI conceptual framework and the new NGSS set to be implemented beginning in the Fall 2016. Within this study, Bryce was the only teacher who implemented the CCSS for ELA to its fullest due to the fact that he utilizes a reform-based approach to science teaching in which guided inquiry and ISI is at the core. The other teachers in this study that were making changes to their instructional practice in light of the CCSS for ELA were doing so in superficial ways such as including more "close reads" of science texts and implementing more frequent instructional strategies around science vocabulary. However, the ways in which they did this were by approaching literacy skills from a content area literacy perspective whereby general literacy techniques are "bandaged on" to content areas and do not honor the unique context of language within the discipline of science. The findings from this study suggest ways in which this knowledge could serve to change teachers' instructional practices through in-service teacher education that promotes the inclusion of reform-based pedagogies, and as a result, disciplinary literacy.

In order to assist science teachers in implementing the CCSS for ELA to its fullest potential, they must be encouraged to adopt more reform-based science teaching approaches within their science instruction, such as the NGSS' Science and Engineering Practices, which is a component of the ISI framework adopted by the EISP project. Within the context of the EISP project, as teachers actively adapt their science teaching approaches towards the Inquiry and ISI orientations (Nargund-Joshi & Liu, 2013), they will increase the number of Science and Engineering Practices incorporated into their instruction. In doing so, the number of CCSS for ELA portraits that are implemented will also increase. As Darling-Hammond and McLaughlin (1995) wrote, "The vision of practice that underlies the nation's reform agenda requires most teachers to rethink their own practice, to construct new classroom roles and expectations about student outcomes, and to teach in ways they have never taught before" (paragraph 1). Within this study, Bryce attributed his success with implementing guided inquiry through choosing a solid physics curriculum, Physics for Everyday Thinking (PET). He chose this particular curriculum because it is already reform-based and he didn't have to "recreate the wheel" (Interview, Fall 2014) in order to incorporate open inquiry into his instruction. He said that teachers tend to try to "do it on their own" (Interview, Fall 2014) which he feels is a problem for teachers as it is time consuming and often ineffective.

Science teacher professional development programs. Opportunities for monthly "break-out" sessions where teachers are encouraged to discuss the implementation as well as share video-recorded lessons of their teaching would assist teachers in their implementation. Science teachers need to receive feedback from their peers about their practice as well as from the leaders of the professional development program (O'Brien, 1992). One approach to this would be to develop or adopt and modify an existing reform-based curriculum for each science subject that also meets the requirements for the Regents exams. By encouraging teachers to actively implement the reform-based curriculum (O'Brien, 1992), teachers "can understand the student's perspective of the lesson and the instructional practice surrounding it" (Luft, 2001, p. 520).

Within professional development, teachers also need to be encouraged to examine their own beliefs about inquiry-based instruction in order to assimilate it into their conceptual framework (Yerrick, Parke & Nugent, 1997) and to participate in discussions about their beliefs and practices within the context of the school environment (Richardson, 1996). By incorporating teacher discussions centered on teacher beliefs and classroom practices at the end of professional development sessions, it has been shown that teachers changed their beliefs (Richardson, 1994). Implementing these suggestions within the existing EISP PLC professional development session might benefit the teachers in the EISP project to incorporate reform-based teaching methods.

Changing teacher beliefs. Although science teachers' beliefs have been shown to have a strong correlation to their science teaching approaches, it is possible to change them through a change in their teaching practice. Once science teachers have been properly supported in implementing inquiry-based instructional strategies and witness improvements in student engagement and performance, their beliefs and attitudes towards reform-based teaching practices may improve (Luft, 2001). The previously mentioned changes to the current EISP professional development model might prove to be the most effective way to encourage teachers to change their teacher practices to incorporate reform-based practices and ISI as well as the full spectrum of the expectations set forth by the CCSS for ELA.

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