MADDEN, LAUREN PAIGE. Examining Elementary Teachers’ Identities through Analysis of Student Science Notebooks. (Under the direction of Dr. Eric N. Wiebe.)

The purpose of this study is to understand how teacher identity influences elementary teachers’ science practices from multiple perspectives—the teacher’s self-reported identity, the researcher’s perspective, and the students’ perspectives. Two frameworks on identity were synthesized and used in this research. The first, developed by Gee (2000-01) examines *who a teacher is* with respect to four areas: nature, institution, discourse, and affinity group belonging. The second, developed by Beijaard, Verloop, and Vermunt (2000) examines factors that drive *what a teacher does* in his/her practice through examining teachers’ expertise divided among three areas: content, pedagogy, and didactics. These frameworks were used to guide interpretation of the data sources in order to better understand how instruction unfolded. The science instruction of one class of second grade students receiving science instruction from three different teachers was studied over the course of one school year.

The first manuscript of this study is a qualitative case study describing the three teachers’ identities and practices from the perspective of the teacher, researcher, and students. Classroom observations, teacher interviews and questionnaires, and student interviews were coded thematically using identity markers as themes. These data sources were triangulated to reveal differences in both the identities and practices among the three teachers. For two of the three teachers, their self-described identities were different from how they were viewed by their students and the researcher. These findings highlight the importance of incorporating multiple perspectives, including those of students, when
describing teachers’ practices and identities. The study revealed that the three experienced teachers at the same grade level had vastly different science needs, underscoring the utility of identity theory for the design of professional development efforts.

The second manuscript of this study is a mixed-methods analysis of the science notebook entries created by each of the students in this second grade class over the course of the school year. Every entry of every notebook was photographed and coded for: unit (and therefore teacher), inquiry phase (pre-, during-, or post-investigation), and driving force (teacher-driven, student-driven, or balanced). In addition, missing and incomplete notebook entries were also documented. Quantitative analysis looked at the frequency of entries based on these codes. Qualitative data included thematic descriptions of how each teacher used the notebooks, teacher interviews, student interviews of their notebook use and classroom observations. All three teachers used similar curricular materials (kits) and received training from the school district on using science notebooks, suggesting that they would likely use the science notebooks in a similar way. However, quantitative differences were found across all three areas (inquiry phases, driving force, and missing entries), and qualitative analysis also indicated each teacher used the notebooks in a very different way. The teacher identity framework provided a useful way of interpreting these differences. These findings suggest that student science notebook analysis can be used in concert with other data sources through an identity framework to provide information about instruction over the course of a unit or school year, providing more robust analysis than classroom observations and interviews alone.
DEDICATION

To my husband, Mike, whose constant love and support made this dissertation possible; to my parents, for instilling a love for science in me, and for teaching me the value of education and hard work.
Lauren Paige O’Neill Madden was born in 1980 to Edward O’Neill, a psychotherapist and Diane O’Neill, a mathematics teacher. She was raised on Long Island, New York along with her younger brother, Sean. She had an interest in science at an early age, and could often be found snorkeling in the pool, conducting surgery on Pound Puppies, and attending chemistry camps at Stony Brook University. She attended Sachem Public Schools, where she was able to explore science with excellent teachers and innovative coursework. After high school, Lauren attended the University of New Hampshire and majored in Earth Science-Oceanography. During this time, her interest in science grew further, as she was able to actively participate in research at the Jackson Estuarine Research Lab.

After receiving a bachelor’s degree, Lauren moved on to the University of South Carolina where she studied Marine Science and conducted research as part of the CARIACO time-series experiment under the direction of Dr. Claudia Benitez-Nelson, and met her husband, Mike Madden. During her M.S. program, Lauren participated in educational outreach including mentoring undergraduate and high school students and volunteering at an after-school science program. These experiences sparked an interest in education that led her to pursue a teaching position at Hand Middle School teaching seventh grade science after receiving her M.S. Several years later, she married Mike, re-located to North Carolina and took a position as a Research Associate at Horizon Research, Inc., where she was able to combine her interests in research and teaching.

In January 2008, Lauren was accepted into the Ph.D. program in Science Education at NC State, and begun working under the direction of Dr. Eric Wiebe on the Graphic-
Enhanced Elementary Science Initiative, where she participated in many aspects of the project until it ended in June 2010. Since then, she has been teaching and assisting on the research for the NC Science Scholars program, under the direction of Drs. M. Gail Jones and Margaret Blanchard.
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I am thankful to other members of the GEES team: Dr. Mike Carter, Rashay Griggs, Shelby Bullock, and especially John Bedward for their support throughout this journey. John has been a sounding board, technology-advisor, teammate, classmate and friend to me since I began at NC State. I would also like to acknowledge the other Science Education faculty members who have helped me to develop as a scholar. I am grateful for the camaraderie of the other science education graduate students, especially Jen Albert, who has helped me tremendously by serving as a second coder, and being a good friend.
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INTRODUCTION

Elementary science education is an area of critical importance, especially as accountability measures have held teachers accountable for instruction in this area since 2006 as a result of *No Child Left Behind* (Duschl, Schweingruber, & Shouse, 2007). Despite this importance, many elementary teachers report a lack of comfort and confidence with science and science teaching. In addition, according to the 2005 National Assessment of Education Progress, 40 percent of US fourth graders are at a below-basic level in their understanding of science (Grigg, Lauko, & Brockaway, 2006). This suggests that high quality professional development is needed to improve science instruction at the elementary level.

Research indicates that the highest quality professional development is coherent, or aligned to teachers’ professional experience, aligned with standards, and fosters professional communication (Garet, Porter, Desimone, Birman, & Yoon, 2001; Wei, Darling-Hammond, Andree, Richardson, & Orphanos, 2009). In order to enhance coherence of professional development experiences, we must make sure that we understand the current state of teachers’ science practices. One way of viewing teachers’ practices is teacher identity, which will be used as a lens for examining teachers’ practices in this study.

Many models for teacher identity exist, but we present a new framework that combines the ideas of Gee (2000-01) and Beijaard, Verloop, and Vermunt (2000). Gee’s frame defines identity as *who a teacher is* considering four key areas: nature, institution, discourse, and affinity group belonging. Beijaard and colleagues described identity as the factors influencing *what a teacher does* by asking teachers to allocate their expertise across three areas: content, pedagogy, and didactics. When we combine these two frameworks, we
can describe teacher identity more completely using information both about who a teacher is and what s/he does in practice. Knowing both these elements of a teachers’ identity can allow us to develop individualized and coherent identity-specific professional development plans.

Existing studies of identity consider two perspectives on teachers’ identities: that of the teacher’s self-reported or *narrated* identity, and that of the researcher’s description of identity, or *designated* identity (Sfard & Prusak, 2005). However, a critical piece of designated identity has been largely missing: the perspective of the student. In this study, we add student-centric data sources (science notebook entry analyses and student interviews) to researcher-centric (classroom observations) and teacher-centric (teacher interviews and questionnaires) data sources to provide a multi-perspective description of each teacher’s identity.

The purpose of this study was to examine differences in three second grade teachers’ identities from three perspectives: the teacher, the researcher, and the students. Specifically, we sought to answer the following questions:

1. How does teacher identity influence the content of students’ science notebook entries?
2. How effective are elementary students’ science notebooks at capturing teacher identity?
3. How can an understanding of teacher identity through science notebook entries inform professional development?

To address these questions, one class of second grade students receiving science instruction from three different teachers was followed during the 2009-10 school year. Over the course
of the school year, the class was observed 11 times during science instruction. Each teacher was interviewed, and completed a questionnaire about her science teaching. Every science notebook entry created by every student (n = 22) in the class was photographed and coded quantitatively (for unit, inquiry phase, driving force, and missing information). Qualitative descriptions of trends in each teacher’s notebook use were also documented. Finally, a subset of four students was interviewed each quarter using a semi-structured protocol based on the teacher’s identity and practices.

The findings from this study are presented in two manuscripts. The first, *Multiple Perspectives on Elementary Teachers’ Science Identities: A Case Study*, is a narrative case study of the class’ science instruction over the course of the school year. The second, *Science Notebooks & Teacher Identity*, is a mixed-methods study examining differences in practices through the analysis of students’ science notebook entries. Following the two manuscripts is an executive summary that reviews the findings of the articles and describes possible future work. The prospectus, observation, and interview protocols can be found in the Appendix.
Multiple Perspectives on Elementary Teachers’ Science Identities: A Case Study
Abstract

This narrative case study examined the relationship between teacher identity and elementary science teaching. Teacher identity is described using two compatible frames (Gee, 2000-01; Beijaard et al., 2000), incorporating three perspectives: the teachers’ self-described identity, the researchers’ view of teacher identity, and the students’ views of teacher identity. Over the course of one school year, we studied one class of second grade students receiving science instruction from three different teachers. Teacher interviews and questionnaires, student interviews, and classroom observations were coded thematically using identity markers as strands. We found that each teacher approached instruction differently, and had unique identity characteristics. Further, the three perspectives of teacher identity were sometimes in conflict with one another within individual teachers, emphasizing the importance of incorporating multiple perspectives in order to give a complete description of teacher identity. This study therefore has meaningful implications for design of elementary science professional development, as each teacher had unique identity characteristics and needs that are not necessarily met by “one size fits all” professional development.
Introduction

Effective teaching is central to student learning in all educational settings. Teachers all bring different experiences and capacities to their jobs. This range of experiences can result in the use of different instructional practices. Understanding these differences can help us to determine which factors influence differences in teaching effectiveness and student learning. In addition, knowledge of these differences in teachers can provide opportunities for designing more effective professional development and ongoing support for teachers.

When we consider teachers at the elementary level in particular, they are typically generalists, as opposed to experts in a particular content area, and tend to have especially varied backgrounds, interests, and preparation (Wilson, Floden, & Ferrini-Mundy, 2002). Elementary teachers are now being held accountable for their students’ performance in science, and this accountability has resulted in increased attention being paid toward science instruction at the elementary level (Duschl, Schweingruber, & Shouse, 2007; Grigg, Lauko & Brockaway, 2006). Elementary teachers tend to be uncomfortable with science in general, and with the use of inquiry based instructional practices and abstract scientific ideas in particular (Duschl et al., 2007; Fulp, 2002; Jarvis & Pell, 2004; Schwarz et al., 2009). Professional development can help elementary teachers to increase confidence and comfort in teaching science (Lee et al., 2008). To better understand how to structure effective professional development, however, we need to know more about these teachers’ current practices. One way to examine these practices and what influences them is through using a lens of science teacher identity.
Theoretical Underpinnings

Teacher identity is a multi-faceted construct that can be used as a lens for examining and understanding teachers’ practices. Teacher identity can be thought of as what “kind of person” someone is (Gee, 2000-01). Identity is informed by personal influences such as likes and dislikes, strengths, self-efficacy, and interests as well as contextual influences such as factors related to a teacher’s community or school (Appleton & Kindt, 2002; Beijaard, Meijer, & Verloop, 2004). Beijaard, Verloop, and Vermunt (2000) proposed that teacher identity incorporates teachers’ self-perception, as well as perception of their teaching, suggesting that there is a connection between identity and teaching practices. As individual teachers’ experiences can change over time, so may teacher identity (Cooper & Olson, 1996). Identity can be viewed from both the teacher’s perspective, and the perspectives of others, referred to as narrated and designated identities respectively (Sfard & Prusak, 2005), and including both of these perspectives can allow us to develop a robust understanding of a teacher’s identity. Most studies of teachers’ designated identities examine just one perspective—that of the researcher. To date, there are no studies considering student’s views on teacher identity, which would provide a more complete understanding of designated identity. Understanding how students see their teachers may thus continue to strengthen our knowledge of teacher identity.

In studies focused on science teaching, science identity has been linked to effective science teaching (Brickhouse, 1990; Helms, 1998; Luehmann, 2007; Luehmann & Markowitz, 2007). Science identity can include identification as: a scientist, a science
teacher, or a science leader. Pedretti, Bencze, Hewitt, Romkey, and Jivraj (2006) found that the likelihood of science teachers incorporating new content into their courses was linked to various identity characteristics including confidence and sense of collegiality with colleagues, emphasizing the importance of interactions with others in defining one’s identity. Appleton and Kindt (2002) found that teachers’ science identities related to their choice of implementing reform based instructional practices. Luehmann (2007) found teachers’ authentic scientific experiences led to an increased sense of respect within their schools, changing the way they were perceived by colleagues and students, suggesting that these science experiences helped shift their designated identities as scientists or science leaders. Taken together, these studies suggest that scientific knowledge and experiences can influence teacher identity and practice.

Most of the literature on teacher identity focuses on studies of pre-service and early-career teachers (e.g. Appleton & Kindt, 2002; Luehmann, 2007; Pedretti et al., 2006; Proweller & Mitchner, 2004; Settlage, Southerland, Smith, & Ceglie, 2009). These studies provide information about individuals who are in the formative stages of developing their identities as teachers (i.e. transitioning from pre-service to practicing teacher), or as science teachers (i.e. becoming an expert in teaching science). However, identity is not static, and can change as teachers encounter new experiences and work in different contexts (Cooper & Olson, 1996). Less is known about teachers’ identities beyond the initial teacher induction phase and its impact on teachers’ practices. A few studies (e.g. Beijaard et al., 2000; Moore, 2008) have examined the identities of more experienced teachers. These reveal some clear differences in teachers who would be considered similar based on other typical measures
highlights the worthiness of better understanding the relationship between identity and practice in more experienced teachers.

The majority of research regarding science teacher identity focuses on teachers at the middle and high school levels (e.g. Beijaard et al., 2000; Moore, 2008; Pedretti et al, 2006). The few studies addressing elementary teacher science identity (Appleton & Kindt, 2002; Varelas et al., 2005) suggest that elementary science teaching is also influenced by teachers’ identification as a scientist, science teacher, or science leader. On page 59, Appleton and Kindt noted, “Those teachers with clear self-perceptions of themselves as teachers and teachers of science more quickly established workable teaching practices in science and were able to progress to thinking about their pupils and the learning in which they were engaging.” Given the increased attention being paid to science at the elementary level, it is critical to understand how elementary teachers’ identities influence their instruction.

Though teacher identity has been shown to be a useful lens for examining teacher practices, there are several key questions left largely unexplored:

1. How can students’ perspectives on teacher identity strengthen our understanding of teachers’ identities?
2. How does teacher identity inform practices of more experienced teachers?
3. How do elementary teachers’ science identities influence their practices?

As stated earlier, teacher identity is a broad concept, and can be defined in multiple ways. In an attempt to investigate the above questions, we applied two compatible frameworks to describe teacher identity (Beijaard et al., 2000, Gee, 2000-01). We believe that the combination of these two frameworks and the inclusion of data sources, both
narrated and designated, can allow us to paint a more complete picture of teachers’ identities. The first framework, developed by Gee, uses four broad areas: Nature, Institution, Discourse, and Affinity, to describe how a teacher is seen by others (or sees him or herself). The second, developed by Beijaard and colleagues, considers a teacher’s identity as her 1 expertise divided among three components: content, pedagogy, and didactics. In this view, content knowledge included just disciplinary content knowledge (excluding pedagogical content knowledge); pedagogy was described as delivery of content to the students; while didactics was described as all non-pedagogical instructional practices, or, “the ways in which a teacher organizes, executes, and evaluates her education in the classroom,” (D. Beijaard, personal communication, January 28, 2010). Used together, these two frames can allow us to describe teacher identity more completely.

Gee’s (2000-01) identity frame has been used to describe science teacher identity, both narrated and designated (Sfard & Prusak, 2005), in many different studies, with most of these being qualitative in nature (e.g. Carlone & Johnson, 2005; Luehmann, 2007; Settlage et al., 2009). Given Gee’s broad definition of identity, it is not surprising that each of these studies used the framework differently. For example, Luehmann used the framework to emphasize the importance of discourse while Carlone and Johnson focused in on describing what “kind of person” a teacher was. Settlage and colleagues used Gee’s framework as an interpretive lens to view qualitative and quantitative data about pre-service teachers’ changing perspectives on their identities. Given the amount of overlap between each of the four identity characteristics (Nature, Institution, Discourse, Affinity), Settlage and colleagues

1 While we acknowledge that teachers can be both male and female, the three teachers in this study are female, thus she and her will be used throughout the paper.
had to collapse some categories, though like Luehmann, they focused on discourse. Gee’s description of teacher identity focuses on what personal characteristics, along with factors inside and outside the classroom that inform a teachers’ practices and decision making. In sum, Gee’s framework provides us with information about who a teacher is.

On the other hand, the framework developed by Beijaard and colleagues (2000) was created to interpret a large number of teachers’ responses to a survey on teachers’ self-reported expertise across three areas: content, pedagogy, and didactics. The intention of this framework was to capture solely teachers’ narrated, or self-described identities, rather than those designated by others (Sfard & Prusak, 2005). This framework has been used less often than the one developed by Gee (2000-01), though recently, Watson (2007) used this personal allocation of expertise in a qualitative study of two pre-service mathematics teachers developing identities as teachers. On the whole, Beijaard and colleagues’ identity framework describes the factors that influence teachers’ actions within their classrooms. These factors are very closely related to factors within the school, district or state, or Gee’s “Institutional-identity” factors, particularly didactical influences (e.g. school rules and policies) and content influences (e.g. standards and curricula guiding instructional decision making), which can play a large role in teachers’ practices. To summarize, the framework described by Beijaard and colleagues makes use of teachers’ expertise in what they do within a classroom.

Together, the frames developed by Gee (2000-01) and Beijaard and colleagues (2000) can be used to give a more complete description of teacher identity. When combined, these two frames can provide a deeper, more robust description of both who a teacher is, and what she does. As noted earlier, Gee’s framework is broad and open to many different interpretive
applications. While this can be advantageous in some circumstances, it can also make findings more difficult to operationalize, for example, into prescriptive strategies for professional development. The integration with Beijaard’s framework allows for a deeper and more uniform framework for elaborating on each of Gee’s four areas.

It can sometimes be difficult to separate teacher characteristics into each of the four areas Gee (2000-01) described. For this reason, it may be easiest to think of this framework as four overlapping circles, as shown in Figure 1. Within each of the four circles, a teachers’ expertise in content, pedagogy, and didactics can be nested.

![Figure 1: Gee’s (2000-01) identity framework.](image)

We present the combined framework with Beijaard and colleagues’ (2000) identity characteristics nested within each of Gee’s (2000-01) four identity markers:

**Nature:**
- Content: teachers’ natural inclinations can drive their desire to learn more about one content area or another. For example, a teacher interested in plants might choose to
take a graduate course in botany or participate in professional development at a botanical garden, and further her content expertise.

- **Pedagogy:** teachers’ natural inclinations can shape instructional experiences for students. For example, a teacher who considers herself a writer by nature might incorporate writing across the curriculum.
- **Didactics:** teachers’ personalities and confidence can influence classroom practices. For example, a teacher who is naturally talkative might not choose to discipline students who talk out in class.

**Institution:**

- **Content:** elementary teachers’ roles within their institutions (schools) are partly defined by the school, district, or state-mandated curricula. Thus the content they must present to students is institutionally-defined.
- **Pedagogy:** teachers’ institutional roles within the classroom dictate what they teach. For example, a second grade teacher teaches the second grade curriculum. Less formal roles, such as “grade level science expert” might lead the teacher to elect to connect science to their teaching of other subjects. For example, through selecting science related writing prompts.
- **Didactics:** some of teachers’ non-pedagogical actions (e.g. homework and discipline policies) are shaped by school or district guidelines. Likewise, some individuals seen as “tough teachers” within the school or grade level might hold those identities due to didactical policies within their own classrooms.

**Discourse:**

- **Content:** teachers’ preferred type of discourse can drive how teachers learn about and understand science content. For example teachers who engage in science related talk with content experts and colleagues might develop more sophisticated understandings of their curricula.
- **Pedagogy:** teachers’ preferred type of discourse can drive pedagogical strategies. For example, those teachers seen as inquisitive might be more likely to ask probing questions during whole class discussions.
- **Didactics:** teachers’ non-pedagogical actions might also be influenced by preferred type of discourse. What might be seen as lively discussion during the lab-cleanup portion of a lesson in one teachers’ classroom could be seen as disruptive behavior in another.

**Affinity:**

- **Content:** teachers’ likes and dislikes about a topic can influence how much she chooses to learn about it. For example, a teacher interested in weather might choose to watch weather related programs on television and bring the knowledge she gains as a result into her teaching.
- **Pedagogy:** teachers’ like for a certain topic might influence what kind of pedagogical strategies they employ. For example, a teacher who enjoys chemistry might be more
likely to allow her students perform chemical reactions with baking soda and vinegar while one who dislikes it might choose to do a demonstration instead.

- **Didactics:** similar to choice of pedagogical strategies, teachers’ likes and dislikes about a topic can guide non-pedagogical decisions in the classroom. For example, a teacher who likes painting might be more likely to post his students’ work from art class on classroom walls.

Using these frames together help elucidate how identity is linked to classroom practices, which, in the end, shapes student learning. Our combined framework describes both who a teacher is, and what she does, incorporating factors at the school and classroom level, as well as specific to teachers’ lives outside the school. Nesting the characteristics described by Beijaard and colleagues (2000) within those areas identified by Gee (2000-01) can provide a structure for explaining each of these overlapping and interacting elements.

Methodologically, this framework allows us to use data sources emerging from teachers’ self-described or narrated identities, and their identities as described by others, or designated identities (Sfard & Prusak, 2005). While some studies have included both narrated and designated identities, none have included student perspectives on designated identities alongside these others. We hope to provide a more complete description of teacher identity for these three teachers by applying the synthesized Gee/Beijaard framework with the following data sources: classroom observations, teacher interviews, teacher questionnaires, student notebook entries, and student interviews, as displayed in Table 1 below.
Table 1

*Description of data sources*

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<th>Description</th>
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</thead>
<tbody>
<tr>
<td>Classroom Observations</td>
<td>Researcher-Designated ID</td>
<td>Can show teachers’ practices and expertise during instruction.</td>
</tr>
<tr>
<td>Teacher Interviews</td>
<td>Teacher-Narrated ID</td>
<td>Can tell us about both who the teacher is and what she does in her classroom.</td>
</tr>
<tr>
<td>Teacher Questionnaires</td>
<td>Teacher-Narrated ID</td>
<td>Can tell us about both who the teacher is and what she does in her classroom.</td>
</tr>
<tr>
<td>Student Notebooks</td>
<td>Student-Designated ID</td>
<td>Can provide information about teacher practices over the course of the school year.</td>
</tr>
<tr>
<td>Student Interviews</td>
<td>Student-Designated ID</td>
<td>Can provide detailed information about students’ understandings of their teachers’ identities.</td>
</tr>
</tbody>
</table>

Using these data sources together, we can better understand both *who the teacher is* and *what the teacher does*. The diagram in Figure 2 depicts which data sources tell us specifically about teacher identity (both who she is, and what informs what she does), as well as which sources tell us about her actions in the classroom. In doing so, data is explicitly linked to a hypothesized mechanism that links teacher identity to classroom practice. Furthermore, these data sources allow us to synthesize information on identity from three perspectives: the teacher’s narrated identity, and the researcher and student’s interpretations or designations of teacher identity.
Figure 2: Framework describing data sources and theoretical perspectives.
Methods

Study Context

This study takes place within the context of one second grade class (Class X) over the course of the 2009-10 school year. Class X is one of three second grade classes in the school, located in an urban/suburban school district in the southeastern United States. The school serves children grades K-5 and has a population that is ethnically diverse (about 35% African American, 13% Latina/o, 4% multiracial, 45% Caucasian, and less than 1% Asian or Native American; about 7% of the students have limited English proficiency) and consists of children from a variety of socioeconomic backgrounds (about 40% of the students receive free or reduced-price lunch). The school uses a district-designated science curriculum consisting of four science kits per year, or one per quarter. In second grade, the teachers use a unique model for science instruction in which each teacher “specializes” in just one kit and rotates through each of the three classes (see Table 2 below). This quasi-experimental study model is based on a Latin square model design, which ensures that all conditions (classes) receive all of the treatments (teachers and kits) over the timeframe of the study (Montgomery, 2008). During the first quarter of the school year, the students are taught science by their homeroom teacher. During the fourth quarter, all three teachers return to their homeroom classes and teach the same kit, *STC Changes* (NSRC, 2004). Throughout the entire school year, the students use the same science notebook. Thus, their notebooks capture their interaction with and instruction from three different teachers.
Table 2

### Table 2

**Instructional Model for Second Grade**

<table>
<thead>
<tr>
<th>Quarter 1</th>
<th>Melissa-STC Lifecycles of Butterflies</th>
<th>Janice- STC Air and Weather</th>
<th>Donna- Insights Sound</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class X</td>
<td>Class Y</td>
<td>Class Z</td>
<td>Class X</td>
</tr>
<tr>
<td>Quarter 2</td>
<td>Class Z</td>
<td>Class X</td>
<td>Class Y</td>
</tr>
<tr>
<td>Class X</td>
<td>Class Z</td>
<td>Class X</td>
<td>Class X</td>
</tr>
<tr>
<td>Quarter 3</td>
<td>Class Y</td>
<td>Class Z</td>
<td>Class X</td>
</tr>
<tr>
<td>Class X</td>
<td>Class Y</td>
<td>Class Z</td>
<td>Class X</td>
</tr>
<tr>
<td>Quarter 4- STC Changes (all three teachers)</td>
<td>Class X</td>
<td>Class Y</td>
<td>Class Z</td>
</tr>
</tbody>
</table>

**Participants**

We explored the identities of the school’s three second grade teachers: Melissa, Janice, and Donna (pseudonyms). Melissa was the homeroom teacher for Class X and taught the *STC Lifecycle of Butterflies* kit during the first quarter and *STC Changes* kit during the fourth quarter (NSRC, 2004). Janice taught Class X during the second quarter and taught the *FOSS Air and Weather* kit (FOSS Project, 2008). Donna taught Class X during the third quarter, and used the *Insights Sound* kit (EDC, 2004).

Class X consisted of 22 students. The science notebook entries for all 22 students were collected and photographed. Four students in the class (2 male, 2 female) were also interviewed once per quarter as part of this study. These four students represent a criterion sample as they were enrolled both in Class X and the school’s after school program and thus were available for interviews outside of the instructional day (Patton, 2001).

**Study Design**

The study followed a narrative case study design following Class X over the course of the 2009-10 school year (Creswell, 2003; Stake, 1995). The case is bound by the experiences of the students during science lessons over the course of the school year. Issues influencing
the case are the three different teachers and the content and curricula those teachers covered (Stake, 1995). A narrative thematic description, using the identity characteristics as themes (Beijaard et al, 2000; Gee, 2000-01), of each of the teachers is given to define and describe the issues surrounding the case (Reissman, 2008)

Data Sources

Classroom observations. Classroom observations were conducted by one researcher (first author) during science instruction for Class X 11 times during the course of the school year. These included three observations during each of the first three quarters and two during the fourth. It should be noted that during one observation in the third quarter, no science instruction took place and the entire class period was devoted to classroom management. For a point of contrast, Janice’s homeroom class (Class Y) was also observed twice during the fourth quarter in which all teachers taught the same kit, STC Changes. During observations, the researcher took copious field notes paying particular attention to use of science notebooks and teacher-student dialogue. Within 48 hours of completing the observation, field notes were coded using a protocol developed for a research initiative this school is taking part in, Graphic-Enhanced Elementary Science (GEES) (GEES Project, 2011). The GEES classroom observation protocol included: a synopsis of the lesson, documentation of when and how science notebooks are used, excerpts of notable dialogue, and information regarding lesson introduction and closure.

Teacher interviews & questionnaires. All three of the teachers were interviewed one-on-one with the first author at some point during their first two weeks of the quarter in which they taught Class X. These interviews were recorded digitally and transcribed
verbatim. Teachers were asked to describe: their interest and preparation in science (including pre- and in-service training); their science teaching style; whether they saw themselves as scientists or science leaders; and their distribution of expertise across content, pedagogy, and didactics. During the fourth quarter, each teacher completed a questionnaire consisting of a Likert-scale survey and open-ended items (see Appendix). The survey items asked teachers to identify (on a 5-point scale) their level of agreement with statements regarding their science teaching and identities. These items were modeled after items included in the Science Teaching Efficacy Belief Instrument (STEBI) (Enochs & Riggs, 1990). Given the small number of teachers taking this survey (n=3), no quantitative analysis was made to teachers’ responses were made to the survey items. The open-ended items asked teachers to describe their teaching and changes in their students over the course of the year.

Science notebooks. Every entry in the science notebooks kept by each of the 22 students in Class X was photographed and catalogued. Themes in the ways each of the three teachers used the notebooks were noted and described.

Student interviews. During the last two weeks of each quarter, four students were interviewed. Each student was interviewed one-on-one during the school’s after school program. The students brought their notebooks to use as a reference during the interviews. The students were asked to describe: whether their teacher was a scientist (and why); what they learned in each science unit; and the things they put in their science notebooks. The interviewer took copious notes and transcribed exact quotations when possible. To ensure that paraphrased notes were accurate representations of interviewee comments, the interviewer read notes aloud and allowed interviewees to edit. It should be noted that the
students’ perspectives on each teacher over the course of the school year might have changed as a result of experiencing instruction from other teachers. To compensate for these changes, during the fourth quarter, the students were asked to describe any differences they noticed in science teaching among the three teachers.

**Analyses**

Each data source was uploaded into Atlas.ti® and coded thematically using identity markers described by Gee (2000-01) and Beijaard and colleagues (2000). These themes were used to describe the identity of each teacher. Places in which data from various sources conflict are also discussed.
Findings

For each of the three teachers, Melissa, Janice, and Donna, we presented a general description along with detailed information about her identity. Within the description of each teacher’s nature, institutional, discourse, and affinity group belonging identities, we provided connections to expertise in content, pedagogy, and didactics. These identities are described below and then summarized in tables.

Melissa

At the time of the study, Melissa was in her sixth year of teaching. She held a BA in Elementary Education, but started her college studies as a Biology major and took several undergraduate courses in science content. In addition, she previously participated in district-sponsored professional development regarding the use of science kits and notebooks, as well as professional development sponsored by an NSF-funded project that focused on using graphics in science notebooks to help students understand invisible scientific phenomena.

During her interview, Melissa was asked to rank her expertise among content, pedagogy and didactics. Melissa reported having the most expertise in content, “I would definitely say that content would be [where I would allocate] the majority of [my expertise]…I think content is most important.” She also indicated that her expertise in pedagogy was greater than in didactics. Melissa described her science teaching style as hands-on, noting that she dislikes “talking at” her students. During four of her five observed lessons, Melissa’s students engaged in hands-on activities. Over the course of the 2009-10 school year, Melissa was observed using a variety of strategies including traditional elements...
such as reading aloud from books and reform-based practices such as use of open-ended student exploration. Typical classroom practices during Melissa’s science lessons included: reflection on prior activities, making predictions about change (both growth of caterpillars and phase changes in water), and use of student directed instruction. During one class in the fourth quarter, Melissa was observed capitalizing on a “teachable moment.” The students were given water in plastic cups that was warmed in the microwave and asked to observe the water’s liquid-gas phase change. One student noted that pressing his hand on top of the cup caused the cup to change shape. At this point, the Melissa re-directed the lesson allowing the entire class to observe another example of phase changes, solid-liquid changes in plastic. An excerpt of the class’ discussion follows:

T: What happened to this cup here? (holds up distorted cup)
S1: [Name] changed the shape.
T: But what if I took a regular cup without hot water and pressed down on it? [presses on a new cup and it breaks] I can’t get this to change shape the way [Name] did. Why is that?
S2: Because you pushed too hard.
T: Well, think about this like the clay you worked with in art class. What is the clay like when you first get it from the teacher?
S3: Its really hard.
T: Good. Then what happens when you play with it for a while?
S3: It gets softer and you can make it into different stuff.
T: Great. The warmth from your hands helps you to be able to shape the clay. It’s like a candle. When we heat candles, they change from solid to liquid. When we added heat to these plastic cups, and [Name] pressed down on the top, the plastic moved a little bit and rolled at the bottom.
S4: At [Name] You made the plastic melt?
T: Well he didn’t but the hot water did. So is plastic a solid liquid or gas?
S5: It’s a solid and a liquid!

In Table 3 below, we can better describe Melissa’s identity with the proposed synthesized Beijaard et al. (2000)/ Gee (2000-01) framework.
Table 3

Description of Melissa’s Identity

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Description</th>
<th>Content, Pedagogy, and Didactics</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Nature</strong></td>
<td>Self: described an inclination toward science; enjoys experimentation and exploration. Students: described her as a scientist. Researcher: observed her sharing her interest and expertise in science.</td>
<td>Her science nature may have led her to engage in science-related professional development. Her choice of exploration-driven pedagogical strategies may also be linked to her science nature.</td>
</tr>
<tr>
<td><strong>Institution</strong></td>
<td>Self: explained that she felt colleagues viewed her as a science leader. Students: believed she was a science leader who taught the other teachers about science. Researcher: observed her acting as a science leader within the school, serving as an expert on butterflies.</td>
<td>Her science leadership role seems to be linked to her demonstrated science content knowledge and pedagogical skills.</td>
</tr>
<tr>
<td><strong>Discourse</strong></td>
<td>Self: reported an interest in talking about science and science teaching. Students: were observed engaging in student-directed science discussions. Researcher: engaged in and observed student-driven science discussions.</td>
<td>Her preferred model for science discourse (student-directed science discussions) seems to be influenced by her content expertise. This discourse model also drives some pedagogical and didactic decision-making.</td>
</tr>
<tr>
<td><strong>Affinity</strong></td>
<td>Self: described a personal interest in science. Students: believed she liked science. Researcher: observed her sharing an interest in science with the students.</td>
<td>Her interest in science is linked to her expertise in the science content, and choice of reform-based pedagogical strategies.</td>
</tr>
</tbody>
</table>

**Nature.** On the whole, Melissa is seen by herself and others as a “science person.” On her questionnaire, Melissa agreed or strongly agreed with survey items around being a scientist and knowledge of how to teach science effectively. However, in her interview at the start of the school year, she was a bit more hesitant in describing herself as an expert. In her words:
I don’t know that I’d say that [I’m a scientist]. I’d like to, but no, I probably wouldn’t say I see myself as a scientist. I mean I like to experiment and I like to explore and stuff like that but I don’t know that I would [say I’m a scientist]. When I think of some other teachers that I definitely see as scientists I don’t know that I could compare myself… I see some other teachers that… soar in that particular area, so I don’t know that I would put myself into that particular area. Not yet.

Despite her uncertainty, Melissa was fairly sure that her students and colleagues viewed her as a scientist, and her students each reported they believed she was a scientist. Some students also believed that Melissa held other roles such as mother (because she has children), mathematician (because she measures), and writer (because they have seen her writing).

**Content, pedagogy, & didactics.** Melissa’s science nature may have led her to pursue professional development in science, thus enhancing her content knowledge and expertise in the classroom. Melissa’s science nature drove her pedagogical choices as well. During the observed lessons, Melissa frequently used experimentation and probing questions to help students address misconceptions and better understand scientific phenomena. During student interviews, the students cited Melissa’s use of experiments as evidence that she was a scientist. Melissa’s science nature has also resulted in her making connections to science throughout her class, both through instruction, and setting. In the student interviews, one student suggested that he knew Melissa was a scientist because she used science to explain other subjects. When probed for an example, the student noted that Melissa discussed soil
Melissa’s science nature influences her expertise across all three areas, content, pedagogy, and didactics.

**Institution.** Along with being a second grade teacher, Melissa held the informal institutional role of science leader within her school and grade level. During her interview, she suggested that she believed she was seen as a science leader by colleagues, and that she hoped to continue developing her expertise in science. In addition, Melissa has teamed with the school’s gifted and talented teacher to develop and maintain a schoolyard ecosystem and butterfly habitat. On her questionnaire, Melissa strongly agreed that she enjoyed talking with colleagues about science suggesting that she also held the identity of an active grade-level team member. Melissa’s students also saw her as a science leader. As one student said during an interview, “She teaches other teachers about science.” Due to the school’s unique science instructional model, she has developed a reputation as the school’s butterfly expert. During an observation, another teacher came in with a chrysalis, for Melissa to study or use in her teaching. She also maintained an open door policy for students to drop in her classroom at the beginning and end of the school day to observe butterflies at various points in their lifecycle, irrespective of when their science lessons are held.

**Content, pedagogy, & didactics.** Melissa had significant pre- and in-service preparation to teach science, and this content knowledge and expertise might be responsible for her assuming the role a science leader within her classroom and school. Her institutional identity of classroom science leader allowed her to provide authentic scientific experiences for her students, as her teaching was characterized by much exploration and experimentation.
Melissa’s institutional identity as classroom teacher seemed to play the strongest part in her non-pedagogical instructional decision-making. Thus, things like classroom management, student discipline, and policies were dictated by her classroom teacher role.

**Discourse.** Melissa valued science discourse and her teaching style was characterized by frequent discussions between teacher and student and among students. There was some whole class discussion in each of the observed lessons in this study, and in each of these, Melissa used probing questions to better understand her students’ conceptions. For example, when students were first introduced to their caterpillars, one child noticed that they were using a paste, rather than green leaves to feed the caterpillars as they grew, and asked why. The teacher then asked students about their pets at home (and their pets’ diets), allowing the students to eventually make sense of the choice to use the paste through the whole-class discussion.

Additionally, Melissa’s science lessons tended to include discourse across the entire inquiry cycle—before investigations Melissa typically had students make predictions and connections to prior activities as a whole class discussion; during investigations, Melissa often paused the class and asked students to share out observations, probing to determine what students understand about the topic; and after investigations, she tended to lead the class in a sense-making discussion connecting the day’s activity to the learning goals. However, Melissa was also observed leading some teacher-driven discourse, especially when relaying instructions to students. On her questionnaire, Melissa also agreed with a statement that it was important for the teacher to provide the right answer for students. This seemed to be in conflict with her typical use student-driven discourse, because during each of the
observed class discussions, Melissa pressed students for understanding rather than providing the right answer.

**Content, pedagogy, & didactics.** Melissa’s content expertise allowed her to direct classroom discourse toward learning goals, without resorting to a teacher-centric transmission model of instruction. Melissa’s science pedagogy was driven by student-directed conversations. On an open-ended question on her year-end questionnaire, Melissa shared that she enjoys using “science talk” with her students. During one of the student interviews, a student described Melissa as a scientist. His evidence was that she is a scientist, “because she asks questions of herself and others.” Melissa’s non-pedagogical instructional practices tend to include less student-driven dialogue and more transmission of information to students. She was observed providing the class with clear instructions on procedures for cleaning up, turning in work, and returning materials. During her interview, Melissa mentioned being extremely limited by the time allowed for science (~30 minutes once per week), thus perhaps rationalizing a more authoritarian style of delivering didactical information to her students.

**Affinity.** On several occasions, Melissa mentioned liking both science teaching and learning science for its own sake. She chose to decorate her classroom with frogs, and volunteered to maintain the school’s butterfly garden and ecosystem. She also reported enjoying reading about science recreationally. In prior years, Melissa taught only the butterfly unit, though during the 2009-10 school year, there were just three teachers at the grade level, thus they decided to all teach the matter unit to their own classes. She welcomed
the opportunity to teach the matter unit at the end of the school year noting, “I was excited to
teach something different,” on her year-end questionnaire.

**Content, pedagogy, & didactics.** Melissa’s science nature seems to be very much
connected to her own love for science. This interest leads her to pursue science related
hobbies and recreation, which in turn, further increase her expertise in the content area.
Melissa’s enjoyment of science teaching leads her to experiment with using new pedagogical
strategies. On her year-end questionnaire, Melissa mentioned that it was important to her to,
“not become stagnant,” in her teaching. Though some of her non-pedagogical instructional
strategies can tend to be more typical of direct instruction, Melissa’s personal affinity for
science and science teaching seem to be connected, as evidenced by her providing
opportunities for students to engage in more authentic science experiences. During an
observation early in the butterfly unit, Melissa had to distribute cups with caterpillars to her
students. The children were antsy and excited to begin their observations; they were calling
out and out of their seats. Rather than reprimanding the students, Melissa empathized,
explaining that she was excited for the caterpillars to arrive as well, before reminding the
students that she would be unable to teach unless they followed classroom rules and
remained seated.

**Janice**

During the 2009-10 school year, Janice was in her fourth year of teaching. She held a
B.S. in Psychology and M.Ed. in Elementary Education with a concentration in Technology.
Janice had no prior college level science content courses, though she did take one science
methods course during her teacher preparation program. Additionally, she took part in the school district’s optional science kit and science notebook training.

During her interview, when asked to rank her expertise among content, pedagogy, and didactics, Janice shared that she was least confident in her content ability, “[my expertise is] definitely not [in] content… I would put that near the bottom.” Instead, she indicated she was most confident with pedagogy. By default, didactics remained in the middle. During that same interview, Janice described her science teaching philosophy as “trial and error,” and added that she, “does what the manual says and tweaks it.” This year was the first time she actually had an opportunity to teach science to second graders, as teaching assignments were different at her school during prior years. From observing Janice’s teaching, both with Class X, and with her homeroom class (Class Y) as a comparison, it was clear that her teaching followed a more regular pattern than that of the other two teachers. In most lessons, students would began by taking out science notebooks, affixed stickers containing focus questions, and labeled sections for predictions, observations and conclusions (the district’s recommended notebook format). Next, Janice asked some questions and provided some direct content instruction. Guided exploration of hands-on materials would follow, with her lessons tending to conclude with a short class discussion and teacher-provided conclusion statement for students to transcribe into their science notebooks.

In Table 4 below, Janice’s identity findings are summarized.
Table 4

Description of Janice’s Identity

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Description</th>
<th>Content, Pedagogy, and Didactics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nature</td>
<td>Self: described a lack of interest in science, and some expertise in technology. Students: were uncertain whether or not she was a scientist. Researcher: observed her relying on her technology expertise during instruction.</td>
<td>Her technology savvy and knowledge seemed to drive her pedagogical strategies.</td>
</tr>
<tr>
<td>Institution</td>
<td>Self: described a lack of interest in holding a science leadership role. Students: thought Janice turned to other teachers for science help. Researcher: observed her assuming the role of classroom leader.</td>
<td>Her classroom leader role results in her use of structured classroom routines, and technology expertise seems to drive her pedagogy.</td>
</tr>
<tr>
<td>Discourse</td>
<td>Self: agreed that talking about science and science teaching were important. Students: reported that she “told” them about science. Researcher: observed teacher-driven discourse around science.</td>
<td>Janice’s reliance on teacher-directed pedagogy and didactics resulted in little student discourse about science.</td>
</tr>
<tr>
<td>Affinity</td>
<td>Self: reported that she was not interested in science. Students: did not report on her interest in science. Researcher: observed teacher discussing her interest in technology.</td>
<td>Her interest in technology seemed to drive her choice of pedagogical strategies. Her lack of content knowledge in science might also be linked to her lack of interest in the topic.</td>
</tr>
</tbody>
</table>

**Nature.** In both her interview and questionnaire, Janice made it clear that she was not a scientist and, instead, preferred mathematics. Her pre-service specialization area was technology, and more than the other teachers, Janice made use of various technology resources available to her, including a Smart Board® and PowerPoint presentations. Though she did not describe herself as such, it was clear to the observer that Janice used her “technology expert” identity throughout her teaching. When students were asked whether
Janice was a scientist, their responses were mixed, with two of the four interviewees reporting that she was a scientist. Several other roles students listed for Janice were: writer, because she writes on the board, and artist because they have seen her drawings.

**Content, pedagogy, & didactics.** During her teacher training, Janice focused on developing her expertise in technology, having selected that area for her concentration. She assumed the role of technology expert when teaching about types of clouds using a PowerPoint presentation to Class X, and through use of interactive Smart Board® games with her homeroom class. Though she was a self-described “math person” we did not see this identity leveraged in her instruction, as there were no examples of her connecting science to math. Janice’s lack of science identity resulted in her being the only one of the three teachers who was observed sharing personal content misconceptions during her teaching. During the fourth quarter, when Janice was observed teaching her homeroom class, she explained, “Condensation is a change from solid to liquid,” and asked students to record this information on a worksheet. She elaborated by using the example of condensation outside a glass containing an icy drink. Later, she used an online interactive quiz to assess students’ understandings of phase changes. When the quiz revealed that her understanding of condensation was inaccurate, she simply told the students that she made a mistake, without asking students to correct this misunderstanding on their worksheets. Janice’s lack of content expertise might have driven her to rely on her didactical expertise to develop instructional routines in ways that helped prevent her from miss-stating science content she was uncertain about.
Institution. Like the other two teachers, one of Janice’s institutional identities is that of a second grade teacher. Data collected as part of her interview and questionnaire suggested that Janice was not interested in becoming a science leader within her school or grade level. She suggested that she can “fake” being a scientist for her students, “I think whatever subject you’re teaching, you know, they’re young enough that they just think you’re the end all be all, you know everything…I think I can fake it.” She also wanted more practice with her science teaching, and would not be interested in attending any additional science related professional development: “Honestly, I think I just need to keep doing it. I’ve found that that’s kind of the best way for me to learn is to just do it.” Interestingly, though she didn’t see herself as a science leader or expert, on her questionnaire, she expressed that she had concerns about the school’s science teaching model. She said, “Accountability [is a concern] when someone else is teaching your kids,” suggesting that she may have some concerns about the other teachers at her grade level ability to effectively teach science.

Content, pedagogy, & didactics. Though Janice acknowledged a lack of content expertise, it was still important to her that her students see her as an expert. While some students did believe Janice was a scientist, several did not. During an interview, one student was fairly certain that Janice was not a scientist, citing that she, “has to look it up,” suggesting that he didn’t believe she had much expertise in this area. Janice’s more rigid teaching style results in her leveraging her institutional role of classroom leader, and using a lot of direct instruction, both pedagogical and didactic. In her classroom leader role, Janice, directed the flow and sequence of classroom activities, rather than relying on student-driven exploration. On her questionnaire, Janice was uncertain whether she was effective at
monitoring science activities or knowing the necessary steps for teaching science effectively. Janice’s classroom leader identity allowed her to follow fairly strict classroom procedures during science instruction. More than the other two teachers, Janice’s class followed a standard routine each lesson, helping her maintain control and leadership within the classroom. These routines led to few disciplinary disruptions and allowed Janice to deliver content as she intended.

**Discourse.** Janice’s instruction included some classroom discourse, though it was typically about procedural information, and relied on teacher-led interactions which resulted in transmission of information to her students. Though there were some examples of classroom observations that included science-driven discussion, these tended to be short, and lacked instances of the teacher pressing for information. Rather, they followed an explicit path, which prohibited students from veering off track, and asking questions Janice seemed unprepared to address. For example, in the excerpt below, Janice explained to the students that they would be making parachutes, and wanted students to predict how the parachutes worked before creating their own examples. In an effort to move the lesson forward, Janice cut the discussion short by providing an answer for the students:

T: What’s your prediction?
S1: When air goes inside the parachute, it helps it float down.
T: So you think it goes in to the parachute?
S1 nods
T: Anyone else?
S2: Air helps it [the parachute to] push in…
T: (interrupting) Traps the air in?
S2: Yeah, traps it and helps it float.
T: OK class, now we’re going to make our parachutes.
Content, pedagogy, & didactics. Janice’s classroom discourse tended to be teacher-directed, and this may be in part because of her uncertainty with the science content. Her pedagogical strategies included some discourse, but most of this discourse was driven by her transmitting information to her students, and providing the “correct” answer. The non-pedagogical instructional practices that Janice used were based on the classroom routines. As a result, the amount of classroom dialogue both whole class and within small groups was limited in Janice’s science teaching.

Affinity. Janice made it clear in her interview and questionnaire that she did not have any personal interest in science. On her questionnaire, she disagreed with the following statement: I have a personal interest in science. During student interviews, they shared that Janice might be an artist or a writer, though during the classroom observations and teacher interviews, we saw no examples of her interest in these areas. In addition, the students’ notebook entries contained few examples of artistic representations of observations or of writing beyond responses to teacher prompts.

Content, pedagogy, & didactics. Janice’s lack of interest in science might explain her lack of content expertise. During her interview, she recalled being a student, and not feeling successful in her own science courses: “Science is one of those things for me in school I was not very good at.” Janice’s reliance on routine pedagogical practices might be due to her dislike for the subject, and her lack of interest might be preventing her from using more reform-based strategies, that might result in students asking questions she is unprepared to answer. While she is not interested in participating in professional development in science, she did mention that she hoped to increase her confidence with the topic, despite her
disinterest for science. During her interview she stated, “I think I need to get more comfortable with the content of it too. I think that will make things easier when I understand more of the [content I’m] teaching.” In terms of didactical expertise, Janice’s classroom routines are effective for managing her classroom well. However, her lack of interest in science might be preventing her from sharing enthusiasm about the topic with her students.

Donna

At the time of the study, Donna had the longest tenure of the school’s second grade teachers, in her 26th year in the position. She held a B.A. in Elementary Education and an M.Ed. in Language Arts. Her science preparation included one methods course at the undergraduate level more than two decades prior to the 2009-10 school year, and no science content coursework. She also participated in the district-sponsored science kit and notebook training.

When asked to rank her own expertise among content, pedagogy and didactics, she selected them in that same order. Her science content knowledge has grown over her career. Her son is a Ph.D. level scientist, and she attributed her increased science content knowledge to conversations with him. When asked about her science teaching methods Donna described, “Ideally, [I start by] presenting [hands-on activities to the class] and students responding to their hands-on activities.” Despite Donna’s extensive teaching experience, all of the observed lessons that Donna taught were characterized by an abundance of classroom management and student discipline issues. In one of the three observations, the entire lesson was dedicated to quieting the students, and no science instruction took place at all. In the other two lessons,
she began with a focus question, which students put in their science notebooks. Next, she led whole class discussion, followed by some exploration of phenomena and data collection, and concluded by responding to questions in science notebooks. Each of these lessons was cut short due to time and classroom management issues.

In Table 5 below are a summary of Donna’s identity findings.
### Table 5

**Description of Donna’s Identity**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Description</th>
<th>Content, Pedagogy, and Didactics</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Nature</strong></td>
<td>Self: described as a scientist, and reported preferring hands-on activities Students: believed she was not a scientist. Researcher: observed her attempt to use hands-on instructional strategies.</td>
<td>Her preference for hands-on activities might be related to her identity as a scientist, but her lack of didactic skill may prevent her from being able to use these to their fullest.</td>
</tr>
<tr>
<td><strong>Institution</strong></td>
<td>Self: reported that all teachers at her grade-level were science equals. Students: were uncertain she taught science. Researcher: did not observe her as an equal or leader in science at her grade level.</td>
<td>Didactical issues seem to prevent her from holding the role of science leader or classroom leader during her instruction.</td>
</tr>
<tr>
<td><strong>Discourse</strong></td>
<td>Self: reported that she enjoys talking about science. Students: did not describe science-related discourse. Researcher: observed her attempt to engage students in this kind of discourse.</td>
<td>Her interest and knowledge of science content seems to drive her preference for science discourse, but her didactical skills prevent her from being able to engage in this type of discourse.</td>
</tr>
<tr>
<td><strong>Affinity</strong></td>
<td>Self: described a personal interest in science. Students: did not comment on her interest in the topic. Researcher: observed her attempting to share her interest in science with the class.</td>
<td>Her lack of classroom management skills stands in the way of her sharing her interest for science with her students.</td>
</tr>
</tbody>
</table>

**Nature.** Donna described herself as a scientist, having mentioned enjoying gardening during her initial interview, “I like to garden.” She also strongly agreed that she has a personal interest in science on the year-end questionnaire. When the students were asked whether Donna was a scientist during their interviews, three of the four believed that she was not. The students also thought that Donna might be a writer (because she types questions for
Content, pedagogy, & didactics. Although Donna asserted that her content expertise in science is a strong point, there were few observations of her actually delivering content to the students. The students were unsure about Donna’s science instruction during the Sound unit. As one student noted, “She doesn’t do any science, just sound. She’s helping us listen better.” On the other hand, another student shared that Donna told them that sounds were made by vibrations. Donna attempted to leverage her science nature to share science with her students in a hands-on manner through observing sound vibrations when making sounds by hitting a desk with a pencil and creating drums out of cans and balloons. Unfortunately, her lack of classroom management expertise prohibited her from using these techniques to their fullest potential. Donna’s difficulty with classroom management dictated much of her instruction. These struggles limited her ability to share her science nature with students.

Institution. Within the school, Donna holds the institutional role of second grade teacher. During her interview, Donna expressed that the second grade teachers saw themselves as “science equals,” while the other two teachers clearly saw Melissa as the grade level science leader. Donna acknowledged that she liked developing expertise in one content area, Sound, though doesn’t appear to have leveraged this “sound expert” identity inside the classroom or school. Because of her poor classroom management, Donna’s role of classroom leader was not established clearly.

Content, pedagogy, & didactics. Though Donna’s content expertise might shape her desire to lead hands-on exploration, very little of this was observed. On her questionnaire,
Donna also reported feeling confident in her pedagogical abilities. During student interviews, the students were able to report some of the mechanical aspects of what they did in Donna’s class such as making kazoos and drums, though only one of the four hinted that she was able to deliver content to the students effectively, suggesting that they learned, “how sounds are made.” When probed, that student noted that sounds were made from vibrations. Donna used extrinsic motivation (passing out candy) to encourage students to stay on task during two observed lessons. This technique backfired as the students started getting out of their seats asking for more candy rather than remaining on task, making it difficult for Donna to hold on to her role as classroom leader. On the other hand, during two of the observations, Donna modeled the student notebook setup on the board, providing a structure for students to use to document their lesson, suggesting that perhaps her institutional role of classroom teacher played a role in her development of some didactical strategies.

**Discourse.** Donna enjoyed science, and mentioned that she enjoys talking about science with others including family members and colleagues on her interview and questionnaire. During the student interviews, the students noted that Donna told them what to put in their student notebooks, suggesting that Donna uses a transmission style of discourse in her instructions. During observations, she attempted to question students and lead discussion, though had some difficulty directing the conversation in a way that would allow her to meet all learning goals. On the day the students created balloon drums, Donna attempted to lead the students in a discussion about the differences in volume and pitch among drums. On the whiteboard in front of her classroom, Donna posted the day’s focus question: “How can we change our drums to create different sounds?” Beneath the question
she also posted: “Pitch = high or low, Volume = loud or soft.” She asked students to think about the question, then to come up and sit at the front of the classroom, where she had balloon drums of a variety of sizes and shapes, and one drum with a suede top (rather than balloon). After explaining how the drums were assembled, Donna asked students to compare the sounds. Students focused on differences in volume making comments such as, “The drum with the [suede] towel is softer because it’s thicker,” and “The balloon vibrates more because its thinner and that makes it louder.” The teacher probed the students about pitch, “What can we tell about high and low sounds?” The students’ responses focused solely on volume.

Next, she paired the students and gave each pair a drum, asking them to explore the drums and answer several questions in their notebooks. The students were not observed explaining differences in pitch.

**Content, pedagogy, & didactics.** Donna’s content knowledge and expertise drove her interest in science discourse. In one observed lesson, she attempted to lead a content-driven discussion with students about volume and pitch, though this resulted in meeting only half her learning goals. In another observed lesson, the students were asked to describe sounds from tapping pencils on their desks and listening to a CD. In those cases, the students were simply mimicking noises, rather than explaining any unique sound characteristics. In two of the observed lessons, Donna attempted to use whole class discussion to engage students with science content. Unfortunately, most of her time was spent quieting students, and in order to make sure students were exposed to her lessons, she would simply tell students what to do or record in their notebooks. Most of Donna’s lesson time was devoted to classroom
management, emphasizing her need for improvement in the non-pedagogical instructional strategies, as these seem to be preventing her from effectively teaching science.

**Affinity.** Donna mentioned having a personal interest in science that has grown since her son chose a career in science. She also mentioned liking teaching the Sound kit because of its hands-on nature. Donna’s interest in science seems to have influenced her allocation of expertise in science content. While she structured some activities towards meeting learning goals, these were not all met. Donna’s interest in the hands-on nature of her kit, Sound might be a reason for her attempts at using student-led discourse and student exploration. Due to the lack of solid classroom management and time allowed for science, investigations were often cut short, preventing students from reaching learning goals. Donna’s struggles with student discipline and classroom management prevented her from sharing her love for science with students.
Discussion

Clearly, each of these teachers approached science instruction with the same group of students in a unique way. To better understand the differences in these teachers’ identities and practices we used multiple data sources from multiple perspectives, as pictured in Figure 2. Through these data sources, we can use the framework depicted in Figures 1 and 2 as a way to explore the critical interactions between the three teachers’ perceptions of who they are and the actions observed as to what they do in the classroom. We can return to the three questions driving our investigation to further explore the utility of our data sources and what they reveal about these interactions:

1. How can students’ perspectives on teacher identity strengthen our understanding of teachers’ identities?
2. How does teacher identity inform practices of more experienced teachers?
3. How do elementary teachers’ science identities influence their practices?

Students’ Perspectives on Identity

Adding the student voice to our descriptions of Melissa, Janice, and Donna’s identities allowed us to describe teacher identity more completely. Student interviews and notebook entries revealed their perceptions of teacher identity that were formed through the teachers’ actions in the classroom, over the entire course of the school year. The students supported their claims about teacher identity characteristics with concrete examples their own experiences in their classes (e.g. Donna is an artist because she can make drums). If we were to consider only the teacher-reported data on identity we might conclude that Melissa and Donna, who both identified as scientists, and both reported enjoying using explorative teaching strategies, had quite similar identities. Using this single data source we might
(incorrectly) assume that similar strategies and instructional outcomes would result from this similar science identity. In fact, classroom observations revealed that this was not the case, and the student interview data helped validate the researcher’s findings. While the researcher’s findings were based on a select number of classroom observations, the students’ perceptions were formed over the course of most of a school year.

In some cases, the student perspective provided information that was aligned with both what was seen through the eyes of the researcher and reported by the teacher herself. The clearest example of this agreement was in descriptions of Melissa. Melissa’s self-described science nature, and affinity for science, was as evident to the students as it was to the researcher, and students cited specific examples of her content knowledge. They also described her institutional role, as a science expert and “teacher of teachers,” in a manner similar to how it was seen by the researcher and reported by the teacher herself. In terms of discourse, the students noted her inquisitive nature, which was also seen in her use of probing questions during whole class discussion in observed lessons. In Melissa’s case, the teacher, researcher, and student perspectives complimented one another to provide a more detailed description of her identity. The alignment of perceptions between teacher and students on Melissa’s identity may have also created a productive and self-reinforcing dynamic between teacher and students. That is, Melissa’s identity and vision of what she was able to achieve in the classroom was joined with a similar level of confidence from her students—i.e., students and teacher were on the same page. Students likely sensed the confidence that science was taking place in the classroom and it was worth participating in. While the researcher’s perspective of a teacher’s identity may be at odds with a teacher’s self-described identity this,
in theory, shouldn’t affect the dynamics in the classroom. However, since students are active players in what unfolds in a classroom, the degree of alignment between teacher and student could be important in shaping both what happens in the classroom and, therefore, what the researcher observes. These dynamics could clearly shape both learning opportunities for students and, possibly, the long-term evolution of a teacher’s identity and teaching strategies. The addition of the student voice in analyzing a teacher’s identity becomes a critical element in helping the researcher understand what is being observed and told to them by the teacher.

In contrast, students provided information about Janice’s identity that conflicted somewhat with what she reported about herself and what was observed by the researcher. For example, the students were uncertain about Janice’s knowledge or interest in science. While several students believed that she was a scientist, one felt differently, reporting that Janice has to “look things up.” Though Janice herself reported having little interest or content expertise in science, she believed that she could project the image of a scientifically knowledgeable teacher. For at least one student, Janice was unable to achieve this goal. Given the conflict in Janice’s self-reported identity and what the students were able to explain, the classroom observations were necessary to help corroborate this information, and these observations revealed that Janice adhered to routines that allow few opportunities to stray into content areas with which she is not confident. In terms of institutional and discourse identity, the students provided little additional information. This contrasted with the researchers’ observations that Janice used consistent routines in her teaching to maintain her institutional role as classroom leader, and teacher-directed conversations that dominated discourse in her classroom. In Janice’s case, the teacher, researcher, and student perspectives
were necessary to provide an accurate description of her identity. Though, the student perspective was perhaps most important for better understanding in-class rather than institutional dimensions of identity.

In contrast to Janice, Donna believed that she was a scientist. The students, however, largely disagreed; three of the four interviewees were uncertain about Donna’s science interest or knowledge, and one believed that she didn’t even teach science. Interestingly, the one student who did not believe Donna taught science suggested she was there to help them learn to listen to the teacher better, emphasizing that most of her class time was devoted to behavior management. The classroom observations corroborated this students’ belief and showed that classroom management issues were the main focus of Donna’s science teaching, and revealed little to her students regarding her interest in or knowledge of science. In Donna’s case the three perspectives on her identity were needed to provide a full description of her identity, as classroom observations provided very little information about her knowledge or interest in science. In contrast to Melissa, there was a large disconnect between student (designated) and self (narrated) identity as a scientist. Not only did the researcher not observe science being taught, much if at all, the students generally didn’t report perceiving science being taught. While the second source of designated identity from the researcher’s observations confirmed the lack of productive science teaching in the classroom, it is unclear whether this disconnect in identity perception led to some of the classroom management issues. This became in effect a negative feedback loop, whereby students did not expect science to be taught in Donna’s classroom and, thus, made it difficult for Donna to do so.
This, of course, could also be the result of larger, more general struggles with effective didactic strategies that masked Donna’s ability to project her identity as a scientist.

While it is important to acknowledge that identity is multi-faceted and that one’s identity can appear different from different perspectives, a teacher’s work is done within the context of the classroom, with an end goal of enhancing student learning. The students’ perspective provides insight on how a teacher’s identity is translated into his or her classroom practices and interpreted by the students. In this study, the students’ perspective was used to enrich our understanding of designated teacher identity. Of particular note, the students’ perspective is formed from a much longer and deeper immersion in the classroom than the researcher. The student interviews took place during the last two weeks of each quarter. Because of the school’s unique rotational teaching schedule (see Table 2), during the third and fourth quarters, the students had experienced science lessons taught by all three teachers and, it is believed, use this as an opportunity to compare the three.

Simply by the nature of their respective roles, the student is a true participant in the classroom while the researcher is only an observer. As a participant, students’ perceptions of identity also have the opportunity to shape both what is observed by the researcher and a teacher’s approach to instruction. Within these three cases, there was an opportunity to see a case where the students, teacher, and researcher were all in general alignment, one where there was some degree of misalignment between the three perspectives and one where the teacher was not in alignment with either the students’ or researcher on key facets of identity. All three data sources were crucial for understanding the implications for classroom instruction for these varying degrees of alignment between students and teacher. For Melissa,
the students’ perspective provided additional information to strengthen what was observed and reported by the teacher herself. For both Donna and Janice, the students offered different information from the other data sources. These multiple perspectives were necessary to develop a more complete understanding of each of these teachers’ identities, and interactions between identity and practice. The student perspective provides rich insight on how students within the class either come to agreement or conflict with the teachers own perceptions of oneself and what are the classroom practices that seem to emerge in response to teacher and student coming together in the crucible of the classroom.

**Experienced Teachers’ Identities**

Most of the research on teacher identity focuses on teachers prior to or early on in their careers, and focuses on the initial establishment of an identity as a teacher (or science teacher). However, the identities of individuals who are more experienced also influence their practices (Cooper & Olson, 1996). Though Melissa and Janice were early on in their careers, both had moved beyond the initial two to three year induction phase, where most studies of early career teacher identity focus, while Donna was a seasoned teacher with an established career. Thus, the case of Class X provided a unique opportunity to explore differences in experienced teachers’ identities, with examples of teachers in different phases in their careers.

We could clearly see how identity characteristics influenced each teacher’s instruction. Melissa leveraged her scientific identity (as both a scientist and science teacher) throughout her teaching, and this nature identity influenced her pedagogy and didactics, creating a classroom environment characterized by exploration and scientific discourse.
Janice used her technology-expert identity to deliver content her students, and this style of delivery was heavily shaped by her didactical identification towards developing classroom routines. It is possible that this pedagogical approach was strictly a result of her low interest and confidence in science. More likely, an existing didactical and pedagogical identity found synergy with her low science identity and high technology identity to shape an instructional approach that served all of these identity elements. In both Melissa and Janice, science identity (or lack thereof) strongly influenced these teachers’ pedagogical practices, and this was seen during each teachers’ instruction with Class X and while both teachers were covering the same unit with their homeroom classes during the fourth quarter. On the other hand, Donna believed she held a science identity (as a science teacher and scientist), that seems to have emerged as her interest in science grew over the course of her career. Despite this interest and science orientation, Donna’s lack of effective didactics prevented her from sharing this emerging identity with her students. It is important to note that if teacher interviews and questionnaires were used exclusively to inform our discussion of teacher identity, it would appear that both Melissa and Donna embodied a similar science identity—inferring the same quality of student learning outcomes. Incorporating the student interviews and classroom observations in our descriptions of identities allowed us to see clear differences in how this scientist identity interacted with other identity elements (and student perceptions of these identity elements) to produce markedly different outcomes in Melissa and Donna’s classrooms.
Elementary Teachers’ Identities

Most of the knowledge base on science teacher identity focuses on teachers at the middle and high school levels, yet the studies in existence on elementary teacher identity suggest that science identity also plays a role in teachers’ practices at the elementary level. Our study closely examined the science teaching and identities of three, second grade teachers interacting with the same class of students. Each teacher approached science in a unique way, and their instruction was tied closely to various facets of their identities. Like many elementary teachers, two of the three teachers in our study, Janice and Donna, had very little academic preparation to teach science, though Donna’s personal interest led her to learn more about the subject on her own. In contrast, Melissa had extensive preparation in science. These differences in preparation may have led to differences in how each teacher taught science. Melissa’s instruction relied heavily on creating more authentic hands-on experiences, while Janice used more focused and teacher-directed instruction that seemed to be used to compensate for her lack of broad, flexible science content knowledge. However, we also see that even with strong knowledge and interest in a subject, which describe who a teacher is (Gee 2000-01), classroom practices, or what a teacher does (Beijaard et al., 2000), can be limited by their lack of expertise across various areas, including didactics, as we saw in the case of Donna. Though Donna reported strong content knowledge, she was limited by her classroom management skills. The data collected in this study was not able to ascribe causality to observed dynamics in Donna’s class. It therefore was not possible to untangle whether poor classroom management masked her science knowledge and interest from her students, or whether the students’ disbelief in Donna’s ability to teach science resulted in the
classroom management issues, or a combination of both. Still, these findings highlight the value of incorporating both frameworks to describe both “what kind of a person” the teacher is as well as where her expertise lays to explain identity. Connecting identity with practice is critical for understanding the implications of identity on student outcomes and similarly requires a rich data set from the classroom (from teacher, researcher, and student perspectives) to understand these mechanisms in their fullest. These identity differences also emphasize the variety of backgrounds elementary teachers bring to their careers, and confirm that more content preparation can lead to more confidence in using reform-based science teaching practices. Donna’s case is also a good example of elements of identity that seem to both be fluid and static over the course of their teaching careers. While Donna’s identity as a scientist evolved over the years due to her personal initiative to learn more about science, her didactic and pedagogical identities seemed to have remained unchanged in a non-productive strategy. It is difficult to believe she did not personally recognize her struggles with classroom management, but seemed unable to address them. Again, these differential temporal dynamics with elements of identity speak to important implications to strategizing about professional development.
Conclusions and Implications

This study provides a unique look at the science identities of three second grade teachers. Using the combined theoretical frameworks described by Gee (2000-01) and Beijaard and colleagues (2000) allowed us to consider both who a teacher is, and what she does in her profession. Including students’ perspectives on teacher identity allowed us to view discrepancies between how teachers view themselves and how they are viewed by others, including the ways students perceive their practices. The student voice also served to validate and expand on the other teacher- and researcher-centric data sources.

The differences in identity across these three teachers suggest each has very different professional development needs. In-service teacher education for elementary science tends to provide the same experiences for every teacher. Moore (2008) suggested that experienced teachers might benefit best from identity focused professional development that provides differentiated development strategies. Perhaps Melissa would benefit most from further content deepening, or leadership training, allowing her to assume more science leadership roles within her school and district. Janice might be best served learning ways to address science content using technology in a way that promotes reform-based practices such as increased individual student exploration. In addition, given her desire to continue teaching the unit without assistance, she might improve her teaching further by learning some new strategies for reflective practice. Likewise, Donna might benefit from professional development centered on reflecting on classroom management practices along with experiences focused on managing effective science classrooms in general. These teacher-
specific experiences could take different forms, from pursuing graduate courses and workshops to working alongside master teachers or scientists, and would allow teachers to focus on improving their science teaching.

This study highlights the importance of incorporating students’ perspectives in descriptions of teacher identity. A follow-up study to this one will expand beyond the sample of four interviewed students and incorporate a quantitative analysis of notebook entries for each of the 22 students in Class X in an effort to understand how students’ work documents differences in the teachers’ practices, and how these relate to differences in teachers’ identities.
References


Science Notebooks & Teacher Identity
Introduction

Recent calls for accountability through high stakes testing have placed an increased importance on elementary science (Grigg Lauko, & Brokaway, 2006). These calls, coupled with research indicating that elementary teachers are poorly prepared to teach science (Duschl, Schweingruber, & Shouse, 2007) suggest that more must be done to better understand the current state of elementary science practices in order to structure professional development efforts to improve student learning at this level. One way to study teacher practices is through examining artifacts of student work. Science notebooks are widely used in elementary schools across the US (Campbell & Fulton, 2003; Klentschy, 2008), and provide opportunities for students to record science instruction over an extended period of time, thus providing a useful artifact for examining teachers’ instructional practices.

The images in Figures 1-3 below are photographs of notebook entries created by the same student, a second grader named Lucia² during typical science lessons taught by three different teachers, Melissa, Janice, and Donna, over the course of one school year. Each of the three teachers used similar inquiry-based science kits to teach science, and each received training both on using science kits and science notebooks in their instruction. However, when we examine the photos, we can see clear differences in the way Lucia used her notebook to document science learning, and we can infer that science instruction was quite different by each of the three teachers.

² All names listed in this report are pseudonyms.
Figure 1: Typical notebook entry created by Lucia during a lesson taught by Melissa.

O (observe): My caterpillars are a bit bigger and they are slower for sure.
P (predict): I think when we blow the objects it will move pretty fast. I think the feather might soar.

O (observe): The feather was flying when I put up my [straw] and blew it in the corner.

C (conclude): The feather is like the wind blowing a leaf.

Figure 2: Typical notebook entry created by Lucia during a lesson taught by Janice.
Figure 3: Typical notebook entry created by Lucia during a lesson taught by Donna.

Lucia’s notebook entries help to illustrate differences in her classroom experiences during science lessons taught by Melissa, Janice, and Donna. This curriculum as experienced by students is different from (though related to) both the curriculum as taught by the teachers, and the curriculum as written in the science kits. If the end goal of science education is to enhance student learning, then understanding how students’ experiences are shaped by instruction is essential for developing ways to improve teachers’ practices. Analysis of differences in the way curriculum is experienced by students can help us to add the student voice to discussions on differences in teacher practice. The purpose of this study is to better understand differences in curriculum as experienced by students for one class of second grade students taught by three different teachers over the course of one school year.
Teacher identity will be used as a lens to help interpret differences in the curriculum experienced by these students.

**Kit-based Science Curricula & Science Notebooks**

In many schools and districts, science kits have replaced traditional textbooks in elementary grades. These kits were developed over the past several decades, largely due to efforts by the National Science Foundation to support well developed and structured kit-based science curricula. The goal of these materials was to aid teachers who are less comfortable with science in providing inquiry-based science instruction and hands-on science experiences at the primary grades (deBoer, 1991). The majority of kits currently used in elementary schools across the nation were developed by: *Full Option Science Systems* (FOSS), the National Science Research Council’s *Science and Technology for Children* (STC), and *Insights* (EDC, 2004; FOSS Project, 2008; NSRC, 2003). These kits are designed to cover a small number (1-3) of learning goals in depth, while also addressing ideas around science inquiry (e.g. making predictions) and science process skills (e.g. experimental design) through the use of hands-on exploration. Schools typically implement 3-4 kits per year, as each kit is designed to be completed in about eight weeks. Though kits have been widely used for several decades, research shows that, on the whole, elementary teachers still tend to prefer more concrete and traditional instructional strategies in science such as reading from textbooks and completing worksheets (Fulp, 2002; Jurisevec, Glazar, Pucko, & Devetak, 2008; Martin, Mullis, & Foy, 2008). These findings suggest that although the teaching materials have changed, the instructional preferences and strategies have not.
Understanding why this is the case, warrants further exploration of how science is taught at the elementary level.

Science notebooks are often used alongside kits as another mechanism for improving science instruction at the elementary level (Aschbacher & Alonzo, 2006; Chesbro, 2006; Ruiz-Primo, Li, Ayala & Shavelson, 2004). Notebooks can support the kits’ goals of increasing science inquiry and developing science process skills, by allowing students to ask questions, make predictions, record, manipulate, and interpret data, and reflect on learning. In addition, they can provide students with opportunities to model more authentic science processes (Campbell & Fulton, 2003; Minogue, Madden, Bedward, Wiebe, & Carter, 2010). Teacher’s guides for FOSS, STC, and Insights kits provide some guidelines for using notebooks alongside activities within the kits, though this guidance tends to be general and not specific to any particular activity (EDC, 2004; FOSS Project, 2008; NSRC, 2003). This dearth of information on notebook integration with kits provides considerable latitude of interpretation on the part of teachers as to how to approach their use to further science learning.

Notebook entries capture the students’ interpretation of science investigations and, thus, the curriculum as experienced by the student when notebooks are used. In addition, when teachers use science notebooks consistently, i.e. using them with each lesson and recording all parts of the activity, they can also serve as a record the teachers’ instruction over the course of a quarter or year. Notebooks can provide opportunities for teachers to differentiate and scaffold instruction by varying the amount of guidance given to students about what to include in each entry, and can provide tools for teachers to use in tracking
students’ progress over time (Baxter, Bass, & Glaser, 2001; Minogue et al., 2010; Ruiz-Primo et al., 2004). They can also serve as tools for formative assessment, as teachers can provide feedback on student work throughout a unit (Ruiz-Primo et al., 2004). Chesbro (2006) proposed using an interactive science notebook model that provides a place to capture teacher-student dialogue. Apart from formal assessment, students can also use the notebooks reflectively to review previous lessons and/or compare prior related work to what they are currently working on. When used this manner, both teachers and students can use the notebooks to communicate science content related to the common curriculum they are experiencing.

Student science notebooks can also be tools for researchers to summatively evaluate teachers’ practices. Unlike classroom observations, which capture snapshots of teachers’ instruction, or pre- and post- student assessments, which provide information about changes in student conceptions, notebooks capture students’ interpretations of instruction throughout the course of an entire unit or school year. As such, they provide information about which science kit activities utilized the notebooks, and which of the kit (and teachers’) learning goals were met through notebook inscriptions. They can also be used to determine which phases of the inquiry cycle were addressed, or whether students were given an opportunity to document their learning before, during, and after investigations (Wiebe, Madden, Bedward, Minogue, & Carter, 2009). In an analysis of science notebooks created by fifth graders, Baxter and colleagues (2001) found very few experimental conclusions, suggesting that these entries failed to capture the complete inquiry cycle. Likewise, Wiebe and colleagues (2009) found that second grade science notebook entries were dominated by during-investigation
entries, such as data tables and observations, again emphasizing that notebooks were not used to their fullest potential to capture questions, predictions, conclusions, reflections, and sense-making.

When notebooks are used in conjunction with science kits, they provide opportunities for students to engage with the kits’ targeted learning goals more deeply over an extended period of time (Klentschy, 2008). One marker of student engagement with these learning goals is entries recording the phases of the inquiry cycle: before-, during- and post-investigation. They can also allow students to grapple with scientific ideas independently (i.e., by not necessarily following the same learning path as other students), allowing students to document their changing conceptions over time. One marker of students’ independent thoughts is the notebook entries’ driving force, which could be teacher-directed information, student-initiated reflections, or a balance between the two. Finally, notebook entries can provide information on discrepancies between how teachers intend for them to be used, and how students actually used them. If teachers use a certain framework for structuring notebook entries, and students leave portions of this structure blank, we can infer that students are not necessarily using the notebooks as the teacher intended.

Though science kits and notebooks have been put in place to aid elementary teachers in providing opportunities for their students to engage in inquiry activities, they are often used to markedly different ends—both across students within a single teacher’s classroom and across teachers. These differences in use suggests that further examination of elementary science teaching practices is needed to better understand how science curriculum is experienced by students and captured in their notebook entries. Figure 4 below, depicts the
relationship between what students capture in their notebook entries relates to teachers’
practices and kit-based materials.

Figure 4: Flow chart describing factors influencing students’ science notebook entries.

In order to understand how students interpret the science kits they use, we must first
understand how teachers’ interpret the materials and put them into practice. Teacher identity
is a construct that can be used as a lens for examining the differences in teachers’ approach to
practice.

**Teacher Identity**

Teacher identity can be described as what “kind of person,” a teacher is (Gee, 2000-01), and can be used as a lens to examine instructional practices. Identity can be seen as
one’s self-description as well as the way one is described by others, referred to by Sfard and
Prusak (2005) as *narrated* and *designated* identity, respectively. Many factors play a role in
shaping a teacher’s identity such as school culture and climate, curricula, personal knowledge
and interests, his or her role in the school, and the type of interactions s/he has with
colleagues and students (Beijaard, Verloop, & Vermunt, 2000; Gee, 2000-01). Certain
elements of a teacher’s identity may remain constant throughout his or her life and career,
while others may change as a result of critical incidents such as professional development (Cooper & Olson, 1996; Eick & Reed, 2001; Moore, 2008).

Research shows that teacher identity has been linked to teachers’ instructional practices, including within the context of science. Pedretti, Bencze, Hewitt, Romkey, and Jivraj (2006) found that teachers who had a sense of control, autonomy, and belonging within their schools were more likely to adopt environmental science ideas into their curricula. Appleton and Kindt (2002) found that elementary teachers’ adoption of reform-based science teaching practices was linked to various identity characteristics such as self-efficacy, confidence, and collegial support. Identification as a scientist is also an important influence on instruction (Brickhouse, 1990; Helms, 1998). Luehmann and Markowitz (2007) found that teachers who participated in collaborative efforts with scientists reported changes in the way they were perceived by others within their schools. Differences in teacher identity can result in differences in the way teachers use science notebooks. Madden, Wiebe, Bedward, Minogue and Carter (in review) found that elementary teachers who identified as scientists had students who created science notebook entries with significantly more pre- and post-inquiry activities documented when compared to other teachers at the same grade level.

Many models for teacher identity exist, but in this study we will focus on a model incorporating two different frameworks, one described by Gee (2000-01) and one described by Beijaard and colleagues (2000). The Gee framework describes who a teacher is by examining four overlapping facets of teacher identity. These are: nature (e.g. a person inclined towards science), institution (e.g. grade level science expert), discourse (e.g. a teacher who uses probing questions), and affinity (e.g. a teacher with a personal interest in
weather patterns). The framework developed by Beijaard and colleagues addresses teachers’ self-described expertise, or what a teacher does. These authors divide teachers’ expertise into three areas: content knowledge, pedagogy, and didactics (or non-pedagogical instructional practices). These two frameworks can be combined by nesting Beijaard and colleagues’ areas of expertise within each of the four characteristics described by Gee. Prior research on teacher identity has primarily relied on either teacher-provided narrated identity via interviews or surveys or designated identity via researcher observations (e.g. Appleton & Kindt, 2002; Luehmann & Markowitz, 2007; Moore, 2008). Science notebooks provide a potentially rich alternative data source to explore designated identity through students’ perspectives on teacher practices, or essentially what a teacher does. As a record of student inscriptions in the course carrying out kit-based activities, notebook entries provide a detailed account of how kit activities were operationalized by the teacher through instruction and then interpreted by the students. As such, they are an important data source for understanding how identity around who a teacher is transformed into what a teacher does. These student-generated data (via notebook entries) are complementary, rather than redundant, to researcher and teacher-centric data sources and provide key insights as to teacher practices in the classroom.

**Study Goal**

The goal of this study is to use teacher identity as a lens to better understand how differences in curriculum as experienced by students, through analyses of student notebooks, can be used to better understand teacher practices. In addition to qualitative and quantitative analyses of science notebooks, we used data from: student interviews, classroom
observations, and teacher interviews to describe Melissa, Janice and Donna’s identities and practices. Figure 5 below describes a methodological framework describing how each of these data sources can help inform us about the teachers’ identities, both who they are (Gee, 2000-01) and what they do (Beijaard et al., 2000).

![Figure 5: Methodological Framework describing how each data source provides information about teacher identity.](image)

The solid arrows in Figure 5 represent ways in which data sources provide information directly about who teachers are and what they do, while the dashed lines provide more indirect or interpretive information about these things. It is important to note that the purpose of student interviews was to provide information from students’ perspectives on how their science notebooks were used, thus provided further corroborating information on how the curriculum was experienced by students.
This study addressed the following research questions:

1. What are the differences in science curriculum as experienced by students for one class of second grade students across three teachers over the course of one school year in terms of:
   a. Inquiry phase (pre-, during- or post-investigation),
   b. Missing or incomplete entries, and
   c. Driving force (teacher-driven, student-driven or balanced).

2. How do differences in curriculum as experienced by students relate to differences in teacher identity?
Methods

Study Context

This study took place within the context of one second grade class (Class X), at an urban-suburban public elementary school serving students grades K-5 in the southeastern US over the course of the 2009-10 school year. The school had an ethnically diverse population (approximately 35% African American, 13% Latina/o, 4% multiracial, 45% Caucasian, and less than 1% Asian or Native American; ~7% of the students have limited English proficiency) and consists of children from a variety of socioeconomic backgrounds (~40% of the students receive free or reduced-price lunch). The school used district-mandated kit-based science curricula, and teachers were encouraged to use science notebooks in their instruction. The district provided some training for teachers in both the kits and the notebooks. Teachers who attended the district-sponsored training on science notebooks learn to use a specific model for setting up notebook entries. This model includes a focus question at the top of the page followed by spaces for predictions, observations, and conclusions labeled P: O: and C: respectively (as can be seen in the entry pictured in Figure 2 above). Four kits are covered at each grade level, one per quarter. In second grade, the four kits are: STC Lifecycles of Butterflies, FOSS Air and Weather, Insights Sound, and STC Changes. The school under study used a unique model for science instruction in that each teacher specializes in just one kit and rotates through each of the four classes. This allows for a quasi-experimental model similar to a Latin Square design that ensures all classes receive the same treatment (teachers and kits) over the duration of the study (Montgomery, 2008). During the 2009-10 school
year, there were just three second grade teachers at this school. For this reason, they elected to each return to their homeroom classes during the fourth quarter and teach the STC Changes kit. The students kept the same science notebook throughout the entire school year. Thus the notebooks, provided a record of students interactions and instruction by all three teachers. The instructional model for second grade (and driving the study design) can be seen in Table 1 below.

Table 1

<table>
<thead>
<tr>
<th>Instructional Model for Second Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>Melissa- STC Lifecycles of Butterflies</td>
</tr>
<tr>
<td>Class X</td>
</tr>
<tr>
<td>Class Z</td>
</tr>
<tr>
<td>Class Y</td>
</tr>
<tr>
<td>Class X</td>
</tr>
</tbody>
</table>

Participants

Class X consisted of 22 students, and the notebooks for each of these students were photographed and analyzed. A sub-sample of four (two male and two female) students’ notebooks was examined further. These four students represent a criterion sample (Patton, 2001) as they were enrolled in both Class X and the school’s after school program thus were available outside of class time for interviews regarding their notebook entries. It should be noted that the after school program is funded by parent-paid tuition, suggesting that a sample students who attend it might not be representative of variety of socio-economic statuses represented at this school.

All three of the school’s second grade teachers, Melissa, Janice, and Donna taught science to Class X. Melissa was the students’ homeroom teacher. She taught the Butterflies
kit (STC Lifecycles of Butterflies) during the first quarter and Changes in Matter kit (STC Changes) during the fourth quarter. Janice taught science to Class X during the second quarter and covered the kit on Air and Weather (FOSS Air & Weather). Donna taught Class X during the third quarter using the Sound kit (Insights Sound).

**Study Design**

The study followed a mixed-methods study design in which quantitative and qualitative data were collected and analyzed concurrently (Cresswell, 2003). The quantitative data consisted of coded student science notebook entries. Qualitative data, including classroom observations, qualitative interpretations of notebook entries, and teacher interviews were then incorporated into our interpretations of notebook use and teacher identity.

**Data Sources & Analyses**

**Quantitative notebook analyses.** Each notebook entry created by each of the 22 students in Class X was coded for the following:

- **Unit:** Butterflies, Air and Weather, Sound, or Changes. This information also indentifies the teacher.
- **Inquiry Phase:** Pre-, During-, or Post Investigation. Each inquiry phase labeled and/or present in each notebook entry was identified and marked. *In some cases entries were double or triple coded when they contained multiple phases. In other cases, the student labeled a phase, but left the section blank. These entries were still marked as including that phase.* Inquiry phase distribution allows us to better understand teachers’ pedagogical and didactical identity and how it translates into practice by providing information on the emphasis teachers put on each of the phases of the inquiry cycle and/or how often they encourage students to document learning in each phase. Inquiry phase analysis also shed light on how deeply the teacher delved into the content.
- **Missing/Incomplete:** Each time a student labeled a section of a notebook entry and left the section blank (e.g. included a space and label for prediction but no prediction was provided), this entry was coded as missing. Knowing how frequently students’ notebooks contain missing or incomplete entries helps us to better understand
teachers’ didactical identity, or ability to monitor how well students were completing
notebook entries as teachers intended. It also may help understand level of
importance the teacher puts on students spending time on their notebook entries.

- **Driving Force:** Teacher-driven, Student-Driven, or Balanced. When multiple student
entries were identical, or entries contained glued-in worksheets or blackline masters,
they were coded as Teacher-Driven. Entries that contained only students’ unique
thoughts were coded as Student-Driven. Entries with a combination of teacher and
student generated material were coded Balanced. The driving force of students’
notebook entries can tell us about teachers’ pedagogical identity in terms of how
often they engage in student exploration or teacher-directed instruction.

A chi-squared analysis was conducted across each of these areas comparing entries created
during lessons for each of the three teachers. For a point of comparison, a sub-sample of four
science notebooks from Class Y (Janice’s homeroom class) was also coded. The proportions
of these entries were not compared statistically as counts were not high enough to conduct
chi-squared tests.

All notebook entries from both Class X, and the sub-sample from Class Y were coded
by one coder. To establish reliability and validity, a second coder coded 22 percent of the
entries, and these were compared to the codes assigned from the first coder. At a first pass,
the two coders were in 77 percent agreement. Discussion on the remaining 23 percent of
codes took place until 100 percent agreement was reached. Additionally, the first coder took
a second pass through all codes two months after initial coding to check and correct for coder
drift. No noticeable coder drift was found.

**Qualitative interpretations of science notebook entries.** General patterns of science
notebook use during classroom observations were documented during classroom
observations. In addition, patterns and trends in entries created during each teacher’s lessons
were also documented during classroom observations.
**Student interviews.** Student interviews with a sub-sample of students from Class X provided information on how students used notebooks from their perspectives, and aided in developing our qualitative descriptions of science notebook entries. These interviews took place four times per year (once per quarter) during the school’s after school program. The interviews took place one-on-one and the students were asked to describe: (1) what they were learning in science, (2) what kinds of things they put in their science notebooks, and (3) to describe various aspects of teacher identity, such as whether they believed their teacher was a scientist. The interviewer took detailed field notes during these interviews. The interviewer read all notes back to interviewees and allowed them to edit until both parties agreed that the discussion was represented accurately.

**Classroom observations.** Over the course of the school year, Class X was observed during 11 science lessons, three times during each of the first three quarters, and twice during the fourth quarter. During observations detailed field notes were taken. Within 48 hours of their completion, observation notes were coded using an observation protocol developed for the Graphic-Enhanced Elementary Science initiative (GEES Project, 2010, see Appendix) which includes: a lesson synopsis, information regarding lesson introduction and closure, excerpts of notable classroom dialogue, and documentation of science notebook use.

**Teacher interviews & questionnaires.** Each of the three teachers was interviewed one-on-one during the first two weeks of the quarter in which they taught Class X. All interviews were recorded digitally and transcribed verbatim. The interviews asked teachers to describe: their interest and preparation in science; their science teaching style; whether they saw themselves as scientists or science leaders; and their distribution of expertise across
content, pedagogy, and didactics. During the fourth quarter, each teacher completed a questionnaire consisting of a Likert-scale survey and open-ended items. The survey items asked teachers to identify (on a 5-point scale) their level of agreement with statements regarding their science teaching and identities. These items were modeled after items included in the Science Teaching Efficacy Belief Instrument (STEBI) (Enochs & Riggs, 1990). The open-ended items asked teachers to describe their teaching and changes in their students over the course of the year.
Findings

Quantitative Science Notebook Analyses

Each of the science notebook entries for all the students in Class X was photographed and analyzed for: number of pages, unit (and thus teacher), inquiry phase, driving force, and percentage of missing or incomplete entries. These quantitative analyses were done in concert with qualitative analyses of notebook use, and used to address Research Question 1, identifying differences in science notebook use among the three teachers.

A total of 509 student notebook pages were created by the 22 students in Class X, with each notebook averaging 23 pages. Every lesson was documented in a one-page notebook entry, or an entry that took up less than one page, thus each photographed notebook page represented one lesson. The students created 266 entries (an average of 12 pages per student, or six per unit) during the two units taught by Melissa, STC Lifecycles of Butterflies and STC Changes. These units included 12 and 16 lessons respectively. On average, Melissa covered half of the content in the Butterfly unit and just under 40 percent of the content in the Changes in Matter unit, given that each entry represented one lesson. Students created 114 entries (an average of five pages per student) during the unit taught by Janice, FOSS Air and Weather. This unit included 4 investigations (with a total of 13 sub-lessons), thus Janice covered about 40 percent of the content in the Air and Weather unit. Students created 129 entries (an average of six pages per student) during the unit taught by Donna, Insights Sound. This unit included 15 lessons; Donna also covered about 40 percent of the content in the sound unit.
Inquiry phase. Across all three inquiry phases, we found significant differences in the proportion of entries in the units taught by each of the three teachers, as displayed in Table 2 below. We can reject our null hypothesis, which assumed that the distribution across all three teachers was the same.

Table 2

<table>
<thead>
<tr>
<th>Inquiry Phase Distribution Across Teachers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teacher</td>
</tr>
<tr>
<td>---------</td>
</tr>
<tr>
<td>Pre</td>
</tr>
<tr>
<td>During</td>
</tr>
<tr>
<td>Post</td>
</tr>
</tbody>
</table>

A post-hoc analysis of residuals indicated that the difference in proportion pre-investigation notebook entries across the three teachers was driven by a lower than expected count for Melissa and higher than expected counts for Janice and Donna. When we consider the during-investigation phase, the post-hoc analysis of residuals suggests that the significant p-value is driven by a lower than expected count for Melissa, and higher than expected count for Janice. Finally, when we examine the post-investigation phase, we the post-hoc analyses of residuals suggests that there was a greater than expected count for Janice, and lower than expected count for Melissa.

In general, in the entries created during the units taught by Melissa contained relatively fewer entries in all three of the inquiry phases. Across all of the teachers, the smallest differences were seen in “during-inquiry” notebook entries, and this is unsurprising as the majority of time spent during science lessons is typically collecting data and making
observations, which are during-inquiry activities. Finally, notebook entries created during the unit taught by Janice contained higher proportions of all three inquiry phases.

**Missing or incomplete entries.** Once again, we found that the teachers differed significantly in the proportion of missing or incomplete notebook entries, as displayed in Table 3 below. We can reject our null hypothesis, which assumed that the proportion would be the same across all three teachers.

Table 3  
*Percentage of Missing or Incomplete Entries Across Teachers*

<table>
<thead>
<tr>
<th>Teacher</th>
<th>Melissa</th>
<th>Janice</th>
<th>Donna</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre</td>
<td>9 %</td>
<td>11 %</td>
<td>27%</td>
</tr>
</tbody>
</table>

*X² (2, n = 509) = 24.079, p < 0.001*

The distribution of missing entries showed that entries created during Donna’s unit had more missing or incomplete portions than those created during the classes taught by the other two teachers. Janice’s students, in turn, had fewer missing or incomplete entries than Donna, but more than Melissa. The post-hoc analysis of residuals indicated that entries created during Donna’s lessons had higher counts for missing than expected, while those created during Janice and Melissa’s entries were lower.

**Driving force.** We found that the driving force of notebook entries was significantly different across units taught by each of the three teachers. These differences are displayed in Table 4 below.
Table 4

*Driving force Distribution Across Teachers*

<table>
<thead>
<tr>
<th></th>
<th>Melissa</th>
<th>Janice</th>
<th>Donna</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student-driven</td>
<td>68 %</td>
<td>14%</td>
<td>53%</td>
</tr>
<tr>
<td>Teacher-driven</td>
<td>11 %</td>
<td>0 %</td>
<td>2 %</td>
</tr>
<tr>
<td>Balanced</td>
<td>21 %</td>
<td>86 %</td>
<td>45 %</td>
</tr>
</tbody>
</table>

\( \chi^2 (4, n = 509) = 144.898, p < 0.001 \)

In terms of student-driven entries, we found the fewest of these in entries created during the unit taught by Janice, and the post-hoc analysis revealed that the count was lower than expected. On the other hand, the greatest proportion of student-driven entries were found in entries created during the two units taught by Melissa, and post-hoc analyses of residuals indicated that the count was higher than expected. On the whole, very few entries were coded as teacher-driven. A post-hoc analysis of residuals suggests that there was a higher than expected count of teacher-driven entries for Melissa, and lower than expected counts for Janice and Donna.

**Observed Science Notebook Use**

Differences in the way each teacher elected to use science notebooks were observed along with quantitative differences in the way students experienced science curricula during instruction with Melissa, Janice, and Donna. During classroom observations, teacher interviews, and student interviews, teachers described different strategies for their use. Table 5 delineates these differences.
### Table 5

**Teachers’ Science Notebook Use**

<table>
<thead>
<tr>
<th>Observed Notebook Use</th>
<th>Strategies Employed</th>
<th>Description of a Typical Entry</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Melissa</strong></td>
<td>• Notebooks were used in all 5 observed lessons of Class X during the Butterflies and Matter units. • Notebooks were used in a different way for each of the observed lessons, e.g. sometimes for making predictions and other times for drawing observations of organisms.</td>
<td>• She used the notebooks across the inquiry cycle, with focused engagement at each inquiry phase. • In some cases, students recorded careful observations, while in others, she asked students to use the notebooks to reflect on prior work, document researchable questions, or define vocabulary. • See Figure 1. • Entries created during Melissa’s lesson tended to be less “typical,” as each entry had a specific focus. For example, in Figure 1, we see written and drawn detailed observations of caterpillars, while in some others, the entries focused on making predictions or formulating questions to research.</td>
</tr>
<tr>
<td><strong>Janice</strong></td>
<td>• Notebooks were used in all 3 observed lessons of Class X. In two cases, the teacher directed students to predict, observe, and conclude the day’s activities. In the third, they made predictions and observations. • Notebooks were used in one of the two observed lessons of Class Y. In this case, students used the notebooks to document observations.</td>
<td>• She used the district-designated P: O: C: format for each entry. • In some cases, she prompted student entries (e.g. I think that blank) to begin a conclusion, while in others she allowed the students to document as they wished within the P: O: C: format. • See Figure 2. • Entries created by students during Janice’s lessons contained two or more phases of the inquiry cycle. For example, in Figure 2, we can see the student entered information at each of the three inquiry phases, although the conclusion statement is less a conclusion, and more of a re-statement of observations.</td>
</tr>
<tr>
<td><strong>Donna</strong></td>
<td>• Notebooks were used in 2 of 3 observed lessons of Class X. • In both cases, the teacher directed students to use their notebooks to document the pre- and during-investigations.</td>
<td>• Using the notebooks to record and respond to focus questions. • Using notebooks to record data in tables. • She encouraged students to document various inquiry phases, but provided little guidance as to what constituted work at each of these phases. • See Figure 3. • In general, entries created during Donna’s lessons contain focus questions and data tables (e.g. the students used the table in Figure 3 to match containers containing similar objects based on sound. • These entries sometimes contained mislabeled inquiry phases (e.g. a conclusion labeled P).</td>
</tr>
</tbody>
</table>
As we can see, despite the fact that all three of these teachers attended the same district-provided training on science notebook use, each teacher used the notebooks quite differently. While all three of the teachers did use the P: O: C: format during some lessons, only Janice used it consistently during most lessons, resulting in students’ notebooks typically containing information at each of the three phases. Although students often documented information at each phase, sometimes the information included was inappropriate, such as the students’ re-statement of observations in the conclusion section of Figure 2. On the other hand, Melissa opted to direct students to use the notebooks to focus in on a specific focus during each lesson, such as making careful observations, or asking questions. She also had students use the notebooks as a tool for recalling and reflecting on earlier activities, which was observed during her lessons, though impossible to capture in quantitative analysis of notebook entries. Finally, Donna used the notebooks primarily as places to document and respond to focus questions, and to record data in tables. While students sometimes labeled sections of these entries with the P: O: C: format, these labels didn’t always correspond to the appropriate inquiry phase.

**Teacher Background and Identity**

Teaching practices, such as science notebook use, can be strongly influenced by teachers’ identity characteristics. To situate and contextualize our findings and comparisons of the notebook entries created by students in Class X during lessons taught by each of these three teachers, we have included background information and identity descriptions for each of the three teachers below.
Melissa

Background. Melissa was the homeroom teacher for Class X and taught the STC Lifecycles of Butterflies and STC Changes kits during the first and fourth quarters respectively. The 2009-10 school year was her fifth year of teaching. She held a B.A. in Elementary Education and took multiple pre-service science courses having begun her studies as a Biology major. She has also participated in optional in-service science professional development, having participated in workshops on science kits and notebooks sponsored by the district and an NSF-funded research initiative.

Melissa’s identity. Melissa is seen by herself and others as a scientist, as she has a natural interest and inclination toward science, suggesting she holds both nature and affinity identities related to science. This has resulted in her assuming the informal institutional identity of science leader within her school and grade level team. Melissa also holds a science-related discourse identity as she values scientific discussion within her classroom and with colleagues. During all her observed lessons, Melissa’s students engaged in rich student-directed discussions around science content.

Melissa’s strong content knowledge drove much of her instruction and allowed her to capitalize on teachable moments exploring students’ ideas. Further, she used this knowledge to help scaffold activities to meet the science kits’ learning goals. Her pedagogical strategies varied and incorporated traditional teaching methods such as reading aloud and reform based practices such as open-ended explorations. She leveraged her scientist identity in her didactical instruction as well—acknowledging that she shares enthusiasm for the subject
when explaining the importance of following instructions when handing out materials during classroom observations.

**Janice**

**Background.** During the second quarter of the 2009-10 school year, Janice used the FOSS *Air and Weather* kit to teach Class X. During that time, she was in her fourth year of teaching. She held a B.A. in Psychology and an M.Ed. in Elementary Education, and chose technology as an area of specialization. During her pre-service training, Janice took one science methods course, and no content courses. She has completed the district’s optional science notebook and kit training.

**Janice’s identity.** Janice’s expertise and interest in technology (nature and affinity identities) led her to use tools such as PowerPoint presentations and Smart Board ® games to deliver science content to her students. She does not see herself as a scientist, or as a science leader within the school, and reported having low content knowledge in science, though believes that she has enough knowledge to “fake it” when teaching science to her students. Additionally, she reported no personal interest in science. Her instruction is based around fairly rigid routines in which she plays the institutional role of classroom leader. Though she mentioned that she likes talking with colleagues about science teaching, the science discourse within her classroom tends to be heavily teacher-directed.

The bulk of Janice’s perceived and observed expertise was in pedagogy and didactics. She reported trying to teach the content as described in the teaching materials and “tweaking it.” Janice relied on her didactical expertise in classroom management and establishment of routines when teaching science to compensate for her lower science content knowledge and
interest. More than the other teachers, Janice used her technology expertise to guide her pedagogical choices.

**Donna**

**Background.** During the third quarter, Donna used the Insights Sound during her lessons with Class X. She held a B.A. in Elementary Education and an M.Ed. in Language Arts. Having taught for 26 years, she had the longest tenure of the three second grade teachers in this study. Her pre-service preparation included one science methods course (three decades prior) and in-service training included the district’s optional science notebook and kit training.

**Donna’s identity.** Donna saw herself as a scientist, as she was involved with science related hobbies such as gardening, thus assuming nature and affinity identities related to science. Within the institution of her grade level, she believed that all three teachers are “science equals,” though Melissa and Janice cited Melissa as the grade level science leader. Within her classroom, she struggled with classroom management, and had a difficult time assuming the role of classroom leader. Donna acknowledged being interested in talking with colleagues about science and science teaching, and attempted to leverage this science discourse identity into her teaching through initiating class discussions about science content.

While Donna enjoyed science, and reported having content expertise in the subject, her ability to teach science was limited by her didactic abilities. Each of her observed lessons was characterized by many disciplinary concerns, which prohibited her from being able to facilitate much science inquiry in her teaching. Further, her students were often unable to complete the entire inquiry cycle as Donna dedicated much of each class period to discipline.
When asked to describe her science pedagogy during an interview, Donna stated that she preferred a hands-on approach. Two of her observed lessons included hands-on investigations, but many students were off task, and the lessons were cut short due to time constraints.
Discussion

Students’ science notebook entries provide information about science instruction via the prescribed curriculum as experienced by the student. A primary aim of this study was to better understand what students’ science notebook entries can tell us about differences in these teachers’ instructional practices through a lens of teacher identity. The Latin Square-type study design (Montgomery, 2008) used in the science instruction of the second grade classes at this school provided us with a unique opportunity to follow one class of second graders learning science with three different teachers over the course of one school year. Because of this design, and the data sources pictured in Figure 5, we were able to better understand these teachers’ practices and their identities—both who they are and what they do in their classrooms. Incorporating the student-generated notebook entries into our other teacher- and researcher-centric data sources has strengthened our understanding of identity and helped us to describe these teachers and their practices more completely.

Differences in notebook entries among teachers

Our quantitative analyses revealed that the students in Class X used their science notebooks differently during units taught by each of the three teachers, suggesting there were clear differences in the way three similar kit-based curricula were experienced by the students. These differences were seen across all three of the areas we coded: inquiry phase, missing/incomplete entries, and driving force. Our classroom observations and teacher interviews indicated that these teachers did in fact use very different instructional practices as well, suggesting that the analysis of student notebook entries as a way of understanding the
curriculum as experienced by students can be a useful tool for supplementing and expanding our insights into differences in teacher practices and their impact on student learning.

When considering the inquiry phase distribution of notebook entries (See Table 2), we saw significant differences in the proportion of entries at each phase among the teachers. Some of these differences were driven by the smaller percentages of notebook entries at each of the three inquiry phases during lessons taught by Melissa in the Lifecycles of Butterflies and Changes in Matter units. This suggests that entries created during her lessons focused on fewer parts of the inquiry cycle, compared to the other two teachers, who tended to include more entries across the entire inquiry cycle (e.g. Melissa might devote an entire notebook entry to the during-inquiry phase, conducting careful observations rather than addressing all three inquiry phases). Despite the lower number of entries in each inquiry phase, a closer examination of these entries created during Melissa’s units revealed that the entries focused on individual phases within the inquiry cycle were more detailed than many entries created in lessons taught by the other two teachers. For example, when we consider the notebook entry pictured in Figure 1, the student included careful, detailed labeled drawings of observations of caterpillars ate, along with a statement describing observed changes in the organism. During the five classroom observations, Melissa used a clear focus to direct students’ notebook entries, which resulted in students engaging with each inquiry phase deeply. Melissa’s identity as a scientist may have driven her preference for deep engagement at each of the phases separately, emphasizing the importance of each part of the inquiry cycle.

On the other hand, the notebook entries created during Janice’s unit (Air and Weather) contained a significantly higher proportion entries across each phases of the inquiry
cycle than those created during lessons taught by the other two teachers. This is not surprising as classroom observations revealed that lessons taught by Janice followed a distinct pattern, including setting up the notebook entries early on in the class period. Her lack of comfort with and interest in science led her to rely on her strength in didactics and establish routines in her science teaching. When we examined notebook entries created during her classes qualitatively, we saw that though they typically contained all three inquiry phases, they did not necessarily contain detailed information about science content at each of those phases. For example, students’ conclusions tended to be short one-sentence comments on the day’s lesson and sometimes lack conclusive information, as can be seen in the entry pictured in Figure 2 where the Lucia restated her observation in the space for conclusions. Janice’s didactical strengths and identity as classroom leader drive her instructional routines, and these routines are captured by students as the curriculum students experience during Janice’s instruction.

Finally, notebook entries created by students during the Sound unit taught by Donna were quantitatively fairly similar to those created during lessons taught by Janice in terms of proportions of each inquiry phase represented. This is likely due to Donna’s suggestions that students respond to focus questions and record data in tables. However, when we looked more carefully at students’ notebook entries, inquiry phases were often mislabeled, suggesting that Donna’s directions for including various phases are sometimes misinterpreted by students. Our classroom observations revealed that Donna’s identity was characterized by a low-level of expertise in didactics, which might explain the lack of guidance students had in labeling the inquiry phases in their notebook entries. In sum, we found that the notebook
entries for Melissa’s were “narrower and deeper,” in content, while those created in Janice and Donna’s lessons were “wider and shallower.”

The proportions of missing or incomplete entries were also different among the three teachers (see Table 3), and these differences were driven by a higher than expected number of missing entries created by lessons taught by Donna. For example, during one classroom observation, Donna asked the students to respond to a focus question, based on the day’s activities, and many students labeled and left space for responses, many students left this part incomplete. This suggests that although Donna made an effort to have students document all three phases of the inquiry cycle, her struggles with classroom management may have prevented her from monitoring to make sure students did so. Classroom observations also revealed that most of Donna’s lessons were dedicated to keeping the class on-task and as a result she was unable to address all three phases of the inquiry cycle, and meet all of her intended learning goals. On the other hand, Janice’s strong classroom management skills allowed her to frequently check in on student progress and resulted in a low proportion of missing or incomplete notebook entries. However, her check-ins with student progress tended to be low-level checks for completeness, as evidenced by the incomplete conclusion sentence seen in the entry in Figure 2. Finally, Melissa’s focus on narrow but deep explorations at each inquiry phase allowed her students to create detailed entries at phase of focus.

The findings displayed on Table 4 suggest that there were also clear differences among entries created during lessons taught by each of the three teachers in terms of driving force, and these are driven by a higher than expected count of teacher and student-driven
entries during lessons taught by Melissa. Returning to the entry pictured in Figure 1, we can see that the student used the notebook to document her own experiences and thoughts, irrespective of what her classmates documented in their notebook entries. This high proportion of student-driven entries suggests that there was more student choice in how to represent thoughts, and perhaps less likelihood of students including all three inquiry phases. Interestingly, entries created during Melissa’s lessons, which contained the most student-driven entries, also contained the greatest percentage of teacher-driven entries. A more careful pass at the teacher-driven entries created during Melissa’s lessons revealed that these tended to be lists of vocabulary. This may be due to the heavy vocabulary load associated with the butterfly unit, which might warrant including more teacher-driven information. This is a clear example of how the curriculum as written influences the curriculum as taught, which is in turn experienced by students, and captured in science notebooks, as described in Figure 4. Many entries created during lessons by all three teachers were coded as balanced. Any evidence that both teacher and student input were included in the entries resulted in notebooks being coded balanced. For example, if teachers provided students with stickers stating the focus question of the lesson, and students determined the remainder of what was included in the entry, these entries were considered balanced. Melissa’s class had the fewest number of entries coded balanced, and this may be due, in part to both the teacher-driven vocabulary pages coded teacher-driven, and the number of student-driven entries we saw in her class. On the other hand, the balanced entries we saw from the other two teachers, Janice in particular, tended to be tied to a very specific structure and covered more inquiry phases at a shallow level, when compared to those in Melissa’s class.
Differences in Teachers Practices and Identity

Our classroom observations and interview with Melissa revealed that she is the most science-natured and interested of all the teachers, and this seemed to result in her using her content knowledge to provide more authentic scientific experiences for her students such as making predications and conducting careful observations. This careful attention to science at each of the inquiry phases may have driven the narrower but deeper entries created by students with a lower proportion of notebook entries dedicated to each individual inquiry phases we saw in lessons taught by Melissa. In addition, Melissa used a greater variety of instructional strategies during her observed classes, showcasing her pedagogical expertise. This variety might have also influenced the differences in how students represented their thoughts within the science notebooks, resulting in the highest proportion of student-driven entries being created in lessons taught by Melissa. In contrast, Donna, who also viewed herself as a science-natured was unable to leverage this science identity into her instructional practice. The classroom observations proved that Donna was often unable to share her own science identity with her students as her lack of didactic skill led to disciplinary issues dominated her instruction and prevented her from leading the class in explorations of science content. Unlike the other two second-grade teachers, Janice did not report having a science identity. Rather, she relied on her didactical strength of establishing classroom routines and to structure her pedagogy in such a way that she avoided having to address content with which she was uncomfortable. This structured science pedagogy manifested itself in notebook entries that followed a very distinct pattern. Taken together, among all three teachers, we were able to better understand differences in notebook entries in light of what
we learned about teachers’ practices and identities through observations and interviews, highlighting the connectedness between her practice and what was experienced by students and captured in their notebooks.
Conclusions & Implications

As we can see, the three teachers in this study each used unique instructional practices that we conclude were influenced by their unique teacher identities. Adding the students’ perspective on these teachers’ identities and practices allowed us to describe these connections more completely and understand how students experienced these practices.

In Class X, science notebooks provided a record of an entire year’s worth of instruction with three different teachers. As such, notebook analyses allowed us to study differences in teachers’ practices (or curriculum as taught) more closely than we could using teacher interviews and observations alone. Most importantly, we could see how the students interpreted these instructional experiences. In our case, we were able to see clear differences in the way three teachers used the notebooks, even when working within the context of the same class, and using similar curricular materials, highlighting the differences in curriculum as written, curriculum as taught, and curriculum as experienced by students. These findings suggest that the science notebook is a useful tool for studying teacher practices over extended periods of time, capturing daily activity from the students’ perspective, which is often missing in studies of teacher practices (e.g. Appleton & Kindt, 2002; Luehmann & Markowitz, 2007). Understanding patterns in how notebooks were used, both through quantitative comparisons of inquiry phase and driving force, and qualitative descriptions of entries allowed us to construct the entire “story” of science instruction over a quarter (and then a school year) rather than simply making inferences based on a few observations or teacher interviews. On the other hand, the observational data was useful for ground-truthing
patterns we saw in notebook entries—for example we saw Janice using rigid routines in her instruction, and this matched up with the consistent pattern we saw in students’ notebook entries.

However, our analysis of science notebooks alone was unable to provide complete descriptions of each of the three teachers’ identities and practices. When we situated the analysis of these notebooks within the context of their classroom actions through observations, and through the teachers’ self-described identities, we were better able to piece together a description of the science instruction for Class X over the course of the 2009-10 school year. For example, though a first quantitative pass, it might look like Melissa’s students engaged in less science inquiry due to the smaller percentage of notebook entries found at each inquiry phase, but our classroom observations revealed that she did address each inquiry phase, but did so using a “narrow but deep” approach by devoting entire lessons to just one or two of the phases of the inquiry cycle (e.g. an entire period spent making careful observations of caterpillars as documented by Lucia in Figure 1). Our qualitative analysis of the pages also supported these findings. We can conclude that notebooks should not be used exclusively to inform us of teacher practices, but rather be used in concert with other tools to paint a more complete picture of instruction over the course of a school year.

In the end, each of the three teachers had a distinct way in which their instruction was captured by students. Melissa’s teaching followed a, “narrow but deep” approach, as she relied heavily on her content expertise and science identity to engage students at various inquiry phases. As previous authors have found (e.g. Brickhouse, 1990; Helms, 1998), Melissa’s identity as a scientist seemed to influence the way her students engaged deeply
with the content. Janice had little confidence in science content, but instead assumed the identity of classroom leader, and leveraged this role to follow the kits’ teachers guide strictly and use classroom routines to ensure she covered all three inquiry phases in a broad and shallow manner. Her lack of confidence in science is typical for elementary teachers (Duschl et al, 2007, Fulp, 2002), but studies suggest that enhancing her confidence in the content area might lead to more reform-based pedagogy (e.g. Appleton & Kindt, 2002). Finally, Donna expressed both an interest in science and content knowledge in this area, suggesting that she could potentially engage her students in authentic science practices. However, she was limited by her lack of skill in classroom management, which prevented her from delivering much content to the students at all. These findings suggest that although science identity is important for successful science teaching at the elementary level, without solid didactical skill, it is impossible to effectively teach science.

There are important implications for the future professional development of these teachers. While all three have received training on the use of science notebooks and have chosen to implement them in their science teaching, it is clear that each teacher interpreted what was presented to them through the district’s professional development differently, and as a result, they are using the notebooks quite differently. These differences, coupled with the differences we were able to see in their practices suggest that each teacher has unique professional development needs, and if the district aspires to have all teachers using notebooks in to maximum effect, further in-service education about the effective use of notebooks is needed. Given the differences in each teacher’s identity and needs, future professional development should be structured in a way that addresses each teacher’s
individual needs and identity. For example, Melissa could benefit from some guidance on
how to help her students capture some of the important elements of the inquiry cycle covered
in class (such as making predictions aloud) in their science notebooks. She could also benefit
from training on using the science notebooks as a tool for formative assessment by
monitoring her students’ notebook entries. While the other two teachers could also benefit
from training on using the notebooks for formative assessment as well, both Janice and
Donna could use additional training on helping their students capture their changing
scientific conceptions in their science notebooks. Janice, might best benefit from training on
how to get her students to record their independent thoughts at each of the three inquiry
phases, providing them with guidance and structure, but not explicit information on what to
put in their notebooks. In addition, given her technology-expert identity, she might benefit
from learning ways to use electronic science notebooks rather than paper versions. Donna on
the other hand might find more success in her teaching by learning more effective classroom
management techniques and guidance on how to monitor her students’ work throughout her
teaching. In addition, she could also use some assistance expressing her personal interest in
science with her students. Personalized professional development plans for each teacher
could help to meet these needs. These plans could include graduate classes, workshops, or
shadowing scientists and expert teachers as well as learning from one another through
professional learning communities.
References


EXECUTIVE SUMMARY

The purpose of this study was to examine differences in teacher identity incorporating the perspective of the students, in an effort to inform future professional development efforts. Classroom observations, teacher interviews, teacher questionnaires, student interviews, and student science notebook analysis were used to describe the science instruction of three elementary teachers with one class of second graders. The findings, presented in two manuscripts, offer a more complete understanding of elementary teachers’ identities, and provide suggestions for creating identity-focused future professional development efforts.

The first manuscript provided a detailed narrative case study of the three teachers’ identities from three perspectives: the teacher’s self-described identity, the researcher’s perspective, and the students’ perspectives. We used the identity markers described by Gee (2000-01)—nature, institution, discourse, and affinity; and Beijaard and colleagues (2000)—expertise in content, pedagogy, and didactics to describe the identities of each of these teachers from three perspectives. We found that each teacher had a unique identity, which led to differences in how they taught science, and differences in what they needed in order to improve their practices. In addition, we found that for two of the three teachers, the different perspectives on teacher identity conflicted. These findings emphasize the importance of incorporating multiple perspectives (including the student) when describing teacher identity, and suggest that even teachers using similar curricular materials at the same school provide different opportunities to learn science. This, in turn, points to the different professional development needs of the teachers.
The second manuscript analyzed the notebook entries created by students in science lessons taught by each of the three teachers in concert with observational and interview data. The notebooks were coded for: unit (and therefore teacher), inquiry phase (pre-, during-, or post-investigation), driving force (teacher-driven, student-driven, or balanced), and whether there were any parts of the entry that were missing or incomplete. Although all three teachers received district-provided professional development around the use of science notebooks, and taught similar kit-based curricula, we found significant differences among the three teachers in each of these areas. When we considered these differences in light of their descriptions of their teaching and observed teaching, it was clear that differences in their identity and practices influenced the way their students used their science notebooks as a learning tool. These findings suggest that science notebook analyses are useful for describing teachers’ practices in concert with other data sources. They also suggest that differences in teacher identity result in differences in the way students represent their thinking in science.

Next steps include re-visiting student interview data about students’ science identities (not used in this study) to examine the connection between teacher identity and student identity. I would also like to conduct a future study following teachers before and after identity-focused professional development. Finally, I hope to examine notebooks as tools for formative assessment, by tracking how teacher feedback influences the content of students’ entries.
APPENDIX
Teacher Interview Protocol

Teacher Pseudonym:   Grade: 
Number of years teaching:   Degree: 
Training from district in science kits or notebooks: 

Thank you for taking the time to talk with me about your science teaching. Please know that anything we talk about is confidential in that I won’t reveal your name or school name when writing reports. I would like to record our conversation to assist my note-taking. Do I have your permission to record this conversation?

1. How would you describe your style of science teaching in a sentence or two?
   a. If you had to describe your expertise as a science teacher between pedagogy, content, and didactics how would you divide it up?
   b. Do you see yourself as a scientist? Do you think your students do? What about your colleagues?

2. I’ve had a chance to observe your class several times now, and to check out your students’ science notebooks. How would you describe your notebook use?
   a. What do you see as the strengths and weaknesses of using science notebooks?

3. How do you use science notebooks as an assessment tool?

4. Do you have any areas in which you would like additional assistance in teaching science in general, or using the interactive science notebook model in particular? If so, what are they?

Thanks, again. We appreciate all of your help this school year!
Student Interview Protocol

Prologue:
Thank you for agreeing to talk with me. The reason why I asked you to talk with me is that I want to know a little bit more about how kids think about science, and what sort of things they’ve been putting in their science notebooks. I’m going to ask you some questions about the things you’ve been learning in school during science and about what sort of information you have been putting in your science notebooks. You won’t get any kind of grade for this, and there are no right or wrong answers. If you want to stop at any point, just let me know and we’ll be finished. Do you have any questions before we begin?

Q1—Can you please tell me about the kinds of things you’ve been learning in science class?
   Probes:
   a. Was there anything in the [current] unit that surprised you? If so, what?
   b. What has been your favorite part of the [current] science unit?

Q2—What kinds of things do you put in your science notebook about [current unit]?
   Probes:
   a. Can you show me some examples?
   b. What do you like best about these?
   c. Can you tell me what you learned about on the days of these entries?
   d. Why did you decide to write/draw ______? 
   e. Were you thinking about other ways you could have shown those thoughts?

Q3—Can you show me the notebook page that is your best work?
   Probes:
   a. What do you like best about this page?
   b. What did you learn on this day?
   c. Why did you decide to write/draw ______?
   d. Were you thinking about other ways you could have shown those thoughts?

Q4—Can you show me the notebook page that was hardest for you to do?
   Probes:
   a. What made this page hard?
   b. What did you learn on this day?
   c. Why did you decide to write/draw ______?
   d. Were you thinking about other ways you could have shown those thoughts?

Q5—Was there anything you learned about during the [current] unit that you didn’t put in your notebooks at all? If so, what was it?

Q6—Is there anything else you’d like to show me in your notebooks? If so, what is it?

Thank you for taking the time to talk with me. Our conversation will help me to understand more about what kids are learning in science.
Teacher Questionnaire

Science Teaching Beliefs Survey & Final Questionnaire

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

SA = STRONGLY AGREE
A = AGREE
UN = UNCERTAIN
D = DISAGREE
SD = STRONGLY DISAGREE

1. I continually find better ways to teach science.
2. I know the steps necessary to teach science concepts effectively.
3. I am effective in monitoring science activities.
4. I understand science concepts well enough to be effective in teaching science.
5. I enjoy teaching science.
6. When teaching science, I welcome student questions.
7. I know what to do to increase student’s interest in science.
8. I have personal interest in science (e.g., gardening, watching television programs about science, reading about science).
9. I think it is important for students to talk about science.
10. When teaching science, it is important for the teacher to provide the correct answer or explanation.
11. I am a science leader in my school.
12. I enjoy talking with colleagues about science and science teaching.

For the next 4 questions, please feel free to answer below or on the back of this page, or via email to me at: LOMadden@gmail.com

13. What do you see as some of the pros and cons of the science teaching model (each teacher doing just one lab for all classes) used at your school?

14. How do you return to your class for the matter unit during the 4th quarter?

15. Were you able to see changes in the way your students learned or talked about science over the course of the school year? If so, what were some of the changes?

16. Did you have a chance to use the science notebooks for assessment this year (even just informal scanning)? If so, how did it work out for you?
GEES Classroom Observation Protocol
2009-2010

**Descriptive Information:**

Researcher:

Teacher/Grade: 

School: 

Condition: Control/Experimental (highlight one) 

Materials: 

Date: 

Start time: 

End time: 

Number of Students: 

# Males: 

# Females: 

Classroom Set-up (describe or sketch set up below):

**Dialogue Between Researcher and Teacher:**

**I. Lesson Introduction**

Instructions: Provide a brief description of how the lesson started and mark whether each of the indicators was present or absent.

<table>
<thead>
<tr>
<th>Introduction Emphasis</th>
<th>Present?</th>
<th>Evidence/Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Provides overview</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. Relates lesson to previous lessons/activities</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. Assesses prior knowledge</td>
<td></td>
<td></td>
</tr>
<tr>
<td>d. Uses science notebooks*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>e. Uses graphics**</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note:
1. Present
0. Absent

*Notebooks use will be addressed in detail later on in protocol
**Graphics will be addressed in detail later on in protocol

II. Event Log/Synopsis:

Instructions: Create an event-driven synopsis for the class period describing both teacher and student actions during each event. Shorthand codes for modes of instruction and teaching materials can be found in the table below the log. Refer to graphics as Graphic A, B, etc., as these will be described in section IV of the protocol.

<table>
<thead>
<tr>
<th>Event Time</th>
<th>Teacher Actions</th>
<th>Student Actions</th>
</tr>
</thead>
<tbody>
<tr>
<td>12:50</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

September 18, 2008 Version, LM
III. Lesson Closure

Instructions: Write 1-2 sentences describing how lesson ended.

Event Log Coding Scheme

<table>
<thead>
<tr>
<th>Mode of Instruction</th>
<th>Code</th>
<th>Materials Used</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whole Class instruction</td>
<td>WCI</td>
<td>Printed Reading Materials</td>
<td>PRM</td>
</tr>
<tr>
<td>Hands-on Activities</td>
<td>HOA</td>
<td>Computer or Computer Technology</td>
<td>CT</td>
</tr>
<tr>
<td>Lecture or Recitation</td>
<td>LR</td>
<td>Overhead projector or LCD</td>
<td>OP</td>
</tr>
<tr>
<td>Drill and Practice</td>
<td>DP</td>
<td>Chalkboard/Whiteboard/Chart Paper</td>
<td>CBC</td>
</tr>
<tr>
<td>Reading Textbook or Kit Materials</td>
<td>KT</td>
<td>Videos/Films/Music</td>
<td>VFM</td>
</tr>
<tr>
<td>Teacher Demonstration</td>
<td>TD</td>
<td>Demonstration models</td>
<td>DM</td>
</tr>
<tr>
<td>Small Group Discussion</td>
<td>SGD</td>
<td>Manipulative/hands on equipment</td>
<td>MHE</td>
</tr>
<tr>
<td>Cooperative Group Work</td>
<td>CGW</td>
<td>Worksheets</td>
<td>WS</td>
</tr>
<tr>
<td>Individual Seat Work</td>
<td>ISW</td>
<td>Science Notebooks</td>
<td>SN</td>
</tr>
<tr>
<td>Open Ended Inquiry</td>
<td>OEL</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Data Collection and/or Manipulation</td>
<td>DCM</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Note-taking (includes copying materials and procedures)</td>
<td>NT</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Homework or Class work Review/Correction</td>
<td>WRC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group Presentation (student)</td>
<td>GP</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Notebook Entry or Log</td>
<td>NE</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

IV. Notable Dialogue

Instructions: transcribe any notable classroom dialogue in the box below.

V. Notebook Use

Instructions: briefly describe notebook entries. Refer to graphics as Graphic A, B, etc., as these will be described in section V of the protocol.

<table>
<thead>
<tr>
<th>Notebook Use</th>
<th>Present?</th>
<th>Driver</th>
<th>Description of Notebook Entry(ies)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Notebooks used before Investigation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Notebooks used during Investigation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Notebooks used after Investigation</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Present/Absent Scale:
1 – Present, 0 – Absent

Driver Codes:
T – teacher, S – student, B – balanced

September 18, 2008 Version, LM
### VIIa. Pictorial Graphic Coding

Instructions: Identify scale, provide a brief description, and thumbnail sketch (if possible) of any pictorial graphics presented or created in the lesson.

<table>
<thead>
<tr>
<th>ID</th>
<th>Scale</th>
<th>Description</th>
<th>Thumbnail Sketch</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Choose one:</td>
<td>Teacher Driven</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Student Driven</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Balanced</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Describe Graphic:</td>
<td>T-Chart on the board for Ss</td>
</tr>
</tbody>
</table>

### VIIb. Data-driven Graphic Coding

Instructions: Identify graphic type, provide a brief description, and thumbnail sketch (if possible) of any data-driven graphics presented or created in the lesson.

<table>
<thead>
<tr>
<th>ID</th>
<th>Graphic Type</th>
<th>Description</th>
<th>Thumbnail Sketch</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>O Chart</td>
<td>Choose one:</td>
<td>Teacher Driven</td>
</tr>
<tr>
<td></td>
<td>O Table</td>
<td></td>
<td>Student Driven</td>
</tr>
<tr>
<td></td>
<td>O Bar Graph</td>
<td></td>
<td>Balanced</td>
</tr>
<tr>
<td></td>
<td>O Histogram</td>
<td>Describe Graphic:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>O Flow Chart</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>O Timeline</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>O Venn Diagram</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>O Line Graph</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>O Double Bubble</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>O KWL</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>O Stem and Leaf Plot</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>O Other (describe)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Examining Elementary Teachers’ Identities through Analysis of
Student Science Notebooks

A Prospectus: March 2, 2010
Elementary Science Education

Elementary Science Education is an area of critical importance, and has become the focus of increased attention in recent years. The most recent results of the National Assessment of Education Progress (2005) indicate that 40 percent of the fourth graders across the United States were performing at a below-basic level in science (Grigg, Lauko, & Brockaway, 2006). With the onset of No Child Left Behind, all elementary students in the US will be assessed in science as of the 2006-07 school year (Grigg et al., 2006, Duschl, Schweingruber, & Shouse, 2007). With this change, performance on science assessments becomes an additional criterion for measuring adequate yearly progress of schools. But, even with the onset of this mandatory assessment in science, emphasis on science still falls behind when compared to language arts and mathematics Consequently, limited time is allotted to science at the elementary level.

Generally speaking, elementary school teachers are typically not comfortable with science content and pedagogy (Duschl et al. 2007, Fulp, 2002). This lack of comfort is often attributed to poor academic preparation in the science content and pedagogy as well as weak content understanding. Specifically, elementary teachers are uncomfortable with inquiry-based science instruction (Duschl et al., 2007; Schwarz, Reiser, Davis, Kenyon, Acher, Fortus, Shwartz, Hug, & Krajcik 2009). Over the last century, inquiry-based instruction has been the preferred path for science instruction by the research community (deBoer, 1991; deBoer, 2000), while in the past thirty years, an effort has been made to increase the use of inquiry-based practices in the K-12 arena (Conderman & Woods, 2008). The inquiry process
models the authentic scientific process, and can occur in a range of different types from student-directed to teacher-guided inquiry (deBoer, 1991; Duschl, 2007).

Over the last 2-3 decades various mechanisms have been put in place to assist elementary teachers with science instruction, specifically in using inquiry-based instruction (deBoer, 1991). Two of these tools are science kits and science notebooks. Inquiry-based science kits have replaced traditional textbooks in many schools and districts across the nation. The National Science Foundation has put forth an effort to support projects developing kit-based science materials, designed to increase the inquiry-based science instruction and hands-on science experiences at the primary grades (deBoer, 1991). In this effort, several publishers have created the majority of kits used in elementary schools across the nation including *Full Option Science Systems* [FOSS], the National Research Council’s *Science and Technology for Children* [STC], and *Insights*. Though each publisher follows a slightly different model in kit development, science kits typically follow the same general instructional model. Science units taught using kits are designed to be completed in about 6-9 weeks, allowing most schools to implement 3-4 kits at each grade level in a school year. The kits typically center around one to three scientific concepts that they cover deeply, rather than a cursory level of coverage of a broad range of science content. The kits typically contain multiple hands-on activities. Despite the widespread use of science kits, a 2000 US survey of teachers revealed that elementary science instruction remains dominated by traditional activities such as reading aloud form a textbook or completing worksheets (Fulp, 2002). This finding suggests that although the materials being used for science instruction have changed, the actual instructional methods have not.
Like science kits, science notebooks have also been widely used as a mechanism for increasing inquiry-based science instruction at the elementary level (Aschbacher & Alonzo, 2006; Ruiz-Primo et al., 2004; Chesbro, 2006). Science notebooks work hand in hand with science kits to support their curricular goals. Science notebooks are places for students to ask questions, make predictions, record, manipulate, and interpret data, and reflect on learning and classroom experiences. Science notebooks are not simply journals, though they share some common features of journals, such as providing places for students to record their thoughts and ideas about science experiences. Science notebooks are also not synonymous with scientists’ notebooks, but they do share some common features as well, in that they are places for students to record, analyze, and manipulate data, and as such become tools for modeling authentic scientific practices. Many models for science notebooks exist, and most contain some combination of teacher-driven materials (such as copied notes or materials from the text or kits) and student-driven entries (such as observations, data, and reflections). There are few guideline for teachers as to what notebooks are and are not used for, but some kit-based curricula provides guidance as to how science notes can be used. For example, the FOSS kits include blackline masters to be used in conjunction with kit lessons. FOSS also provides a handbook for teachers (FOSS, n.d.) on using notebooks in conjunction with their kits. In this handbook, the authors suggest using the notebooks to model professional practice (like a scientist’s notebook) and to record observations and structure explanations. FOSS also publishes science notebook templates to be used in conjunction with its kits, and demonstrates strategies for the use of these templates in its handbook. STC on the other hand, provides a short section on science notebook use in each of its kits (STC, n.d.) and
focuses most of its guidance on science notebook use around writing in science. The STC guidelines suggest incorporating a specific format for notebook use including: questions, predictions, prior knowledge, procedures, observations, conclusions, new questions, and finally reflection. The STC handbook also provides short vignettes from teachers using science notebooks.

The enactment of inquiry-based curricula and pedagogical strategies, such as the use of science kits and science notebooks, is influenced by many factors, both contextual and teacher-specific. Contextual factors include things like the school’s focus (or lack thereof) on science, the actual time allotted for science instruction, and the availability of science materials. Teacher-specific factors include things like content knowledge and confidence in science, like or dislike of science, teaching philosophy and expertise, amount of professional development received in science, and teacher identity. These teacher-specific factors, in particular, influence the pedagogical strategies implemented, and in turn, the particular strategies employed can influence student learning. Pedagogical strategies can be documented in many ways, including classroom observations, teacher interviews and student work.

**Elementary Science Teaching Practices**

There are many factors that play a role in how science is taught at the elementary school level. School instructional foci, as laid out in administrative guidelines have a firm influence on how much time is allotted for science. Even though No Child Left Behind mandates that science must be assessed, and counts towards adequate yearly progress, many schools choose to focus primarily on mathematics and language arts (Conderman & Woods,
2008; Fulp, 2002; Marx & Harris, 2006). Fulp (2002) reported on the results of a nation-wide survey and found that on average, science is taught for less than 20 minutes per day in elementary schools, compared to 114 and 53 minutes for language arts and mathematics, respectively. Similarly, in a survey of third grade classrooms across the US, the National Institute of Child Health and Human Development (2005) found that only six percent of instructional time was spent on science instruction compared to 56 percent for literacy and 29 percent for mathematics. It should also be noted that designated science time varies considerably from school to school even within a district (Minogue, Madden, Bedward, Wiebe, & Carter, in press; Lee & Luykx, 2005).

While time allotted for teaching science is a major factor influencing teaching practices, these practices are also influenced by curricula. Curriculum enactment is dependent on choice of curricula and materials by the teacher, school, or district as well as general availability of materials. Furthermore, regardless of which curriculum is being used, the implemented instruction might be different from the intended curriculum, and the interactions between curricula and implementation must be examined. Marx & Harris (2006) reported that science kit curriculum developers’ understanding on enactment is based on very small, outdated datasets, and suggest that research is needed on how these curricula are being implemented to suggest modifications and edits so that the materials may be used more effectively. In another study, Dickerson, Clark, Dawkins, and Horne (2006), found very few significant differences in performance of students learning science using kits compared to those using more traditional instructional materials, which suggests that although kits may be used, they are not necessarily taught using reform-based practices.
The individual teacher is the one who, in the end, makes the decisions on how and what science is taught within the constraints of his/her classroom. These decisions are heavily influenced by teacher content knowledge and confidence. As recently as 2000, nationwide elementary science instruction was dominated by worksheets and textbook reading (Fulp, 2002). While the use of reform-based curricula has increased significantly in the post-No Child Left Behind era, the actual implementation of these curricula is limited by time available for science, materials available to teachers, and teacher content knowledge and confidence (Marx & Harris, 2006). Many elementary teachers report feeling uncomfortable teaching various science disciplines (Fulp, 2002; Duschl et al., 2007), and this lack of comfort is often attributed to a small amount of preparation to teach science content. Weld and Funk (2005) reported that participation in inquiry-based undergraduate science content courses increased preservice teachers’ confidence and self-efficacy in teaching science at the elementary level. Professional development can also influence teacher practices. Lee, Adamson, Maerten-Rivera, Lewis, Thornton, and LeRoy (2008) found that professional development around the mechanical use of teaching materials increases teacher confidence, thus increasing the likelihood of using the materials effectively. Garet, Porter, Desimone, Birman, and Yoon (2001) noted on page 934 that, “Teachers who experience professional development that is coherent—that is, connected to their other professional development experiences, aligned with standards and assessments, and fosters professional communication—are more likely to change their practice.”

Teacher identity is a multi-faceted construct that can be used as a lens to allow us to examine and better understand teachers’ practices. Teacher identity is shaped by school
climate and culture, curricula, and teaching materials—many of the elements already indicated by prior research as influencing instructional practice. A teacher’s identity is also influenced by his or her discourse and interactions with colleagues and students, his or her knowledge and interests, his or her role in the school, both formal and informal (Beijaard, Verloop, & Vermunt, 2000; Gee, 2000-01). When considering science teaching in particular, identification as a scientist is also an important influence on instruction (Helms, 1998; Brickhouse, 1990). Several studies report that critical events such as specific professional development experiences can influence and make lasting changes in teacher identity (Appleton & Kindt 2002; Eick & Reed, 2001). Professional Development can also influence teacher identity through providing opportunities for teachers to interact within their school or district communities. Teacher identity can inform professional development efforts as well. Moore (2008) suggested creating identity-focused professional development efforts to better meet the needs of teachers.

Several studies have examined how teacher identity influences instructional practices and decisions. Pedretti, Bencze, Hewitt, Romkey, and Jivraj (2006) found likelihood to incorporate environmental science ideas into curricula was closely linked to the teacher identity components of sense of confidence, control, autonomy, belonging to school community. These authors used the common threads in these teachers’ identities to inform preservice teacher education. Similarly, Appleton and Kindt (2002) found various components of teacher identity such as confidence, self-efficacy, collegial support and “critical incidents” influenced adoption or lack thereof of reform based practices. Most studies around the influence of teacher identity on teaching practices rely on data collected
through classroom observations and self-reported survey data from teachers. Two recent studies have considered teachers perspectives on student learning when describing teacher identity (Pedretti et al. 2006; Settlage, Southerland, Smith, & Ceglie, 2009). However, these studies fall short in not interviewing students or examining artifacts of student work. At the current time, there are no studies in the literature analyzing the influence of teacher identity on teacher practices analyzing artifacts of student work.

Student science notebook entries provide a record of science instruction that can be used to investigate teacher identity. Notebooks capture students’ interpretation of science instruction in ways that make them a robust formative assessment tool (Ruiz-Primo et al. 2004; Aschbacher & Alonzo 2006). These student artifacts cannot only be used as a self-reflective tool by teachers, they can also be used by other researchers to study teacher identity. These entries can be coupled with other types of data such as observations of science instruction, teacher interviews, and student interviews to complete the picture of science instruction that a student experiences, thus providing important information concerning teacher identity. Madden, Wiebe, Bedward, Minogue, and Carter (2010) found that second and fifth grade elementary school students created different kinds of notebook entries in classes taught by teachers who received professional development around a science notebook model documenting the complete inquiry cycle than with control teachers. Interviews with these treatment teachers revealed additional similarities in teacher identity among them, further indicating that student notebook entries might be used as a vehicle for investigating teacher identity. These data also suggest that teacher identity might be
connected to likelihood to participate in professional development around innovative science instructional practices.

**Summary**

With the current increased focus on elementary science, it is important to understand which factors influence elementary science teaching practices. Science notebook entries provide a record of teacher practices as interpreted by the student, and these notebooks are a valuable resource for understanding instruction. When combined with observational and interview data, science notebook analyses provide a rich and novel context for studying teacher practices. Teacher identity can be used as a lens to examine these practices as captured in student science notebook entries. In turn, this better understanding of identity-influenced practices can be used to structure future professional develop efforts to better suit the needs of elementary teachers of science.

**Research Questions**

1. How does teacher identity influence the content of students’ science notebook entries?
   - Teacher identity influences practices which are captured in student science notebook entries.
   - Students’ views of a teacher’s identity also incorporated in notebook entries.

2. (Methodological question) How effective are elementary students’ science notebooks at capturing teacher identity?
   - Does the content of science notebooks match what students report knowing (both through interviews and classroom observations)?
• Does the content of science notebooks match what teachers intended to cover (through observed presented content)?

• Do we see things in observations that aren’t captured in science notebooks?

3. (Next steps/implications question) How can an understanding of teacher identity through science notebook entries inform professional development?

• Moore (2008) encourages identity-focused professional development without much guidance on what constitutes identity-focused professional development. This leaves space for us to explore what identity-focused professional developments might look like.

• What modifications to our data collection methodology would help in understand teacher identity and its impact on science learning?
REVIEW OF THE LITERATURE

This study seeks to address the broad educational need for enhancing inquiry-based instructional practices in elementary science. Recent reports, such as *Taking Science to School*, show that elementary teachers are unprepared to teach science and, specifically, that these teachers are uncomfortable with the inquiry process (Duschl et al., 2007). These findings, coupled with the large numbers of elementary students performing at a below basic levels on standardized tests (Grigg et al., 2006), suggest that increased attention must be paid to science instruction at the elementary level. This study will be conducted in an effort to address these concerns by focusing on the influence of teacher identity on instructional practices, and how those practices are captured in students’ science notebooks in conjunction with a kit-based science curriculum. Finally, implications of this study’s findings will be used to propose recommendations for future professional development efforts. Thus, this section will review the literature in three key areas: (1) science notebooks in elementary school; (2) teacher identity; and (3) professional development.

**SCIENCE NOTEBOOKS**

**Introduction**

Science notebooks are widely used in elementary science instruction (Campbell & Fulton, 2003; Klentschy, 2008). The science notebook serves as a meaning-making tool for students, and can provide a record of teacher practices, as reflected by student work. This record, coupled with other data can be a useful lens for understanding the classroom practices of the teacher.
What is a science notebook?

Science notebooks are used alongside other inquiry-based instructional strategies to enhance science instruction (Campbell & Fulton, 2003; Klentschy, 2008). They are places for students to record their thinking and actions throughout science lessons. Science notebooks can be used as tools by both the student and the teacher. For students, these notebooks are places for students to grapple with higher-order thinking skills such as metacognition and reflection, as the notebooks document changes in student thinking over time (Klentschy, 2008). Teachers can use the notebooks as a tool for tracking changes in student thinking over the course of a quarter or school year (Minogue et al., in press; Baxter et al., 2001; Ruiz-Primo, Li, Ayala, & Shavelson, 2004). Science notebooks also provide opportunities for enhancing literacy (Campbell & Fulton, 2003; Klentschy, 2008; Baxter et al., 2001). Notebooks that include writing activities can also be used to help solve the “time issue” in elementary schools, as some literacy content can be covered at the same time as science. In sum, notebooks can provide teachers and students with a useful record of science over an extended period of time.

Science notebooks serve as a place for students to: ask questions before investigations and as they come up throughout investigations, make predictions, make meaning of their experiences, record and interpret data, and reflect on learning and experiences. Campbell and Fulton (2003) cautioned that science notebooks are not simply journals, which primarily act as places to record thoughts and reflections. Though science notebooks share some common features with journals because they are places for students to reflect on learning, document experiences, and record thoughts, they are intended for students to use recording ideas
throughout the entire inquiry cycle. Shepardson and Britsch (2001) suggested that student science notebooks can be used to make three “worlds” of students’ science experiences visible to the reader. These three worlds are: experienced (or documentation of past related experiences); imagined (or students’ imagined explanations for phenomena); and the science investigation itself (or actual documentation of what went on during science instruction). If used as a tool for recording these three worlds of science knowing, teachers can leverage notebooks to assist in the sense-making process and help structure scaffolding of instruction to aid in reaching learning goals.

Campbell and Fulton (2003) also argued that a student science notebook is not the same thing as a scientists’ notebook. Scientists often have different notebooks for different purposes (e.g. one notebook for recording field observations and another for documenting use of a particular machine). However, like scientists’ notebooks, student science notebooks are used for keeping careful records of their observations. Campbell and Fulton (2003) suggested that these careful records of observations are what differentiates science from simply casual observation. Furthermore, science notebooks do allow students to model one element of professional practice of scientists, as they can be an organized living document of science experiences (Minogue et al., in press).

Many models for science notebooks exist, and these can range from completely unstructured documents for students to record thoughts to highly structured notebooks that consist of a collection of teacher- or textbook- created materials. Many researchers (e.g. Klentschy, 2008; Campbell & Fulton, 2003) suggest that a notebook model somewhere between these two extremes is the ideal. For example, notebook entries could be scaffolded
by teachers such that they follow a certain structure, or incorporate some specific
terminology, but also allow for students to represent their own thinking within those
parameters. Chesbro (2006) proposed using a two-sided model for science notebooks with
teacher-driven material (including teacher comments) on one side and student-driven
material on the other. This model, termed an interactive science notebook allows for student
work to remain untouched by the teacher, and captures dialogue between the teacher and
student. Several groups have used science notebooks to provide evidence for inquiry
practices in the classroom (e.g. Klentschy & Molina-De La Torre, 2003; Ruiz-Primo et al.,
2004; Baxter et al., 2001) and most of the studies involved students using notebooks with
some combination of teacher- and student-driven materials. These studies focused on
students capturing or recording various types of activities within the documents, along with
evidence of teacher feedback within the notebook entries. Notebooks, when used in an
interactive way, can allow researchers an opportunity to better understand how inquiry-based
activities are leveraged in the classroom.

Notebooks in conjunction with other inquiry-based practices

While the act of creating science notebook entries represents an inquiry-type activity
itself, notebooks are often used alongside other inquiry based instructional practices, such
engaging in dialogue about science, and in concert with science kits. Science notebooks can
be tools for assisting students with discourse about science (Lemke, 1990; Chesbro, 2006).
The interactive science notebook model captures some discourse between the teachers and
students, thus becoming a tool for discourse itself. However, the notebook, when used as a
record of science activities also serves as a way for students to structure arguments and
discussions around scientific ideas both with peers and with teachers (Lemke, 1990). Thus, notebooks are tools for enhancing scientific dialogue among students.

Science notebooks are often used alongside science kits (Klentschy, 2008, Klentschy & Molina-De La Torre, 2003). Science kits are instructional units and materials centered on a few learning goals, and intended to be completed in six to eight weeks. Many publishers offer kits, and two of the most commonly used kits are Full Option Science Systems [FOSS] and Science and Technology for Children [STC] (FOSS, n.d.; STC, n.d.). FOSS and STC kits tend to focus on science content, inquiry, and laboratory skills. These kits contain 10-16 sequential lessons driven by hands-on explorations and observation. Given the constraints of day-to-day classroom instruction, lessons from science kits are not always taught in the publisher’s intended order, and lessons can sometimes be combined or abbreviated (Baxter et al., 2001; Minogue et al., in press). When notebooks are used in conjunction with kits, they can be used as a document to record the enacted curriculum through the eyes of the student experiencing the instruction. They can also provide evidence for which phases of the inquiry cycle the students experience, as abbreviated lessons might not allot equal time to activities before-, during- and after an investigation, or time for documenting all three of these types of activities.

**Notebooks as tools for assessment**

Science notebooks can be used for both summative and formative assessment. In fact, Hargrove and Nesbit (2003) found that when science notebooks are used as assessment tools, increases can be found in students’ science and mathematics scores. Ruiz-Primo and colleagues (2004) conducted a study of fifth-grade students’ science notebooks, graded
summatively using a rubric, compared to other measures of science learning, specifically laboratory performance assessments. These authors found that it was possible to reliably score students’ notebooks, and that student notebook scores correlated well with other performance indicators. Campbell and Fulton (2003) offered some guidance for teachers using science notebooks as tools for formative assessment. These authors differentiated between assessment of the notebook and assessment using the notebook. Assessments of notebooks tend to focus on things like neatness, completion, spelling, and labels. On the other hand, assessment using the notebook focuses only on whether or not the student provided evidence for meeting the intended learning goal. Though Campbell and Fulton (2003) argued that both types of assessment can be meaningful for teachers and students, it is assessment using the notebooks that provides information about students’ scientific conceptions. The publishers of the STC science kits also offer teachers some guidance (and rubrics) for assessment of science notebooks, but these tips lack information regarding assessment of science content.

Science notebooks have also been used for formative assessment. In their 2004 study, Ruiz-Primo and colleagues also studied formative feedback provided by teachers in science notebooks. Baxter and colleagues (2001) examined fifth grade students’ science notebook entries and found that while teachers sometimes did provide comments on student work, these were rarely about the substance of the entry. In both of these studies, the authors offered suggestions for improving feedback to enhance student learning such as specific comments regarding what evidence students provide for meeting the learning goals.
Nesbit, Hargrove, Harrelson, and, Maxey (2004) provided some suggestions for using the notebooks as tools for formative assessment such as having teachers use rubrics and sticky notes to provide feedback in a specific manner. Self-assessment is one type of formative assessment that gives students ownership and responsibility over their own learning and enhances metacognitive skills (Black & Wiliam, 1998). Hargrove and Nesbit (2003) suggested that self-regulation practices, and thus increased frequency of student self-assessment can come with regular science notebook use. Likewise, both FOSS and STC offer some suggestions for using the notebooks for a self-assessment purpose. FOSS (n.d.) provides some basic notebook guidelines along with all of its kits, and suggests incorporating self-assessment into the reflection portion of student notebook entries. STC (n.d.) on the other hand encourages teachers to use simple summative assessment rubrics for grading; providing these for students ahead of time can also aid with self-assessment. Science teachers can also use the content of students’ science notebook entries to inform future lessons and make instructional decisions (Alonzo & Aschabacher, 2004; CAPSI, n.d.). Thus, notebooks provide teachers and students with an opportunity to record and track self-assessment.

**Notebooks as a place to capture teacher practices**

When students use science notebooks, they are often creating entries that correspond with the day or lesson’s instruction. As such, the notebooks serve the purpose of documenting the outcomes of their teachers’ instructional practices from the perspective of the student. When used in a consistent manner (i.e. the notebook entries follow a specific structure and include the various parts of the lesson separately), the notebooks provide a document of the instructional sequence during science lessons as reflected in student work.
For example, notebooks can be used to record classroom activities across the entire inquiry cycle, pre-, during-, and post-investigation (Wiebe et al., 2009; Minogue et al., in press). Pre-investigation activities might include things like focus questions and predictions, while during-investigation activities include things like data tables and observations, and post-investigation activities include conclusions and reflections. When science notebooks are used in an interactive manner, such as the model proposed by Chesbro (2006), the entries also capture dialogue between teacher and student. In sum, the science notebooks serve as a document for recording classroom practice along with instructional sequence. They can provide information about which phases of the inquiry cycle were emphasized and record interactions between teachers’ and students.

**Inconsistent use of notebooks**

Though science notebooks hold much promise for improving elementary science instruction, notebooks are often used inconsistently. In their 2001 study of fifth grade science notebooks, Baxter and colleagues found that there were few conclusions in notebook entries, and most of these were the result of whole-class share out discussions rather than independent conclusions. Similarly, Wiebe and colleagues (2009) conducted an analysis of second grade science notebook entries and found that nearly all were created in the during-investigation phase. This suggests that the notebooks served as a place for recording data and observations, but not for other important learning tasks notebooks can help with (e.g. asking questions, making predictions, reflecting, etc.). Furthermore, the notebook entries are not providing a complete record of the entire inquiry cycle, rather just of the middle phase. To ensure that notebooks are supporting instruction more effectively, teachers could incorporate
instructional scaffolds and create model science notebooks to assist students in capturing all 
three phases of the inquiry cycle and instructional sequence.

Summary

In conclusion, science notebooks are important and useful tools for enhancing 
inquiry-based science instruction as they allow students to document their experiences, ask 
questions, and reflect on learning. They also hold promise for providing a record of the 
students’ perspective on the teachers’ instructional sequence. However, they may not 
provide a completely accurate record, so these data should be triangulated with other data 
sources to create a more complete picture of instruction. Regardless, the teacher practices 
captured in notebooks (along with those absent from notebook entries) are informed by 
teacher identity. Thus, the notebooks may provide a new perspective for examining teacher 
identity through the lens of the student.

Teacher Identity

Introduction

Teacher identity is a useful lens for examining teacher practices, as captured in 
science notebooks. Teacher identity has multiple facets. In the past, teacher identity has been 
examined from the perspective of the teachers themselves (i.e. self-reported data) as well as 
through the lens of the researcher. Classroom observations, interviews with teachers, and 
survey data have all been used as evidence for constructing information about teacher 
identity. In this study we will add a new perspective, that of the student, on teacher identity. 
The student lens will be examined through new data sources (student interviews and science 
notebook analysis) to support this new perspective on teacher identity.
Teacher Identity Formation

Teacher identity is a multi-faceted description of one’s self as a teacher. Helms (1998) described identity as viewing oneself (and one’s teaching) as others see us (and our teaching). Likewise, Beijaard, and colleagues (2000) offered that identity could be thought of as how teachers perceive themselves as teachers and what influences their perceptions of their teaching. As individuals’ experiences can change over time, so can identity (Cooper & Olson, 1996).

There are many things that can inform a teacher’s self-identity, which in turn influence teacher identity, including likes and dislikes, strengths, self-efficacy, and interests. These identity-influences go beyond areas of past academic success and confidence in teaching (Appleton & Kindt, 2002). The influences on a teachers’ identity are both personal and contextual; identity is informed by his or her personal experiences as well as by those she encounters in the community and at school (Cooper & Olson, 1996; Beijaard, Meijer, & Verloop, 2004). Emotion and emotionally driven experiences can also play a role in identity formation for teachers (Zembylas, 2003). These experiences can come in many forms and are sometimes termed critical events (Appleton & Kindt, 2002; Volkman & Anderson, 1998). Sometimes the critical event can take the form of a teacher working through and finding resolution to a dilemma, while other times critical events are simply salient teachable moments or professional development experiences.

Components of teacher identity

In discussing teachers’ identities, Gee (2000-01) defined four components of what he termed professional identity. These components are:
• N-identity, or identity as defined by nature (e.g. an only child)
• I-identity, or identity as defined by institutions (e.g. a second grade teacher)
• D-identity, or identity as defined by discourse (e.g. dynamic conversationalist)
• A-identity, or identity as defined by affinity group (e.g. fan of a certain musical genre)

It is important to note that there is a lot of overlap between these groups. For example, if a person was a science leader within a school, this would be considered part of her I-identity, though it would also play a role the type of discourse she participated in, thus influencing her D-identity. Other recent studies examining teacher identity have used the lens described by Gee (2000-01) to view teacher identity (see also Varelas, House, & Wenzel, 2005; Luehmann, 2007; Settlage et al., 2009). Helms (1998) employed a frame for viewing teachers’ identities that overlaps with the Gee (2000-01) frame quite a bit, but also includes teachers’ prospective views of themselves in the future. Helms’ (1998) frame also uses four dimensions: teacher actions; institutional, cultural, and social expectations (I-, D-, and A-), values and beliefs (N-identity), and descriptions of one future self as a teacher. This framework, developed as part of a qualitative multi-case study relies on teachers’ self-descriptions through interviews.

Like Helms (1998), Beijaard and colleagues (2000) asked teachers to describe themselves as teachers. Unlike the Gee and Helms frames, this study focused on the teachers’ descriptions of expertise rather than the factors informing it. Beijaard and colleagues (2000) asked the teachers to divide their total teaching expertise among three areas: content knowledge, pedagogical knowledge, and didactical knowledge in a quantitative survey study.
Content was described as only disciplinary content knowledge (i.e. not including pedagogical content knowledge), while pedagogical knowledge included general pedagogical skills and delivery of content to students (both pedagogical knowledge and pedagogical content knowledge). Didactical knowledge was described as, “the ways in which a teacher organizes, executes and evaluates his/her education in the classroom” (D. Beijaard, personal communication, January 28, 2010). While some other frames consider various influences on teacher identity this one is unique in that it considers the distribution of one’s identity, as opposed to what informs it.

Several researchers (e.g. Helms, 1998; Brickhouse, 1990; Varelas et al., 2005) also incorporate science teachers’ views of themselves as scientists as part of science teacher identity. In her multi-case study, Helms (1998) used the teachers’ changing view of herself as a scientist as one measure of identity. Brickhouse (1990) suggested that a teachers’ thinking about herself as a scientist can influence her science instruction, and that view may or may not influence the way she chooses to teach certain content. However, Brickhouse (1990) also concluded that although teachers’ self-identification as scientists can influence instruction, many other factors, specifically time, school climate and standards may over-ride scientific self-identity in instructional decisions. Varelas and colleagues (2005) recommended encouraging scientific dialogue and discourse among teachers to develop scientist identities, thus leveraging the D-identities of teachers to foster scientific identification. Grier and Johnston (2009) found that teacher candidates who were career changers from STEM careers tended to develop a blended teacher identity throughout their preparation program that incorporated some amount of their former STEM careers. Likewise,
Eick (2009) also found that pre-service teachers’ early scientific experiences played a strong role in the formation of their science teacher identities. In sum, scientist-identities can play a critical role in one’s development as a teacher of science.

Like Varelas and colleague’s (2005) examination of scientific discourse as an influence on teacher identity formation, other researchers have mirrored this idea of discourse as a mechanism for developing other parts teacher identities beyond scientist self-identification. For example, vanDriel, Beijaard, & Verloop, (2001) suggested that practical pedagogical knowledge can also be fostered through collaborative dialogue with colleagues. tenDam and Blom (2006) suggested that a teachers’ role within a school, as in how they interact with parents, students, and colleagues can help to inform his or her identity. Taken together, these findings suggest that teacher’s D-identities can be leveraged to develop their teaching, and that I-identities can play a big role in how discourse occurs (Gee, 2000-01).

**Previous studies on teacher identity**

**Preservice and beginning teachers.** Much of what we know about teacher identity comes from studies of teachers at the beginning of their careers. Most of what is known about teacher identity formation comes from the study of pre-service teachers construction of their professional identities (e.g. Settlage et al., 2009; Luehmann, 2007; Proweller & Mitehener 2004; Pedretti et al., 2006) all studied pre-service teachers that sought to examine construction of professional identity. Similarly, Appleton and Kindt (2002) worked with early career teachers examining their identity development during the transition from student teacher to beginning teacher. While some elements’ of a teacher’s identity might remain fairly constant throughout their career, others, such as I-identity characteristics, might change
with increased time in the profession. Recognizing this possibility, Settlage and colleagues (2009) interviewed new teachers over time to try to better understand how identities change over time.

**Experienced teachers.** Other researchers (e.g. Moore, 2008; Varelas et al., 2005; Helms, 1998) studied the identities of more experienced teachers. For example, Moore (2008) examined the sociocultural influences on teachers’ identities; defined as positional identities, in an effort to craft better professional development experiences for teachers further along in their careers. On the other hand, Varelas and colleagues (2005) and Helms (1998) studied how personal science experiences play into experienced teachers’ identities. Varelas et al. (2005) examined the influence of real scientific lab experiences on teachers while Helms (1998) asked teachers about the role science plays in their lives. Beijaard and colleagues (2000) also worked with some more experienced teachers, and with that experience came the ability to self-assess their own expertise among three key areas: pedagogy, didactics, and content. Knowing that identity is a construct that changes over time, better understanding experienced teachers’ identities can help us to meet their changing needs for professional development and growth over time.

**Elementary Teachers’ Scientific Identities**

Most of the studies of teacher identity specific to science teacher identity have focused on teachers at the middle and high school levels (e.g. Beijaard et al, 2000; Pedretti et al., 2006; Helms, 1998; Moore, 2008; Volkman & Anderson, 1998). Beilock, Gunderson, Ramirez, and Levine (2010) found that elementary teachers’ mathematics anxiety can lead to difficulties in student achievement in mathematics, begging the question: does the same hold
true for elementary teachers lacking confidence in science? Elementary teachers are increasingly required to teach science with the mandates required by *No Child Left Behind* now holding teachers accountable for student achievement in science. Many reports (e.g. Fulp, 2002; Duschl et al., 2006) indicate that science is an area in which elementary teachers feel little confidence, suggesting that perhaps science teacher identity is an important lens to use for examining elementary teachers science practices. Several studies have taken this approach. For example, Appleton and Kindt (2002) examined the science teaching practices of early career elementary teachers and found, “those teachers with clear self-perceptions of themselves teachers and teachers of science more quickly established workable teaching practices in science and were able to progress to thinking about their pupils and the learning in which they were engaging” (p. 59). In their 2005 study, Varelas and colleagues studied how the scientist and science-teacher identities of a number of pre-service teachers, two of whom were elementary teachers, changed after having experienced some authentic science practices in a field environment. Those changes led to some more authentic science practices during their student-teaching experiences. It is clear that scientific and science-teacher identities of elementary school teachers strongly influence how they teach science, and warrant further study.

**Methodologies for Examining Identities**

Many of the existing studies of teacher identity are qualitative in nature, and rely on case studies or multi-case studies of exemplar teachers, both positive and negative (e.g. Helms, 1998; Volkman & Anderson, 1998; Moore, 2008; Appleton & Kindt, 2002). Data sources informing these case studies typically include semi-structured interviews (Moore,
2008; Pedretti et al., 2006; Anderson & Kindt, 2002) and some of these follow standard interview protocols such as the *Teachers’ Pedagogical Philosophy Inventory* [TPPI] (Eick & Reed, 2002). Observations of teaching, planning, and interacting with others are often used in constructing case studies as well (Moore, 2008; Pedretti et al., 2006; Appleton & Kindt; Eick & Reed, 2002). In some studies, teacher journals or reflections are also used to build their cases (Volkman & Anderson, 1998).

In some studies of teacher identity, more quantitative measures are used to determine teacher identity. For example, in their case study, Pedretti and colleagues (2006) used surveys and questionnaires coupled with observational and interviews. In another completely quantitative study, Beijaard et al. (2000) also used questionnaires with retrospective pre-post items about expertise allocation early in their careers and at the present. These questionnaires also contained open-ended questions used as a second data point describing identity. Other researchers (Settlage et al., 2009; Bleicher, 2004) used the *Science Teaching Efficacy Belief Instrument* [STEBI] instrument to better explain characteristics of teacher identity. In some studies these were also coupled with observational and interview data to paint a more complete picture on identity along with self-efficacy (Settlage et al., 2009). These quantitative studies allow us to better understand commonalities in teacher identities and characteristics across larger numbers of teachers.

**Student Perspectives on Teacher Identity**

Students provide a unique lens for examining teacher identity. Nearly all studies of identity consider just two viewpoints: that of the teacher and that of the researcher. Self-reported data allow teachers to describe attributes of their own identities (Beijaard et al,
2000; Helms, 1998). However, even these self-reported data are interpreted through the lens of the researcher, especially when the researcher relies on her own interpretation of observed events. When using specific analytical frameworks (e.g. Gee, 2000-01), the perspective of the researcher is used to classify information about teacher identity into specific categories. Recently, several studies have acknowledged that students are also part teacher identity development (Proweller & Mitchner, 2004; Settlage et al., 2009). Proweller and Mitchner (2004) incorporated teachers’ impressions on student learning in their discussion of identity, but this work fell short of questioning the students themselves. Similarly, Settlage and colleagues (2009) asked pre-service teachers to describe their student needs, but again, did not question the students themselves. This gap in the literature leaves an opportunity to explore a third perspective on teacher identity—that of the student. Since most of a teachers’ profession involves interaction with students, students might hold the key to a better understanding of teacher identity.

**Teacher Identity & Professional Development**

One goal of professional development is to introduce teachers to innovative teaching practices. Several researchers have examined the influence of teacher identity on likelihood to adopt innovations in teaching (Appleton & Kindt, 2002; Volkman & Anderson, 1998; Pedretti et al., 2006). Appleton and Kindt (2002) found that various components of teacher identity, including confidence, self-efficacy, and collegial support play a role in teachers adoption (or lack thereof) of reform based practices after professional development. Several studies suggest that exposure to critical incidents such as a positive professional development experience or teachable moment, can change the way teachers view themselves and their
teaching (Appleton & Kindt, 2002; Volkman & Anderson, 1998). In a similar study, Pedretti and colleagues (2006) also found that various aspects of teacher identity, including self-confidence, sense of control, and sense of belonging to a school community influenced teachers’ likelihoods to adopt environmental science ideas into their curricula.

Professional development experiences that spark teachers to change the way they think about themselves might change their affinity group affiliation, the type of role they play in an institution, and type of discourse they participate in (Gee, 2000-01). Likewise, these types of incidents might change the way teachers view their own teaching expertise (Beijaard et al., 2000). Moore (2008) found that even seemingly similar teachers have quite different identities and thus different needs through professional development, suggested that identity-focused professional development might be a better way to address in-service teacher education. In a study of pre-service teachers, Eick (2009) developed individually-tailored internship experiences for pre-service teachers based upon their identity characteristics, and found this lead to higher self-efficacy and reflective practice; this suggests that the same could hold true for identity-focused in-service professional development. Moore-Mensah (F. Moore-Mensah, personal communication, November 5, 2009) suggested taking teachers’ personal goals and perceived student goals into account when structuring professional development activities, leading to more effective learning. Taken together, these findings suggest that creating identity-specific in-service teacher education efforts might be a useful step for enhancing reform-based practices.
Summary

Teacher identity is a construct with many dimensions, and can allow one to consider many aspects of what influences teacher practice. One element of teacher identity is scientific identity, and research has found that teachers’ self-identification with science can influence their instruction. While we do know that elementary teachers tend to be poorly prepared in science and lack confidence in their science teaching, we know very little about elementary teachers’ actual scientific identities. Thus, information about elementary science teacher identities might have promise for helping to meet the need of improving elementary science instruction. Finally, science teacher identity has been examined primarily from the viewpoint of the researcher or the teacher herself. Students interact with teachers throughout their science instruction and might hold critical information about teacher identity that could be used to inform professional development efforts to improve elementary science education on the whole.

Professional Development

Introduction

Professional development is a mechanism for enhancing a teacher’s professional capabilities. These enhanced capabilities and collegiality engendered through professional development can also lead to higher teacher retention rates (Luft, Roehrig, & Patterson, 2003; Darling-Hammond, Wei, Andree, Richardson, & Orphanos, 2009). In the current age of accountability in education, professional development is necessary to ensure that teachers are up to speed on educational innovations and professionally competent.
Professional development is closely linked to teacher identity, as professional development can be shaped by identity and vice versa (Moore, 2008). Teachers who volunteer to participate in professional development dominate many of the published studies on professional development, especially those over long timeframes, but little is known about the teachers who do not normally participate. Moore (2008), studied the characteristics of some seemingly similar teachers, and found their own individual wants and needs to be quite different; one can infer that this is often the case with many seemingly similar teachers from the same schools and districts, yet little choice in terms of professional development is offered to large groups of teachers. Supovitz and Zief (2000) conducted a survey on a group of teachers who did not volunteer for a district wide science professional development activity. The authors found that the non-volunteers had little in common besides the fact that many were caretakers for small children or elderly relatives. When these non-volunteers were questioned about their wants and needs for professional development, the responses showed an overwhelming preference for one-day workshops inside the school on teacher workdays. This suggests that efforts should be made to modify existing professional development activities to make them more conducive to in-school settings, such as after school study groups, or more mentoring and coaching.

**Models for Professional Development**

Researchers have developed many models for teacher change through the use of professional development (see Appendix for models). Guskey (1986) argued that teacher beliefs change only after teachers gain evidence of student learning, and depicted this series of changes motivated by professional development as a flow-chart. Kennedy (1999)
compared multiple studies on professional development, also using a flow-chart model similar to that of Guskey (1986), to describe changes that result from professional development. However, Kennedy’s chain stopped with “changes in student learning” and did not include changes in teacher attitudes or beliefs. Supovitz and Turner (2000) proposed a model similar to the one used by Kennedy, but situated their flow-chart in the larger context of the school, district and state, indicating that professional development must take the teachers’ context into account. Fishman Marx, Best, and Tal (2003) abandoned the flow-chart model for professional development and offered a multi-dimensional cyclic model emphasizing that teachers beliefs have an important influence on professional development and student learning.

Regardless of the model used to view professional development, we must recognize that there are multiple types of professional development programs offered to teachers, which fall under two large umbrellas of “traditional” and “reform.” Garet et al. (2001) reported that 79 percent of teachers’ professional development experiences could be categorized as traditional in nature. Traditional professional development outside the typical school setting, and can include workshops, institutes, college and graduate courses, and conferences (Garet et al., 2001; Penuel et al. 2007). On the other hand, reform-based professional development can come in many different formats. Reform activities that typically occur during the school day include mentoring and coaching and study groups where teachers can examine and analyze artifacts of teaching practice (Loucks-Horsley & Masumoto, 1999; Garet et al., 2001; Penuel et al., 2007). Reform practices that typically occur outside the school day are internships working with practicing scientists in the field or lab (Loucks-Horsley &
Masumoto, 1999), and developing professional networks of teachers within common content-areas or grade levels (Penual et al., 2007).

**Elements of Professional Development**

Professional development is composed of five main elements: content, strategy, site, media, and context (Fishman et al., 2003; Loucks-Horsley & Masumoto, 1999). The content of a professional development experience can include: disciplinary content instruction, pedagogical instruction, and pedagogical content knowledge. In addition, the content of a professional development activity focused on a particular curriculum or course can include the intended curriculum itself (Loucks-Horsley & Masumoto, 1999). Professional development strategies are the pedagogical approaches used by the providers (e.g., coaching techniques, lecture, online discussions, etc.). Penuel et al. (2007) found that using logistical technical support as a strategy for professional development had a significant effect on teachers’ use of reform-based instruction, as increasing familiarity with technology can increase teacher confidence in using new strategies.

The site of a professional development experience can often play a role in the level of teacher participation, especially when comparing in-school and out-of-school experiences. Supovitz and Turner (2000) argued that professional development must occur in the context of a teacher’s normal working environment in order to be successful. Loucks-Horsley and Masumoto (1999) supported that the context that professional development is set in (e.g., whether or not it is in line with school/district/state goals) is an essential element to consider. With the increasing prevalence of distance education as a mechanism for delivering professional development, the context of professional development can also vary due to type
of distance education strategy. For example, Annetta and Shymansky (2008) conducted a study comparing three modes of distance professional development (interactive discussions, live discussions around taped video, and asynchronous) and found that those modes most like face-to-face experiences (i.e. interactive synchronous discussions) were most effective at delivering professional development to participants. Monet and Etkina (2008) incorporated a distance education component (giving feedback) into their professional development efforts and found this to be a useful way to monitor and adjust the professional development experience for all participants. Implications for using distance education as a context for professional development includes greater feasibility for providing opportunities for many teachers. However, it is important to note the choice of distance education mode is a key critical factor.

**Effective Professional Development**

The effectiveness of professional development is sometimes determined through meta-analyses across multiple projects conducting professional development. Garet et al. (2001) conducted a meta-analysis of professional development experiences of over 1000 teachers involved with Eisenhower foundation grants. Kennedy (1999) also studied groups of teachers involved with Eisenhower-funded projects, but limited their analysis to only studies that examined student learning and specific to science instruction. On the other hand Banilower, Heck, and Weiss (2007) and Supovitz and Turner (2000) conducted meta-analysis studies of professional development experiences associated with the Local Systemic Change initiatives. Banilower et al. (2007) noted that a key element to successful professional development is that it is not approached as a “one size fits all”-type of activity,
and should be structured to meet specific needs and goals. For example, analysis of student work is probably best approached through small study groups or coaching while deepening teachers’ content knowledge might be better approached through a workshop.

Duration is often cited as a critical element to the success of professional development, both in time span over which the development takes place as well as the total number of contact hours for the participants (Banilower et al., 2007; Supovitz & Turner, 2000; Guskey, 1986). Not surprisingly, Garet et al. (2001) found that with an increased duration, the professional development makes more connections to teacher goals and experiences and therefore results in more content being presented. Guskey (1986) suggested that increasing time span over which the activities take place by using follow-up sessions to provide teacher feedback is essential for increasing coherence for teachers. Some studies have also found correlations between increased contact hours and increased teacher use of reform practice (e.g. Supovitz & Turner, 2000), but Banilower et al., (2007) cautioned that the data to support these correlations are mixed and the increase in teacher performance is small in magnitude. Supovitz and Turner (2000) reported that teachers used significantly more of inquiry-based instruction after 80 hours of professional development, but changes in investigative classroom cultures occurred only after 160 hrs of professional development. Deepening teacher content knowledge is also considered an essential element to the success of teacher professional development (Garet et al., 2001; Kennedy, 1999; Fishman et al., 2003). Kennedy (1999) found that increased specificity in content offered at a professional development experience (i.e., content specific to a particular curriculum or grade level goal) has larger positive effects than generic professional development. Fishman et al. (2003)
divide the “content” of professional development into three broad categories: disciplinary content knowledge [CK], pedagogical knowledge [PK], and pedagogical content knowledge [PCK], and found that focusing on how students learn content, PCK, can lead to better results than professional development which is focused more in giving teachers new instructional strategies, PK. Along the same lines, “active learning,” or a focus on reviewing actual teacher practice (e.g., by reviewing student work or receiving feedback on teaching), can also be a key element to successful professional development (Garet et al., 2001). Thus, it follows that reform-based activities like mentoring and study groups would be conducive to increasing the amount active learning associated with professional development. Fishman et al. (2003) found that showing teachers their students’ pre- and post-test scores and brainstorming ways to address common student concerns was helpful and suggested this as a method for continual improvement of professional development over time.

As Garet et al. (2001) explained, “Teachers who experience professional development that is coherent—that is, connected to their other professional development experiences, aligned with standards and assessments, and fosters professional communication—are more likely to change their practice.” Guskey (1986) supported this notion by asserting that teachers must be able to collect evidence that the implemented changes are working—through feedback, student achievement, follow-up sessions, etc. One way to increase the coherence of a professional development experience is to increase the teachers’ confidence in the mechanical use of instructional materials (Lee et al., 2008). Penual et al. (2007) offered that providing teachers with technical support and guidance can increase the coherence of a professional development experience because it leaves teachers better prepared to implement
innovations. Penuel et al. (2007) found that teachers who were able to tailor teaching materials to specific school situations were better prepared to effectively implement materials and increased inquiry-based teaching practices. It follows that professional development at a school or district level can foster these types of changes.

**Measures of effectiveness**

There are many ways to measure the effectiveness of professional development including: observations (of the professional development itself or of participants actively teaching), providing surveys to teachers, studying student performance, having teachers log their teaching practices, or writing reflective journals. Teacher surveys are by far the most common measures of professional development effectiveness, but are not without fault. Fishman et al., (2003) described these surveys as “opinionnaires” and argued that surveys are often skewed and hold value only when triangulated with other data (e.g., classroom observations or student learning data). Supovitz and Turner (2000) noted the cost effectiveness of surveys and suggested validating survey data in a similar way. Lee et al. (2008), conducted professional development in which teachers worked in small groups to brainstorm improvements for their program and curricular materials after filling out questionnaires as a method of providing feedback on professional development experiences. The teachers in their study were able to voice their opinions separately from questionnaires, encouraging honest responses. Garet et al. (2001) argued that although data collected through teacher surveys may be skewed, but this bias would always occur in the same direction, thus comparisons between surveys were valid.
Naturally, measuring professional development through student learning can take many forms, such as using assessments either built into curriculum materials or standardized testing, or by analyzing student work in science notebooks (Fishman et al., 2003). One limitation to this approach is that many factors influence student work, so that this is not necessarily an accurate measure. Teaching logs can also be used to better understand strategies and techniques used after attending professional development. Barrow & Sawanakunanont (1994) used this technique to analyze continued use of teaching strategies one year after an 8-week long professional development experience around the use of inquiry based and hands on science teaching. While these logs are cost effective, they rely heavily on teacher self-report data and are prone to bias (Garet et al., 2001) in over-reporting the use of activities suggested by the professional development.

Monet & Etkina, (2008) used reflective journals as a mechanism for providing formative feedback to professional development providers. In this study, teachers attended various workshops and submitted structured online journal entries after each session. They were asked: “What did you learn, how did you learn it, and which areas are still uncertain?”, and their responses were coded by professional development providers. This study was limited by its small sample size (n = 10) and ambiguity in data coding, but they proposed formative assessment of the providers themselves, thus allowing the experience to be tailored to teacher needs as it progressed. In addition, these journal entries were coupled with teacher survey data to provide a broader picture of the effectiveness of the professional development experience.
Sustainability of Professional Development

A longer-term measure of professional development success could be whether or not professional development’s proposed innovations are sustainable. Fishman and Krajcik, (2003) suggest that the innovation must be usable, (i.e., adaptable to the unique context of a school or district) in order to be sustainable. This might be an argument for using the Supovitz & Turner (2001) model for professional development (see Appendix) when planning the professional development. Further, Fishman and Krajick (2003) argued that the innovations presented must be specific to the needs of the teachers and include the necessary tools (teacher background information, manipulatives, etc.). The authors also argued that innovations presented at professional development must be flexible and adaptable to individual schools and classrooms. Many innovations presented to teachers through professional development occur through grant-funded projects, which are normally funded in 3-5 year cycles, and consist of small pilot studies, followed by scale-up, or implementation with larger groups of teachers. With these cycles, scale-ability becomes an additional concern. One method for increasing the sustainability and scale-ability of innovations presented in professional development is to build some of the professional development into the curriculum materials themselves (Ball & Cohen, 1996; Fishman et al., 2003). Ball and Cohen (1996) suggested changing teachers’ guides to be more educative for teachers by including common student thinking and misconceptions around major ideas as well as questioning probes. The authors noted limitations of doing so, such as a teachers guide cannot tell a teacher when to work one on one with a student or move from one topic to the next. Teachers are also limited by their amount of planning and preparation time, especially
at the elementary level. Teachers might not read additional background information when time for planning is already tight.

**Teacher Identity**

Various elements of teacher identity such as confidence in teaching, general pedagogy and reflective practice could enhance the likelihood of a teacher deciding to participate in professional development (Beijaard et al., 2000). Supovitz and Zief (2000) reported that the majority of professional development participants are volunteers, which begs the question of what would encourage a teacher to volunteer. Teachers with N- and A-identities associated with science (e.g. were a strong science student, or enjoy science hobbies) might choose to volunteer to participate in science professional development over some others (Gee, 2000-01). Likewise, some teachers with I-identities such as science leader or grade level chair might be volunteered by their school or administration to participate in professional development (Gee, 2000-01). Regardless of how a teacher might end up participating in a professional development experience, one’s D-identity could certainly influence the ways she interacts at the professional development experience (Gee, 2000-01). These differences in interactions might also influence the likelihood of encountering an identity-shifting critical event that could spark teachers to change or improve their practices (Appleton & Kindt, 2002; Volkman & Anderson, 1998).

Finally, in her study of three seemingly similar high school science teachers, Moore (2008) found each of these teachers had unique needs and wants for their professional development experiences, suggesting that perhaps making professional development more focused on individual needs of teachers could enhance its efficacy.
Summary

In conclusion, professional development is an essential tool for improving science teacher education. Banilower et al. (2007) found that teacher attitudes towards teaching science and using reform-based practices increased with all professional development, but we must realize that there are many options and models to choose from, with many different typical outcomes, thus it needs to be planned carefully. Fishman & Krajick (2003) suggested that the 3-5 year funding cycles that dictate the structure of most professional development efforts need to be increased to produce more sustainable changes. Since this is unlikely, careful planning with follow-up might be the best method for achieving longer-term implementations. Schools and districts also need to pay more attention to funding professional development. In looking to the future of professional development, we must include an increased focus on distance education, or mixed-formats combining face-to-face experiences with online. This might be an especially important technique for enhancing the skills of the “non-volunteer” teachers who often opt out of participating in district-wide professional development opportunities due to family obligations. Finally, incorporating a focus on unique characteristics of teacher identity could help teachers to meet their own learning goals and the goals of their students through professional development, thus enhancing their buy-in to the professional development experience and likelihood to make lasting changes to their practice.
Overall Summary

With increased accountability for teachers in elementary science, there is a need to improve science instruction at the elementary level. Some of this improvement can be achieved through incorporating more inquiry-based practices used by teachers. Science notebooks are useful tools for enhancing inquiry-based science instruction in elementary schools. When used regularly, these notebooks also provide us with a record of a teacher’s practices and instructional sequence. Since teaching practices are heavily influenced by teacher identity, knowing more about teacher identity can allow us to develop more effective professional development strategies to assist elementary science teachers. The current state of the research on science teacher identity relies on information from just two perspectives: the teacher, and the researcher. Students, and their work, can hold additional information about teacher practices as informed by identity. This third perspective can allow us to better understand identity and, thus, better inform professional development strategies.

This study will consist of a year-long case study of one group of second grade students taught by three different teachers over the course of a school year. The teachers will each be observed teaching this one group of students multiple times and participate in face-to-face interviews focused on their science teaching. Each student’s science notebook will include notebook entries created during lessons with all three of the teachers, thus providing a unique lens for studying teacher practices. Each student notebook from the class will be photographed and analyzed, and a sub-sample of students will be interviewed face-to-face quarterly to describe the types of entries created with each of the teachers as well as their views on their teachers’ identity. Finally, findings from the analysis of this case will be used
to suggest next-steps for identity-focused professional development to enhance elementary science instruction.
METHODOLOGY

Introduction

The purpose of this study is to better understand how differences in teacher identity influence science instruction and student learning. The study will take place during one school year (2009-10) with one group of second grade students taught by three different teachers over the course of the school year. A mixed-methods case study research design will be used to explore the case of this group of students.

Mixed methods research has been defined as, “an intellectual and practical synthesis based on qualitative and quantitative research; it is the third methodological or research paradigm…It recognizes the importance of traditional quantitative and qualitative research but also offers a powerful third paradigm choice that often will provide the most informative, complete, balanced and useful research results,” (Johnson, Onwuegbuzie, & Turner, 2007). However, some authors (e.g. Greene, 2008) argue that mixed-methods research is not a separate paradigm, but simply a combination of both qualitative and quantitative research. Mixed methods approaches allow for multiple types of data sources to be used to examine one phenomenon. With these multiple data sources, biases associated with both qualitative and quantitative methods alone are reduced (Creswell, 2003). Likewise, when one uses multiple methods to collect data, evidence provided through either qualitative or quantitative research can be enriched and strengthened (Mackenzie & Knipe, 2006). Furthermore, mixed methods approaches can legitimize data sources that may not have been used in the past.
(Greene, 2008). In sum, mixed methods research can produce a rich and thorough understanding of a phenomenon.

Mixed methods research can be used to look at data sources differently. This methodology allows one to quantitize qualitative data. For example, researchers can code observation notes for quantitative analysis (Teddle & Tashakkori, 2006) or code frequencies of various types of events (Miles & Huberman, 1994). Conversely, mixed methods can allow researchers to qualitize quantitative data, or “tell the story” behind aggregated quantitative codes or explaining trends in numeric data (Teddle & Tashakkori, 2006). Finally, mixed-methods studies allow for both quantitative and qualitative research questions to be asked (Creswell, 2003; Teddle & Tashakkori, 2006). Mixed methods research allows us to use the same data sources in multiple ways.

Case studies are used to study a particular phenomenon bound by parameters, such as time and activity (Stake, 1995; Creswell, 2003; Miles & Huberman, 1994). Case studies are the preferred mechanism for answering how and why questions about a particular phenomenon (Yin, 2009). Case studies use a variety of data sources, both qualitative and quantitative to examine the issues (referred to as θ) associated with a case, (referred to as Θ) (Yin, 2009; Stake, 1995). In case studies, issues are the critical factors influencing the phenomenon (Stake, 1995). In this study, the case (Θ) is bound by the science instruction (activity) for one year (time) of one group of second grade students. The key issue (θ) associated with the science instruction is that science is taught by three different teachers over the course of the year. A lens of teacher identity will be used to describe differences in
teachers (Gee, 2000-01, Beijaard et al., 2000). Teacher identity will allow us to clearly examine key issue, $\theta$, differences in teachers.

Specifically, a mixed-methods concurrent triangulation strategy will be employed to describe the case of this group of second grade students (Creswell, 2003). In concurrent studies, both quantitative and qualitative data are collected during the same time period. Equal priority will be given to the quantitative and qualitative data. When concurrent mixed-methods designs are used, qualitative data can explain any discrepancies in quantitative data (Driscoll, Appiah-Yeobah, Salib & Ruppert, 2007). Triangulation occurs when data sources are combined during the data analysis phase of a study when a combination of methods are used to study the same phenomenon (Johnson et al., 2007). Figure A below illustrates the concurrent triangulation study that will be used.

Figure A: Concurrent Triangulation Strategy (adapted from Creswell, 2003 fig 11.3a pg. 214)

**Data sources.** Multiple qualitative and quantitative data sources will be used to examine this case. In this study the qualitative data sources include: classroom observation notes, narrative teacher interviews, narrative student interviews, and qualitative descriptions of student notebook entries and trends in notebook data. The classroom observation notes
capture the synopsis of a lesson and descriptions of classroom interactions both between the teacher and student and among students. The narrative teacher interviews include descriptions of science teaching style, personal interest in science, preparedness to teach science, views of oneself as a scientist, and opinions on science notebooks. The narrative student interviews capture students’ view of themselves and their teachers as scientists, descriptions of their notebook entries and synopses of what they have learned in science. The qualitative descriptions of student notebook entries and trends in data will be used to tell the story of the teachers’ instruction as documented by students in the notebooks. These qualitative data sources, when viewed through the lens of teacher identity will allow us to describe $\theta$, or the differences in science instruction by the three teachers throughout the course of the school year.

Quantitative data sources in this study include the quantitative codes of science notebook entries and classroom observation notes, and teacher responses to a modified STEBI-B (Bleicher, 2004) and interest in science survey (Bleicher, 2010). The entries created by students in their science notebooks will be coded for inquiry phase (pre-, during-, and post-investigation) and driving force (teacher-driven, student-driven, or balanced). Classroom observation notes will be coded for instructional strategies employed (whole class instruction, small group activities, hands-on activities, and independent seat work), along with observed use of notebooks (pre-, during- and post-investigation). The STEBI-B is an instrument that has been modified and used in a number of studies of teacher identity (e.g. Bleicher, 2004, 2010; Settlage et al., 2009), and allows teachers to quantify their beliefs and preparedness about science teaching. The Interest in Science Survey allows teachers to
quantitatively document their own personal interest in science and has been shown to correlate well with the STEBI-B instrument (Bleicher, 2010). Together, these quantitative data sources will provide a numeric understanding for differences in teachers’ science instruction.

**Reliability and validity.** In this mixed-methods case study, reliability will be established through the use of protocols (Yin, 2009) to guide and organize data collection. Construct validity will be established through studying the same phenomenon using multiple qualitative and quantitative data sources (Yin, 2009). Internal validity will be established through pattern matching and building explanations across these data sources (Yin, 2009). Finally, external validity will be ensured by comparing the results of these case studies to those published in the literature (Yin, 2009). Establishing this methodology will ensure both a reliable and valid study.

**Research Questions**

In order to better understand how teacher identity influences science instruction, the following research questions will be addressed:

1. How does teacher identity influence the content of students’ science notebook entries?
   - Teacher identity influences practices which are captured in student science notebook entries.
   - Students’ views of a teacher’s identity also incorporated in notebook entries.
2. (Methodological question) How effective are elementary students’ science notebooks at capturing teacher identity?
   o Does the content of science notebooks match what students report knowing (both through interviews and classroom observations)?
   o Does the content of science notebooks match what teachers intended to cover (through observed presented content)?
   o Do we see things in observations that aren’t captured in science notebooks?

3. (Next steps/implications question) How can an understanding of teacher identity through science notebook entries inform professional development?
   o Moore (2008) encourages identity-focused professional development without much guidance on what constitutes identity-focused professional development. This leaves space for us to explore what identity-focused professional developments might look like.
   o What modifications to our data collection methodology would help in understand teacher identity and its impact on science learning?

Study Context

This study will take place in one public elementary school in urban/suburban central North Carolina. This school is participating in another ongoing science education research project. The school’s science curriculum consists of science kits, with each grade implementing four kits per year (one per quarter). The teachers at this school and throughout the district are encouraged to use science notebooks in conjunction with the kits. All teachers in the district are offered optional training in the use of the science kits as well as in science
notebooks provided by the district. The particular group of students being used as the case in this study were selected due to the instructional model for science teaching employed at their grade.

In this school, the second grade uses a unique model for science teaching, as displayed in Table 1 below. There are a total of three second grade teachers (Teachers A, B, and C). Each teacher specializes in one kit (*STC Life Cycles of Butterflies, Insights Sound, and STC Air and Weather* for Teachers A, B, and C respectively). During the first quarter of the school year, each teacher stays with her own class for science, teaching the kit in which she specializes. During quarters two and three, the teachers rotate through the other two classes. During the fourth quarter, all three teachers return to their own class for science, and all teach the same kit, *STC Changes*. The student group that will serve as the case of for this study is Class X, as highlighted in Table 1 below.

**Table 1:**

**Science Instructional Design**

<table>
<thead>
<tr>
<th>Quarter 1</th>
<th>Teacher A- STC Lifecycles of Butterflies</th>
<th>Teacher B-Insights Sound</th>
<th>Teacher C-STC Air and Weather</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class X</td>
<td>Class X</td>
<td>Class Y</td>
<td>Class Z</td>
</tr>
<tr>
<td>Quarter 2</td>
<td>Class Z</td>
<td>Class X</td>
<td>Class Y</td>
</tr>
<tr>
<td>Quarter 3</td>
<td>Class Y</td>
<td>Class Z</td>
<td>Class X</td>
</tr>
<tr>
<td>Quarter 4- STC Changes (all three teachers)</td>
<td>Class X</td>
<td>Class Y</td>
<td>Class Z</td>
</tr>
</tbody>
</table>
Data Collection

Multiple data sources will be used in this study to answer research questions specified above. Data will be collected on the case, Class X, for all four quarters, and for Classes Y and Z during the fourth quarter.

**Classroom observations.** During Quarters 1-3, each of the teachers (A, B, and C) will be observed three times while teaching Class X, thus the students will remain constant in the comparisons between these three teachers. Each teacher will be observed twice teaching her own class during the fourth quarter, thus the instructional materials will remain constant when comparing the three teachers. There will be fewer observations per teacher during the fourth quarter as science is taught at the same time for all classes, and time allotted for science during this quarter will be abbreviated due to state high-stakes testing. During all observations, the researcher will take extensive field notes with special attention given to the use of science notebooks, instructional strategies, and interactions between teacher and student and among students. Within 48 hours of completing the observation, field notes will be coded using a protocol developed for the research initiative this school is taking part of, Graphic-Enhanced Elementary Science [GEES] (Wiebe et al., 2009). The observation protocol was developed after consulting three key sources: the Reform Teaching Observation Protocol [RTOP] (Piburn, 2000), Horizon Research Inc.’s Classroom Observation Protocol (Horizon Research Inc., 1999), and Project Inquiry’s classroom observation protocol (Project Inquiry, 2000). The RTOP and Horizon Research Inc. protocols are commonly used across the research literature, but are primarily focused on
middle and secondary science. Project Inquiry’s protocol was developed by another NSF-funded project and was made publically available. This protocol was specific to elementary science and documents science notebook use along with other instructional strategies. The GEES classroom observation protocol includes elements of all three of these other protocols and elaborates on the use of science notebooks. It also includes areas to document use of graphics in science instruction (data on graphics will not be presented in this study).

Science Notebooks. Every notebook from every student in Class X will be photographed and coded for: inquiry phase and driving force. The inquiry phase refers to whether or not the notebook entry was created before, during, or after the scientific investigation. The driving force will indicate whether the entry was driven by the teacher or student, or was some balance in between (Wiebe et al., 2009). Evidence for teacher-driven entries includes identical entries for all students, or consist of handouts or worksheets attached to notebook pages. Narrative themes in notebooks will be identified and described qualitatively, both by the researcher after coding and by a sample of students interviewed quarterly using their notebooks (see Student Interview section below). A small sample (N ~ 5) of science notebooks from students in Classes Y and Z will also be collected, photographed and coded to use as a comparison.

Teacher Interviews. Toward the end of the quarter in which they teach Class X, and at the end of the fourth quarter, each teacher will participate in a face-to-face interview. Each interview will be recorded digitally and transcribed. The interviews will follow a semi-structured protocol (Creswell, 2003) and focus on their science teacher identity and use of
science notebooks. To address science teacher identities, the teachers will be asked to describe what informs their science instruction (i.e. school or district guidelines, interaction with colleagues, content knowledge, interaction with students or personal interest) to address the four components of professional identity described by Gee (2000-01). The teachers will also be asked to describe their views of their personal strengths and weaknesses in science instruction, and allocation of personal expertise in science instruction (Beijaard et al., 2000). Finally, the teachers will be asked about their own views of themselves as a scientist along with factors influencing their views (i.e. interest, education, or discourse with colleagues). To address their use of science notebooks, teachers will be asked to describe how they use the notebooks along with what they see as the strengths and weaknesses of using science notebooks. The second set of interviews, during the fourth quarter, will be conducted in an effort to determine if any changes in science teacher identity occurred through the course of the year or with having taught multiple classes or multiple kits.

**Student Interviews.** One time per quarter, four students from Class X will be interviewed during an after school program one-on-one. The interviews will occur during the last two weeks of instruction per quarter. These interviewees represent within-case sampling of participants (Miles & Huberman, 1994). It should be noted that they also represent a convenience sample, as they are the only four students in Class X who are also part of the after school program. This method was selected as to not pull students away from instructional time during the school day. The student interviews will not be audio-recorded (due to IRB restrictions), but detailed notes will be taken by the interviewer. The interviews will ask students to describe their notebook entries and science instruction, including
identification of places where notebooks do not fully capture the instructional sequence. The 
students will also be asked to provide their impressions on whether or note the teacher views 
him/herself as a scientist or assumes any other role during science class (e.g. writer, artist). 
Several recent studies by Settlage et al. (2009) and Pedretti, Bencze, Hewitt, Romkey, and 
Jivraj (2006) both suggest that teachers’ impressions of how they’re viewed by students 
might play an important role in teacher identity, but studies actually addressing these 
questions with the students themselves have not yet been completed. Finally, students will 
be asked each quarter to describe how they view themselves during science class.

**Teacher Surveys.** During the fourth quarter of the school year, the teachers will each 
complete the STEBI-B and Interest in Science Surveys (Bleicher, 2004, 2010) to 
quantitatively describe their own science interest, preparation, and self-efficacy. These 
instruments will provide an additional data point to be used in describing the science teacher 
identity of these three teachers. Since the sample size of teachers is very small (N=3), no 
statistical analyses will be performed on these responses. They will be used instead to 
provide an additional perspective on science teacher identity and will strengthen any 
qualitative descriptions that emerge after considering the other data sources (Yin, 2009).

**Data Reporting**

In an effort to disseminate the findings of this study, I anticipate writing three papers 
to address each of the three research questions. These proposed papers are as follows:
• To address Research Question 1: an mixed methods case study paper will be written to describe the case of Class X over the course of a school year, comparing differences in the three teachers through the lens of teacher identity.

• To address Research Question 2: a study comparing and contrasting data collected through the analysis of science notebooks and through observational and interview data will be conducted. This represents a methodological study around the efficacy of science notebooks as tools for capturing science instruction.

• To address Research Question 3: a synthesis of findings from this study will be used to provide recommendations for in-service elementary teacher science professional development focusing on identity-focused professional development.
REFERENCES


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